Duo & Duo R

User Guide

FLIR Duo User Guide

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1 Introduction

1.1 Scope

Thank you so much for your purchase of the FLIR Duo or Duo R! Designed for commercial use, the Duo camera system is more than a simple thermal camera. It is a visible + thermal imaging instrument and data recorder that can add tremendous value to small Unmanned Aerial System (sUAS) operations and services.

This guide shows how to get your plug-and-play FLIR Duo camera mounted, connected, and collecting images & video.

Unless specifically stated otherwise, all features and functions of the Duo also apply to the Duo R. The Duo R functions identically to the Duo, with the addition of radiometric functionality to make non-contact temperature measurements.

1.2 Revision History

Version	Date	Comments
100	01/02/2017	Initial Release

2 Resources

There are many resources to help you operate your FLIR Duo:

2.1 FLIR Website / Tech Support Information

In several locations throughout this document, the FLIR Duo website is referenced as a source of additional information. This website can be accessed via the following URL:

http://www.flir.com/suas

Additionally, FLIR's Technical Support department is referenced as a resource for obtaining additional help or information. The department can be accessed via the following phone number: (866) 667-7732.

2.2 FLIR Systems Documents (available on website)

Document Number	Document Title
n/a	FLIR Duo Quick Datasheet
436-0100-01-19	FLIR Duo Technical Drawing
n/a	FLIR Duo STEP File
102-9012-01	Interface Requirements Specification for FLIR TIFF File Format (Web Link)
n/a	FLIR UAS Radiometry Tech Note (Web Link)

2.3 External Documents

Document Number	Document Title
n/a	MAVLink Protocol (Web Link)

2.4 Abbreviations / Acronyms

Abbreviation/ Acronym	Components
AGC	Automatic Gain Control
ESD	Electrostatic Discharge
FFC	Flat Field Correction
FOV	Field of View
GUI	Graphical User Interface
I/O	Input / Output
IR	Infrared
NTSC	National Television System Committee
OSD	On Screen Display
PAL	Phase Alternating Line
PWM	Pulse Width Modulation
µSD	MicroSD (memory card)

3 What's in the box

Your FLIR Duo comes with the Duo camera and a multi-function bench cable for testing the device.

Please note that disassembling the camera can cause permanent damage and will void the warranty. Operating the camera outside of the specified input voltage range or the specified operating temperature range can cause permanent damage. The camera housing is not sealed. Avoid exposure to dust and moisture.

3.1 Unpacking Your Camera

The FLIR Duo comes with the following components:

3.1.1 FLIR Duo Camera

Figure 1. Duo with Camera Mount

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3.1.2 Bench Cable

The Bench Cable should be used for connecting the FLIR Duo to a computer USB port for power[1] and file transfer, as well as video output testing with an analog video monitor. Analog video output is accessed by connecting the yellow RCA pigtail to a video display. Digital video is not accessible from the miniUSB port, but can be displayed using the microHDMI port.

The Bench Cable can also be used for connecting FLIR Duo to standard Radio/Control (R/C) Pulse Width Modulation (PWM) outputs. See Table 1 for pin definitions.

Connecting to a MAVLink-compatible autopilot is possible by building a customized cable based on accessing miniUSB pin1 and pin3 for MAVLink TX and RX. The MAVLink interface operates at a default data rate of 57.6 kbps, with the ability to switch to 115.2 kbps, 230.4 kbps through the user App. See Section 6 for more information.

Powered USB port

RCA Video

Camera 10-pin mini-USB port

PWM1

PWM2

Figure 2. Bench Cable

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[1] 5 V, 0.44 A (average), 0.66 A (peak)

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4 Connecting to the Camera

This section describes the properties and methods of interfacing with the FLIR Duo, both mechanically and through software.

4.1 Mechanical Interface

4.1.1 Size / Weight

The overall size of the Duo is 58.9 mm x 40.9 mm x 30 mm (2.32 x 1.61 x 1.19 in), including the lens but excluding cables and buttons (which protrude slightly). Weight is approximately 65 grams (2.3 oz.). These mechanical specifications do not take into account any additional mounting hardware. For additional details, please see the Duo Technical Drawing referenced in Section 2.2.

4.1.2 Mounting

The Duo camera form-factor conveniently fits with most popular action-camera accessories: there are many available commercial off-the-shelf (COTS) gimbals and mounts available for mounting the Duo onto different UAS airframes. Refer to the Duo Technical Drawing for additional information.

Figure 3. Core dimensions

4.2 Electrical Interface

4.2.1 Bench Testing

For initial bench testing, connect the 10-pin mini-USB connector on the Bench Cable (see Section 3.1.2) to the mini-USB port on the Duo camera. Connect the RCA plug on the Bench Cable to an analog video monitor. Connect the USB (Type-A) connector on the Bench Cable to an available USB port on your computer. Connect the PWM1 and PWM2 to a standard R/C PWM source, if needed. If using an HDMI display, connect the camera to the display using an HDMI cable (not included). If HDMI is used, the camera will automatically detect the connection and switch over to HDMI video output.

4.2.2 Mini-USB Cables

FLIR Duo is compatible with many commercial off-the-shelf (COTS) 10-pin mini-USB cables that are used to provide power to, and receive video from, action cameras commonly mounted on small unmanned aerial systems (sUAS). The included bench cable is for initial setup and configuration of the Duo. The internal wires of the FLIR bench cable are color coded to help you build a custom sUAS

cable that can be used to integrate Duo to your airframe. Please refer to the Duo Technical Drawing for electrical interface guidelines and USB connector pinout.

Simply plug the chosen cable into the mini-USB port on the FLIR Duo, connect power to an appropriate filtered and regulated power supply, and video to a downlink, if desired. Approximate operating current of the Duo camera is 440 mA at 5Vdc, (2.2 Watts). Peak current can reach as high as 660 mA (3.3 Watts).

