ThermoVision™ Sentry II

Operator's manual

FLIR SYSTEMS™

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1 System description

The ThermoVision™ Sentry II from FLIR Systems is a high performance thermal imaging system that incorporates the latest in uncooled detector technology. The ThermoVision™ Sentry II contains a 320 × 240 uncooled microbolometer focal plane detector array. By removing the cryogenic cooler from the design, the system provides superior reliability, low power consumption, lower life cycle cost, and extremely quick start-up times.

The ThermoVision™ Sentry II features a dual field-of-view (WFOV = 20° × 15°, NFOV = 5° × 3.75°) for wide area surveillance, and close-up inspections. Electronic zoom as well as autofocus are included for enhanced target recognition, along with freeze frame capabilities, and various image enhancement functions.. The system autoscan feature allows the unit to sequentially scan between multiple user-definable positions thereby reducing the operator work load.

The system also features a side-mounted 1/4" color CCD video camera with autofocus and 12x electronic zoom / 18x optical zoom, allowing the operator to toggle between IR imaging and video imaging.

The ThermoVision™ Sentry II can be configured for stand-alone operation, or it can be fully configured into a comprehensive surface surveillance network. This makes it an ideal solution for a wide variety of applications including perimeter surveillance, border surveillance, and force protection.

2 Packing list

The ThermoVision™ Sentry II and its accessories are normally delivered in a hard transport case which typically contains the items below.

On receipt, inspect all items and check them against the delivery note. Any damaged items must be reported to the local FLIR Systems representative immediately.

Description	Part Number	Qty.
ThermoVision™ Sentry II	614004798	1
Joystick Controller Unit (JCU)	194 783	1
Junction Box (JB)	194 782	1
Power Supply (PS)	194 684	1
Power cable, 3 m/10 ft.	194 628	1
▪ System cable, 15 m / 50 ft, *or* ▪ System cable, 61 m / 200 ft	▪ 1 196 215 (15 m / 50 ft), *or* ▪ 1 196 216 (61 m / 200 ft)	1
JCU cable, 3 m/10 ft.	194 612	1
Operator's Manual	1 558 193	1
FAT Record 5/20	Doc. No. PP_614004452	1
FAT Record ThermoVision™ Sentry II	Doc. No. PP_614004798	1
Certificate of Conformity		1
Transport case, set of two	1 909 240	1
Video cable	908 929	1

3 Connecting system components

3.1 Important notes

All electrical connections on the pan/tilt head, i.e. connections for power input and signal input/output, are provided through one or several connectors located in a protected and recessed area on the bottom part of the pan/tilt head.

- Always disconnect the system from the mains supply before connecting or disconnecting any cables.
- The connectors should be sealed with the protective caps when not in use.

3.2 Connection overviews

3.2.1 Pan/tilt head (PTH)

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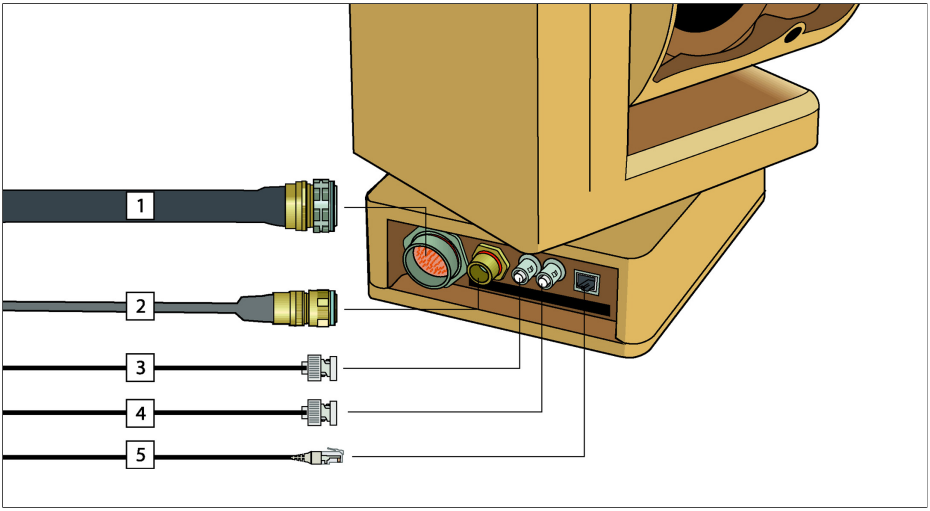

Figure 3.1 Connecting cables to the pan/tilt head (PTH)

Figure 3.2 Explanations of callouts

Callout	Explanation
1	▪ **System cable from junction box to J1 connector**, *or* ▪ **JCU cable from joystick controller unit to J1 connector** This cable connects between junction box (J9 connector) and J1 connector and is used as an 'one cable solution' when controlling the pan/tilt head from a remotely located joystick controller unit, i.e. one that is not directly connected to the pan/tilt head. When controlling the pan/tilt head directly using a joystick controller unit, the cable connects between the J10 connector on the joystick controller unit, and the J1 connector. **Part No.:** System cable, 1 196 215 (15 m / 50 ft), 1 196 216 (61 m / 200 ft) **Part No.:** JCU cable, 194 612 **SEE ALSO:** For an example in a typical system configuration, see the following figures: ▪ Figure 4.1 Typical system overview – Example 1 on page 15 ▪ Figure 4.3 Typical system overview – Example 3 on page 17

Callout	Explanation
2	**Power cable from power supply to J2 connector** This cable connects between the power supply and the J2 connector. **Part No.:** 194 628 **NOTE:** The J2 connector must not be used to power the ThermoVision™ Sentry II when power is supplied via junction box and system cable (= J9 connector on junction box and J1 connecor on pan/tilt head). **NOTE:** The J2 connector is marked J13 when the Exterior Housing Heaters Option (P/N 614 005 142) is installed. **SEE ALSO:** For an example in a typical system configuration, see figure 4.3 Typical system overview – Example 3 on page 17.
3	**Video cable from external monitor to J3 connector** This cable connects between an external video monitor and the J3 connector. **Part No.:** 908 929 **SEE ALSO:** For an example in a typical system configuration, see figure 4.3 Typical system overview – Example 3 on page 17.
4	**Video cable from external monitor to J11 connector** This cable connects between an external video monitor and the J11 connector. **Part No.:** 908 929 **SEE ALSO:** For an example in a typical system configuration, see figure 4.3 Typical system overview – Example 3 on page 17.
5	**Ethernet cable from a LAN switch to J14 connector** This cable connects between a LAN switch in a local area network and the J14 connector. **NOTE:** Please note the following: ▪ The possibility to connect the pan/tilt head to a local area network is an extra option ▪ Maximum cable distance between the pan/tilt head and the LAN switch: 100 m / 328 ft. ▪ Maximum cable distance between the LAN switch and the host computer: 10 m / 33 ft. **SEE ALSO:** For an example in a typical system configuration, see figure 4.4 Typical system overview – Example 4 on page 18.

3.2.2 Junction box (JB)

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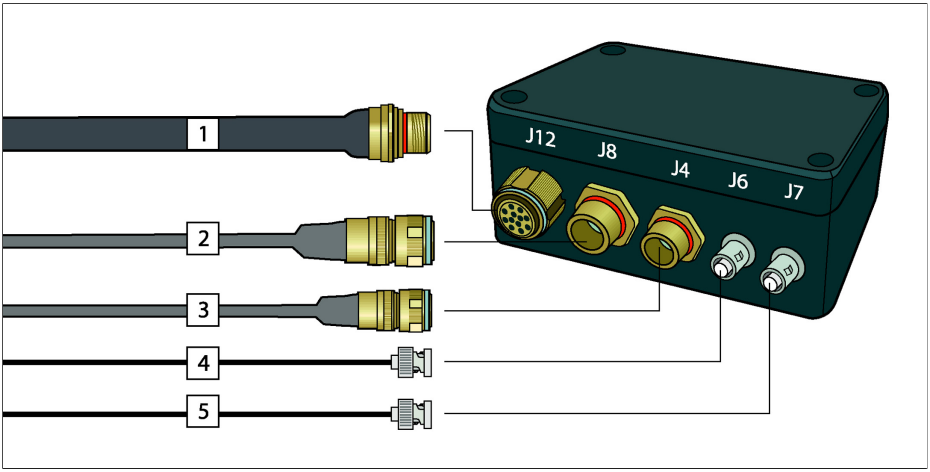

Figure 3.3 Connecting cables to the junction box (JB): Side 1

Figure 3.4 Explanations of callouts

Callout	Explanation
1	(Reserved for future capabilities)
2	**Host cable from host computer to J8 connector** This cable connects between a host computer and the J8 connector when controlling a Sentry system using a junction box. **Part No.:** 614 005 140 **SEE ALSO:** For an example in a typical system configuration, see figure 4.1 Typical system overview – Example 1 on page 15.
3	**Power cable from power supply to J4 connector** This cable connects between the power supply and the J4 connector. **Part No.:** 194 628 **SEE ALSO:** For an example in a typical system configuration, see figure 4.1 Typical system overview – Example 1 on page 15.
4	**Video cable from video monitor to J6 connector** This cable connects between an external video monitor and the J6 connector. **Part No.:** 908 929 **SEE ALSO:** For an example in a typical system configuration, see figure 4.1 Typical system overview – Example 1 on page 15.

Callout	Explanation
5	**Video cable from video monitor to J7 connector** This cable connects between an external video monitor and the J7 connector. **Part No.:** 908 929 **SEE ALSO:** For an example in a typical system configuration, see figure 4.1 Typical system overview – Example 1 on page 15.

3.2.2.1 Important note about the J6 and J7 video connectors

Use the J6 and J7 video connectors according to the following procedures:

- *When using one video monitor*, use the J6 connector and set **IR/TV video swap** in the **Maintenance** dialog box to **Yes**. This makes the currently active video channel (IR or TV) to be always displayed on the video monitor.
- *When using two video monitors*, use the J6 and J7 connectors and set **IR/TV video swap** in the **Maintenance** dialog box to **No**. This makes each video channel (IR or TV) stay on their respective video monitor. In this case the active video channel indicator will be displayed on the monitor that displays the currently active video channel.

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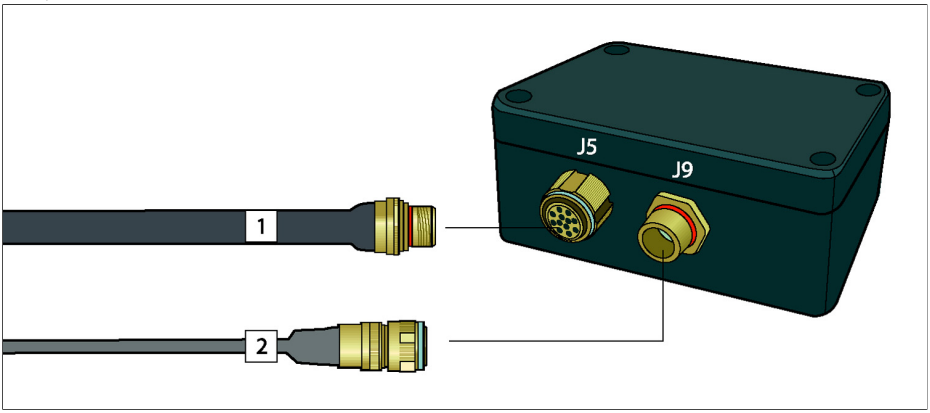

Figure 3.5 Connecting cables to the junction box (JB): Side 2

Figure 3.6 Explanations of callouts

Callout	Explanation
1	**System cable from pan/tilt head to J5 connector** This cable connects between the pan/tilt head (J1 connector) and the J5 connector and is used as an 'one cable solution' when controlling the pan/tilt head from a remotely located joystick controller unit, i.e. one that is not directly connected to the pan/tilt head. **Part No.:** System cable, 1 196 215 (15 m / 50 ft), 1 196 216 (61 m / 200 ft) **SEE ALSO:** For an example in a typical system configuration, see figure 4.1 Typical system overview – Example 1 on page 15.
2	**JCU cable from joystick controller unit to J9 connector** This cable connects between the joystick controller unit (J10 connector) and the J9 connector when controlling the pan/tilt head using a junction box. Part No.: 194 612 **SEE ALSO:** For an example in a typical system configuration, see figure 4.1 Typical system overview – Example 1 on page 15.

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3.2.3 Power box (PB)

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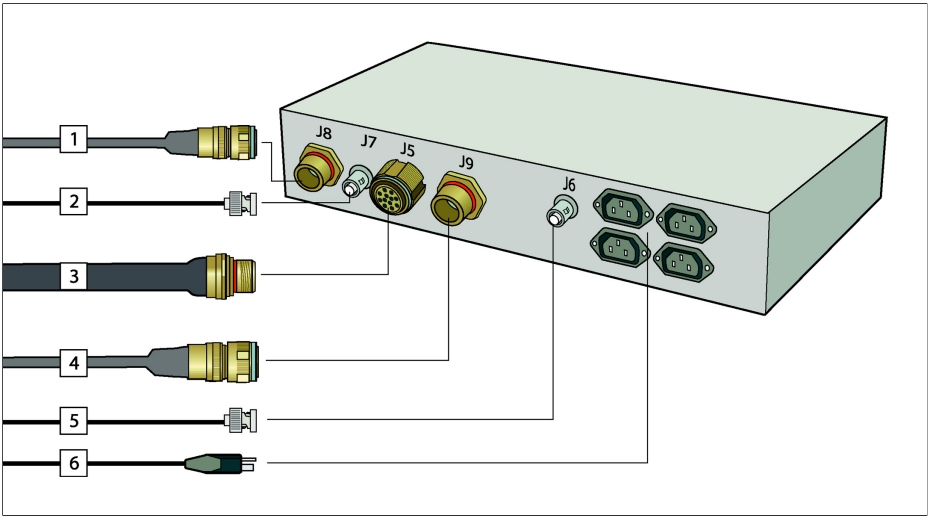

Figure 3.7 Connecting cables to the power box (PB)

Figure 3.8 Explanations of callouts

Callout	Explanation
1	**Host cable from host computer to J8 connector** This cable connects between a host computer and the J8 connector when controlling a Sentry system using a power box. **Part No.:** 614 005 140 **SEE ALSO:** For an example in a typical system configuration, see figure 4.2 Typical system overview – Example 2 on page 16.
2	**Video cable from external video monitor to J7 connector** This cable connects between an external video monitor and the J7 connector. **Part No.:** 908 929 **SEE ALSO:** For an example in a typical system configuration, see figure 4.2 Typical system overview – Example 2 on page 16.

Callout	Explanation
3	**System cable from pan/tilt head to J5 connector** This cable connects between pan/tilt head (J1 connector) and the J5 connector and is used as an 'one cable solution' when controlling the pan/tilt head from a remotely located joystick controller unit, i.e. one that is not directly connected to the pan/tilt head. **Part No.:** 1 196 215 (15 m / 50 ft), 1 196 216 (61 m / 200 ft) **SEE ALSO:** For an example in a typical system configuration, see figure 4.2 Typical system overview – Example 2 on page 16.
4	**JCU cable from joystick controller unit to J9 connector** This cable connects between the joystick controller unit (J10 connector) and the J9 connector when controlling the pan/tilt head using a junction box. **Part No.:** 194 612 **SEE ALSO:** For an example in a typical system configuration, see figure 4.2 Typical system overview – Example 2 on page 16.
5	**Video cable from external video monitor to J6 connector** This cable connects between an external video monitor and the J6 connector. **Part No.:** 908 929 **SEE ALSO:** For an example in a typical system configuration, see figure 4.2 Typical system overview – Example 2 on page 16.
6	**Power cable from mains to power box** This cable is shipped either with a European or US standard mains plug. It connects between mains and power box. **SEE ALSO:** For an example in a typical system configuration, see figure 4.2 Typical system overview – Example 2 on page 16.

3.2.4 Joystick controller unit (JCU)

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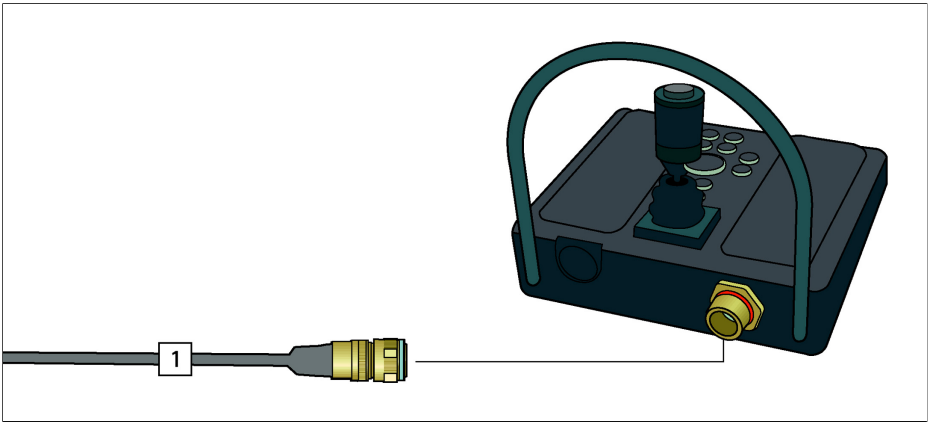

Figure 3.9 Connecting cables to the joystick controller unit (JCU)

Figure 3.10 Explanations of callouts

Callout	Explanation
1	▪ **JCU cable from junction box to J10 connector**, *or* ▪ **JCU cable from pan/tilt head to J10 connector** This cable connects between junction box (J9 connector) and J10 connector and is used as an 'one cable solution' when controlling the pan/tilt head from a remotely located joystick controller unit, i.e. one that is not directly connected to the pan/tilt head. When controlling the pan/tilt head directly, the cable connects between the J1 connector on the pan/tilt head, and the J10 connector. **Part No.:** 194 612 **SEE ALSO:** For an example in a typical system configuration, see the following figures: ▪ Figure 4.1 Typical system overview – Example 1 on page 15 ▪ Figure 4.3 Typical system overview – Example 3 on page 17

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3.2.5 Power supply (PS)

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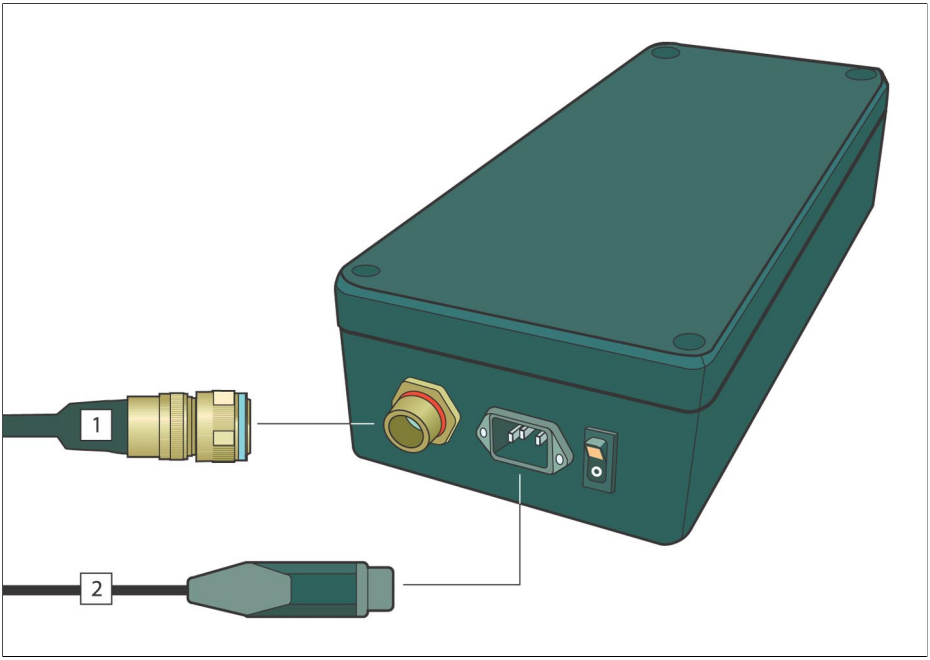

Figure 3.11 Connecting cables to the power supply (PS)

Callout	Description
1	▪ **Power cable from junction box (JB) to power supply (PS)**, or ▪ **Power cable from pan/tilt head (PTH) to power supply (PS)** This cable either connects between the J2 connector on the pan/tilt head and the power supply, or the J4 connector on the junction box and the power supply. **Part No.:** 194 628 **SEE ALSO:** For an example in a typical system configuration, see the following figures: ▪ Figure 4.1 Typical system overview – Example 1 on page 15 ▪ Figure 4.3 Typical system overview – Example 3 on page 17
2	**Power cable from mains to power supply (PS)** This cable is shipped either with a European or US standard mains plug. It connects between mains and power supply. **SEE ALSO:** For an example in a typical system configuration, see figure 4.1 – Typical system overview – Example 1 on page 15.

