



User's manual **FLIR Ax5 series**



User's manual

FLIR Ax5 series



Table of contents

1	Legal disclaimer	1
1.1	Legal disclaimer	1
1.2	Usage statistics	1
1.3	Changes to registry	1
1.4	U.S. Government Regulations	1
1.5	Copyright	1
1.6	Quality assurance	2
1.7	Patents	2
1.8	EULA Terms	2
2	Safety information	4
3	Notice to user	5
3.1	User-to-user forums	5
3.2	Calibration	5
3.3	Accuracy	5
3.4	Disposal of electronic waste	5
3.5	Training	5
3.6	Documentation updates	5
3.7	Important note about this manual	5
4	Customer help	6
4.1	General	6
4.2	Submitting a question	6
4.3	Downloads	7
5	Introduction	8
6	List of accessories and services	9
7	Mechanical installation	11
8	Focusing the camera	12
8.1	Focusing cameras with 5, 9, 13, and 19 mm lenses	12
8.1.1	Necessary tools	12
8.1.2	Procedure	12
8.2	Focusing cameras with 25 mm lenses	13
8.2.1	Necessary tools	13
8.2.2	Procedure	13
9	Downloads	14
10	About I/O, synchronization, and measurement	15
10.1	FLIR Ax5 General Purpose I/O	15
10.2	FLIR Ax5 synchronization	15
10.3	FLIR Ax5 measurement	16
11	Technical data	19
11.1	Online field-of-view calculator	19
11.2	Note about technical data	19
11.3	FLIR A15 f=19 mm	20
11.4	FLIR A15 f=19 mm (7.5 Hz)	23
11.5	FLIR A15 f=9 mm	26
11.6	FLIR A15 f=9 mm (7.5 Hz)	29
11.7	FLIR A15 f=9 mm with SC kit	32
11.8	FLIR A15 f=9 mm with SC kit (7.5 Hz)	35
11.9	FLIR A35 f=19 mm	38
11.10	FLIR A35 f=9 mm	41
11.11	FLIR A35 f=9 mm with SC kit	44
11.12	FLIR A5 f=5 mm	47
11.13	FLIR A5 f=5 mm (7.5 Hz)	50
11.14	FLIR A5 f=5 mm with SC kit	53
11.15	FLIR A5 f=5 mm with SC kit (7.5 Hz)	56
11.16	FLIR A5 f=9 mm	59

Table of contents

11.17	FLIR A5 f=9 mm (7.5 Hz)	62
11.18	FLIR A65 f=13 mm	65
11.19	FLIR A65 f=13 mm (7.5 Hz)	68
11.20	FLIR A65 f=13 mm with SC kit (7.5 Hz)	71
11.21	FLIR A65 f=25 mm	74
11.22	FLIR A65 f=25 mm (7.5 Hz)	77
12	Mechanical drawings	80
13	Pin configurations and schematics	87
13.1	M12 connector pin configuration	87
13.2	Pig-tail end of cable	87
13.3	SYNC input/output schematics	88
13.4	GP input/output schematics	88
14	Declaration of conformity	89
15	Cleaning the camera	90
15.1	Camera housing, cables, and other items	90
15.1.1	Liquids	90
15.1.2	Equipment	90
15.1.3	Procedure	90
15.2	Infrared lens	90
15.2.1	Liquids	90
15.2.2	Equipment	90
15.2.3	Procedure	90
16	About FLIR Systems	91
16.1	More than just an infrared camera	92
16.2	Sharing our knowledge	92
16.3	Supporting our customers	92
16.4	A few images from our facilities	93
17	Glossary	94
18	Thermographic measurement techniques	97
18.1	Introduction	97
18.2	Emissivity	97
18.2.1	Finding the emissivity of a sample	97
18.3	Reflected apparent temperature	100
18.4	Distance	100
18.5	Relative humidity	100
18.6	Other parameters	100
19	History of infrared technology	102
20	Theory of thermography	105
20.1	Introduction	105
20.2	The electromagnetic spectrum	105
20.3	Blackbody radiation	105
20.3.1	Planck's law	106
20.3.2	Wien's displacement law	107
20.3.3	Stefan-Boltzmann's law	108
20.3.4	Non-blackbody emitters	109
20.4	Infrared semi-transparent materials	111
21	The measurement formula	112
22	Emissivity tables	116
22.1	References	116
22.2	Tables	116

1.1 Legal disclaimer

All products manufactured by FLIR Systems are warranted against defective materials and workmanship for a period of one (1) year from the delivery date of the original purchase, provided such products have been under normal storage, use and service, and in accordance with FLIR Systems instruction.