Note: FLIR Duo has **over-voltage and reverse polarity protection on power pins.** *However, exceeding the wide voltage specification (5-26 Vdc) will damage the camera and void the warranty. Applying reverse polarity should not damage the unit, but it will prevent the camera for powering on and is not recommended.*

Figure 4: Mini-USB 10-pin Layout

Table 1: Mini-USB Port 10-pin Assignment

Mini-USB Port		Bench Cable Internal Wire Color
2	Main Power	red
4	Data Low	white
6	Data High	green
8	Reserved	
10	Main Power GND	black
1	PWM_1 / MAVLink TX Out	yellow
3	PWM_2 / MAVLink RX In	purple
5	Video Low	Black jacket with video high inner blue wire and surrounding shell ground
7	Video High	

9	Reserved

4.3 Software Interface

The Duo camera is configured and operated through the FLIR UAS mobile device app. See Section 5 for additional details.

Note: The Duo camera is not compatible with the FLIR Camera Controller User Interface software. When connected to the USB port on a computer, the camera appears as a mass storage device only.

There is no Software Developer's Kit or API available for the camera. However, advanced camera control can be arranged using PWM or MAVLink integration (see Section 6).

4.4 Camera Operation

Booting /Powering Up
Record LED – Off and then Orange flashing
Status LED – Red flashing

Bluetooth Status
Status LED – Green for Bluetooth off
Status LED – Blue for Bluetooth on

Record ability
Record LED – Orange flashing: Unable to Record
Record LED – Green: Ready to Record
Record LED – Red flashing: Actively Recording

Firmware Update
Status LED – Purple flashing

Record LED

Status/Bluetooth

Figure 5. Camera Status and Record LED Description

The Duo does not have an on/off switch. When power is applied the camera will boot automatically; this takes less than 30 seconds.

- When power is applied to the camera, the Status LED blinks red for approximately 20 seconds, then changes to solid blue, indicating that Bluetooth is enabled.

- The Record LED will go from blinking orange to solid green, indicating that the camera is ready for operation
  - o Note 1: If connected to a computer, the "Record" LED will continue blinking orange, indicating that the device is in "USB Mass Storage" mode
  - o Note 2: If "Record" LED continues blinking orange while connected to a battery or bench power supply, this indicates that there is no SD card in the camera
- Launch the FLIR UAS app on your mobile device.
  - o Use the app to configure camera settings as desired
    - ▪ See Section 5 for information on camera settings & operating modes
  - o Disable the Bluetooth radio in preparation for flight
    - ▪ Simply press the Bluetooth button on the side of the Duo, and confirm that the Status LED turns green
    - ▪ The Duo will automatically disable the Bluetooth radio after 2 minutes if no commands are received from the app. It can be re-started by pressing the Bluetooth button on the camera

Note: The Bluetooth interface is only intended for use during ground operations. FLIR does not recommend flying while Bluetooth is enabled. Bluetooth interface has limited range and high latency.

- Your FLIR Duo is now ready for use. Press the Record button on the camera or in the app to start recording, or use PWM signals. The "Record" LED blinks red while recording video, or flashes red each time it captures a still image.

4.5 Camera Troubleshooting

- The Duo can be rebooted & reset to factory defaults through the FLIR UAS App
  - o With the App connected to the Duo, go to:
    - ▪ "Settings" -> "About" -> "Reset To Factory Defaults"

- To reboot the system manually:
  - o Press and hold the "Record" button on the Duo for at least 5 seconds

- To reboot and perform a factory reset to all default settings manually:
  - o Press and hold both the "Record" and "Bluetooth" buttons for 10 seconds

5 The FLIR UAS App

The FLIR UAS app is the primary configuration interface for the Duo camera. It is compatible with mobile devices equipped with Bluetooth LE running iOS 8.0 or later and Android V 4.3 or above. The screenshots shown in this user manual are for the iOS App version; however, the menu system for Android is quite similar.

Figure 6: FLIR launch screen

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5.1 Home Screen

When launched, the FLIR UAS APP will automatically identify local FLIR UAS cameras; Confirm that Bluetooth is enabled on your Duo device, then select the camera from the camera select screen. After connecting to the camera, the Home screen will be displayed. The Home screen shows camera status and allows the user to adjust the *MSX, IR Color Palette*, *Display Video Mode*, and Record Mode (*Video*, or *Still Images*) settings. The current PWM states are also displayed at the top of the Home screen.

The lower portion of the screen displays record mode ("Video" or "Still Images"), "Record" button, "Recalibrate" button (this initiates a flat field correction (FFC)), and "Settings" button.

Figure 7. Home Screen

5.1.1 MSX

The Duo has the ability to enhance the IR imagery using FLIR's patented MSX image blending technology. Enable this feature to record real-time MSX-enhanced thermal imagery, or disable it to record raw thermal image data. To activate, press the "Enable" or "Disable" text on the App, and select the desired mode.

To adjust MSX settings, simply press the MSX bar on the App home screen to access the MSX drop-down menu.

Note: To record video with MSX enhancements, be sure to set the IR Video mode to H264. MSX will not be recorded on 14-bit (TIFF Sequence) IR imagery, since this is recorded as raw video data.

5.1.1.1 MSX Strength

Use this feature to adjust the degree to which the MSX details show up in the IR imagery. A lower setting results in a softer effect, while a higher setting results in a stronger effect.

5.1.1.2 Alignment

The "Horizontal Align" and "Vertical Align" features allow the user to adjust the alignment between the visible image detail and the IR imagery with MSX enabled. Objects at different distances may require slight tuning of the alignment settings to achieve an optimal image, particularly for objects close to the camera.

5.1.1.2 Recommended MSX Alignment procedure

The MSX alignment adjustment can be used to optimize the MSX alignment for different use cases. Objects at different distances will require slightly different alignment settings to achieve an ideal image. The following method is a useful way to tune the MSX alignment prior to recording:

1) With the camera stationary, point at an easily-identifiable object at a distance similar to the intended flight height.
    a. For example, if you intend to fly at 20m above ground for a given video capture, focus on an object 20m away
2) While viewing the IR image with MSX enabled on a display monitor, adjust the MSX alignment settings to achieve optimal alignment for the test subject
3) Proceed with flight and data recording, and attempt to keep the Duo camera at the intended flight height to obtain optimal MSX-enhanced imagery.