4 Typical system overviews

4.1 Controlling a Sentry system using a junction box (JB)

10593803;a2

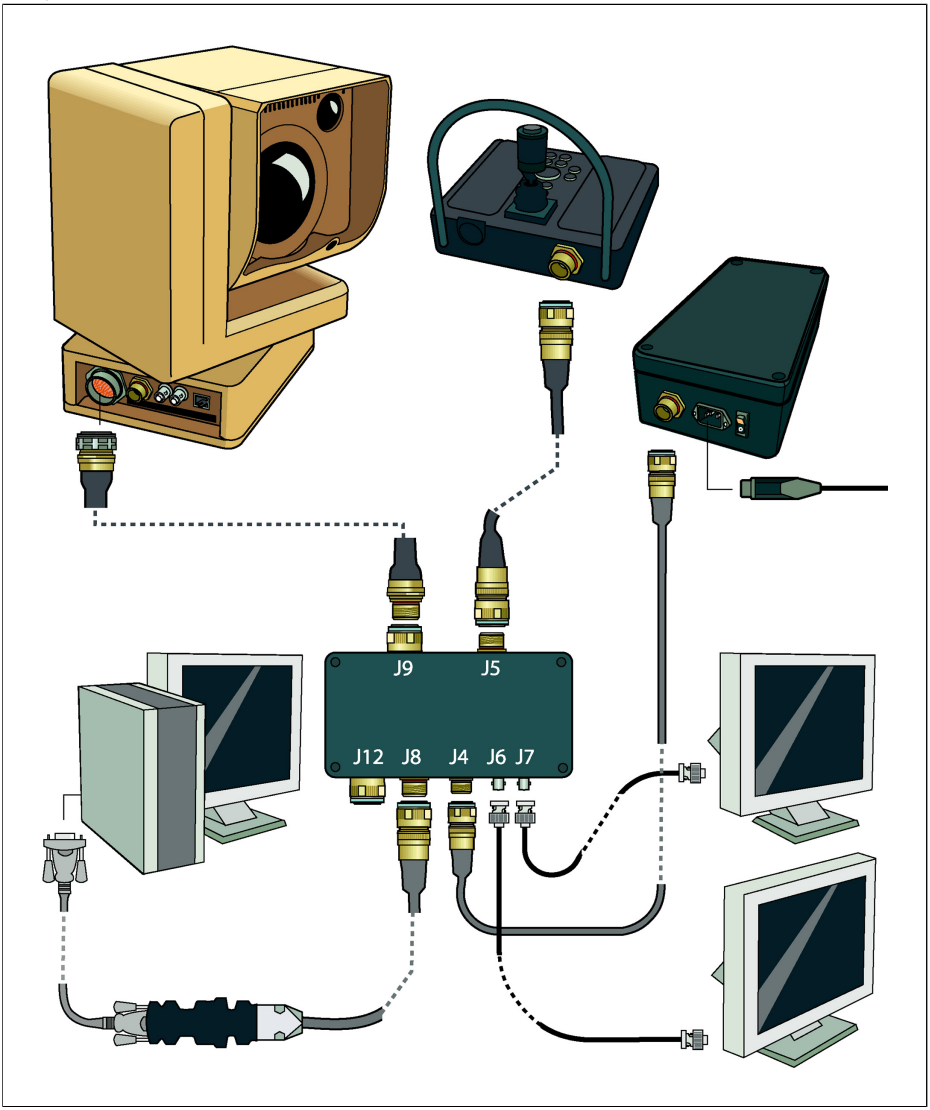

Figure 4.1 Typical system overview – Example 1

4.2 Controlling a Sentry system using a power box (PB)

10593903;a2

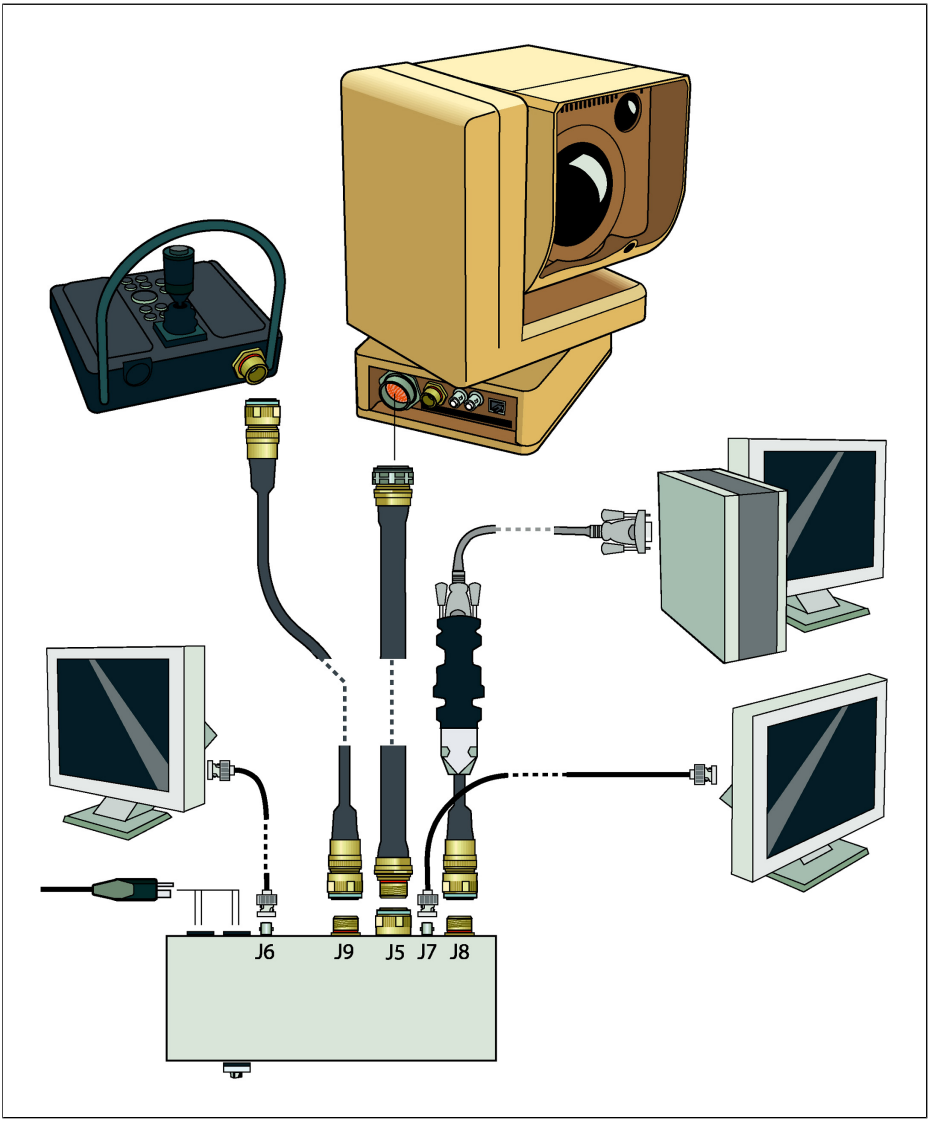

Figure 4.2 Typical system overview – Example 2

4.3 Controlling a Sentry system directly, using the joystick controller unit (JCU)

10594003;a2

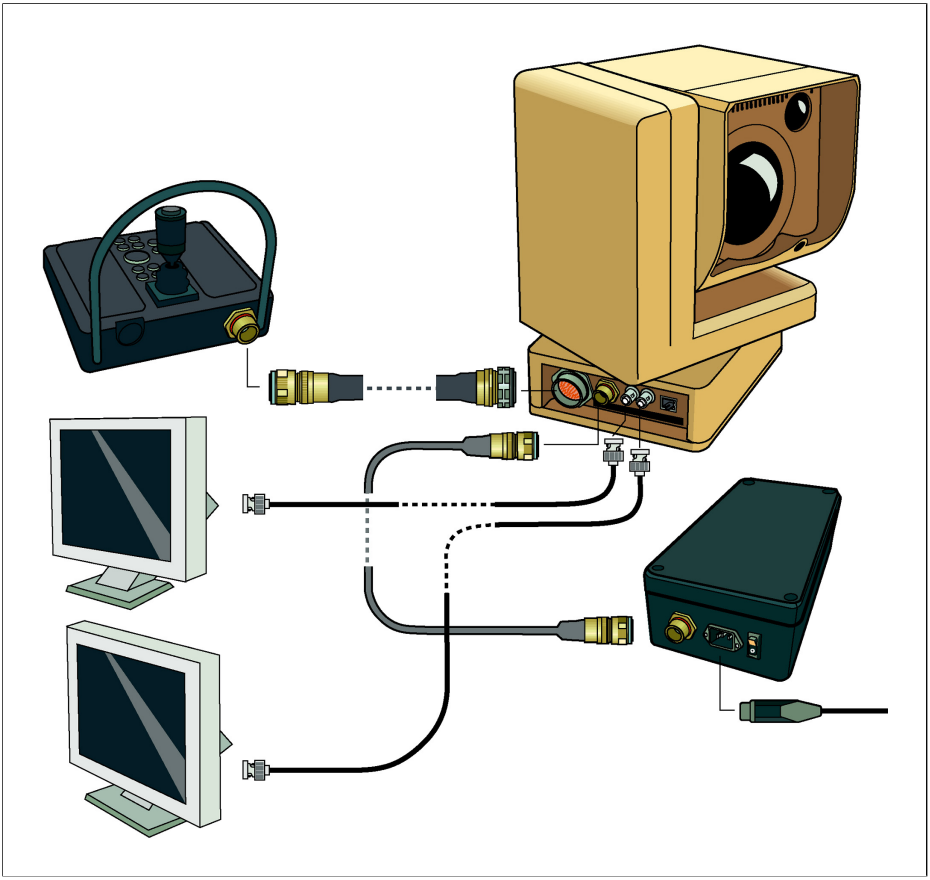

Figure 4.3 Typical system overview – Example 3

4.4 Controlling a Sentry system in a LAN network

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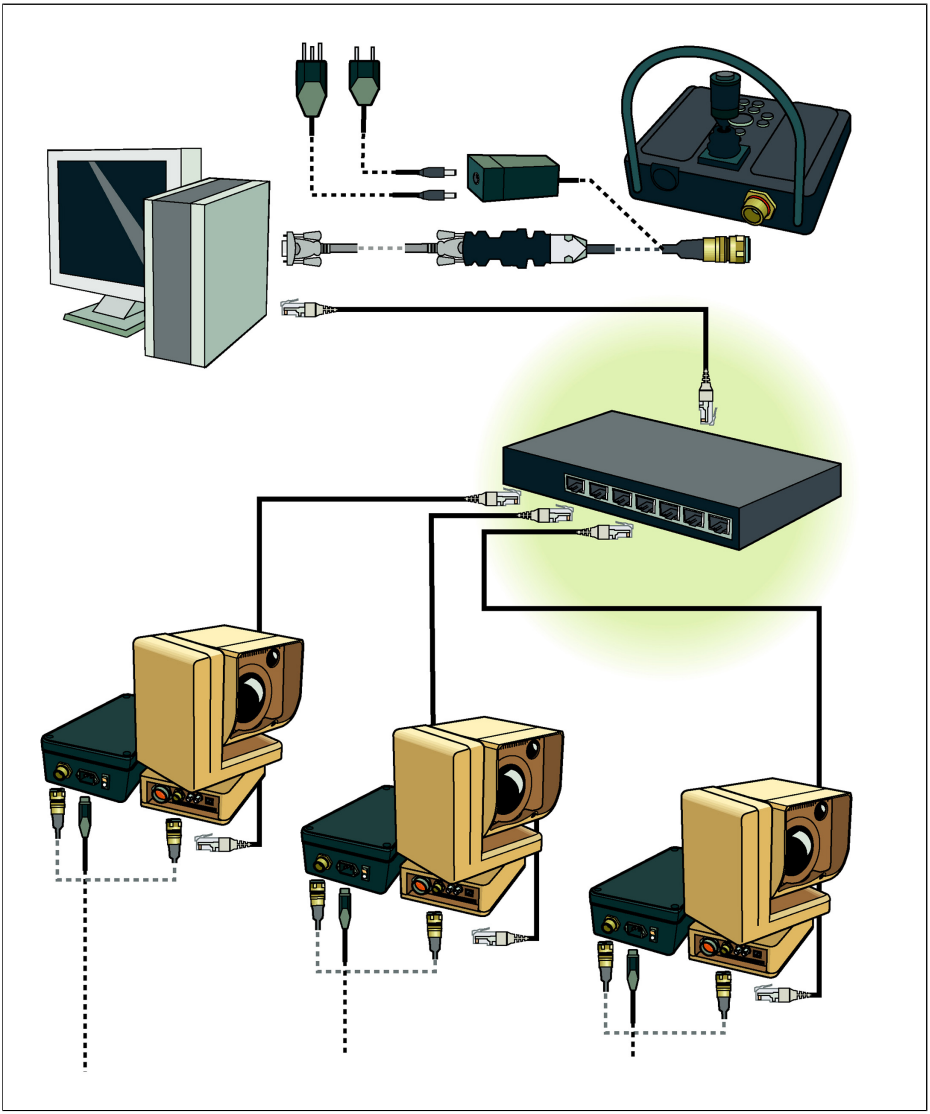

Figure 4.4 Typical system overview – Example 4

5 Mechanical installation

The pan/tilt head has a mounting plate on the bottom side of the housing. The plate is manufactured according to customer needs.

SEE ALSO: For more information, see the following sections:

- 12.18 – Mounting plate, standard – Pan/tilt head (PTH) on page 87
- 12.19 – Mounting plate, TASS – Pan/tilt head (PTH) on page 88

Different camera applications call for different ways of mechanically installing the pan/tilt head and for that reason specific information regarding the installation can not be given. However, the mounting plate consists of a aluminum plate fastened to the pan/tilt head with eight machine-threaded screws and this plate can easily be removed and re-drilled if the customer needs a different hole layout.

To make it easy to mechanically install the pan/tilt head in horizontal position, there is a water level indicator in the bottom part of the pan/tilt head (see below).

10043803;a1

Figure 5.1 Level indicator

6 Joystick Controller Unit (JCU)

The joystick controller unit comprises a joystick, eleven push buttons (one is located on the top of the joystick), four arrow buttons on a navigation pad, and is used to provide system control. The joystick provides continuously variable cross-coupled (X to Y axis) control of the system azimuth and elevation position. There are two additional controls found on the joystick – a rotating collar used to provide the focus control, and a push button located on the top of the joystick which is used to change between the two system fields-of-view. All switches (except for the push button on the joystick) are back-lit for operator convenience.

Illumination is adjusted by the control located on the back of the joystick controller unit (see below).

10043903;a1

Figure 6.1 Illumination control

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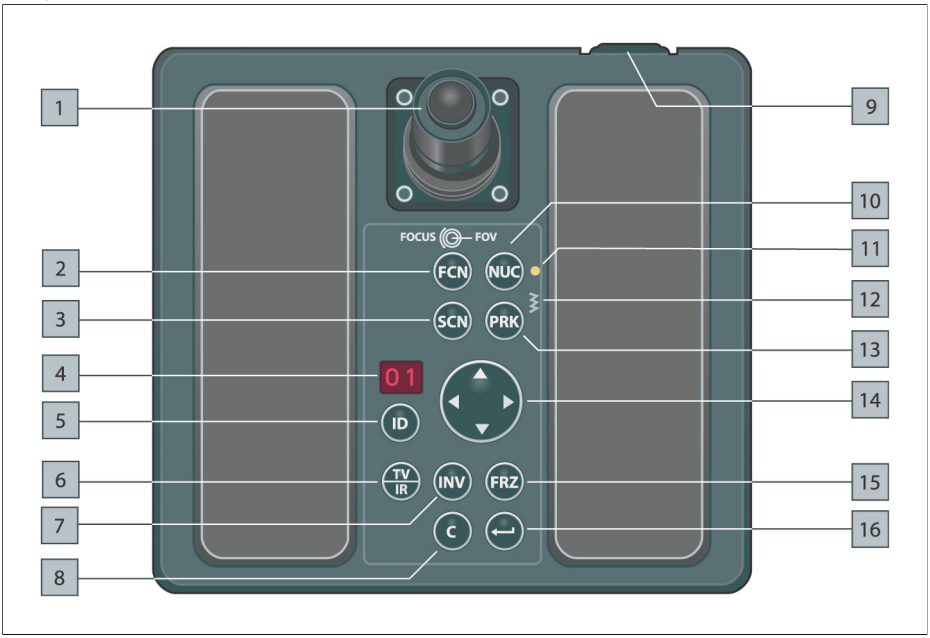

Figure 6.2 Keypad buttons

Callout	Description
1	Joystick with focus (collar) & FOV (button).
2	▪ Press FCN + ▲▼ to increase or decrease level ▪ Press FCN + ◄► to decrease or increase span **NOTE:** The FCN button has specific functionality when Remote Power Controller (RPC) is used. For more information about RPC, see section 6.3 – Remote Power Controller (only TASS protocol) on page 27.
3	▪ Press SCN to enter AUTOSCAN mode ▪ Press SCN to resume AUTOSCAN mode
4	(Reserved for future capabilities)
5	(Reserved for future capabilities)
6	Press TV/IR to toggle between TV imaging and IR imaging.
7	Press INV to toggle between IR palette and inverted IR palette.
8	Press C to exit menus and dialog boxes.
9	Backlight control.

Callout	Description
10	▪ Press NUC < 1 sec. to perform an image calibration ▪ Press NUC > 1 sec. to perform an auto-focus sequence The behavior can be inverted by changing the setting for **Nuc button** (**Setup** → **Image**)
11	Indicator LED for communication between JCU and the imaging unit: ▪ At startup = flashing light. ▪ During normal use = steady light.
12	Indicator LED for system heaters. If lit, the system heaters are on.
13	Press PRK to park the system. Move the joystick or press SCN to unpark the system
14	Press the navigation pad ▲▼ or ◄► to navigate in menus and dialog boxes.
15	Press FRZ to freeze/unfreeze the image. **NOTE:** The FRZ button has specific functionality when Remote Power Controller (RPC) is used. For more information about RPC, see section 6.3 – Remote Power Controller (only TASS protocol) on page 27.
16	Press ENTER ↵ to continue, confirm, or exit. **NOTE:** The ENTER button has specific functionality when Remote Power Controller (RPC) is used. For more information about RPC, see section 6.3 – Remote Power Controller (only TASS protocol) on page 27.

6.1 Joystick controller unit indicators & switch functions

The following is a description of the different indicators and switches on the joystick controller unit.

6.1.1 Joystick control symbols

These symbols indicates the arrangement of the focus and FOV switches in the joystick.

SEE ALSO: See also section 6.2.2 – Joystick button (located on the top of the joystick) on page 27.

6.1.2 Status indicator

This LED shows the communication between the joystick controller unit and the processor located in the imaging unit.

At start-up, the LED will be continuously lit for a couple of seconds. After that it will begin flashing, indicating the system's boot sequence. When the joystick controller unit is properly communicating with the ThermoVision™ Sentry II processor it will be continuously lit.

NOTE: The indicator LED does not indicate system faults.

6.1.3 NUC button

The NUC (non-uniformity correction) function performs an image calibration to correct for image non-uniformities that arise due to the slightly different gain characteristics that occur from detector to detector within the array.

In IR mode, pressing the NUC button < 1 second will perform an image calibration. In both IR and TV mode, pressing the NUC button > 1 second will perform an auto-focus sequence. This is the default behavior. The behavior can be inverted by changing the setting for **Nuc button** (**Setup** → **Image**).

To make it possible for the camera to auto-focus properly, there are a few things that the user should think about:

To think about when auto-focusing
The area that the camera uses when auto-focusing is a 64 x 64 pixel box, centered vertically and horizontally on the screen.
The camera may experience difficulties auto-focusing when the image has low contrasts between different areas.
The user should keep the camera steady when auto-focusing.
Horizontal or vertical lines in the image should not be parallel to the pixel lines on the screen.
The camera may experience difficulties auto-focusing if it is completely out of focus when beginning the auto-focus sequence.
The camera may experience difficulties auto-focusing if the target is moving rapidly.
When auto-focusing in NFOV (narrow field-of-view) the distance to target must be more than 15 m / 49.2 ft.
When auto-focusing in WFOV (wide field-of-view) the distance to target must be more than 2 m / 6.6 ft.

6.1.4 Heater indicator

If the ambient temperature is below freezing point, heaters will automatically be switched on to heat the system before the system itself is switched on. This LED indicates that the heaters are in use.

System heating takes several minutes – up to 30 minutes if the ambient temperature is -32 °C / -25.6 °F).

NOTE: The indicator LED does not indicate system faults.
NOTE: The system heaters turn on at start-up only.