Products which are not manufactured by FLIR Systems but included in systems delivered by FLIR Systems to the original purchaser, carry the warranty, if any, of the particular supplier only. FLIR Systems has no responsibility whatsoever for such products.

The warranty extends only to the original purchaser and is not transferable. It is not applicable to any product which has been subjected to misuse, neglect, accident or abnormal conditions of operation. Expendable parts are excluded from the warranty.

In the case of a defect in a product covered by this warranty the product must not be further used in order to prevent additional damage. The purchaser shall promptly report any defect to FLIR Systems or this warranty will not apply.

FLIR Systems will, at its option, repair or replace any such defective product free of charge if, upon inspection, it proves to be defective in material or workmanship and provided that it is returned to FLIR Systems within the said one-year period.

FLIR Systems has no other obligation or liability for defects than those set forth above.

No other warranty is expressed or implied. FLIR Systems specifically disclaims the implied warranties of merchantability and fitness for a particular purpose.

FLIR Systems shall not be liable for any direct, indirect, special, incidental or consequential loss or damage, whether based on contract, tort or any other legal theory.

This warranty shall be governed by Swedish law.

Any dispute, controversy or claim arising out of or in connection with this warranty, shall be finally settled by arbitration in accordance with the Rules of the Arbitration Institute of the Stockholm Chamber of Commerce. The place of arbitration shall be Stockholm. The language to be used in the arbitral proceedings shall be English.

1.2 Usage statistics

FLIR Systems reserves the right to gather anonymous usage statistics to help maintain and improve the quality of our software and services.

1.3 Changes to registry

The registry entry HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Lsa\LmCompatibilityLevel will be automatically changed to level 2 if the FLIR Camera Monitor service detects a FLIR camera connected to the computer with a USB cable. The modification will only be executed if the camera device implements a remote network service that supports network logons.

1.4 U.S. Government Regulations

This product may be subject to U.S. Export Regulations. Please send any inquiries to exportquestions@flir.com.

1.5 Copyright

© 2014, FLIR Systems, Inc. All rights reserved worldwide. No parts of the software including source code may be reproduced, transmitted, transcribed or translated into any language or computer language in any form or by any means, electronic, magnetic, optical, manual or otherwise, without the prior written permission of FLIR Systems.

The documentation must not, in whole or part, be copied, photocopied, reproduced, translated or transmitted to any electronic medium or machine readable form without prior consent, in writing, from FLIR Systems.

Names and marks appearing on the products herein are either registered trademarks or trademarks of FLIR Systems and/or its subsidiaries. All other trademarks, trade names or company names referenced herein are used for identification only and are the property of their respective owners.

1.6 Quality assurance

The Quality Management System under which these products are developed and manufactured has been certified in accordance with the ISO 9001 standard.

FLIR Systems is committed to a policy of continuous development; therefore we reserve the right to make changes and improvements on any of the products without prior notice.

1.7 Patents











One or several of the following patents and/or design patents may apply to the products and/or features. Additional pending patents and/or pending design patents may also apply.