5.1.2 IR Color Palette

The Duo detects and images long wave infrared radiation. Within the camera, this radiation is mapped to a range of 255 colors. Using black and white palette, such as White Hot, this range is converted to shades of gray with 0 being totally black and 255 being totally white. Different palettes are available to change the appearance of the image. The most common selection is typically White Hot (hotter objects appear lighter in color than cooler objects) or HotMetal (hotter objects appear reddish white as oppose to cooler objects in the scene).

Figure 8. Thermal IR Color Palettes

There are two types of palettes offered in the Duo camera.

1. **Linear:** Scene radiation is mapped to pixel values where color is uniformly distributed from one shade to another as pixel intensity increases. These palettes are the most common palettes for general use. (**WhiteHot** & **HotMetal** palettes)
2. **Contrast:** Enhanced observed contrast by mapping pixel values to divergent color schemes. Subtle differences between object temperatures become more apparent. (**Rainbow** palette)

5.1.3 Display Video Mode

The Duo streams analog or HDMI video from the output ports. Selection of the display video mode toggles between a **Visible** stream only, thermal infrared (**IR**) stream only, and a **Picture-In-Picture** stream that shows both visible and thermal. Note that this setting does NOT impact what video is recorded to disk – see the "Settings" -> "Main" -> "Recorded Video" setting for information on that feature.

This feature will also impact the image thumbnail for the Radiometric JPEG file format: set to "IR" to use the IR imagery as the thumbnail, or set to "Visible" or "Picture-In-Picture" for a visible image thumbnail. Note that both IR & Visible image components are still recorded, and accessible through FLIR Tools.

Figure 9. Video Display mode selection

5.1.4 Video/Still Image

The **Video** and **Still Images** tabs configure the Duo recording mode. The system cannot capture a still image during recording of video (or vice versa). The type of video or image files can be configured in **Settings**.

5.1.4.1 Video

Video recordings can record either visible, infrared, or both simultaneously. File type settings are adjustable in the **Settings** screen.

5.1.4.2 Still Images

Configures image capture at a user-selectable interval from one frame per second (slider setting of "1s") to one frame every 60 seconds (slider setting of "60s"). Duo can be configured to record visible and IR as separate data files or as one combined FLIR Radiometric JPEG file.

Use the "Single" slider setting (far left) to record a single still image.

Video Recording Mode

Still Image Recording Mode

Still Image Recording interval from
- Single snapshot
- 1 frame per second
- Up to 60 frames per second

Figure 10: Video/Still Images and Record, shown in Still Images mode at 5-second intervals.

5.1.5 Record

The "Record" button either captures a still image, or starts/stops live video recording. See Section 7 for details on available file formats.

Press to start recording

Red square indicates active recording

Figure 11: "Record" button shown in "ready" and "active recording" states.

5.1.6 Recalibrate

To maintain optimum performance, thermal imaging cameras must occasionally perform an internal recalibration. This is accomplished using an internal shutter, and takes less than one second. During recalibration, a subtle audible "click" can be heard, and live video is momentarily frozen. This function takes place automatically (based on internal camera parameters), and can be manually initiated through user command via the "Recalibrate" button on the home screen, or through an appropriately-configured PWM channel.

Recalibrating prior to taking critical measurements will ensure the most consistent image contrast.

5.1.7 Settings

The "Settings" button is used to configure additional operational parameters and camera modes.

5.1.7.1 Main

Figure 12. Main Settings (Radiometry tab, for Duo R, not shown)

- **Analog Display Format:** Select NTSC or PAL as the format of the video that is output to the 10-pin mini USB port. This setting does not affect the format of the video that is saved to the microSD card.

<p align="center">Figure 13: Analog Display Format selection</p>

- **Digital Display Format:** Select digital output stream format (through the microHDMI port). Available options are **720p30** (30hz, 720p), **1080p30** (30hz, 1080p), and **1080p60** (60hz, 1080p). Note that this does not change the actual recording frequency, only the display rate frequency when connected to a digital monitor.

- **Recorded Video:** This setting determines the type of sensor data that is saved to the µSD card. The Duo can be setup to record **Visible Only**, **IR Only**, or **IR & Visible**.

<p align="center">Figure 14: Recorded Video selection</p>

- **IR Format:** Infrared video can be saved as **8-bit (H264)** that has FLIR AGC (automatic gain correction), MSX, Spot Meter (Duo R only), and color palette applied, or **14-bit (TIFF Sequence)** raw sensor data. See Section 7 for more details.

- o **Note:** The "IR Quality" and "Visible Quality" settings determine the amount of compression applied to the video. "High" quality indicates minimal compression and larger file sizes, while "Low" quality indicates high compression and smaller file sizes.

Figure 15: IR Format selection

- **Still File Type:** Select formats for still images and video saved to the µSD card (See Section 7)

Figure 16: Still File Type selection

- **Camera Orientation Flip:** Select image orientation. If the camera will be mounted upside-down, enable this setting to vertically flip the images recorded by the Duo.

- **Enable LED:** Turns on/off the Status and Bluetooth LEDs. LED indicators will still be displayed while camera is booting up, even if this setting is turned off.

- **Audible tone:** Turns on/off the audible indicator for video recording. Even when turned off, the speaker will beep three times when the camera is ready after power-up.

5.1.7.2 Accy. Port

See Section 6 for information on connecting via PWM and MAVLink.

5.1.7.3 Radiometry

The Radiometry tab provides access to all the temperature measurement functions and settings available on the Duo R. If connecting to a standard Duo camera, this tab will not be visible and these features are unavailable. See FLIR's UAS Radiometry Tech Note (see Section 2.2 for the link) for a detailed discussion on how to obtain accurate temperature readings for UAS applications.

Figure 17. Radiometry Tab

- **Temperature Unit** – Units of measure displayed on the analog video. Select between Celsius and Fahrenheit.

- **Spot Meter** – Turns on or off the spot meter (fixed 4x4 pixel array) in the center of the image and the digital temperature in the lower left corner of the image.