6.1.5 PRK button

Momentarily pressing the PRK button places the system into the PARK mode of operation where the locking pins are activated. System start-up time when the system is in stand-by mode is approx. 5 seconds. To exit the PARK mode, either move the joystick and the system will then power up and enter the NORMAL mode of operation, or – if the system has been programmed with scan parameters (programmed scan points) – press the SCN button to directly enter the AUTOSCAN mode.

6.1.6 Arrow buttons

The function of the arrow buttons will change depending on the system mode.

NORMAL mode active	
Pressing up/down arrow buttons	Electronic zoom in (up) and zoom out (down).
Pressing left/right arrow buttons	Previous (left) or next (right) autoscan position. If no scan parameters have been entered there will be no action.

AUTOSCAN mode active	
Pressing up/down arrow buttons	No action on the system operation.
Pressing left/right arrow buttons	Previous (left) or next (right) autoscan position. This however will also exit the AUTOSCAN mode (returning the system to NORMAL mode).

MENU mode active	
Pressing up/down/left/right arrow buttons	Allows the operator to move through menus, change menu features and item values.

6.1.7 FRZ button

Each depression of the FRZ button will freeze the image, or – if the image is already frozen – unfreeze it. The *Frozen* icon is displayed when the image is frozen.

NOTE: The FRZ button has specific functionality when Remote Power Controller (RPC) is used. For more information about RPC, see section 6.3 – Remote Power Controller (only TASS protocol) on page 27.

6.1.8 ENTER button

Normally the ENTER button will continue, confirm, or exit. It usually places the system into the MENU mode, displaying the menu bar with the last selected menu, and active feature.

NOTE: The ENTER button is disabled when the camera is in AUTOSCAN mode.
NOTE: The ENTER button has specific functionality when Remote Power Controller (RPC) is used. For more information about RPC, see section 6.3 – Remote Power Controller (only TASS protocol) on page 27.

6.1.9 FCN button

The FCN (function) button is used with the other buttons to provide additional functionality to other controls. The FCN button is pressed simultaneously with the button that contains the extended function to activate that feature.

NORMAL mode active (manual level/span is selected)	
Pressing FCN + Up arrow	Increases the level setting
Pressing FCN + Down arrow	Decreases the level setting
Pressing FCN + Left arrow	Increases the span setting
Pressing FCN + Right arrow	Decreases the span setting

NOTE: Pressing FCN + any arrow on the navigation pad will turn level/span into MANUAL mode.

AUTOSCAN mode active	
Pressing FCN	Exits the AUTOSCAN mode and enters the PROG POSITIONS mode

NOTE: The FCN button has specific functionality when Remote Power Controller (RPC) is used. For more information about RPC, see section 6.3 – Remote Power Controller (only TASS protocol) on page 27.

6.1.10 SCN button

If autoscan positions have already been entered, a momentary depression on the SCN (scan) button will activate the AUTOSCAN mode. If the scan was previously stopped, it will resume the AUTOSCAN mode from the last scan position, otherwise it will start the scanning process from the first active scan point in the current list. While the unit is in the AUTOSCAN mode, Autoscan is displayed at the upper left section of the image.

If scan parameters have not been entered, the SCN button will have no effect on the system operation.

6.1.11 ID display

In a network set-up, this display indicates which unit is currently selected.

6.1.12 ID button

To switch units in a network set-up, this button is depressed while the desired unit number is selected with the left/right arrow button.

6.1.13 INV button

Each depression of the INV (invert) button will toggle between the currently used IR palette and the inverted palette, i.e. **Gray** to **Inv Gray**, **White Hot** to **Black Hot**, **Rainbow** to **Inv Rainbow**, or **Iron** to **Inv Iron**.

6.1.14 TV/IR button

This button is used to toggle between TV and IR imaging.

6.1.15 C button

The function of the C button will change depending on the system mode.

PROG POSITIONS mode active	
Pressing C (cancel)	Begins the process to exit the PROG POSITIONS mode (a prompt will appear asking the operator to verify that he wishes to exit).

AUTOSCAN mode active	
Pressing C (cancel)	Exits the AUTOSCAN mode and returns to the NORMAL mode.

MENU mode active	
Pressing C (cancel)	Moves the system from the MENU mode to the NORMAL mode without changing the current menu settings. Exits the active dialog box.

6.2 Joystick

The joystick is used to control the position of the imager (pan and tilt functions). The functionality of the joystick changes with the system mode of operation as follows:

NORMAL mode active	
Moving joystick left/right	Imager pans left/right.
Moving joystick forward/backward	Imager tilts up/down (polarity is selectable in the **Pan/tilt** menu). **SEE ALSO:** See also section 8.1 – Pan/tilt menu on page 34

AUTOSCAN mode active	
Any movement of the joystick	Makes the system enter the NORMAL mode of operation. Pan/tilt functions will then be the primary joystick functions as described above.

PROG POSITIONS mode active	
Moving joystick left/right	Imager pans left/right.
Moving joystick forward/backward	Imager tilts up/down

6.2.1 Joystick handle

Turning the top of the joystick (the joystick collar) will adjust the imager focus:

- Turning the joystick clockwise will adjust the focus for distant objects (*Far focus* is displayed during the focus)
- Turning the joystick counter-clockwise will adjust the focus for near objects (*Near Focus* is displayed during the focusing)

SEE ALSO: See also section 6.1.1 – Joystick control symbols on page 22.

6.2.2 Joystick button (located on the top of the joystick)

Pressing the button located on the top of the joystick will toggle between the system WFOV (wide field-of-view) and NFOV (narrow field-of-view) optics.

Pressing the button for more than 1 second will enable **Slave mode on**.

SEE ALSO: For more information, see also:

- Section 6.1.1 – Joystick control symbols on page 22
- Section 8.2.1.9 – Slave mode on/Slave mode off on page 39
- Section 8.2.2.7 – Slave mode on/Slave mode off on page 40

6.3 Remote Power Controller (only TASS protocol)

6.3.1 General information

A ThermoVision™ Sentry II system can be remotely switched on and switched off by using a built-in feature called Remote Power Controller (RPC). When the camera is switched off, it will automatically be parked.

The RPC always listens to the system communication, also when the system is in PARK mode. When the RPC detects a power off command, it switches off the system power and when it detects a power on command it switches on system power.

6.3.2 How to switch power on using the RPC

Follow this procedure to switch power on:

Step	Action
1	Press and hold down the FCN button on the joystick controller unit (JCU).
2	While the FCN button is held down, press and hold down the ENTER button.
3	Hold both buttons down for more than three seconds.
4	Release the FCN button, then release the ENTER button. The power has now been switched on.

6.3.3 How to switch power off using the RPC

Follow this procedure to switch power off:

Step	Action
1	Press and hold down the FCN button on the joystick controller unit (JCU)
2	While the FCN button is held down, press and hold down the FRZ button
3	Hold both buttons down for more than three seconds.
4	Release the FCN button, then release the FRZ button. The power off sequence has now been initiated and the Sentry unit will be switched off in 10 seconds.

6.3.4 Important notes regarding the RPC

- It will take nominally 10 seconds from inititating the power off sequence to actual power down. This delay is introduced to allow the ThermoVision™ Sentry II unit to park the imager properly.
- The JCU will not reflect the power status of the ThermoVision™ Sentry II unit. The user should use the video monitor for feedback.
- The RPC only works at a baudrate of 9600 Bd.

7 Display symbology

7.1 General information

The ThermoVision™ Sentry II system operates in a number of *modes*. Each mode is a combination of settings and functions designed to assist the operator in performing a particular task. In addition to the operating modes, there are also a number of controls that can be used to optimize the system's performance, or enhance system operation.

The ThermoVision™ Sentry II system takes the thermal video of the area within the field-of-view and displays it on the video display unit (-s). Symbology is also overlaid on the imagery and provides system time/date, azimuth/elevation indicators, focus indicator, NFOV brackets, crosshair, and polarity (**White hot** or **Black hot**) indicator.

7.2 System display & symbols

7.2.1 System display

10594903;a2

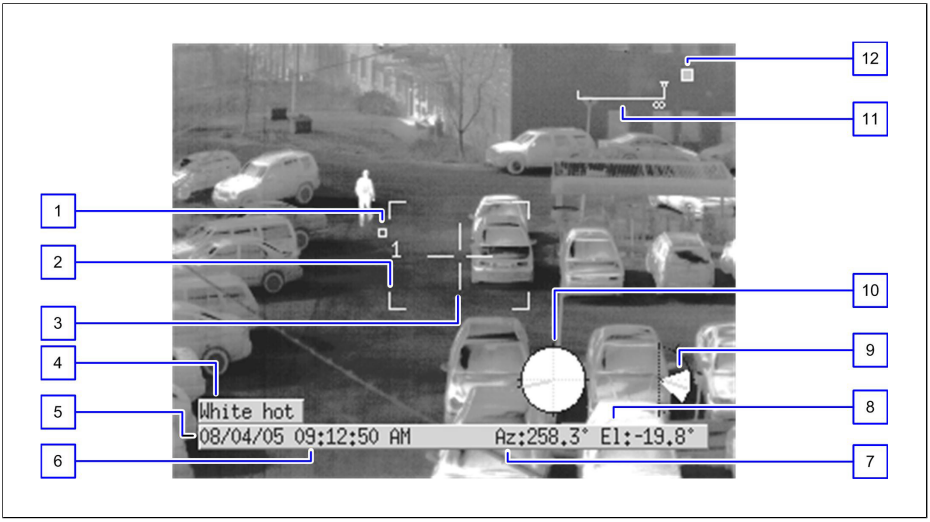

Figure 7.1 System display

The symbology actually displayed is mode and function dependent, and can be removed from the display by using the **Declutter** feature if desired. The display is shown with all of the symbology activated (DECLUTTER mode is not active).

NOTE: The DECLUTTER mode is only active until the operator presses the ENTER key.

Callout	Description
1	Preset position number
2	NFOV reticule
3	Crosshair reticle
4	Image polarity
5	System date
6	System time
7	Digital azimuth indicator
8	Digital elevation indicator
9	Analog elevation indicator

Callout	Description
10	Analog azimuth indicator
11	Focus position indicator
12	Active channel

7.2.2 In-depth explanations of symbols

7.2.2.1 Preset position number

Preset position numbers (1 through 32) are displayed on the image, and show the locations of any currently set autoscan points. While the system is in AUTOSCAN mode, it tracks the preset position during changes in azimuth, elevation, FOV (field-of-view), focus and electronic zoom settings. Preset positions are set when the unit is in the PROG POSITIONS (Program autoscan points) mode.

7.2.2.2 NFOV (narrow field-of-view) reticle

The NFOV reticle is displayed when the system is in the WFOV (wide field-of-view), and provides an indication of the area viewed when the NFOV is selected.

7.2.2.3 Crosshair reticle

The crosshair reticle shows the center of the current field-of-view. When setting preset positions (for AUTOSCAN mode), it defines, or shows the location of the point to be entered.

7.2.2.4 Image polarity

The image polarity shows if white is set to represent hot or black is set to represent hot.

7.2.2.5 System date

The system date is located at the bottom left of the display, and is shown in either YY-MM-DD, MM/DD/YY or DD/MM/YY format. The system date is set from the **Setup** menu (the date format is set from the **Local adaptions** dialog box, while the actual date is set from the **Date & time** dialog box).

7.2.2.6 System time

The system time is located at the bottom of the display and is displayed in either 12 or 24 hour format. The system time is set from the **Setup** menu (the time format is set from the **Local adaptions** dialog box while the actual system time is set from the **Date & time** dialog box).

7.2.2.7 Digital azimuth indicator

The digital azimuth indicator is located at the bottom of the display directly below the analog display, and provides a numeric readout of the imager azimuth relative to the entered reference angle.

7.2.2.8 Digital elevation indicator

The digital elevation indicator is located at the bottom of the display (directly below the analog elevation readout) and provides a numeric readout of the imager elevation.

7.2.2.9 Analog elevation indicator

The analog elevation indicator is located at the right bottom of the display; directly above the digital elevation readout (*El: xxx.x*), and provides an indication of the imager look-ahead setting relative to system minimum and maximum.

7.2.2.10 Analog azimuth indicator

The analog azimuth indicator is located at the bottom of the display, directly above the digital azimuth readout (*Az: xx.x*), and is corrected for a user-definable reference angle. The indicator looks like a small 'clock' with the system look ahead located at the 12 o'clock position if no reference angle is entered (straight behind is at 6 o'clock).

7.2.2.11 Focus position indicator

The focus position indicator is located at the upper right corner of the display, and provides an indication of the focus travel from near (left) to distant (right).

7.2.2.12 Active channel indicator

The active channel indicator is shown on the screen to indicate which channel – i.e. TV or IR – is active.

7.2.2.13 Additional indicators not shown in the illustration

7.2.2.13.1 Level & span (gain) indicators

The level & span (gain) indicators, are located at the bottom left of the screen (over the system date and time) when **Manual level & span** is first selected. They provide the operator with an indication of the current system level & span settings.

7.2.2.13.2 Other indicators

One or several of the following text strings and / or icons will be displayed when the functions they represent are triggered:

- **Zooming in**
- **Zooming out**
- **Focus far**
- **Focus near**

- **Frozen**
- **Autoscan**
- Zoom box
- **Adjusting**
- **Park**

7.2.2.14 Declutter function

At times the operator may want to remove all the symbology from the image. The system is capable of two levels of symbology display: **Declutter none** (all symbology is displayed normally as defined from the **Setup** → **Symbology** menu), and the DECLUTTER mode where all of the symbology is removed.

NOTE: The DECLUTTER mode is only active until the operator presses the ENTER key.

8 System software menus

The system's software menus provide the operator with a simple interface to define system features and enter system constants. Access to the MENU mode is made by pressing the ENTER button located on the joystick controller unit. The three main menus are shown in the menu bar found at the top of the screen with the currently selected menu/feature highlighted. Features are presented directly as a command (**Freeze** or **Change palette** for example), while selections that do not directly perform an action, but open a dialog box allowing further selections to be made, are identified by a feature title followed by three periods (**Image...** or **Date & time...** for example). Features that are not currently available for selection will appear shaded in the menu.

The left/right arrow buttons are used to move between the different menus, and the up/down arrow buttons are used to move between the menu features or in dialog boxes. When a title is highlighted, pressing the ENTER button will either activate the feature and exit the MENU mode, or open the dialog box for further selection. To exit a menu (or the MENU mode) press the ENTER button to accept any changes, or use the C button to back out of the MENU mode without altering any of the current settings.

8.1 Pan/tilt menu

8.1.1 When IR is selected:

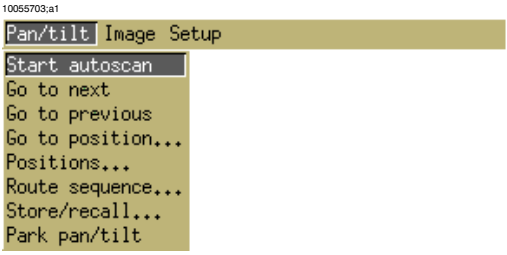

Figure 8.1 **Pan/tilt** menu when IR is selected

The **Pan/tilt** menu is used to start the AUTOSCAN mode, go to any of the programmed scan points, enter the PROG POSITIONS mode, delete, store, recall, and alter previously defined lists of points, and place the system into the PARK mode. The up/down arrow buttons are used to move between the different menu features. Pressing the ENTER button will activate the currently highlighted feature and then exit the MENU mode, or open the dialog box for further selections. To exit the pan/tilt menu without making any changes, press the C (cancel) button.

8.1.1.1 Start autoscan

The system starts the AUTOSCAN mode.

8.1.1.2 Go to next

The system moves as fast as possible to the next point in the currently active scan routine.

8.1.1.3 Go to previous

The system moves as fast as possible to the previous point in the currently active scan routine.

8.1.1.4 Go to position

10056603;a1

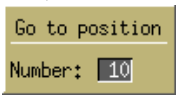

Figure 8.2 **Go to position** dialog box

When selected, a dialog box appears allowing the operator to go to any one of the 32 possible programmed positions (even if the position has been defined as non-active). Use the left/right arrow buttons to increment/decrement the setting, press the ENTER button when the desired point is shown.

8.1.1.5 Positions

10056703;a1

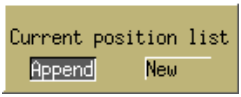

Figure 8.3 **Current position list** dialog box

Selecting **Positions** and then **Append** or **New** in the following **Current position list** dialog box will enter the system PROG POSITIONS mode. This allows the operator to define new scan points, or alter previously entered point settings. If no current list exists, the system will go directly to the data point collection mode; if an active position list already exists, the operator is given the option to append it, or create a new list.

Append allows the operator to modify the current list by adding new points, or adjusting the points scan parameters. To add a point move the imager to the desired position using the joystick, and then press the ENTER button. The next available position number will be assigned to the new point. Next, set the desired scan speed from the present point to the next point (use the left/right arrow buttons). Use the up/down arrow buttons to select the dwell dialog item and then use the left/right arrow to adjust the dwell setting. Field of view, focus and zoom position are saved automatically. Press the ENTER button to accept the new position and repeat the procedure for any

new points. To exit the PROG POSITIONS mode, press the C button. A dialog box will appear to confirm that the operator wishes to exit. Choose **Yes** by pressing the ENTER button.

If **New** is selected a second dialog box will appear. Selecting **Yes** will give the operator the option of deleting the currently selected position list (deleting any previously set points), and **No** will return the system to the normal mode of operation.

To change the settings of a scan point, select **Positions** in the **Pan/tilt** menu. This will bring up the **Current position list** dialog box mentioned above. By selecting **Append** the system will enter PROG POSITIONS mode. Pressing the FCN key in this mode will bring up the **Edit position** dialog box where the desired settings can be changed, and confirmed by pressing ENTER.

Pressing the FCN key without releasing it will instead give the operator the possibility to move a stored scan point by moving the joystick.

8.1.1.6 Route sequence

10056803;a1

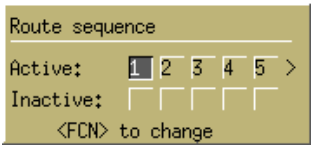

Figure 8.4 Route sequence dialog box

The **Route sequence** dialog box allows the operator to define the scan protocol, that is, whether the scan points are covered in the sequence as entered (1 through X and then start over), or if the scan process is to be different from the entered sequence by making some of the entered points inactive. The sequence order can also be changed.

Use the left/right arrow buttons to select the point to be affected, next press the FCN button. The operator can now use the left/right arrow buttons to move the position of the point within the list, or the up/down arrow buttons to move the point from inactive to active or active to inactive status. When the points are correctly positioned press the ENTER button to accept the changes and return to the NORMAL mode.

8.1.1.7 Store/recall

10056903;a1

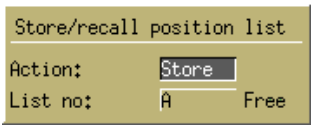

Figure 8.5 **Store/recall position list** dialog box

The **Store/recall position list** dialog box allows the operator to store, recall, or delete lists or configurations of scan points. The operator can save four lists of scan points for future use.

SEE ALSO: Usage of the **Store/recall position list** dialog box is covered in the section 9.3.5 – Editing an autoscan list on page 54

8.1.1.8 Park pan/tilt

Places the system into the PARK mode.

8.1.2 When TV is selected:

10044303;a1

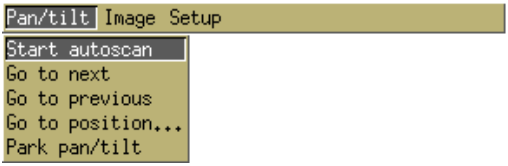

Figure 8.6 **Pan/tilt** menu when TV is selected

8.1.2.1 Start autoscan

This is the same feature as when IR is selected.

SEE: For information, see section 8.1.1.1 – Start autoscan on page 34.

8.1.2.2 Go to next

This is the same feature as when IR is selected.

SEE: For information, see section 8.1.1.2 – Go to next on page 35.

8.1.2.3 Go to previous

This is the same feature as when IR is selected.

SEE: For information, see section 8.1.1.3 – Go to previous on page 35.

8.1.2.4 Go to position

This is the same feature as when IR is selected.

SEE: For information, see section 8.1.1.4 – Go to position on page 35.

8.1.2.5 Park pan/tilt

This is the same feature as when IR is selected.

SEE: For information, see section 8.1.1.8 – Park pan/tilt on page 37.