000279476-0001; 000439161; 000499579-0001; 000653423; 000726344; 000859020; 001106306-0001; 001707738; 001707746; 001707787; 001776519; 001954074; 002021543; 002058180; 002249953; 002531178; 0600574-8; 1144833; 1182246; 1182620; 1285345; 1299699; 1325808; 1336775; 1391114; 1402918; 1404291; 1411581; 1415075; 1421497; 1458284; 1678485; 1732314; 2106017; 2107799; 2381417; 3006596; 3006597; 466540; 483782; 484155; 4889913; 5177595; 60122153.2; 602004011681.5-08; 6707044; 68657; 7034300; 7110035; 7154093; 7157705; 7237946; 7312822; 7332716; 7336823; 7544944; 7667198; 7809258 B2; 7826736; 8,153,971; 8018649 B2; 8212210 B2; 8289372; 8354639 B2; 8384783; 8520970; 8565547; 8595689; 8599262; 8654239; 8680468; 8803093; D540838; D549758; D579475; D584755; D599,392; D615,113; D664,580; D664,581; D665,004; D665,440; D677298; D710,424 S; DI6702302-9; DI6903617-9; DI7002221-6; DI7002891-5; DI7002892-3; DI7005799-0; DM/057692; DM/061609; EP 2115696 B1; EP2315433; SE 0700240-5; US 8340414 B2; ZL 201330267619.5; ZL01823221.3; ZL01823226.4; ZL02331553.9; ZL02331554.7; ZL200480034894.0; ZL200530120994.2; ZL200610088759.5; ZL200630130114.4; ZL200730151141.4; ZL200730339504.7; ZL200820105768.8; ZL200830128581.2; ZL200880105236.4; ZL200880105769.2; ZL200930190061.9; ZL201030176127.1; ZL201030176130.3; ZL201030176157.2; ZL201030595931.3; ZL201130442354.9; ZL201230471744.3; ZL201230620731.8.

1.8 EULA Terms

- You have acquired a device ("INFRARED CAMERA") that includes software licensed by FLIR Systems AB from Microsoft Licensing, GP or its affiliates ("MS"). Those installed software products of MS origin, as well as associated media, printed materials, and "online" or electronic documentation ("SOFTWARE") are protected by international intellectual property laws and treaties. The SOFTWARE is licensed, not sold. All rights reserved.
- IF YOU DO NOT AGREE TO THIS END USER LICENSE AGREEMENT ("EULA"), DO NOT USE THE DEVICE OR COPY THE SOFTWARE. INSTEAD, PROMPTLY CONTACT FLIR Systems AB FOR INSTRUCTIONS ON RETURN OF THE UNUSED DEVICE(S) FOR A REFUND. **ANY USE OF THE SOFTWARE, INCLUDING BUT NOT LIMITED TO USE ON THE DEVICE, WILL CONSTITUTE YOUR AGREEMENT TO THIS EULA (OR RATIFICATION OF ANY PREVIOUS CONSENT).**
- **GRANT OF SOFTWARE LICENSE.** This EULA grants you the following license:
 - You may use the SOFTWARE only on the DEVICE.
 - **NOT FAULT TOLERANT.** THE SOFTWARE IS NOT FAULT TOLERANT. FLIR Systems AB HAS INDEPENDENTLY DETERMINED HOW TO USE THE SOFTWARE IN THE DEVICE, AND MS HAS RELIED UPON FLIR Systems AB TO CONDUCT SUFFICIENT TESTING TO DETERMINE THAT THE SOFTWARE IS SUITABLE FOR SUCH USE.