Figure 18. Spot Meter OSD, with "Temperature Unit" set to Fahrenheit

- **Emissivity** – Measure of the target surface ability to emit thermal energy. Values from 50-100% can be configured.
- **Air Temp**. – Ambient temperature of the operating environment. Values from 0 to 40° C (32 to 104° F) can be configured.
- **Sky Condition** – Measure of the cloud cover above the operating site. This affects the background radiation incident on the scene. Choose between Clear, Scattered, and Cloudy.
- **Humidity** – Relative moisture content of the air. Three settings are available; Low (<30%), Medium (~45%), High (>60%).
- **Subject Distance** – Distance from the camera to the subject in the scene. Values from 0-200m (0-218 yards) can be configured.

5.1.7.4 About

The "About" screen provides information on the current software installed on the Duo, as well as the App version.

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Figure 19. About Page

- **Part No.** – FLIR part number of the Duo camera currently connected to the app.
- **Serial No.** – Serial number of the Duo camera currently connected to the app. A "D" indicates a Duo, while a "DR" indicates a Duo R.
- **Firmware Version** – Version of firmware currently loaded in the Duo camera.
- **FW Upgrade Version** - Detects if a camera upgrade file exists on the μSD card. If one is available, the "Upgrade Available" dialog will start. Choose "Continue" to begin the firmware upgrade process. See Appendix A for details on how to upgrade camera firmware.
- **App Version** - Version of software currently loaded on the mobile device.

- **App Upgrade Version** – If the mobile device is connected to the Internet, the Duo app will automatically search for any available app updates. If one exists, the user will have the option to update by following the link to the FLIR web page.
- **Free SD Space** –Reports available space of SD memory gigabytes (GB).
- **Disable Screen Lock** – Prevents the Bluetooth interface from shutting off after 2 minutes by keeping the APP active.
- **Bluetooth Power** – Adjusts the Bluetooth transmitter power and affects the maximum range at which the Duo camera can connect to the mobile device. Power values are expressed in percent.
- **Scan for Devices:** Searches for any FLIR UAS camera in the area and provides user ability to change cameras.
- **Disable Bluetooth:** Powers down the Bluetooth radio on the camera. The camera will normally disable the Bluetooth after two minutes of inactivity. See Persistent Bluetooth.
- **Reset To Factory Defaults** – Resets settings in the Duo camera to original factory configuration. This is required during most FW updates as the internal memory map will change as new features are added.
- **Terms and Conditions** – Legal statements pertaining to the Duo product and FLIR UAS App

6 PWM & MAVLink Operation

6.1 PWM

6.1.1 Connecting to a PWM Compatible Flight Controller

The FLIR Duo camera is software- and connector-compatible with standard R/C PWM controllers using the MiniUSB pinouts. An illustrative PWM implementation connection is described in Table 2. Other flight controllers or I/O modules may require different cables or connectors. Refer to the FLIR Duo Technical Drawing for detailed information.

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Figure 20. PixHawk Flight Controller for PWM

Table 2: PWM Connection

MiniUSB Port		Bench Cable Internal Wire Color	Aircraft Power Source	P1 - AUX Out (M20-1060300)[2]		P2 - AUX Out (M20-1060300)	
2	Main Power	red	5-26 Vdc				
10	Main Power GND	black	GND				
1	PWM_1	yellow	⟶	PWM_1	1		
10	GND	black	⟶	GND	3		
3	PWM_2	purple	⟶			PWM_2	1
10	GND	black	⟶			GND	3

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[2] All cable plug part numbers are Hirose

6.1.2 Configuring PWM Connection

Using the accessory port on the Duo and the included Bench Cable, camera functions can be controlled directly from the sUAS flight controller via PWM signals (refer to the controller manual for configuration instructions). Select the desired setting from the list of available PWM functions. **No two channels can be assigned to the same function.** Any functions currently assigned to PWM channels will not appear in the list of available functions for other channels.

To configure, select the "Settings" button on the Main page. Select the **Accy. Port** tab at the top of the page. Ensure Serial Protocol is set to PWM. Select a PWM channel to configure (Figure 21). Select the desired function. Select the number of states (Figure 22). The number of states will depend on the type of switch that is being mapped on the flight controller. For a three-position switch, the number of states will be three. Assign functions to the available states for each signal. Next, program the flight controller to provide signals to the Aux Out ports for the PWM connectors on the Bench Cable.

The Duo accepts standard PWM inputs for the R/C industry, 3.3-5vdc, 50Hz. LOW = 1ms/20ms, MID = 1.5ms/20ms, HIGH = 2ms/20ms.

Figure 21. PWM Settings allow for control of Recording (start/stop and mode), IR Color Palette selection, Recalibrate, and streaming Display Video Mode

Figure 22. Function Selection

6.2 MAVLink

6.2.1 Connecting to a MAVLink Compatible Flight Controller

The FLIR Duo camera is compatible with many MAVLink autopilots using the MiniUSB pinouts, illustrated in Figure 23 and Table 3. Other flight controllers or I/O modules may require different cables or connectors. Refer to the FLIR Duo Technical Drawing for detailed information.

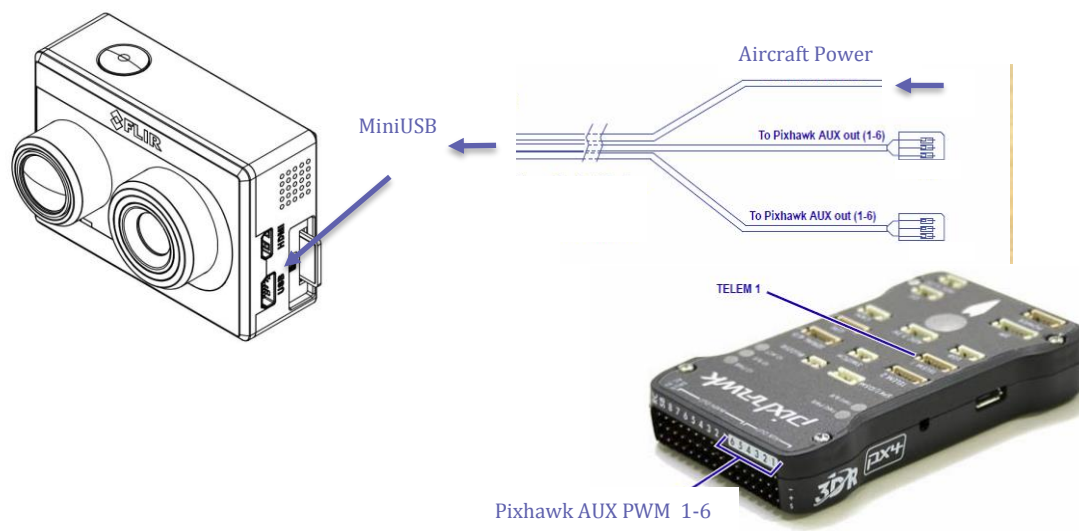**Figure 23. PixHawk Flight Controller for MAVLink**