8.2 Image menu

8.2.1 When IR is selected

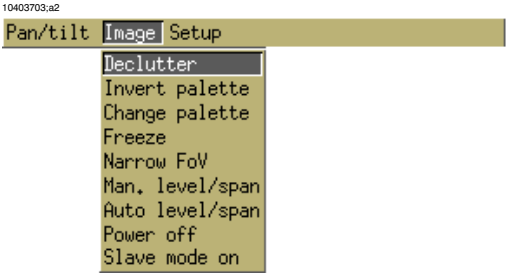

Figure 8.7 Image menu when IR is selected

The **Image** menu is used to define appearance of the system video display. The up/down arrow buttons are used to move between the different menu features; pressing the ENTER button will activate the currently highlighted feature, and then exit the MENU mode. To exit the **Image** menu without making any changes, press the C (cancel) button.

8.2.1.1 Declutter

The **Declutter** feature allows the operator to temporarily remove all of the displayed symbology from the system display. The symbology will return the next time the ENTER button is pressed.

8.2.1.2 Invert palette

Highlighting and pressing enter inverts the palette currently in use, and then exits the MENU mode.

- **Gray (white hot)** to **Inv gray (black hot)**, or back;
- **Rainbow** to **Inv rainbow**, or back;
- **Iron** to **Inv Iron**, or back.

8.2.1.3 Change palette

Highlighting and pressing ENTER changes the palette currently in use, and then exits the MENU mode. The palettes will 'rotate' from **Gray** to **Rainbow** to **Iron**, and then back to **Gray** and start over again. If the palette currently in use is inverted, the newly selected palette will also be inverted.

8.2.1.4 Freeze/Live

Changes the display from live image to frozen image, or back. A frozen image is identified by the text **Frozen** in the display.

8.2.1.5 Narrow FoV/Wide FoV

Changes the current field-of-view in use from **Wide FoV** (normal) to **Narrow FoV** (zoomed), or back.

8.2.1.6 Man. level/span

When selected, level & span values are locked, and a dialog box is shown at the bottom left of the display. The left/right arrow buttons are used to select either the level or span for adjustment, while the up/down arrow buttons adjusts the setting. Pressing ENTER accepts these setting for the image and removes the control bar. Pressing the C button will reset the level & span to the previous values. **Man. Level/span** can be selected again to continue the adjustments.

SEE ALSO: See also section 6.1.3 – NUC button on page 23.
NOTE: The system will remain in manual level/span mode until **Auto level/span** is selected.

8.2.1.7 Auto level/span

When selected, the system will automatically select an image enhancement method for best overall image contrast. The method selected depends on the settings in the **Setup** – **Image dialog** box.

8.2.1.8 Power off/Power off

This function switches off the power to the detector module. A test image will be displayed.

8.2.1.9 Slave mode on/Slave mode off

When **Slave mode on** is selected, and the operator switches to TV mode, the same field of view as in IR mode will be used and the camera will carry out an autofocus sequence.

8.2.2 When TV is selected

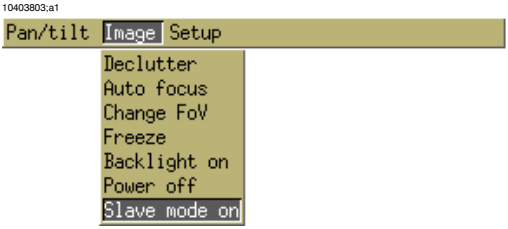

Figure 8.8 **Image** menu when TV is selected

8.2.2.1 Declutter

This is the same function as when IR is selected.

SEE: For information, see section 8.2.1.1 – Declutter on page 38.

8.2.2.2 Auto focus

Choosing this function executes a momentary auto-focus adjustment. Due to the risk of mechanical wear, continuous auto-focus is not provided.

8.2.2.3 Change FoV

This is the same function as when IR is selected.

8.2.2.4 Freeze/Live

This is the same function as when IR is selected.

SEE: For information, see section 8.2.1.4 – Freeze/Live on page 39.

8.2.2.5 Backlight on/Backlight off

This function offers a backlight compensation. If an object appears in front of a very light background – or if the object is very dark – selecting this function increases the image quality. There are two choices – **Backlight on** and **Backlight off**.

8.2.2.6 Power off/Power on

This function switches the TV camera off, which will turn the image black. When the TV is switched off, all menu items except **Power On** in the **Image** menu are gray and can not be selected.

8.2.2.7 Slave mode on/Slave mode off

When **Slave mode on** is selected, and the operator switches to IR mode, 5° field of view will be used for IR mode if the current TV field of view is less than 15°. If not, 20° field of view for IR mode will be used.

The camera will also carry out an autofocus sequence.

8.3 Setup menu

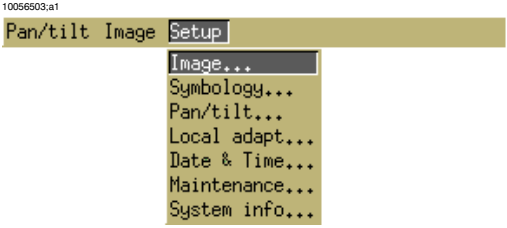

Figure 8.9 **Setup** menu

The **Setup** menu is used to define system constants and symbology. The up/down arrow buttons are used to move between the different dialog box selections, and the ENTER button is used to open a dialog box. Within the dialog boxes, the up/down arrow buttons are used to move between the features while the left/right arrow buttons are used to adjust system settings or values.

Pressing the ENTER button will accept any changes made and then exit the MENU mode, or press C to exit without making any changes to the current settings

8.3.1 Image

8.3.1.1 When IR is selected

The **Setup** – **Image** dialog box is used to define the appearance of the system display and symbology.

10057003;a3

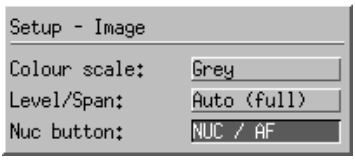

Figure 8.10 **Setup** – **Image** dialog box

Label	Explanation
Color scale	The **Color scale** feature allows the operator to select the palette that the display is shown in. Options include: ▪ **Gray** ▪ **Gray inv** (inverted) ▪ **Rainbow** ▪ **Rainbow inv** (inverted) ▪ **Iron** ▪ **Iron inv** (inverted)
Level/Span	The **Level/span** feature determines how the system will process the thermal information in the generation of the displayed image. Options include: ▪ **Manual** ▪ **Auto (linear)** ▪ **Auto (full)** = histogram equalization ▪ **DDE L** = Low filtering. Improves details in high contrast images ▪ **DDE H** = High filtering. Improves details in low contrast images

Label	Explanation
Nuc button	▪ **NUC** / **AF** = When pressing the NUC button for less than 1 second, the camera performs an image calibration. When pressing and holding the NUC button for more than 1 second, the camera performs an auto-focus sequence. **This is the default detting.** ▪ **AF** / **NUC** = When pressing the NUC button for less than 1 second, the camera performs an auto-focus sequence. When pressing and holding the NUC button for more than 1 second, the camera performs an image calibration.

8.3.1.2 When TV is selected

10059003;a1

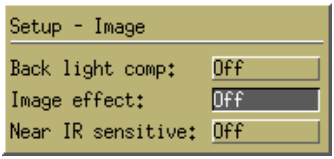

Figure 8.11 Setup – Image dialog box

Label	Explanation
Back light comp	**SEE:** See section 8.2.2.5 – Backlight on/Backlight off on page 40.
Image effect	The **Image effect** feature allows the operator to select between: ▪ **Off** ▪ **B/W** Selecting **Off** puts the TV imager in color mode, while selecting **B/W** puts it in black & white mode.
Near IR sensitive	This function offers increased sensitivity to IR radiation by removing a built-in cut-off IR radiation filter. The feature is especially valuable under twilight conditions. **NOTE:** The normal position of the cut-off filter is in the raypath of the TV imager.

8.3.2 Symbology

From the **Setup** – **Symbology** dialog box the operator defines how the overlaid symbology is displayed.

8.3.2.1 When IR is selected

10057103;a1

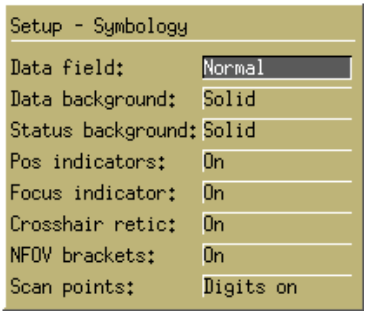

Figure 8.12 **Setup** – **Symbology** dialog box

Label	Explanation
Data field	The **Data field** option affects the two lines of information presented at the bottom of the display. Three choices are available: ▪ **Normal** (both lines are shown) ▪ **Reduced** (only the bottom line is shown, i.e. date, time, and digital azimuth/elevation) ▪ **None** (both lines are disabled)
Data background	The **Data background** feature can be used to put a solid background behind the lines of symbology, making them more visible.
Status background	The **Status background** feature can be used to put a solid background behind the status symbology (**Frozen**, **Autoscan**, **Near focus** etc.), making it more visible.
Pos indicators	**Pos indicators** affects the analog azimuth and elevation indicators. Three options are available: ▪ **On** (the indicators are always shown) ▪ **Off** (the indicators are disabled) ▪ **When changed** (the indicators are not shown unless the imager is changing positions).

Label	Explanation
Focus indicator	**Focus indicators** affects the presentation of the analog focus indicator. Three options are available: ▪ **On** (the indicators are always shown) ▪ **Off** (the indicators are disabled) ▪ **When changed** (the indicator is only shown during a change of focus).
Crosshair retic	The **Crosshair retic** selection controls the presentation of the crosshair indicator. Two options are available: ▪ **On** (the indicator is always shown) ▪ **Off** (the indicator is disabled)
NFOV brackets	The **NFOV brackets** selection controls the presentation of the NFOV reticule that is displayed when the system is in the WFOV (and is used to provide an indication of the area viewed when the NFOV is selected). Two options are available: ▪ **On** (the indicator is always shown) ▪ **Off** (the indicator is disabled)
Scan points	The **Scan points** selection controls the presentation of the programmed scan points. Three options are available: ▪ **Digits on** (the scan point identification number (digit) and the targeting square are shown) ▪ **On** (only the targeting square is shown) ▪ **Off** (no symbology is shown).

8.3.2.2 When TV is selected

This is the same dialog box as when IR is selected.

NOTE: NFOV brackets and **Scan points** will not be visible on the screen or in the dialog box when TV is selected.

8.3.3 Pan/tilt

10055803;a1

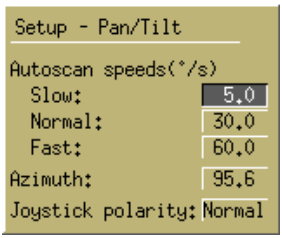

Figure 8.13 **Setup** – **Pan/tilt** dialog box

The **Setup** – **Pan/tilt** dialog box is used to set the system slew rates used during auto-scanning, and the system azimuth reference angle.

Use the up/down arrow buttons to select the setting to be adjusted, and the left/right arrow buttons to adjust the values. The **Slow**, **Normal**, and **Fast** slew setting are shown in approximate degrees/second, and are adjustable in 0.1° increments. Each selection settings can be adjusted from 0.1° to 120° per second (pan) and 0.1 to 60° per second (tilt). The setting must follow a logical progression, that is, it is not possible to adjust the normal setting to a value that is less than the slow setting.

SEE ALSO: See also section 9.3.1 – Autoscan point parameters on page 52.

The **Azimuth** reference angle can be adjusted from 000.0° to 359.9° in 0.1° units. This value is used to set true azimuth when the ThermoVision™ Sentry II itself can not be mounted in a *true north* direction.

The operator can also set the **Joystick polarity** by selecting either **Normal** or **Pilot**. **Normal** means that the pan/tilt head moves downwards when the operator moves the joystick towards himself. Selecting **Pilot** means that the pan/tilt head moves downwards when the operator moves the joystick away from himself.

8.3.4 Local adapt

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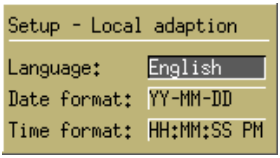

Figure 8.14 **Setup** – **Local adaption** dialog box

The **Setup** – **Local adaption** dialog box is used to adjust the format that system date, time, and the language that the symbology is displayed in. Use the up/down arrow buttons to move the highlight bar between the menu selections, and the left/right arrow

buttons to adjust values/settings. Pressing the ENTER button will accept any changes made and then exit the MENU mode, or press C to exit without making any changes to the current settings.

Label	Explanation
Language	English + optional languages
Date format	▪ MM/DD/YY ▪ DD/MM/YY ▪ YY-MM-DD
Time format	▪ HH:MM:SS (24 hour format) ▪ HH.MM.SS (24 hour format) ▪ HH:MM:SS PM (12 hour format)

8.3.5 Date & Time

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Figure 8.15 **Setup** – **Date & Time** dialog box

The system time and date is set from within the **Setup** – **Date & Time** dialog box. The format that the information is presented in depends on the settings made in the **Local Adaptions** dialog box. For example, if the 12 hour (a.m./p.m.) format has been selected, the time setting can be adjusted from 12 p.m. through 12 a.m. If the 24 hour format is active 1 through 24 can be set. Use the up/down arrow buttons to move the highlighted bar through the selections, and the left/right arrow buttons to adjust values/settings. Pressing the ENTER button will accept any changes made and then exit the MENU mode, or press C to exit without making any changes to the current settings.

Label	Explanation
Year	1981--2038
Month	1 through 12
Day	1 through 31
Hour	▪ 12 a.m. through 12 p.m. ▪ 1 through 24 (format dependent)
Minute	00 through 59

8.3.6 Maintenance

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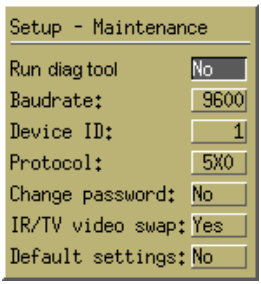

Figure 8.16 **Setup** – **Maintenance** dialog box

The **Setup** – **Maintenance** dialog boxis used to define system constants such as the system password (if used), and the protocol.

Label	Explanation
Run diag tool	**Yes** or **No**
Baudrate	▪ **1200 bps** ▪ **2400 bps** ▪ **4800 bps** ▪ **9600 bps** ▪ **19200 bps** If the **Baudrate** is changed, it will be necessary to restart the system before the change will take effect. **NOTE:** For best performance, **9600 bps** or **19200 bps** should be selected.
Device ID	**1** through **31**

Label	Explanation
Protocol	▪ 5X0 ▪ TASS ▪ PELCO D (**NOTE:** By default, a ThermoVision™ Sentry II system is shipped without PELCO D protocol. The customer must specifically request PELCO D protocol.) **Protocol** is selectable to **5X0**, **TASS** or **PELCO D**. The 5X0 protocol is also used in the ThermaCAM™ 500 series cameras and is an ASCII protocol using 'xon/xoff handshaking'. If the protocol is changed, it will be necessary to restart the system before the change will take effect. Optional protocols are available upon request. **NOTE:** The 5X0 protocol is a point-to-point protocol. No Device ID can be selected.
Change password	**Yes** or **No** When the maintenance menu is entered, a password dialog box will appear (if the password is the default system value 0000, the password dialog box will not be displayed). To change a value, use the up/down arrow buttons. To select another digit, use the left/right arrow buttons. When the right password is present, press the ENTER button. If the wrong password is entered a warning will appear. When the correct password is entered the maintenance menu will appear. To change the password, set the **Change password** selection to **Yes**, and press the ENTER button. A dialog box will appear allowing the operator to enter the new password.
IR/TV video swap	**Yes** or **No** If **Yes** is selected the active video signal is swapped between the two video outputs on the pan/tilt head when the operator toggles between IR and TV. If two monitors are used (one for IR and one for TV) this means that the images move between the monitors, instead of only moving the indicator for active channel between the monitors. **SEE:** See section 7.2.2.12 – Active channel indicator on page 32.

Label	Explanation
Default settings	Yes or No **NOTE:** Selecting **Yes** resets all parameters to factory settings, *except lists of scanpoints, baud rate and protocols*.

8.3.7 System info

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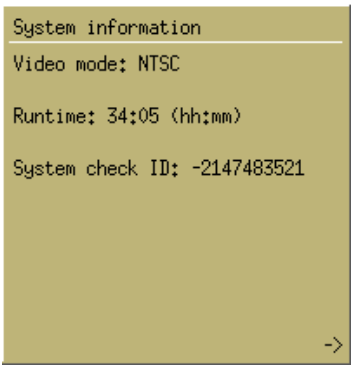

Figure 8.17 **System information** dialog box

The **System information** dialog box contains information about the system, such as:

Label	Explanation
Video mode	NTSC or PAL
Runtime	Hours and minutes
System check ID	Configuration number

Hardware and firmware information is also available.

9 System operation

The ThermoVision™ Sentry II system operates in a number of modes. Each mode is a combination of settings and functions designed to assist the operator in performing a particular task. In addition to the operating modes, there are also a number of controls that can be used to optimize the systems' performance, or enhance system operation.

9.1 PARK mode

In the PARK mode the system is in the parked position with the locking pins activated. The PARK mode is entered by pressing the PRK button on the joystick controller unit, or by accessing the **Pan/tilt** menu and selecting the **Park pan/tilt** feature. The PARK mode can be exited by either moving the joystick and then enter the NORMAL mode, or – if the system has been programmed with scan parameters (programmed scan points) – the operator can also press the SCN button which will let him enter the AUTOSCAN mode of operation.

SEE ALSO: See also section 8.1 – Pan/tilt menu on page 34.

9.1.1 Manual control of the locking pins

There are two locking pins in the system – one for elevation, and one for azimuth. These are normally activated by an electric motor when the system is placed into the PARK mode.

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Figure 9.1 Locking pins

It is also possible to control the locking pins manually. Use a large screwdriver (or a coin) to press, and then rotate the stainless lead located on the side of the system.

To unlock, press and rotate clockwise; to lock, press and rotate counter-clockwise.

NOTE: Do not use excessive force.

9.2 NORMAL mode

In the NORMAL mode, system pan and tilt functions (imager directional control) are directed by using the joystick. The up/down arrow buttons electronically zoom in and out. If positions have been previously programmed, the left/right arrow buttons will slew the imager to the next (right button) or previous (left button) preset position. If positions have not been programmed the left/right arrow buttons will have no effect on the system operation. The NORMAL mode allows all of the active features to be utilized.

9.3 AUTOSCAN mode

The AUTOSCAN mode allows the operator to scan up to 32 pre-determined pointing positions. The system dwell time (i.e. the time that the imager stays on the target), scan rate (rate of change in between the preset positions), focus, and field-of-view for each point is fully programmable.

From the NORMAL mode the AUTOSCAN mode is normally entered by pressing the SCN button on the joystick controller unit, or by accessing the **Pan/tilt** menu and selecting **Start autoscan**. It is also possible to enter the AUTOSCAN mode directly from the PARK mode by pressing the SCN button.

SEE ALSO: See also section 8.1 – Pan/tilt menu on page 34.

If scan parameters have not been entered, pressing the SCN button will have no effect on the system.

The operator can exit the AUTOSCAN mode, by either moving the joystick in any direction, pressing the C (cancel) button, or by pressing either the left or right arrow buttons. The system will then return to the NORMAL mode. It is also possible to exit the AUTOSCAN mode and directly enter the PROG POSITIONS mode by pressing the FCN button.

NOTE: The ENTER button is disabled when the camera is in autoscan mode.

9.3.1 Autoscan point parameters

When the PROG POSITIONS mode is active and points are being entered, the system automatically takes care of recording the parameters associated with each point, such as the dwell time or field-of-view in use.

The PROG POSITIONS mode can be entered two different ways:

- From the joystick controller unit with the AUTOSCAN mode active, press the FCN button
- From the system menu structure by highlighting the **Positions** dialog box and then pressing the ENTER button

With the PROG POSITIONS mode active, point the system at the target using the joystick. Adjust the focus, field-of-view, (or zoom), scan rate (speed to the next point) and dwell time, and then press the ENTER button. The system will automatically assign the point with the next available point identification number and all of the necessary coordinates for the system to find the point again once the AUTOSCAN mode has been started.

Four speed settings are available for the scan rate, i.e. **Slow**, **Norm**, **Fast**, and **Max**. The **Max** setting will slew the imager at the maximum possible system slew speed. The other settings are user-definable from 0.1° to 120° per second (pan) and 0.1° to 60° per second (tilt).

SEE ALSO: See also section 8.1 – Pan/tilt menu on page 34.

The target dwell time can be set from 0 to 60 seconds (from 0 to 1 second in 0.2 second intervals, and from 1 to 60 seconds in 1 second intervals). Use the up/down arrow buttons to move between the speed and dwell selections, and the left/right arrow buttons to adjust the values/selections.

When the settings are correct, press the ENTER button to accept the position. The operator can now move the imager to the next position and repeat the process to enter the next point (-s). Up to 32 points can be selected for autoscan.

To exit the PROG POSITIONS mode, press the C (cancel) button. The operator will be prompted to verify that the current programming session is to end. If so, press the ENTER button.

NOTE: Entering autoscan point parameters is only possible when the camera is in IR mode.

9.3.2 Initiating the AUTOSCAN mode

From the NORMAL mode, the AUTOSCAN mode is entered pressing the SCN button on the joystick controller unit, or by selecting **Start autoscan** from the system **Pan/tilt** menu (press the ENTER button to initiate the MENU mode and display the system menus). It is also possible to enter the AUTOSCAN mode directly from PARK mode by pressing the SCN button. When autoscan is started from the system menus or the PARK mode it will always start with the first position in the current points list. When using the SCN button to start autoscanning, it will resume the scan from the currently selected position if the scan was previously stopped (or if the operator has used the

left/right arrow buttons to step through the different positions). When the system is in the AUTOSCAN mode, the message *Autoscan* is displayed at the upper left of the screen.

9.3.3 Stopping the AUTOSCAN mode

Once the autoscan sequence has begun, it can be interrupted in several different ways.

Action	Result
By moving the joystick	The system will enter the NORMAL mode
By pressing the left or right arrow button	The system will move to either the previous (left) or next (right) scan point and then enter NORMAL mode
By pressing the C (cancel) button	The system will enter the NORMAL mode
By pressing the FCN button	The system will enter the PROG POSITIONS mode
By pressing the PRK button	The system will enter the PARK mode

9.3.4 Restarting the AUTOSCAN mode

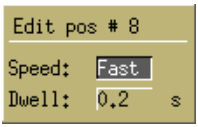
If stopped, the AUTOSCAN mode can be restarted by simply pressing the SCN button on the joystick controller unit, or by selecting **Start autoscan** from the system **Pan/tilt** menu. From the NORMAL mode, press the ENTER button to initiate the MENU mode and display the system menus).

If the AUTOSCAN mode is started by using the SCN button, it will start the autoscan from the next active autoscan point. Using the menu to start the scanning sequence will always start the scan from the beginning of the list of active scan points.

9.3.5 Editing an autoscan list

Follow this procedure to edit an autoscan list:

Step	Action
1	Press **SCN**, then press **FCN**.
2	Move to the desired point using the navigation pad.

Step	Action
3	To change the position of the point, press and hold down **FCN** while repositioning the camera using the joystick. This will also display the **Edit pos** dialog box. 10056303;a1  **Figure 9.2 Edit pos** dialog box
4	If the **Edit pos** dialog box is not displayed, press **FCN** and do **one** of the following: ▪ Make necessary changes in the **Edit pos** dialog box, then press **ENTER**. Note that focus and field of view also can be changed. ▪ Delete the point by pressing **FCN** + **C**, then press **ENTER**
5	Press **C** and select **YES**, then press **ENTER**.

The **Route sequence** feature in the **Pan/tilt** menu can also be used to edit the order of scanning, or to (temporarily) delete a point. When selected, the currently programmed points (and their activity state, either active or non-active) are displayed.

To change the scan order, first identify the point to be changed using the left/right arrow buttons, next press the FCN button. Use the left/right arrow buttons to change the selected points position within the scan list. When the points position is correct there are two options:

- Press the ENTER button to accept and quit
- Press the FCN button to go back to the point identify phase

A point can be made inactive by using the left/right buttons to highlight the point, pressing the FCN button, and then using the down arrow button to move the point to the inactive list (or, a point can be selected from the inactive list and the up arrow button used to return it to the active list). A new point can be selected to be moved by again pressing the FCN button and selecting it, or the new change in scan order can be implemented by pressing the ENTER button.

9.3.5.1 Multiple lists of points

The **Store/recall** feature found in the system **Pan/tilt** menu allows the operator to save and manipulate up to four lists of 32 points. Selecting the **Store/recall** feature brings up the **Store/recall position list** dialog box. The up/down arrow buttons allow the operator to select the action to be performed (store, recall, or delete a list), or the selection of the list to be recalled/named (A, B, C, or D can be selected).

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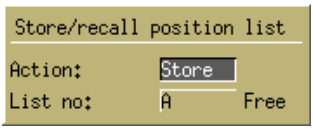

Figure 9.3 Store/recall position list dialog box

The **Action** dialog box item allows the operator to select between storing the current configuration of scan points, recalling a previously saved configuration, or deleting a list that has been previously stored and is no longer needed. The left/right arrow buttons are used to move between the different options. The **List no.** dialog box item shows the currently selected list of points, and the list status. If the word **Used** is next to the list designation, then it currently contains a configuration of previously stored points that can be recalled (by selecting **Recall** from the **Action** dialog box item and press the ENTER button), deleted, (by selecting **Delete**) or saved for future recall (by selecting **Store**) and then pressing the ENTER button. The word **Free** shows that there is currently not a configuration of scan points stored at this location.

NOTE: It is important to remember that when a configuration of lists is recalled from memory, the currently loaded configuration will be overwritten by the new configuration. If the operator want to save the current configuration of scan points, it must be done before the new list is retrieved.

10 Maintenance & cleaning

10.1 Camera body, cables & accessories

The camera body, cables and accessories may be cleaned by wiping with a soft cloth. To remove stains, wipe with a soft cloth moistened with a mild detergent solution and wrung dry, then wipe with a dry soft cloth.

NOTE: Do not use benzene, thinner, or any other chemical product on the camera, the cables or the accessories, as this may cause deterioration.

10.2 Lenses

In order to make the system withstand severe field conditions, all lenses are coated with a hard carbon thin film coating.

To clean the lenses, any consumer-grade glass cleaner can be used.

11 Technical support

For technical support, service inquiries, or comments & questions about the documentation, please contact FLIR Systems Imaging using one of the following two e-mail addresses:

- imagingboston.support@flir.com (US / North American customers only)
- imagingsweden.support@flir.se

For telephone numbers to FLIR Systems Imaging offices, see the back cover of this manual.

12 Technical appendices

12.1 Technical specifications

12.1.1 System specifications

Video format	NTSC (RS-170) or PAL (CCIR)
Serial interface	RS-422, RS-485
Power	18–32 VDC (optional 110–220 VAC/50–60 Hz)
Power consumption	35 W (average)
Built-in test (BIT)	Yes
Dimensions	397 × 300 × 226 mm (15.63 × 11.81 × 8.90")
Weight	21 kg (46.3 lbs)

12.1.2 Thermal imager specifications

Detector type	Focal Plane Array (FPA), uncooled microbolometer, 320 × 240 pixels.
Field of view, WFOV	20° × 15°
Field of view, NFOV	5° × 3.75°
Spectral range	7.5–13 μm, built-in atmospheric filter with cut-on @ 7.5 μm.
Electronic zoom	1x to 4x
Field of view switch time	<0.8 second
Digital image resolution	14-bit
Gain/span (level) adjustment	Auto or manual
Image processing	Linear, by histogram equalization, or by DDE
Palettes	Black/white, rainbow, iron (+ inverted)
Front lens defrosting	Electrical heater elements

12.1.3 Video camera specifications

Image sensor	1/4" color CCD
Picture elements, NTSC	768 (H) × 494 (V)
Picture elements, PAL	752 (H) × 582 (V)

Field of view, FOV	48° to 2.7°, continuous
Electronic zoom	12 times, continuous
Minimum sensitivity	0.7 lx (f/1.4)
Horizontal resolution, NTSC	> 470 TVL
Horizontal resolution, PAL	> 460 TVL
Optical zoom	18x, continuous
Close focus; wide (48°)	< 0.5 m (1.6 ft.)
Close focus, narrow (2.7°)	< 0.8 m (2.6 ft.)
Remote control	Serial RS-232 (all functions)
Video format	RS-170 EIA, NTSC or PAL
Environmental protection	IP65

12.1.4 Pan/tilt head specifications

Azimuth control	Continuous 360°
Elevation control	-35°–+60°
Slew rate	0°–120° per second
Pointing accuracy	±3.0 mrad with ±0.1 mrad repeatability
Autoscan	Multiple positions and multiple programs with programmable dwell time, slew rate, zoom, focus and field of view
Park position	Lockable position protects optics

12.2 List of relevant documents

Name	Doc. No.
FAT Procedure Integrator 5/20	PE_614004452
FAT Procedure ThermoVision™ Sentry II	PE_614004798
FAT Record Integrator 5/20	PP_614004452
FAT Record ThermoVision™ Sentry II	PP_614004798
ICD Sentry II: Interface Control Drawing	PM501745
PELCO "D" Protocol Integrator's manual	1 558 151
TASS Commands in ThermoVision™ Sentry Product Line	1 121 714
Technical specification ThermoVision™ Sentry II	PM501706
ThermoVision™ Sentry 5X0 Camera Commands Manual	1 557 546
ThermoVision™ Sentry II Integrator's Manual (available by special request only)	1 558 204

12.3 Diagnostic tools

NOTE: Subject to change without further notice.

12.3.1 General

The processing unit in the ThermoVision™ Sentry II comprises a built-in system of tests that the operator can initiate. The dialog boxes below show the tests that can be performed and an example of a result.

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Figure 12.1 Setup – Diag tools: Press the navigation pad left/right for each test to include or exclude it from the diagnostic test.

10603503;a1

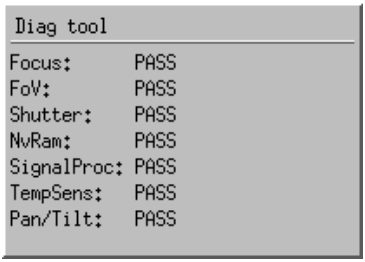


Figure 12.2 Setup – Diag tools: Example of a result

12.4 Troubleshooting guide

The following table is a guide for actions taken to correct simple operational faults that may occur during normal use of the ThermoVision™ Sentry II.

Symptom	Action
No image appears on the screen at power on, or the picture is distorted or continually scrolling.	▪ Check the video cable connecting the imager to the video monitor. ▪ Check that the monitor is set to the correct TV system (PAL/NTSC) ▪ Check the system status LED at the remote control. The LED should give a flashing light during start-up and a steady light when the system is operational. If not, check the power cable and the mains cable to the power supply.
The system does not start in cold environment.	▪ Depending on the ambient temperature for the sensor, it will take up to 20 minutes for the heaters to warm the system up in extreme cold (yellow light is flashing).
The imager starts normally and the screen display appears but no IR image.	▪ The imager is still in parking position. Move the joystick. ▪ The image could be totally out of focus. Adjust focus.
The system starts up properly and gives an acceptable image but the imager does not react on commands from the remote control unit.	▪ Check the cable connecting the imager to the remote control unit.
No video graphics overlay appear on the screen.	▪ Declutter is chosen. Press the ENTER button and check in the **Symbology** dialog box.
The image is totally black or white.	▪ Change the auto-adjust setting.
The image is of bad quality.	▪ Perform a NUC.
The autoscan points can not be changed.	▪ Make sure the camera is in IR mode.
Expected menu commands are not displayed.	▪ Menu commands depend on the imaging mode (TV mode or IR mode). Make sure the correct mode is selected.

12.5 Parts list

Denomination	P/N	Description
Host cable, complete	614 005 140	Host cable, complete with converter RS-485 → RS-232
JCU cable 3 m (10 ft.)	194 612	J9–J10. 23S + 23S connectors
Operator's manual	1 558 193	Installation & operator's manual
Power cable 3 m (10 ft.)	194 628	J4 Power supply
System cable 15 m (50 ft.)	1 196 215	J1–J5. 23S + 23P connectors, dual video
System cable 61 m (200 ft.)	1 196 216	J1–J5. 23S + 23P connectors, dual video
ThermoVision™ Sentry II	614 004 798	PTH (614 004 799) + THI (614 004 452)
ThermoVision™ Sentry JB	194 782	Junction box
ThermoVision™ Sentry JCU	194 783	Joystick controller unit
ThermoVision™ Sentry PS	194 684	Separate power supply
ThermoVision™ Sentry TV	614 005 008	PAL TV option
ThermoVision™ Sentry TV	614 005 009	NTSC TV option
THV Integrator 5/20	614 004 452	Infrared camera
Video cable 3 m (10 ft.)	908 929	BNC connectors

12.6 Precautions under adverse weather conditions

12.6.1 Built-in heaters

ThermoVision™ Sentry II is designed and manufactured to meet strict specifications and can be used under the most demanding weather conditions that may occur in field situations.

Apart from the protection by design – such as sealings, bearings and encapsulation – a number of built-in heaters automatically turn on at start-up in cold temperatures to protect the electronics and to defrost the lens.

12.6.2 Adverse weather conditions

Despite the steps that have been taken to secure the operation of the camera under adverse weather conditions – such as heavy snowfall or freezing rain – situations may arise where the pan/tilt head is exposed to ice build-up. In such situations it is strongly advised to let the pan/tilt head move continuously, e.g. by making one of the autoscan lists into a *de-icing autoscan list*. It is recommended that this autoscan list is saved and always used as a de-icing autoscan list.

Follow this procedure to create an autoscan list for adverse weather conditions:

Step	Action
1	Select **Store/recall** in the **Pan/tilt** menu.
2	Choose an autoscan list – preferably one that is not used for surveillance.
3	Edit the autoscan list according to the instructions given in section 9.3.5 – Editing an autoscan list on page 54.
4	Select **Start autoscan** in the **Pan/tilt** menu.

When editing the autoscan list used for de-icing, it is important that the scan points are chosen so that the pan/tilt head moves over the whole azimuth and elevation range. This effectively prevents the build-up of ice. The dwell time at each scan point should be set to zero so that the pan/tilt head moves on to the next scan point immediately.

NOTE: It is also recommended to visually check the pan/tilt head with regards to ice build-up – both on a regular basis in cold weather and when it has been operating under adverse weather conditions.

12.7 Description of the Exterior Housing Heaters Option (P/N 614 005 142)

12.7.1 Description of package

The Exterior Housing Heaters Option package consists of the following items:

- Foil heaters – mounted inside the pan/tilt head
- One power supply (P/N 194 684)
- One power cable (20 m / 66 ft., P/N 614 005 448)

NOTE: If any item is missing, or has been damaged during transit, please contact your local sales office.

12.7.2 General information

Although the camera system is factory tested to -32 °C / -25.6 °F and built to meet the most demanding field conditions, situations may arise where internal heating is needed – such as heavy snowfall and freezing rain. The Exterior Housing Heaters Option is designed to secure the operation of ThermoVision™ Sentry II camera system with regards to pan and tilt movements in such situations.

10558703;a2

Figure 12.3 Exterior Housing Heaters Option, showing one of the foil heaters

12.7.3 Electrical & mechanical design

The Exterior Housing Heaters Option consists of foil heaters which are mounted on critical surfaces inside the pan/tilt head. By powering the foil heaters from an external power supply, surfaces that otherwise would suffer a risk of ice build-up will be kept at a temperature well above ±0 °C / +32 °F.

Power consumption: 250 W

NOTE: Depending on ambient temperature, it takes several minutes or more until the heaters reach optimum temperature.

12.8 Description of the Sentry II IP Option

12.8.1 General information

The Sentry II IP option provides the necessary hardware and software to let an external computer (i.e. annunciator) control a series of pan/tilt heads in a local area network. Each pan/tilt head is powered from its own power supply and connected to a LAN switch using a non-crossover FTP/STP cable with RJ45 connectors, connected to the J14 connector. To control the pan/tilt heads, a standard PC running a security & surveillance application is connected to the LAN switch.

Optionally, a joystick controller unit can be connected to the standard PC, using a customer-manufactured cable.

The Sentry II IP option hardware is a PC 104 stack consisting of a CPU and two framegrabber boards. The software is running on this CPU and includes a video / communication server and a web configuration utility. The server can deliver 2 channels of full frame rate MPEG2 video over 100 Mbit Ethernet.

12.8.2 Necessary parts

- One or several ThermoVision Sentry II IP pan/tilt heads
- Necessary numbers of power supplies (PS) to power the pan/tilt heads
- Necessary numbers of non-crossover FTP/STP cables with RJ45 connectors
- A crossover FTP/STP cable with RJ45 connectors if connecting to the pan/tilt head directly, using a standard PC (for changing network settings etc.)
- A COTS LAN switch (a 10/100 Mb, 10/100/1000 Mb or a Gigabit switch)
- A standard PC running a suitable security & surveillance application
- A joystick controller unit (JCU)
- A cable to connect the joystick controller unit to the PC

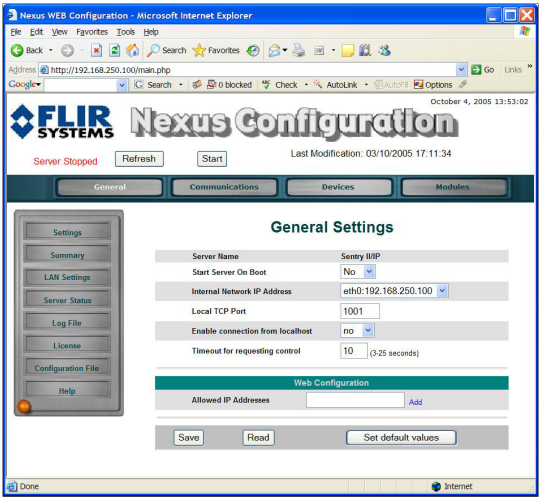
12.8.3 Important notes

Please note the following:

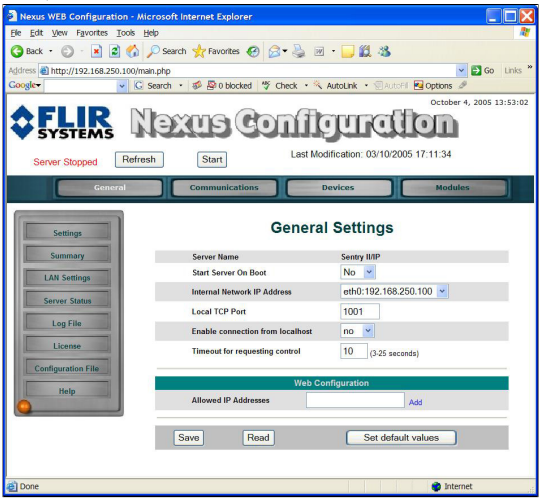
- The pan/tilt head can not be controlled directly using a joystick controller unit and the J1 connector as long as the IP option is enabled
- There is a maximum time delay of 3 minutes between when the temperature of the pan/tilt head reaches 0° C / +32° F and when the IP option is enabled
- When using the IP option the baudrate must be set to **9600** and protocol must be set to **TASS** (**Setup** → **Maintenance**).
- By default the IP option is disabled when the pan/tilt head is shipped from factory
- By default the IP address is set to **192.168.250.100**
- As far as is practically possible all necessary settings are made at factory. Additional settings should be made by a network technician.
- The J14 connector should be sealed with the protective cap when not in use

- Maximum cable distance between the pan/tilt head and LAN switch: 100 m / 328 ft.
- Maximum cable distance between LAN switch and host computer: 10 m / 33 ft.