Table 3: MAVLink Connection

MiniUSB Port		Bench Cable Internal Wire Color	P2 - MAVLink (DF13-6S-1.25C)[3]	
2	Main Power	red	1	Main Power: 5 Vdc
10	Main Power GND	black	6	Main Power GND
1	MAVLink TX Out	yellow	3	MAVLink RX In
3	MAVLink RX In	purple	2	MAVLink TR Out

6.2.2 Configuring MAVLink Connection

Many UAS flight controllers support the MAVLink serial protocol to provide an interface with external components. The Duo can be configured to use this bus to capture available telemetry data provided by GPS, altimeter, accelerometers, etc. This data is saved as standard EXIF metadata in all Still Image files. This data is not saved to Video files as there is no current standard for recording video metadata. Metadata is accessible through standard photo editing applications, file explorers, and suggested mapping applications.

The following MAVLink 3.0 messages are currently supported by the Duo FW 1.2.4 or newer:

Command	MAVLink Message ID	R/S (Receive / Send)	Notes
HEARTBEAT	0	R/S	
PING	4	R/S*	If PING is received, then will reply with a PING
SYSTEM_TIME	2	R	
ATTITUDE	30	R	
GLOBAL_POSITION_INT	33	R	

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[3] All cable plug part numbers are Hirose

GLOBAL_POSITION_INT_COV	63	R	
HIL_GPS	113	R	
MOUNT_STATUS	158	R	

Command	MAVLink Component ID	R/S (Receive / Send)	Notes
MAV_COMP_ID_CAMERA	100	/	

Command	MAVLink Command ID	R/S (Receive / Send)	Notes
MAV_CMD_DO_CONTROL_VIDEO	200	R	Custom FLIR parameters
MAV_CMD_DO_DIGICAM_CONFIGURE	202	R	Custom FLIR parameters
MAV_CMD_DO_DIGICAM_CONTROL	203	R	Custom FLIR parameters
MAV_CMD_IMAGE_START_CAPTURE	2000	R	Custom FLIR parameters
MAV_CMD_IMAGE_STOP_CAPTURE	2001	R	
MAV_CMD_VIDEO_START_CAPTURE	2500	R	Custom FLIR parameters
MAV_CMD_VIDEO_STOP_CAPTURE	2501	R	
MAV_CMD_USER_1	31010	R	Custom FLIR parameters

FLIR Duo communicates on the MAVLink bus at 57600 baud which is standard for most devices, as default, but is configurable from the app. Where possible, ensure RTSCTS is disabled as this is known to cause issues with communication. If all available flight controller ports are full, you may need to investigate using a splitter cable to attach additional devices. Please refer to Table 1 for miniUSB Port pin-out when building custom cables.

Duo can operate in a receive-only configuration much like an onscreen display (OSD), and therefore does not require the TX pin from the camera to be connected to the RX pin on a flight controller. Please note that all flight controllers will sleep a serial port if no connection is detected. The TX port can only be disconnected when used in a Y-harness with a device providing a "heartbeat".

Please see Appendix B for the full MAVLink protocol implementation.

6.2.3 Duo-specific Custom MAVLink Commands

In addition to the MAVLink commands listed above, the Duo camera supports certain customized MAVLink commands to control various parameters of the camera. Experienced users familiar with MAVLink can update the communication protocol on their Ground Station Controller to enable greater in-flight control of the Duo camera.

Please see Appendix B for the custom MAVLink protocol implementation.

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7 File Formats

The Duo can save image data in a number of file formats.

7.1 Radiometric JPEG (FLIR Tools)

The Radiometric JPEG (RJPEG) format has both the compressed visible JPEG image and 14-bit raw IR sensor data in a single file. Although this image can be viewed with any JPEG viewer, accessing the full-data will require FLIR Tools or FLIR Research IR software. If the camera is setup for MAVLink integration, telemetry will be captured and saved in standard metadata fields.

Figure 24: FLIR Tools can be used for advanced thermal analysis on Radiometric JPEGS

7.2 JPEG

The JPEG format of the Duo stores the compressed visible image. This is the full-resolution visible image that can be viewed with any JPEG viewer. If the camera is setup for MAVLink integration, telemetry will be captured and saved in standard metadata fields.

7.3 TIFF, TIFF-Sequence

TIFF is uncompressed 14-bit raw IR sensor data with no post processing; radiometric count values are recorded for each pixel. If the camera is setup for MAVLink integration, telemetry will be captured and saved in standard metadata fields.

The following links provide information on viewing 14-bit TIFF images and TIFF-sequence videos.

Table 4: Visible Sensor Image Formats Recorded on microSD Card

File Format	Feature					Use	Software
	Visible Image	IR 8-bit Colorized Palette	IR Raw 14-bit	AGC	Telemetry[4]		
Visible Still Image File Type							
JPEG	√				√	Mapping, Research	JPEG imaging tool
Visible Video File Type							
MOV (H.264)	√					Reporting	Any video tool

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[4] Requires MAVLink integration

Table 5: Thermal IR Sensor Image Formats Recorded on microSD Card

File Format	Feature					Use	Software
	Visible Image	IR 8-bit Colorized Palette	IR Raw 14-bit	AGC	Telemetry[5]		
Thermal IR Still Image File Type							
RJPEG	√	√[6]	√	√	√	Reporting, Research	FLIR Tools, FLIR ResearchIR, any image tool
TIFF			√		√	Mapping, Research	Pix4D, Drone Deploy, Matlab, ImageJ
Thermal IR Video File Type							
MOV (H.264)		√		√		Reporting	Any video tool
TIFF-Seq			√			Mapping, Research	FLIR ResearchIR, Matlab, ImageJ

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[5] Requires MAVLink integration

[6] IR 8-bit Thermal Colorized Recording only in **Display Video Mode: IR**. Always accessible using FLIR Software.