12.8.4 How to start the video server

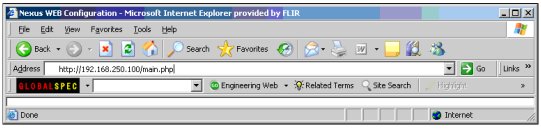
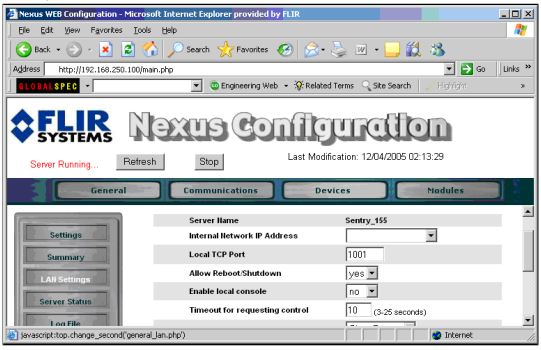
Step	Action
1	To start the video server, click the **Start** button at the top of the page. 10712203;a2 

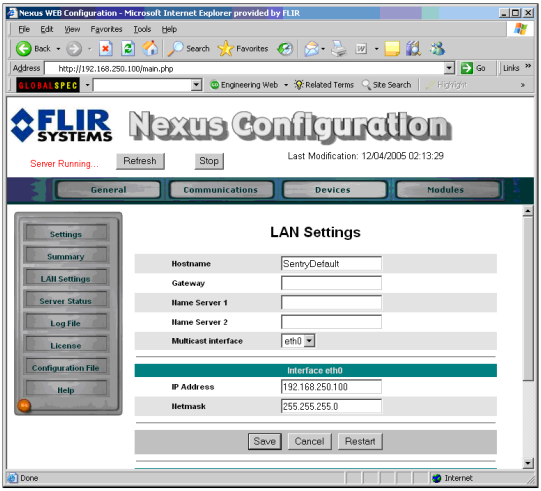
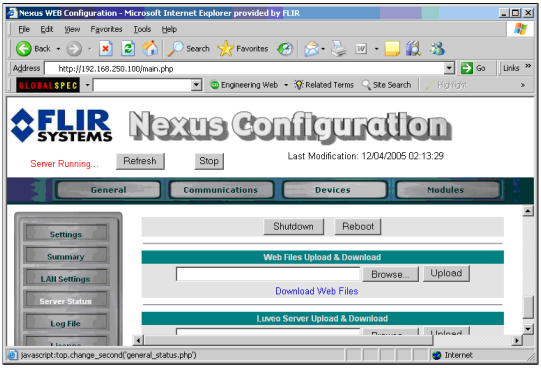
12.8.5 How to change the video server start-up options

Step	Action
1	To change the video server start-up options, do one of the following: ▪ To make the server start automatically when the camera starts, select **Yes** in the **Start Server On Boot** list box and the click **Save** at the bottom of the page. This also means it is not possible to control the camera using the Joystick Controller Unit (JCU) when the camera has started. ▪ To make the server *not* start automatically when the camera starts, select **No** in the **Start Server On Boot** list box and the click **Save** at the bottom of the page. 10712203;a2 

12.8.6 How to change the IP address

Follow this procedure to change the IP address:

Step	Action
1	Connect a standard PC to the pan/tilt head using one of the following methods: ▪ Directly, using a crossover FTP/STP cable with RJ45 connectors ▪ Through the LAN network, using a non-crossover FTP/STP cable with RJ45 connectors
2	Start your Internet browser of choice, and enter the following address in the address field: **http://192.168.250.100/main.php** 10595003;a1 
3	Click **LAN settings** in the left pane: 10595103;a1 

Step	Action
4	Enter a new IP address in the **IP Address** text box, and click **Save** when all changes are done. You can also change **Host name** and **Net mask**. **Host name** may be set freely, but **Net mask** may need to be set to **255.255.0.0** 10595203;a1 
5	Click **Server Status** in the left pane and then click **Reboot**: 10595303;a1 

12.9 Overview & location of connectors

Name	Type	Function	Location	Mating connector
J1	D38999/24WE99PN, 23-pin	System	Pan/tilt head	D38999/26WE99SN, 23-pin
J2[1]	D38999/24WB98PN, 6-pin	Local power in	Pan/tilt head	D38999/26WB98SN, 6-pin
J3	BNC, standard config.	Video 1	Pan/tilt head	BNC, standard config.
J4	D38999/24WB98PN, 6-pin	Power in	Junction box	D38999/26WB98SN, 6-pin
J5	D38999/26WE99SN, 23-pin	System	▪ Junction box ▪ Power box	D38999/24WE99PN, 23-pin
J6	BNC, standard config.	Video 1	▪ Junction box ▪ Power box	BNC, standard config.
J7	BNC, standard config.	Video 2	▪ Junction box ▪ Power box	BNC, standard config.
J8	D38999/24WC98PN, 10-pin	Network in	▪ Junction box ▪ Power box	D38999/26WC98SN, 10-pin
J9	D38999/24WE99PN, 23-pin	System	▪ Junction box ▪ Power box	D38999/26WE99SN, 23-pin
J10	D38999/24WE99PN, 23-pin	System	Joystick controller unit	D38999/26WE99SN, 23-pin
J11	BNC, standard config.	Video 2	Pan/tilt head	BNC, standard config.
J12	D38999/26WC98SN, 10-pin	Network out	Junction box	D38999/24WC98PN, 10-pin
J13[2]	D38999/24WB98PN, 6-pin	Heaters Power in	Pan/tilt head	D38999/26WB98SN, 6-pin
J14	RJ45	Ethernet	Pan/tilt head	RJ45
No des.	IEC320	Power in	Power supply	IEC320
No des.	D38999/24WB98SN, 6-pin	Power out	Power supply	D38999/26WB98SN, 6-pin

[1] The J2 connector is marked J13 when the Exterior Housing Heaters Option (P/N 614 005 142) is installed.

[2] The J13 connector is marked J2 when no Exterior Housing Heaters Option (P/N 614 005 142) is installed.

12.10 Pin configuration – Pan/tilt head (PTH)

12.10.1 J1 – 23-pin connector

NOTE: Pin designations are printed on connector.

Pin	Signal name	Wire type
A	Reserved	
B	Reserved	
C	TV Video negative	Coax 75 Ω
D	TV Video positive	Coax 75 Ω
E	Terminator disable	AWG 26
F	RS485CONSRX_A	AWG 26 twisted pair
G	RS485CONSRX_B	AWG 26 twisted pair
H	RS485CONSTX_A	AWG 26 twisted pair
J	RS485CONSTX_B	AWG 26 twisted pair
P	RS485TX_EN_A	AWG 26 twisted pair
R	RS485TX_EN_B	AWG 26 twisted pair
S	Video positive	Coax 75 Ω
T	Signal GND	AWG 26
U	Remote present	AWG 26
V	Heater on	AWG 26
W	28 VDC return	AWG 20
X	Video negative	Coax 75 Ω
Y	Video GND	AWG 26
Z	28 VDC	AWG 20

12.10.2 J2 – 6-pin connector

NOTE: The J2 connector is only available when no Exterior Housing Heaters Option (P/N 195 278) is installed.
NOTE: Pin designations are printed on connector.

Pin	Signal name	Wire type
A	28 VDC return	AWG 20

Pin	Signal name	Wire type
B	28 VDC return	AWG 20
C	28 VDC	AWG 20
D	28 VDC	AWG 20
E	RXD test	AWG 24
F	TXD test	AWG 24

12.10.3 J3 – BNC connector

Standard configuration.

12.10.4 J11 – BNC connector

Standard configuration.

12.10.5 J13 – 6-pin connector

NOTE: The J13 connector is only available when the Exterior Housing Heaters Option (P/N 195 278) is installed.
NOTE: Pin designations are printed on connector.

Pin	Signal name	Wire type
A	Heater_Return	AWG 20
B	Heater_Return	AWG 20
C	28V_Heater	AWG 20
D	28V_Heater	AWG 20
E	RXD test	AWG 24
F	TXD test	AWG 24

NOTE: Heater_Return and 28V_Heater are separated from 28 VDC and 28 VDC return.

12.11 Pin configuration – Joystick controller unit (JCU)

12.11.1 J10 – 23-pin connector

NOTE: Pin designations are printed on connector.

Pin	Signal name	Wire type
A	Reserved	
B	Reserved	
C	TV Video negative	Coax 75 Ω
D	TV Video positive	Coax 75 Ω
E	Terminator disable	AWG 26
F	RS485CONSRX_A	AWG 26 twisted pair
G	RS485CONSRX_B	AWG 26 twisted pair
H	RS485CONSTX_A	AWG 26 twisted pair
J	RS485CONSTX_B	AWG 26 twisted pair
K	RS485HOSTRX_A	AWG 26 twisted pair
L	RS485HOSTRX_B	AWG 26 twisted pair
M	RS485HOSTTX_A	AWG 26 twisted pair
N	RS485HOSTTX_B	AWG 26 twisted pair
P	RS485TX_EN_A	AWG 26 twisted pair
R	RS485TX_EN_B	AWG 26 twisted pair
S	Video positive	Coax 75 Ω
T	Signal GND	AWG 26
U	Remote present	AWG 26
V	Heater on	AWG 26
W	28 VDC return	AWG 20
X	Video negative	Coax 75 Ω
Y	Video GND	AWG 26
Z	28 VDC	AWG 20

12.12 Pin configuration – Junction box (JB)

12.12.1 J4 – 6-pin connector

NOTE: Pin designations are printed on connector.

Pin	Signal name	Wire type
A	28 VDC return	AWG 20
B	28 VDC return	AWG 20
C	28 VDC	AWG 20
D	28 VDC	AWG 20
E	N/C	
F	N/C	

12.12.2 J5 – 23-pin connector

NOTE: Pin designations are printed on connector.

Pin	Signal name	Wire type
A	Reserved	
B	Reserved	
C	TV Video negative	Coax 75 Ω
D	TV Video positive	Coax 75 Ω
E	Terminator disable	AWG 26
F	RS485CONSRX_A	AWG 26 twisted pair
G	RS485CONSRX_B	AWG 26 twisted pair
H	RS485CONSTX_A	AWG 26 twisted pair
J	RS485CONSTX_B	AWG 26 twisted pair
P	RS485TX_EN_A	AWG 26 twisted pair
R	RS485TX_EN_B	AWG 26 twisted pair
S	Video positive	Coax 75 Ω
T	Signal GND	AWG 26
U	Remote present	AWG 26
V	Heater on	AWG 26

Pin	Signal name	Wire type
W	28 VDC return	AWG 20
X	Video negative	Coax 75 Ω
Y	Video GND	AWG 26
Z	28 VDC	AWG 20

12.12.3 J6 – BNC connector

Standard configuration.

12.12.4 J7 – BNC connector

Standard configuration.

12.12.5 J8 – 10-pin connector

NOTE: Pin designations are printed on connector.

Pin	Signal name	Wire type
A	5 V pull-up	
B	28 VDC	AWG 20
C	Screen connect	
D	GND	
E	Terminator disable	
F	RXPOS_HOSTUP	
G	RXNEG_HOSTUP	
H	TXPOS_HOSTUP	
J	TXNEG_HOSTUP	
K	Signal GND	

12.12.6 J9 – 23-pin connector

NOTE: Pin designations are printed on connector.

Pin	Signal name	Wire type
A	Reserved	
B	Reserved	
C	TV Video negative	Coax 75 Ω

Pin	Signal name	Wire type
D	TV Video positive	Coax 75 Ω
E	Terminator disable	AWG 26
F	RS485CONSRX_A	AWG 26 twisted pair
G	RS485CONSRX_B	AWG 26 twisted pair
H	RS485CONSTX_A	AWG 26 twisted pair
J	RS485CONSTX_B	AWG 26 twisted pair
K	RS485HOSTRX_A	AWG 26 twisted pair
L	RS485HOSTRX_B	AWG 26 twisted pair
M	RS485HOSTTX_A	AWG 26 twisted pair
N	RS485HOSTTX_B	AWG 26 twisted pair
P	RS485TX_EN_A	AWG 26 twisted pair
R	RS485TX_EN_B	AWG 26 twisted pair
S	Video positive	Coax 75 Ω
T	Signal GND	AWG 26
U	Remote present	AWG 26
V	Heater on	AWG 26
W	28 VDC return	AWG 20
X	Video negative	Coax 75 Ω
Y	Video GND	AWG 26
Z	28 VDC	AWG 20

12.12.7 J12 – 10-pin connector

NOTE: Pin designations are printed on connector.

Pin	Signal name	Wire type
A	MULTIDROP	
B	28 V	AWG 20
C		
D	MULTIDROP RTN	
E		

Pin	Signal name	Wire type
F	TXPOS_HOSTDOWN	
G	TXNEG_HOSTDOWN	
H	RXPOS_HOSTDOWN	
J	RXPOS_HOSTDOWN	
K	Signal GND	

12.13 Basic dimensions 1 – Joystick controller unit (JCU)

10042203;a2

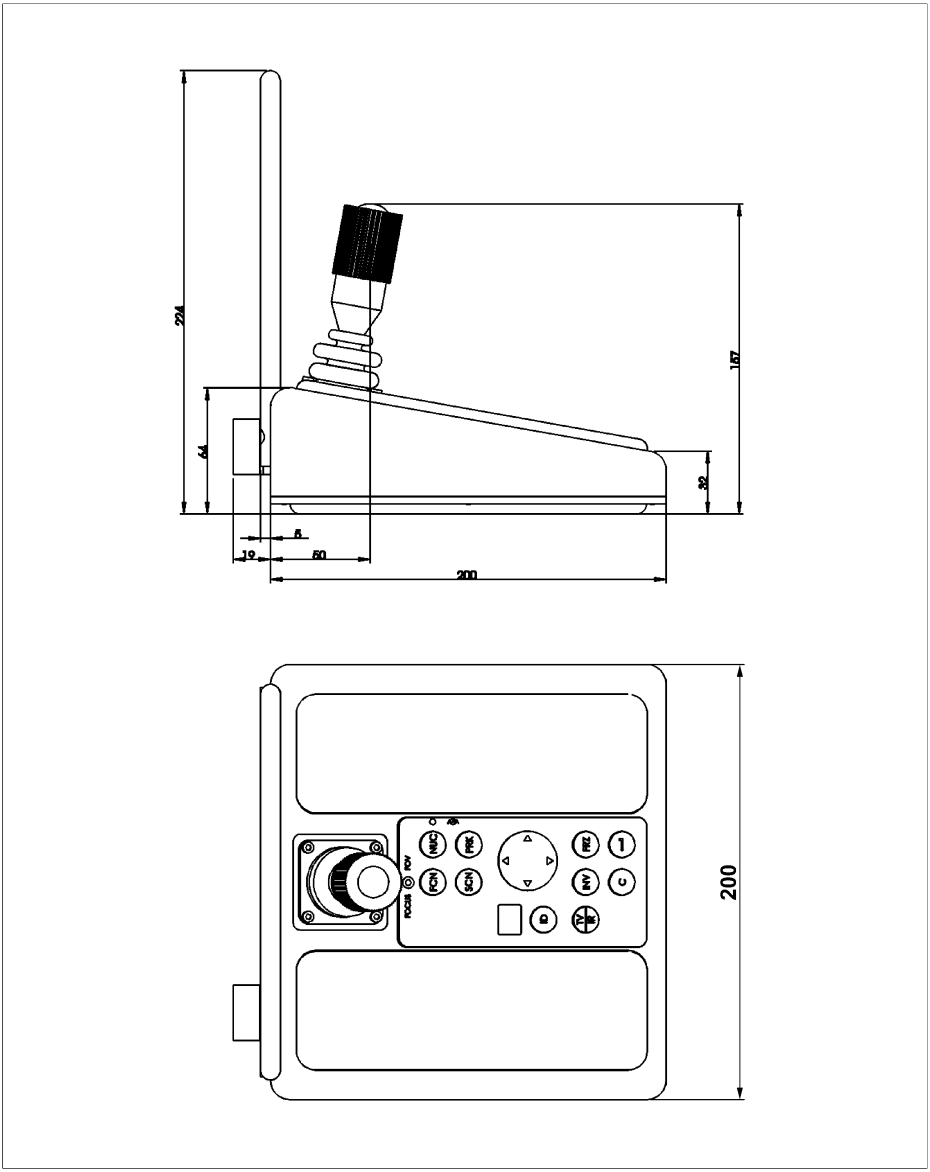


Figure 12.4 Basic dimensions 1 – Joystick controller unit (JCU)

12.14 Basic dimensions 2 – Joystick controller unit (JCU)

10059303;a1

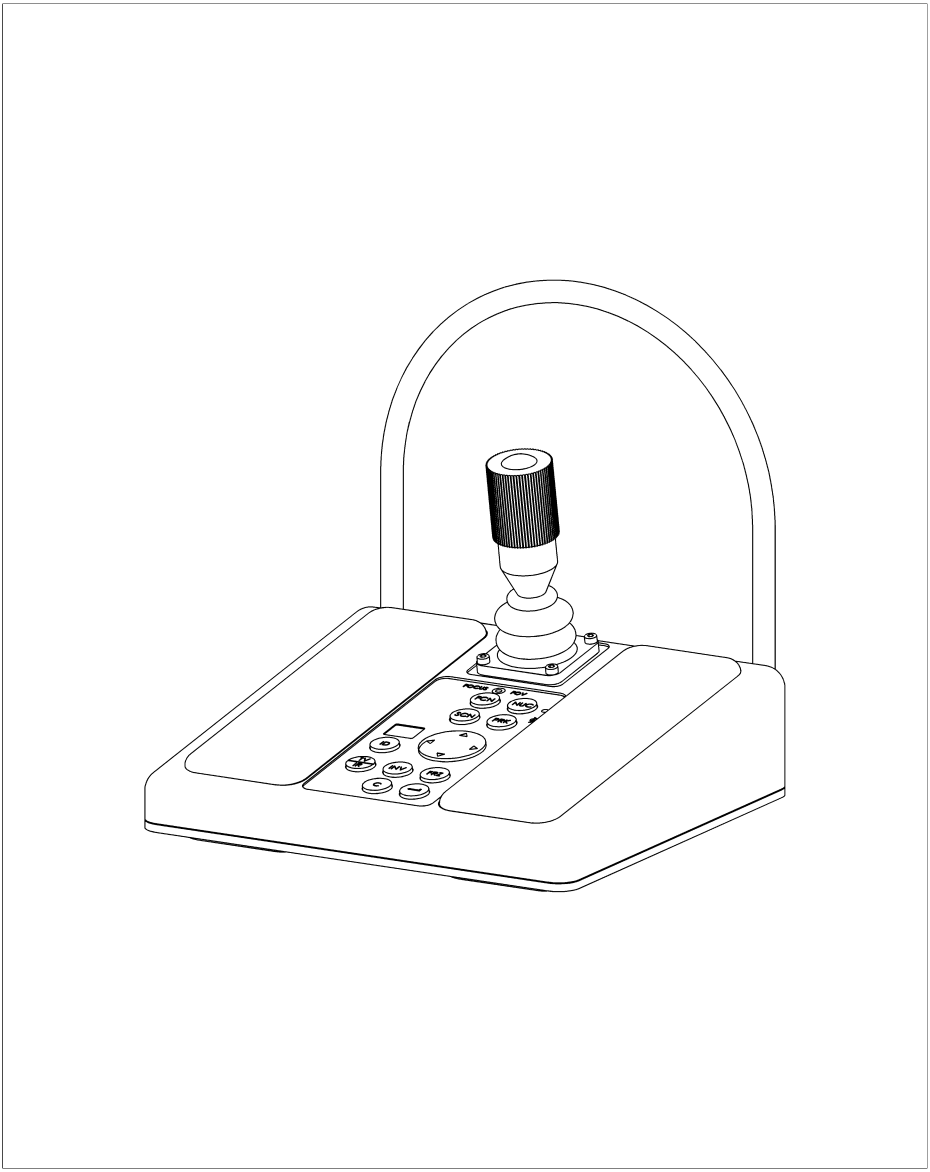


Figure 12.5 Basic dimensions 3 – Joystick controller unit (JCU)

12.15 Basic dimensions 3 – Pan/tilt head (PTH)

10061903;a2

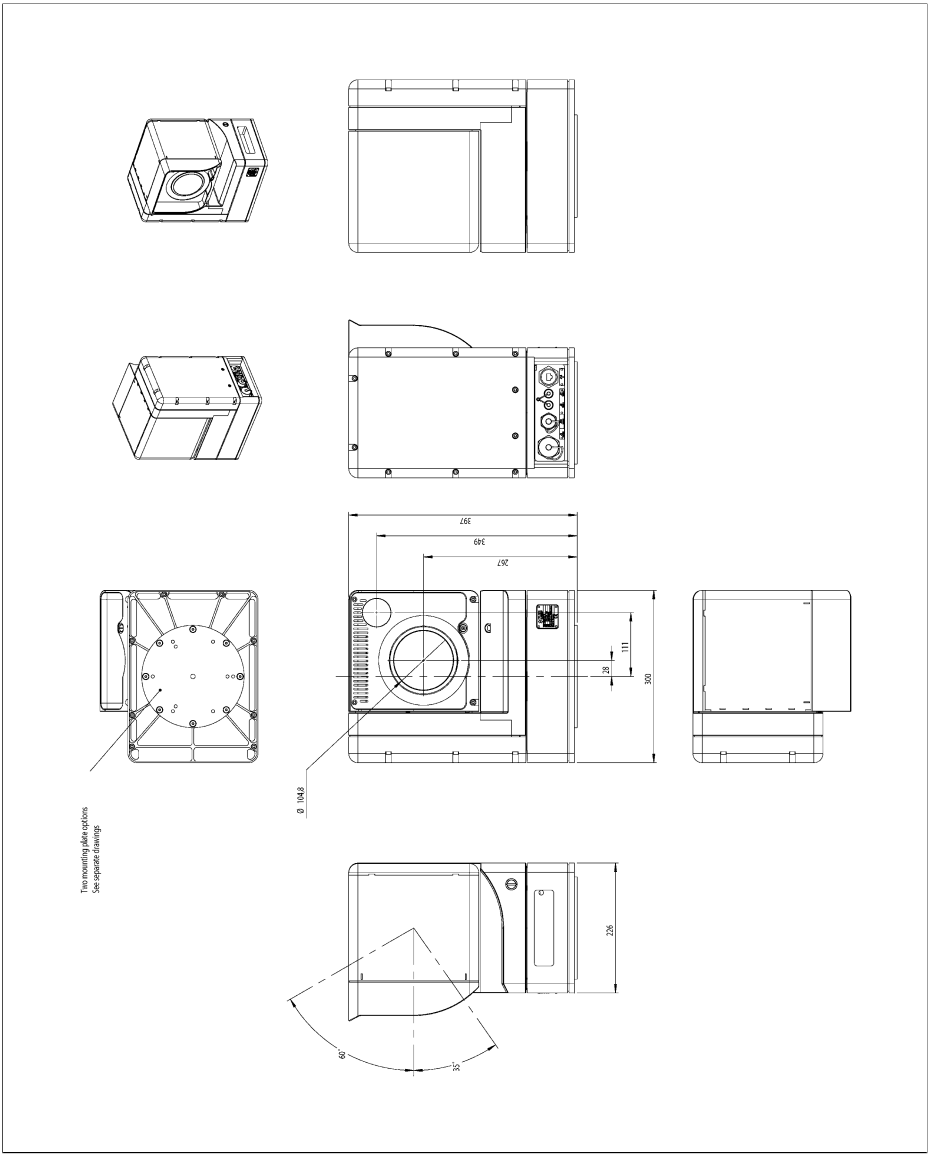


Figure 12.6 Basic dimensions 4 – Pan/tilt head (PTH)

12.16 Basic dimensions 5 – Junction box (JB)

10042503;a1

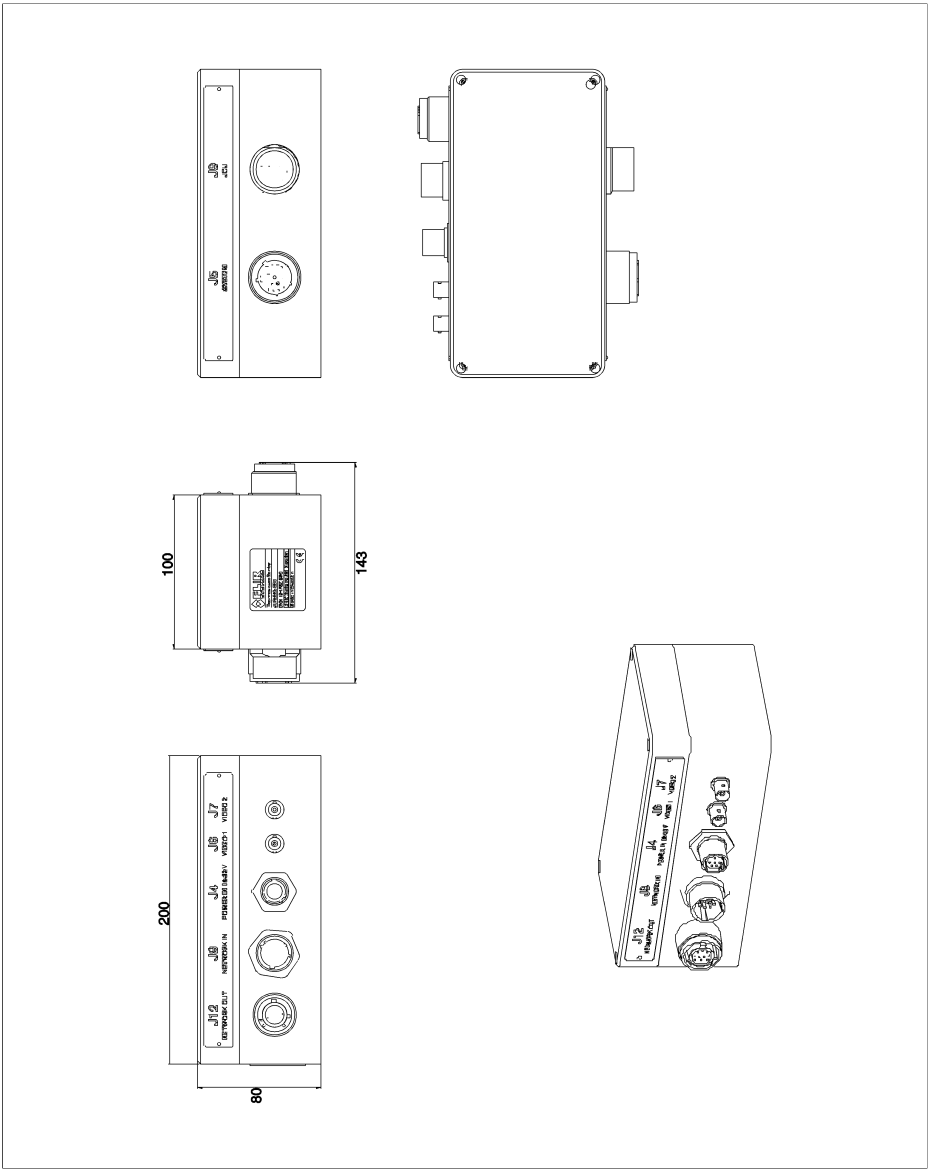


Figure 12.7 Basic dimensions 6 – Junction box (JB)

12.17 Basic dimensions 6 – Power supply (PS)

10050603;a3

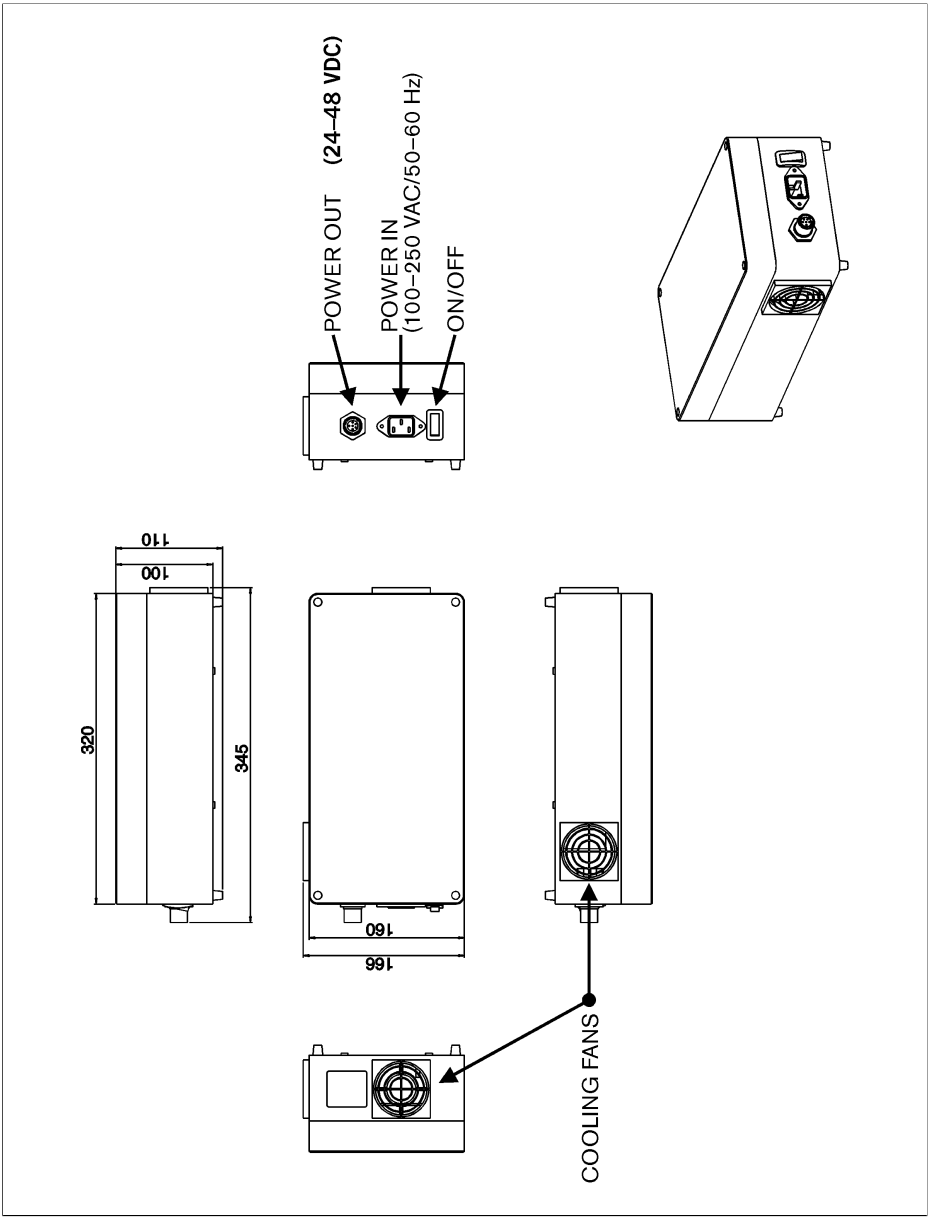


Figure 12.8 Basic dimensions 7 – Power supply (PS)

12.18 Mounting plate, standard – Pan/tilt head (PTH)

10027103;a2

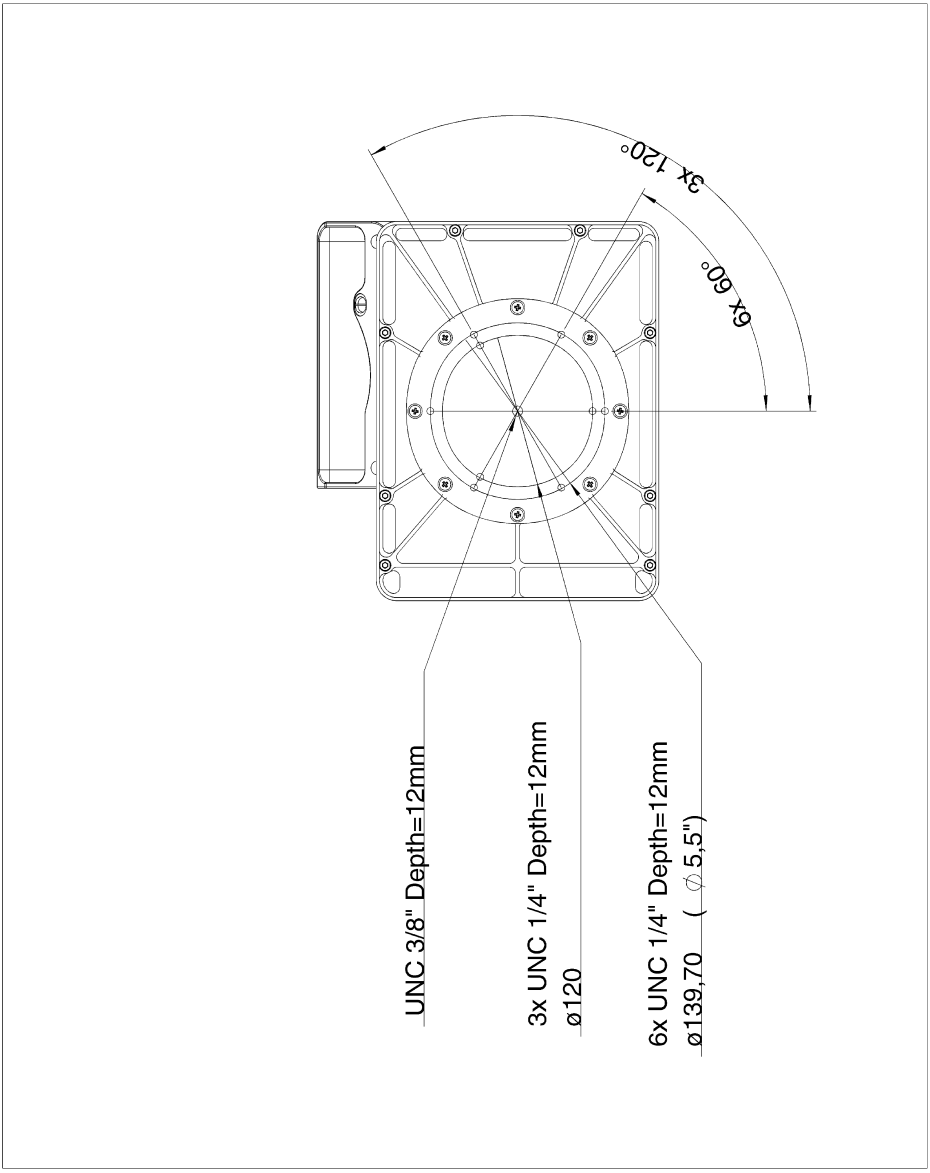


Figure 12.9 Mounting plate, standard (P/N 119 259).

12.19 Mounting plate, TASS – Pan/tilt head (PTH)

10594803;a1

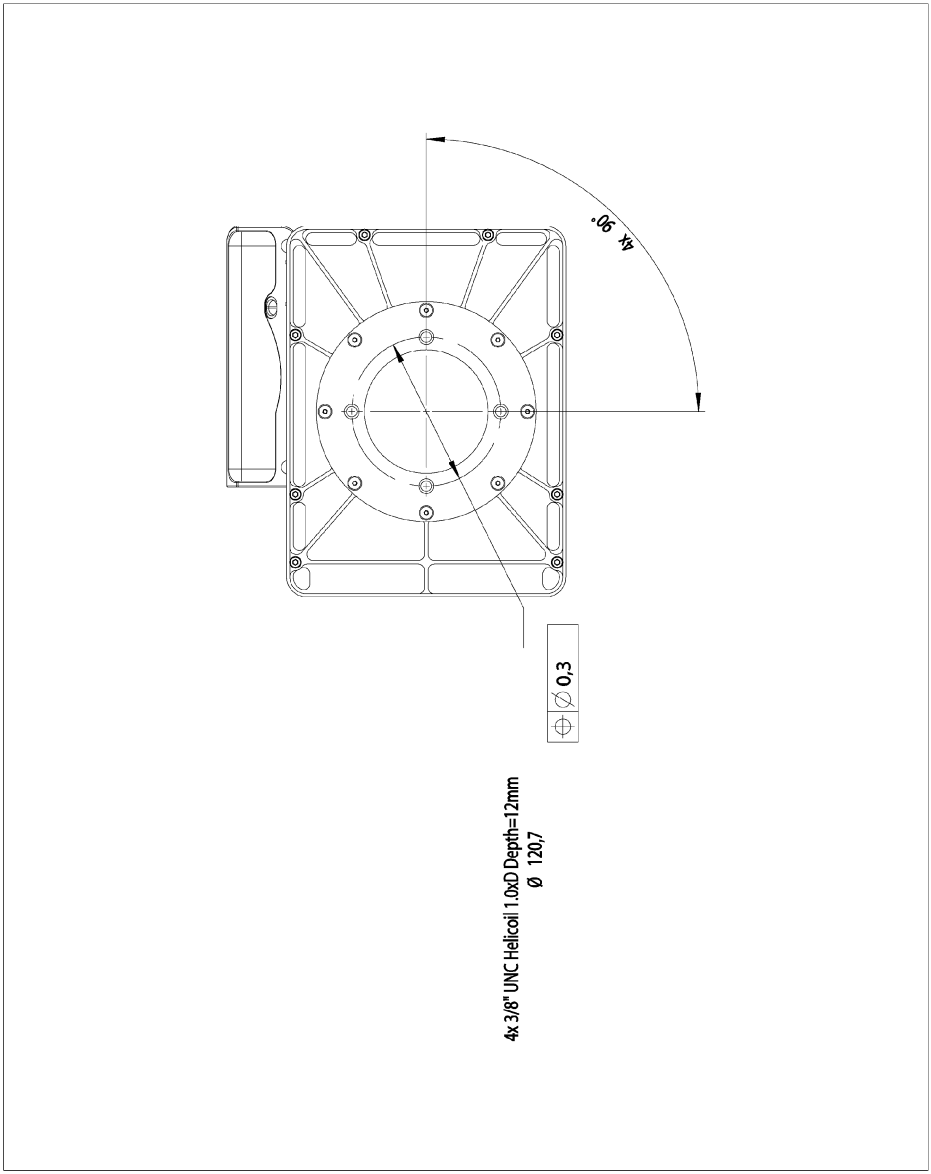


Figure 12.10 Mounting plate, TASS (P/N 1 120 341).

13 History of infrared technology

Less than 200 years ago the existence of the infrared portion of the electromagnetic spectrum wasn't even suspected. The original significance of the infrared spectrum, or simply 'the infrared' as it is often called, as a form of heat radiation is perhaps less obvious today than it was at the time of its discovery by Herschel in 1800.

10398703;a1

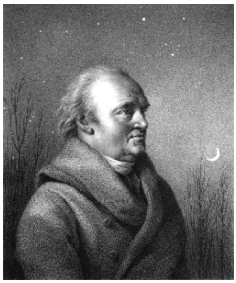


Figure 13.1 Sir William Herschel (1738–1822)

The discovery was made accidentally during the search for a new optical material. Sir William Herschel—Royal Astronomer to King George III of England, and already famous for his discovery of the planet Uranus—was searching for an optical filter material to reduce the brightness of the sun's image in telescopes during solar observations. While testing different samples of colored glass which gave similar reductions in brightness he was intrigued to find that some of the samples passed very little of the sun's heat, while others passed so much heat that he risked eye damage after only a few seconds' observation.

Herschel was soon convinced of the necessity of setting up a systematic experiment, with the objective of finding a single material that would give the desired reduction in brightness as well as the maximum reduction in heat. He began the experiment by actually repeating Newton's prism experiment, but looking for the heating effect rather than the visual distribution of intensity in the spectrum. He first blackened the bulb of a sensitive mercury-in-glass thermometer with ink, and with this as his radiation detector he proceeded to test the heating effect of the various colors of the spectrum formed on the top of a table by passing sunlight through a glass prism. Other thermometers, placed outside the sun's rays, served as controls.

As the blackened thermometer was moved slowly along the colors of the spectrum, the temperature readings showed a steady increase from the violet end to the red end. This was not entirely unexpected, since the Italian researcher, Landriani, in a similar experiment in 1777 had observed much the same effect. It was Herschel,

however, who was the first to recognize that there must be a point where the heating effect reaches a maximum, and that measurements confined to the visible portion of the spectrum failed to locate this point.

10398903;a1

Figure 13.2 Marsilio Landriani (1746–1815)

Moving the thermometer into the dark region beyond the red end of the spectrum, Herschel confirmed that the heating continued to increase. The maximum point, when he found it, lay well beyond the red end—in what is known today as the 'infrared wavelengths.'

When Herschel revealed his discovery, he referred to this new portion of the electromagnetic spectrum as the 'thermometrical spectrum.' The radiation itself he sometimes referred to as 'dark heat,' or simply 'the invisible rays,' Ironically, and contrary to popular opinion, it wasn't Herschel who originated the term 'infrared.' The word only began to appear in print around 75 years later, and it is still unclear who should receive credit as the originator.

Herschel's use of glass in the prism of his original experiment led to some early controversies with his contemporaries about the actual existence of the infrared wavelengths. Different investigators, in attempting to confirm his work, used various types of glass indiscriminately, having different transparencies in the infrared. Through his later experiments, Herschel was aware of the limited transparency of glass to the newly-discovered thermal radiation, and he was forced to conclude that optics for the infrared would probably be doomed to the use of reflective elements exclusively (i.e. plane and curved mirrors). Fortunately, this proved to be true only until 1830, when the Italian investigator, Melloni, made his great discovery that naturally occurring rock salt (NaCl)—which was available in large enough natural crystals to be made into lenses and prisms—is remarkably transparent to the infrared. The result was that rock salt became the principal infrared optical material, and remained so for the next hundred years, until the art of synthetic crystal growing was mastered in the 1930's.

10399103;a1

Figure 13.3 Macedonio Melloni (1798–1854)

Thermometers, as radiation detectors, remained unchallenged until 1829, the year Nobili invented the thermocouple. (Herschel's own thermometer could be read to 0.2°C (0.036°F), and later models were able to be read to 0.05°C (0.09°F). Then a breakthrough occurred; Melloni connected a number of thermocouples in series to form the first thermopile. The new device was at least 40 times as sensitive as the best thermometer of the day for detecting heat radiation—capable of detecting the heat from a person standing 3 meters away (10 ft.).

The first so-called 'heat-picture' became possible in 1840, the result of work by Sir John Herschel, son of the discoverer of the infrared and a famous astronomer in his own right. Based upon the differential evaporation of a thin film of oil when exposed to a heat pattern focused upon it, the thermal image could be seen by reflected light where the interference effects of the oil film made the image visible to the eye. Sir John also managed to obtain a primitive record of the thermal image on paper, which he called a 'thermograph.'

10399003;a2

Figure 13.4 Samuel P. Langley (1834–1906)

The improvement of infrared-detector sensitivity progressed slowly. Another major breakthrough, made by Langley in 1880, was the invention of the bolometer. This consisted of a thin blackened strip of platinum connected in one arm of a Wheatstone bridge circuit upon which the infrared radiation was focused and to which a sensitive galvanometer responded. This instrument is said to have been able to detect the heat from a cow at a distance of 400 meters (1311 ft.).