7.4 Recommended Application Links

- FLIR Tools: http://www.flir.com/instruments/display/?id=54865

- FLIR ResearchIR: http://www.flir.com/Science/display/?id=51371

- Pix4D: https://pix4d.com/

- ImageJ: https://imagej.nih.gov/ij/download.html

- MATLAB: http://www.mathworks.com/products/matlab/

  o When using MATLAB it is recommended that the FLIR Atlas SDK is installed to expose the full metadata set available from FLIR radiometric JPEG files: http://support.flir.com/resources/atlas-matlab

- Software Developers can access full metadata from FLIR radiometric JPEGs by integrating the Atlas SDK: https://flir.custhelp.com/app/answers/detail/a_id/1043/kw/atlas%20sdk

8 Care of FLIR Duo

- Power your FLIR Duo with a regulated 5-26 Vdc power source. Using more than 26 Vdc will damage the camera and void the warranty.

- Do not touch the lens. If the lens gets dirty, a light dusting of air should dislodge any dust particles. If the lens is still noticeably dirty, use 75% Isopropyl alcohol and lens tissue. Use light wiping motions with a fresh section of lens tissue with each swipe so as not to drag dust or dirt particles back over the lens surface.

- FLIR Duo cameras have been focused at the factory and optimized for the maximum UAS range. Opening the camera may compromise the external seal of the camera, and factory focus will be lost. This also voids the camera warranty.

- The FLIR Duo is neither water nor dust resistant. Care for it as you would any valuable piece of electronics equipment.

If you have questions about your Duo camera, contact FLIR Tech Support at **1-866-667-7732**.

Appendix A - Software and Firmware Update

How to Update App

Download the latest handset application from the appropriate web store for your platform. Some handy links are listed below. Also be sure to keep the firmware and Mobile App up to date on your device to receive continuous improvements.

iOS APP store (Web Link)

Android APP store (Web Link)

Android APK file direct DL (Web Link)

How to update Firmware (FW)

Please download the latest firmware from the FLIR web site here.
(http://www.flir.com/suas/duo/software)

Duo Firmware Upgrade Procedure

Instructions:

1) Connect to the Duo with the Bluetooth application and make note of all your settings. The firmware upgrade will require resetting the camera settings to defaults.

2) Download the latest firmware update from http://www.flir.com/suas/duo/software

3) Connect the Duo to your computer via miniUSB
   a) The Duo will appear as a removable storage device on your computer
   b) Drag & drop latest firmware (.ITM file) onto the Duo camera
   c) Connect to the Duo over Bluetooth via the FLIR UAS App
   d) Follow the automated in-app prompts to update device FW
       i. Do not restart camera during FW update
       ii. This step can also be initiated through "Settings" -> "About" -> "FW Upgrade Version"
   e) After the device reboots, connect again over Bluetooth via the FLIR UAS App

4) Confirm that the correct FW has been uploaded by again viewing the "Settings" -> "About" tab.

5) Restore User Settings. From your notes in Step 1 reconfigure any Main, Accessory Port, and Radiometry (Duo R only) settings for your specific application. You can also delete the firmware update file from your microSD card (it does not automatically delete itself).

Appendix B - MAVLink Implementation

CMD ID	Field Name	Data Type	Description (MAVlink published data)	FLIR Implementation	Device Implementation
					FLIR Duo / R
0	**HEARTBEAT**		Shows the system is present and responding.		
	System ID		MAVlink packet Byte 3	Standard	1
	Component ID		MAVlink packet Byte 4	Standard	100
	Type	uint8_t	MAV_TYPE_GENERIC - Generic micro air vehicle.	Standard	0
	Autopilot	uint8_t	MAV_AUTOPILOT_INVALID - No valid autopilot, e.g. a GCS or other MAVLink component	Standard	8
	Base Mode	uint8_t	MAV_MODE_FLAG_MANUAL_INPUT_ENABLED - 0b01000000 remote control input is enabled.	Standard	64
	Custom Mode	uint32_t	A bitfield for use for autopilot-specific flags.	Standard	0
	System Status	uint8_t	MAV_STATE_ACTIVE - System is active and might be already airborne. Motors are engaged.	Standard	4
	MAVLink Version	uint8_t	MAVLink version, not writable by user	Standard	Standard
2	**SYSTEM_TIME**		System master clock time.		
	Time Unix	uint64_t	Timestamp of the master clock in microseconds since UNIX epoch.	Standard	If time is valid, it will be set to the device.
	Time Boot	uint32_t	Timestamp of the component clock since boot time in milliseconds.	Standard	Ignored

4	PING		System latency diagnostics.		
	Time Unix	uint64_t	Timestamp (microseconds since UNIX epoch or microseconds since system boot)	Standard	Ignored
	Sequence	uint32_t	PING sequence	Standard	Standard
	System ID	uint8_t	0: request ping from all receiving systems, if greater than 0: message is a ping response and number is the system id of the requesting system	Standard	See description above
	Component ID	uint8_t	0: request ping from all receiving components, if greater than 0: message is a ping response and number is the system id of the requesting system	Standard	See description above
30	ATTITUDE		The attitude in the aeronautical frame.		
	Time Boot	uint32_t	Timestamp (milliseconds since system boot)	Ignored	Ignored
	Roll	float	Roll angle (rad, -pi..+pi)	Metadata	MAV Roll
	Pitch	float	Pitch angle (rad, -pi..+pi)	Metadata	MAV Pitch
	Yaw	float	Yaw angle (rad, -pi..+pi)	Metadata	MAV Yaw
	Roll Rate	float	Roll angular velocity (rad/s)	Metadata	MAV Roll Rate
	Pitch Rate	float	Pitch angular velocity (rad/s)	Metadata	MAV Pitch Rate
	Yaw Rate	float	Yaw angular velocity (rad/s)	Metadata	MAV Yaw Rate
33	GLOBAL_POSITION_INT		Filtered GPS position		
	Time Boot	uint32_t	Timestamp (milliseconds since system boot)	Ignored	Ignored
	Latitude	int32_t	Latitude, expressed as * 1E7	Metadata	GPS Latitude
	Longitude	int32_t	Longitude, expressed as * 1E7	Metadata	GPS Longitude
	Altitude (MSL)	int32_t	Altitude in meters, expressed as * 1000 (millimeters), AMSL (not WGS84 - note that virtually all GPS modules provide the AMSL as well)	Metadata	GPS Altitude
	Altitude (Relative)	int32_t	Altitude above ground in meters, expressed as * 1000 (millimeters)	Metadata	MAVRelativeAltitude

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Velocity X	int16_t	Ground X Speed (Latitude), expressed as m/s * 100	Metadata calculated	GPS Speed
Velocity Y	int16_t	Ground Y Speed (Longitude), expressed as m/s * 100	Metadata calculated	GPS Speed
Velocity Z	int16_t	Ground Z Speed (Altitude), expressed as m/s * 100	Metadata calculated	GPS Speed
Heading	uint16_t	Compass heading in degrees * 100, 0.0..359.99 degrees. If unknown, set to: UINT16_MAX	Metadata	GPS Track

63	**GLOBAL_POSITION_INT_ COV**		Higher resolution filtered GPS position		
	Time Boot	uint32_t	Timestamp (milliseconds since system boot)	Ignored	Ignored
	Time Unix	uint64_t	Timestamp (microseconds since UNIX epoch) in UTC. 0 for unknown.	Ignored	Ignored
	estimator_type	uint8_t	Class id of the estimator this estimate originated from.	Ignored	Ignored
	Latitude	int32_t	Latitude, expressed as * 1E7	Metadata	GPS Latitude
	Longitude	int32_t	Longitude, expressed as * 1E7	Metadata	GPS Longitude
	Altitude (MSL)	int32_t	Altitude in meters, expressed as * 1000 (millimeters), AMSL (not WGS84 - note that virtually all GPS modules provide the AMSL as well)	Metadata	GPS Altitude
	Altitude (Relative)	int32_t	Altitude above ground in meters, expressed as * 1000 (millimeters)	Metadata	MAVRelativeAltitude
	Velocity X	float	Ground X Speed (Latitude), expressed as m/s * 100	Metadata	GPS Speed
	Velocity Y	float	Ground Y Speed (Longitude), expressed as m/s * 100	Metadata	GPS Speed
	Velocity Z	float	Ground Z Speed (Altitude), expressed as m/s * 100	Metadata	GPS Speed
	covariance	float[36]	Covariance matrix (first six entries are the first ROW, next six entries are the second row, etc.	Ignored	Ignored

113	**HIL_GPS**		RAW GPS from sensor		
	time_usec	uint64_t	Timestamp (microseconds since UNIX epoch or microseconds since system boot)	Ignored	Ignored

fix_type	uint8_t	0-1: no fix, 2: 2D fix, 3: 3D fix. Some applications will not use the value of this field unless it is at least two, so always correctly fill in the fix.	Ignored		Ignored
lat	int32_t	Latitude (WGS84), in degrees * 1E7	Metadata		GPS Latitude
lon	int32_t	Longitude (WGS84), in degrees * 1E7	Metadata		GPS Longitude
alt	int32_t	Altitude (AMSL, not WGS84), in meters * 1000 (positive for up)	Metadata		GPS Altitude
eph	uint16_t	GPS HDOP horizontal dilution of position in cm (m*100). If unknown, set to: 65535	Metadata		GPSXYAccuracy
epv	uint16_t	GPS VDOP vertical dilution of position in cm (m*100). If unknown, set to: 65535	Metadata		GPSZAccuracy
vel	uint16_t	GPS ground speed (m/s * 100). If unknown, set to: 65535	Ignored		Ignored
vn	int16_t	GPS velocity in cm/s in NORTH direction in earth-fixed NED frame	Ignored		Ignored
ve	int16_t	GPS velocity in cm/s in EAST direction in earth-fixed NED frame	Ignored		Ignored
vd	int16_t	GPS velocity in cm/s in DOWN direction in earth-fixed NED frame	Ignored		Ignored
cog	uint16_t	Course over ground (NOT heading, but direction of movement) in degrees * 100, 0.0..359.99 degrees. If unknown, set to: 65535	Ignored		Ignored
satellites_visible	uint8_t	Number of satellites visible. If unknown, set to 255	Ignored		Ignored
158	**MOUNT_STATUS**		Orientation of gimbal		
pointing_a	uint32_t	Pitch (deg*100)	Metadata		Yaw (camera)
pointing_b	uint32_t	Roll (deg*100)	Metadata		Pitch (camera)
pointing_c	uint32_t	Yaw (deg*100)	Metadata		Roll (camera)
Target System	uint8_t	System ID	Ignored		Ignored
Target Component	uint8_t	Component ID	Ignored		Ignored

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200	**MAV_CMD_DO_CONTROL_VIDEO**		Control onboard camera system.	Adjust operational modes of FLIR camera	
	Mission Param #1	float	Camera ID (-1 for all)	Standard	100
	Mission Param #2	float	Transmission: 0: disabled, 1: enabled compressed, 2: enabled raw	Video signal made available to Analog video or HDMI port	0 = IR 1 = VIS 2 = VIS with IR PIP
	Mission Param #3	float	Transmission mode: 0: video stream, >0: single images every n seconds (decimal)	Ignore	Ignored
	Mission Param #4	float	Recording: 0: disabled, 1: enabled compressed, 2: enabled raw	Video data to record to disk	0 = IR 1 = VIS 2 = IR and VIS
	Mission Param #5	float	Empty	Ignored	Ignored
	Mission Param #6	float	Empty	Ignored	Ignored
	Mission Param #7	float	Empty	Ignored	Ignored
202	**MAV_CMD_DO_DIGICAM_CONFIGURE**		Configure an on-board camera.	Adjust FLIR camera image modes	
	Mission Param #1	float	Modes: P, TV, AV, M, Etc	Set Scene (AGC) mode	Ignored
	Mission Param #2	float	Shutter speed: Divisor number for one second	Set Color Palette	0 = HotMetal 1 = WhiteHot 2 = Rainbow
	Mission Param #3	float	Aperture: F stop number	Set Scene ROI range	Ignored
	Mission Param #4	float	ISO number e.g. 80, 100, 200, Etc	Set camera Gain Mode	Ignored
	Mission Param #5	float	Exposure type enumerator	Rotate image 0 or 180 deg	0 = No rotation 1 = 180 deg rotation