An English scientist, Sir James Dewar, first introduced the use of liquefied gases as cooling agents (such as liquid nitrogen with a temperature of −196°C (−320.8°F)) in low temperature research. In 1892 he invented a unique vacuum insulating container in which it is possible to store liquefied gases for entire days. The common 'thermos bottle', used for storing hot and cold drinks, is based upon his invention.

Between the years 1900 and 1920, the inventors of the world 'discovered' the infrared. Many patents were issued for devices to detect personnel, artillery, aircraft, ships—and even icebergs. The first operating systems, in the modern sense, began to be developed during the 1914–18 war, when both sides had research programs devoted to the military exploitation of the infrared. These programs included experimental systems for enemy intrusion/detection, remote temperature sensing, secure communications, and 'flying torpedo' guidance. An infrared search system tested during this period was able to detect an approaching airplane at a distance of 1.5 km (0.94 miles), or a person more than 300 meters (984 ft.) away.

The most sensitive systems up to this time were all based upon variations of the bolometer idea, but the period between the two wars saw the development of two revolutionary new infrared detectors: the image converter and the photon detector. At first, the image converter received the greatest attention by the military, because it enabled an observer for the first time in history to literally 'see in the dark.' However, the sensitivity of the image converter was limited to the near infrared wavelengths, and the most interesting military targets (i.e. enemy soldiers) had to be illuminated by infrared search beams. Since this involved the risk of giving away the observer's position to a similarly-equipped enemy observer, it is understandable that military interest in the image converter eventually faded.

The tactical military disadvantages of so-called 'active' (i.e. search beam-equipped) thermal imaging systems provided impetus following the 1939–45 war for extensive secret military infrared-research programs into the possibilities of developing 'passive' (no search beam) systems around the extremely sensitive photon detector. During this period, military secrecy regulations completely prevented disclosure of the status of infrared-imaging technology. This secrecy only began to be lifted in the middle of the 1950's, and from that time adequate thermal-imaging devices finally began to be available to civilian science and industry.

14 Theory of thermal imaging

14.1 Introduction

The subjects of infrared radiation is still new to many who will use an infrared camera. In this section the theory behind thermal imaging will be given.

14.2 The electromagnetic spectrum

The electromagnetic spectrum is divided arbitrarily into a number of wavelength regions, called *bands*, distinguished by the methods used to produce and detect the radiation. There is no fundamental difference between radiation in the different bands of the electromagnetic spectrum. They are all governed by the same laws and the only differences are those due to differences in wavelength.

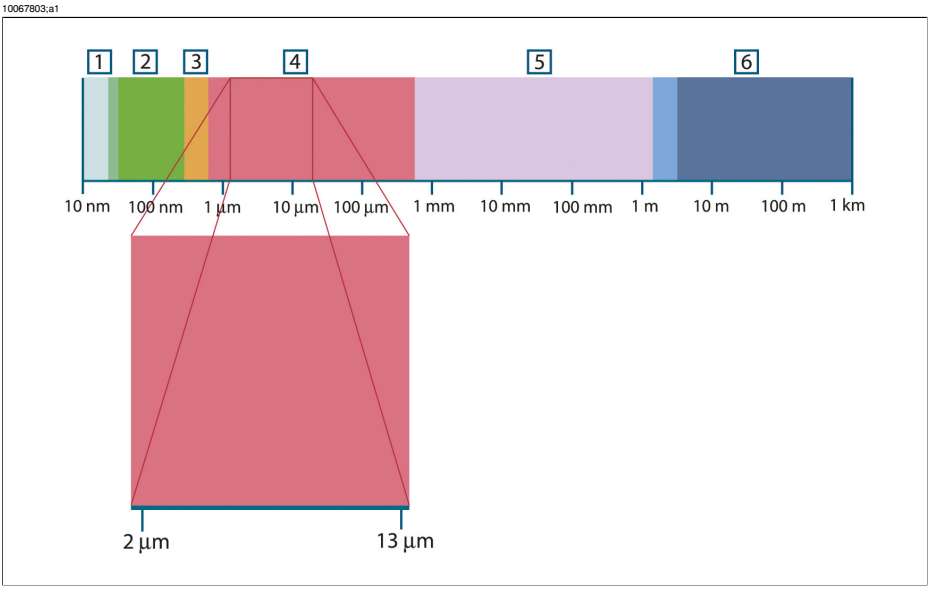


Figure 14.1 The electromagnetic spectrum. **1:** X-ray; **2:** UV; **3:** Visible; **4:** IR; **5:** Microwaves; **6:** Radiowaves.

Thermal imaging makes use of the infrared spectral band. At the short-wavelength end the boundary lies at the limit of visual perception, in the deep red. At the long-wavelength end it merges with the microwave radio wavelengths, in the millimeter range.

The infrared band is often further subdivided into four smaller bands, the boundaries of which are also arbitrarily chosen. They include: the *near infrared* (0.75–3 µm), the *middle infrared* (3–6 µm), the *far infrared* (6–15 µm) and the *extreme infrared* (15–100

µm). Although the wavelengths are given in µm (micrometers), other units are often still used to measure wavelength in this spectral region, *e.g.* nanometer (nm) and Ångström (Å).

The relationships between the different wavelength measurements is:

$$10\ 000\ \text{Å} = 1\ 000\ \text{nm} = 1\ \mu = 1\ \mu\text{m}$$

14.3 Blackbody radiation

A blackbody is defined as an object which absorbs all radiation that impinges on it at any wavelength. The apparent misnomer *black* relating to an object emitting radiation is explained by Kirchhoff's Law (after *Gustav Robert Kirchhoff*, 1824–1887), which states that a body capable of absorbing all radiation at any wavelength is equally capable in the emission of radiation.

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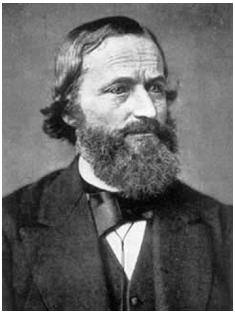

Figure 14.2 Gustav Robert Kirchhoff (1824–1887)

The construction of a blackbody source is, in principle, very simple. The radiation characteristics of an aperture in an isotherm cavity made of an opaque absorbing material represents almost exactly the properties of a blackbody. A practical application of the principle to the construction of a perfect absorber of radiation consists of a box that is light tight except for an aperture in one of the sides. Any radiation which then enters the hole is scattered and absorbed by repeated reflections so only an infinitesimal fraction can possibly escape. The blackness which is obtained at the aperture is nearly equal to a blackbody and almost perfect for all wavelengths.

By providing such an isothermal cavity with a suitable heater it becomes what is termed a *cavity radiator*. An isothermal cavity heated to a uniform temperature generates blackbody radiation, the characteristics of which are determined solely by the temperature of the cavity.

If the temperature of blackbody radiation increases to more than 525 °C (977 °F), the source begins to be visible so that it appears to the eye no longer black. This is the incipient red heat temperature of the radiator, which then becomes orange or yellow

as the temperature increases further. In fact, the definition of the so-called *color temperature* of an object is the temperature to which a blackbody would have to be heated to have the same appearance.

Now consider three expressions that describe the radiation emitted from a blackbody.

14.3.1 Planck's law

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Figure 14.3 Max Planck (1858–1947)

Max Planck (1858–1947) was able to describe the spectral distribution of the radiation from a blackbody by means of the following formula:

$$W_{\lambda b} = \frac{2\pi hc^3}{\lambda^5\left(e^{hc/\lambda kT} - 1\right)} \times 10^{-6}\left[Watt/m^2\mu m\right]$$

where:

$W_{\lambda b}$	Blackbody spectral radiant emittance at wavelength λ.
c	Velocity of light = 3×10^8 m/s
h	Planck's constant = 6.6×10^{-34} Joule sec.
k	Boltzmann's constant = 1.4×10^{-23} Joule/K.
T	Absolute temperature (K) of a blackbody.
λ	Wavelength (μm).

NOTE: The factor 10^{-6} is used since spectral emittance in the curves is expressed in Watt/m^2m. If the factor is excluded, the dimension will be Watt/m^2μm.

Planck's formula, when plotted graphically for various temperatures, produces a family of curves. Following any particular Planck curve, the spectral emittance is zero at $\lambda = 0$, then increases rapidly to a maximum at a wavelength λ_{max} and after passing it approaches zero again at very long wavelengths. The higher the temperature, the shorter the wavelength at which maximum occurs.

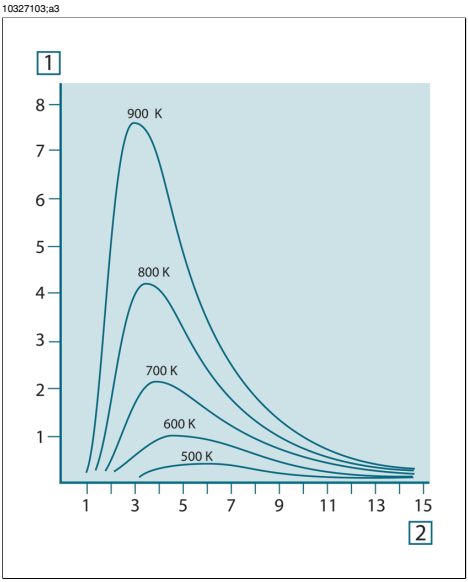

Figure 14.4 Blackbody spectral radiant emittance according to Planck's law, plotted for various absolute temperatures. **1:** Spectral radiant emittance ($W/cm^2 \times 10^3(\mu m)$); **2:** Wavelength (µm)

14.3.2 Wien's displacement law

By differentiating Planck's formula with respect to λ, and finding the maximum, we have:

$$\lambda_{max} = \frac{2898}{T}[\mu m]$$

This is Wien's formula (after *Wilhelm Wien*, 1864–1928), which expresses mathematically the common observation that colors vary from red to orange or yellow as the temperature of a thermal radiator increases. The wavelength of the color is the same as the wavelength calculated for λ_{max}. A good approximation of the value of λ_{max} for a given blackbody temperature is obtained by applying the rule-of-thumb 3 000/T µm. Thus, a very hot star such as Sirius (11 000 K), emitting bluish-white light, radiates with the peak of spectral radiant emittance occurring within the invisible ultraviolet spectrum, at wavelength 0.27 µm.

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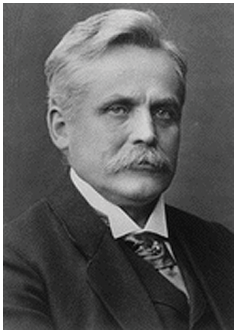

Figure 14.5 Wilhelm Wien (1864–1928)

The sun (approx. 6 000 K) emits yellow light, peaking at about 0.5 µm in the middle of the visible light spectrum.

At room temperature (300 K) the peak of radiant emittance lies at 9.7 µm, in the far infrared, while at the temperature of liquid nitrogen (77 K) the maximum of the almost insignificant amount of radiant emittance occurs at 38 µm, in the extreme infrared wavelengths.

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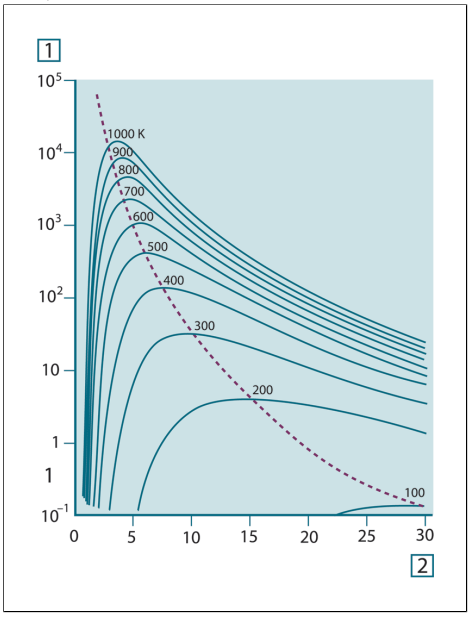

Figure 14.6 Planckian curves plotted on semi-log scales from 100 K to 1000 K. The dotted line represents the locus of maximum radiant emittance at each temperature as described by Wien's displacement law. **1:** Spectral radiant emittance (W/cm^2 (µm)); **2:** Wavelength (µm).

14.3.3 Stefan-Boltzmann's law

By integrating Planck's formula from $\lambda = 0$ to $\lambda = \infty$, we obtain the total radiant emittance (W_b) of a blackbody:

$$W_b = \sigma T^4 \ [\mathrm{Watt/m^2}]$$

This is the Stefan-Boltzmann formula (after *Josef Stefan*, 1835–1893, and *Ludwig Boltzmann*, 1844–1906), which states that the total emissive power of a blackbody is proportional to the fourth power of its absolute temperature. Graphically, W_b represents the area below the Planck curve for a particular temperature. It can be shown that the radiant emittance in the interval $\lambda = 0$ to λ_{max} is only 25 % of the total, which represents about the amount of the sun's radiation which lies inside the visible light spectrum.

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Figure 14.7 Josef Stefan (1835–1893), and Ludwig Boltzmann (1844–1906)

Using the Stefan-Boltzmann formula to calculate the power radiated by the human body, at a temperature of 300 K and an external surface area of approx. 2 m^2, we obtain 1 kW. This power loss could not be sustained if it were not for the compensating absorption of radiation from surrounding surfaces, at room temperatures which do not vary too drastically from the temperature of the body – or, of course, the addition of clothing.

14.3.4 Non-blackbody emitters

So far, only blackbody radiators and blackbody radiation have been discussed. However, real objects almost never comply with these laws over an extended wavelength region – although they may approach the blackbody behavior in certain spectral intervals. For example, a certain type of white paint may appear perfectly *white* in the visible light spectrum, but becomes distinctly *gray* at about 2 µm, and beyond 3 µm it is almost *black*.

There are three processes which can occur that prevent a real object from acting like a blackbody: a fraction of the incident radiation α may be absorbed, a fraction ρ may be reflected, and a fraction τ may be transmitted. Since all of these factors are more or less wavelength dependent, the subscript λ is used to imply the spectral dependence of their definitions. Thus:

- The spectral absorptance α_λ = the ratio of the spectral radiant power absorbed by an object to that incident upon it.
- The spectral reflectance ρ_λ = the ratio of the spectral radiant power reflected by an object to that incident upon it.
- The spectral transmittance τ_λ = the ratio of the spectral radiant power transmitted through an object to that incident upon it.

The sum of these three factors must always add up to the whole at any wavelength, so we have the relation:

$$\alpha_\lambda + \rho_\lambda + \tau_\lambda = 1$$

For opaque materials $\tau_\lambda = 0$ and the relation simplifies to:

$$\alpha_\lambda + \rho_\lambda = 1$$

Another factor, called the emissivity, is required to describe the fraction ε of the radiant emittance of a blackbody produced by an object at a specific temperature. Thus, we have the definition:

The spectral emissivity ε_λ = the ratio of the spectral radiant power from an object to that from a blackbody at the same temperature and wavelength.

Expressed mathematically, this can be written as the ratio of the spectral emittance of the object to that of a blackbody as follows:

$$\varepsilon_\lambda = \frac{W_{\lambda o}}{W_{\lambda b}}$$

Generally speaking, there are three types of radiation source, distinguished by the ways in which the spectral emittance of each varies with wavelength.

- A blackbody, for which $\varepsilon_\lambda = \varepsilon = 1$
- A graybody, for which $\varepsilon_\lambda = \varepsilon$ = constant less than 1
- A selective radiator, for which ε varies with wavelength

According to Kirchhoff's law, for any material the spectral emissivity and spectral absorptance of a body are equal at any specified temperature and wavelength. That is:

$$\varepsilon_\lambda = \alpha_\lambda$$

From this we obtain, for an opaque material (since $\alpha_\lambda + \rho_\lambda = 1$):

$$\varepsilon_\lambda + \rho_\lambda = 1$$

For highly polished materials ε_λ approaches zero, so that for a perfectly reflecting material (*i.e.* a perfect mirror) we have:

$$\rho_\lambda = 1$$

For a graybody radiator, the Stefan-Boltzmann formula becomes:

$$W = \varepsilon\sigma T^4 \, [\mathrm{Watt/m^2}]$$

This states that the total emissive power of a graybody is the same as a blackbody at the same temperature reduced in proportion to the value of ε from the graybody.

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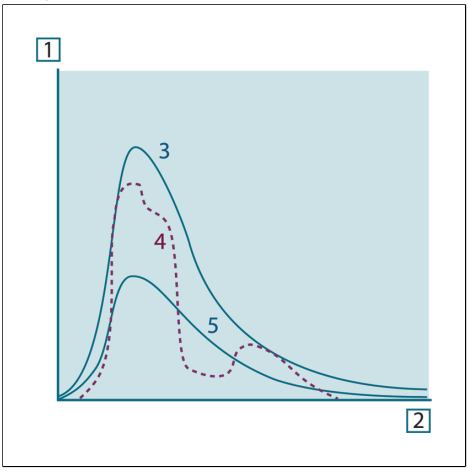

Figure 14.8 Spectral radiant emittance of three types of radiators. **1:** Spectral radiant emittance; **2:** Wavelength; **3:** Blackbody; **4:** Selective radiator; **5:** Graybody.

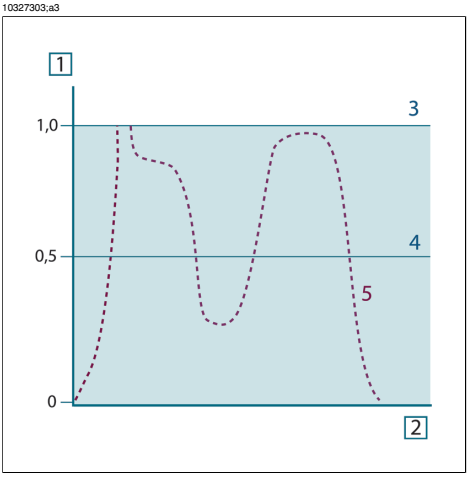

Figure 14.9 Spectral emissivity of three types of radiators. **1:** Spectral emissivity; **2:** Wavelength; **3:** Blackbody; **4:** Graybody; **5:** Selective radiator.

14.4 Infrared semi-transparent materials

Consider now a non-metallic, semi-transparent body – let us say, in the form of a thick flat plate of plastic material. When the plate is heated, radiation generated within its volume must work its way toward the surfaces through the material in which it is partially absorbed. Moreover, when it arrives at the surface, some of it is reflected back into the interior. The back-reflected radiation is again partially absorbed, but some of it arrives at the other surface, through which most of it escapes; part of it is reflected back again. Although the progressive reflections become weaker and weaker they must all be added up when the total emittance of the plate is sought. When the resulting geometrical series is summed, the effective emissivity of a semi-transparent plate is obtained as:

$$\varepsilon_\lambda = \frac{(1-\rho_\lambda)(1-\tau_\lambda)}{1-\rho_\lambda\tau_\lambda}$$

When the plate becomes opaque this formula is reduced to the single formula:

$$\varepsilon_\lambda = 1-\rho_\lambda$$

This last relation is a particularly convenient one, because it is often easier to measure reflectance than to measure emissivity directly.

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A note on the technical production of this manual

This manual was produced using XML – eXtensible Markup Language. For more information about XML, point your browser to: http://www.w3.org/XML/

Readers interested in the history & theory of markup languages may also want to visit the following sites:

- http://www.gla.ac.uk/staff/strategy/information/socarcpj/
- http://www.renater.fr/Video/2002ATHENS/P/DC/History/plan.htm

A note on the typeface used in this manual

This manual was typeset using Swiss 721, which is Bitstream's pan-European version of Max Miedinger's Helvetica™ typeface. Max Miedinger was born December 24th, 1910 in Zürich, Switzerland and died March 8th, 1980 in Zürich, Switzerland.

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- 1926–30: Trains as a typesetter in Zürich, after which he attends evening classes at the Kunstgewerbeschule in Zürich.
- 1936–46: Typographer for Globus department store's advertising studio in Zürich.
- 1947–56: Customer counselor and typeface sales representative for the Haas'sche Schriftgießerei in Münchenstein near Basel. From 1956 onwards: freelance graphic artist in Zürich.
- 1956: Eduard Hoffmann, the director of the Haas'sche Schriftgießerei, commissions Miedinger to develop a new sans-serif typeface.
- 1957: The Haas-Grotesk face is introduced.
- 1958: Introduction of the roman (or normal) version of Haas-Grotesk.
- 1959: Introduction of a bold Haas-Grotesk.
- 1960: The typeface changes its name from Neue Haas Grotesk to Helvetica™.
- 1983: Linotype publishes its Neue Helvetica™, based on the earlier Helvetica™.

For more information about Max Miedinger, his typeface and its influences, please visit http://www.rit.edu/~rlv5703/imm/project2/index.html

The following file identities and file versions were used in the formatting stream output for this manual:

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