	Mission Param #6	float	Command Identity	Set MSX function	0 = Disabled 1 = Enabled
	Mission Param #7	float	Main engine cut-off time before camera trigger in seconds/10 (0 means no cut-off)	Set MSX strength	0 thru 100, inclusive
203	**MAV_CMD_DO_DIGICAM_ CONTROL**		[Control on-board camera.](#)	Adjust FLIR camera image parameters	
	Mission Param #1	float	Session control e.g. show/hide lens	Command FFC	1 = Command FFC
	Mission Param #2	float	Zoom's absolute position	Set eZoom level	Ignored
	Mission Param #3	float	Zooming step value to offset zoom from the current position	Ignored	Ignored
	Mission Param #4	float	Focus Locking, Unlocking or Re-locking	Set Scene image tuning parameter 1	Ignored
	Mission Param #5	float	Shooting Command	Set Scene image tuning parameter 2	Ignored
	Mission Param #6	float	Command Identity	Set Scene image tuning parameter 3	Ignored
	Mission Param #7	float	Empty		
2000	**MAV_CMD_IMAGE_STAR T_CAPTURE**		[Start image capture sequence](#)	Command Still image capture	
	Mission Param #1	float	Duration between two consecutive pictures (in seconds)	Interval between captures	0 through 60, inclusive
	Mission Param #2	float	Number of images to capture total - 0 for unlimited capture		Ignored
	Mission Param #3	float	Resolution in megapixels (0.3 for 640x480, 1.3 for 1280x720, etc)	FFF = FLIR File Format, also called Radiometric JPEG	1 = JPEG & TIFF 2 = FFF
2001	**MAV_CMD_IMAGE_STOP _CAPTURE**		[Stop image capture sequence](#)	Command Still stop capture	
	Mission Param #1	float	Reserved	Ignored	Ignored

	Mission Param #2	float	Reserved	Ignored	Ignored
2500	**MAV_CMD_VIDEO_START _CAPTURE**		Starts video capture	Command Video capture	
	Mission Param #1	float	Camera ID (0 for all cameras), 1 for first, 2 for second, etc.	Standard	Standard
	Mission Param #2	float	Frames per second	Set video file type	1 = H264 2 = TIFF
	Mission Param #3	float	Resolution in megapixels (0.3 for 640x480, 1.3 for 1280x720, etc)	Standard	Ignored
2501	**MAV_CMD_VIDEO_STOP_ CAPTURE**		Stop the current video capture	Command Video stop capture	
	Mission Param #1	float	Reserved	Ignored	Ignored
	Mission Param #2	float	Reserved	Ignored	Ignored
31010	**MAV_CMD_USER_1**		User defined command	Set radiometric parameters	
	Mission Param #1	float	User Defined	Set temperature unit	0 = C 1 = F
	Mission Param #2	float	User Defined	Set OSD temperature meter	0 = OFF 1 = Set SPOT_METER to 1
	Mission Param #3	float	User Defined	Set Subject Emissivity	50 to 100, inclusive -999 = Ignore
	Mission Param #4	float	User Defined	Set Sky Condition	0 to 100, inclusive -999 = Ignore
	Mission Param #5	float	User Defined	Set Air Temperature	-50 to 327, inclusive -999 = Ignore

Mission Param #6	float	User Defined	Set Humidity	0 to 100, inclusive -999 = Ignore
Mission Param #7	float	User Defined	Set Subject Range	0 to 2000, inclusive -999 = Ignore

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This product is protected by patents, design patents, patents pending, or design patents pending.

If you have questions that are not covered in this manual, or need service, contact FLIR Commercial Systems Customer Support at 805.964.9797 for additional information prior to returning a camera.

This documentation and the requirements specified herein are subject to change without notice.

This equipment must be disposed of as electronic waste.
Contact your nearest FLIR Commercial Systems, Inc. representative for instructions on how to return the product to FLIR for proper disposal.

FCC Notice. This device is a subassembly designed for incorporation into other products in order to provide an infrared camera function. It is not an end-product fit for consumer use. When incorporated into a host device, the end-product will generate, use, and radiate radio frequency energy that may cause radio interference. As such, the end-product incorporating this subassembly must be tested and approved under the rules of the Federal Communications Commission (FCC) before the end-product may be offered for sale or lease, advertised, imported, sold, or leased in the United States. The FCC regulations are designed to provide reasonable protection against interference to radio communications. See 47 C.F.R. §§ 2.803 and 15.1 et seq.

Industry Canada Notice. This device is a subassembly designed for incorporation into other products in order to provide an infrared camera function. It is not an end-product fit for consumer use. When incorporated into a host device, the end-product will generate, use, and radiate radio frequency energy that may cause radio interference. As such, the end-product incorporating this subassembly must be tested for compliance with the Interference-Causing Equipment Standard, Digital Apparatus, ICES-003, of Industry Canada before the product incorporating this device may be: manufactured or offered for sale or lease, imported, distributed, sold, or leased in Canada.

Avis d'Industrie Canada. Cet appareil est un sous-ensemble conçu pour être intégré à un autre produit afin de fournir une fonction de caméra infrarouge. Ce n'est pas un produit final destiné aux consommateurs. Une fois intégré à un dispositif hôte, le produit final va générer, utiliser et émettre de l'énergie radiofréquence qui pourrait provoquer de l'interférence radio. En tant que tel, le produit final intégrant ce sous-ensemble doit être testé pour en vérifier la conformité avec la Norme sur le matériel brouilleur pour les appareils numériques (NMB-003) d'Industrie Canada avant que le produit intégrant ce dispositif puisse être fabriqué, mis en vente ou en location, importé, distribué, vendu ou loué au Canada.

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