-
- **NO WARRANTIES FOR THE SOFTWARE.** THE SOFTWARE is provided “AS IS” and with all faults. THE ENTIRE RISK AS TO SATISFACTORY QUALITY, PERFORMANCE, ACCURACY, AND EFFORT (INCLUDING LACK OF NEGLIGENCE) IS WITH YOU. ALSO, THERE IS NO WARRANTY AGAINST INTERFERENCE WITH YOUR ENJOYMENT OF THE SOFTWARE OR AGAINST INFRINGEMENT. **IF YOU HAVE RECEIVED ANY WARRANTIES REGARDING THE DEVICE OR THE SOFTWARE, THOSE WARRANTIES DO NOT ORIGINATE FROM, AND ARE NOT BINDING ON, MS.**
 - **No Liability for Certain Damages.** **EXCEPT AS PROHIBITED BY LAW, MS SHALL HAVE NO LIABILITY FOR ANY INDIRECT, SPECIAL, CONSEQUENTIAL OR INCIDENTAL DAMAGES ARISING FROM OR IN CONNECTION WITH THE USE OR PERFORMANCE OF THE SOFTWARE. THIS LIMITATION SHALL APPLY EVEN IF ANY REMEDY FAILS OF ITS ESSENTIAL PURPOSE. IN NO EVENT SHALL MS BE LIABLE FOR ANY AMOUNT IN EXCESS OF U.S. TWO HUNDRED FIFTY DOLLARS (U.S.\$250.00).**
 - **Limitations on Reverse Engineering, Decompilation, and Disassembly.** You may not reverse engineer, decompile, or disassemble the SOFTWARE, except and only to the extent that such activity is expressly permitted by applicable law notwithstanding this limitation.
 - **SOFTWARE TRANSFER ALLOWED BUT WITH RESTRICTIONS.** You may permanently transfer rights under this EULA only as part of a permanent sale or transfer of the Device, and only if the recipient agrees to this EULA. If the SOFTWARE is an upgrade, any transfer must also include all prior versions of the SOFTWARE.
 - **EXPORT RESTRICTIONS.** You acknowledge that SOFTWARE is subject to U.S. export jurisdiction. You agree to comply with all applicable international and national laws that apply to the SOFTWARE, including the U.S. Export Administration Regulations, as well as end-user, end-use and destination restrictions issued by U. S. and other governments. For additional information see <http://www.microsoft.com/exporting/>.

	WARNING
Make sure that you read all applicable MSDS (Material Safety Data Sheets) and warning labels on containers before you use a liquid. The liquids can be dangerous. Injury to persons can occur.	
	WARNING
Applicability: FLIR Ax5.	
Do not use screws that are too long. If you use screws that are too long, damage to the camera will occur. The maximum depth of the M3 holes is 4 mm (0.15 in.).	
	CAUTION
Do not point the infrared camera (with or without the lens cover) at strong energy sources, for example, devices that cause laser radiation, or the sun. This can have an unwanted effect on the accuracy of the camera. It can also cause damage to the detector in the camera.	
	CAUTION
Do not use the camera in temperatures more than +50°C (+122°F), unless other information is specified in the user documentation or technical data. High temperatures can cause damage to the camera.	
	CAUTION
Do not apply solvents or equivalent liquids to the camera, the cables, or other items. Damage to the battery and injury to persons can occur.	
	CAUTION
Be careful when you clean the infrared lens. The lens has an anti-reflective coating which is easily damaged. Damage to the infrared lens can occur.	
	CAUTION
Do not use too much force to clean the infrared lens. This can cause damage to the anti-reflective coating.	
	CAUTION
Applicability: Cameras with an automatic shutter that can be disabled.	
Do not disable the automatic shutter in the camera for a long time period (a maximum of 30 minutes is typical). If you disable the shutter for a longer time period, damage to the detector can occur.	
	NOTE
The encapsulation rating is only applicable when all the openings on the camera are sealed with their correct covers, hatches, or caps. This includes the compartments for data storage, batteries, and connectors.	
	CAUTION
Applicability: Cameras where you can remove the lens and expose the infrared detector.	
Do not use the pressurized air from the pneumatic air systems in a workshop when you remove dust from the detector. The air contains oil mist to lubricate the pneumatic tools and the pressure is too high. Damage to the detector can occur.	

3.1 User-to-user forums

Exchange ideas, problems, and infrared solutions with fellow thermographers around the world in our user-to-user forums. To go to the forums, visit:

<http://www.infraredtraining.com/community/boards/>

3.2 Calibration

FLIR Systems recommends that you verify your calibration yearly. You can verify the calibration yourself or with the help of a FLIR Systems Partner. If preferred, FLIR Systems offers a calibration, adjustment, and general maintenance service.

3.3 Accuracy

For very accurate results, we recommend that you wait 5 minutes after you have started the camera before measuring a temperature.

3.4 Disposal of electronic waste



As with most electronic products, this equipment must be disposed of in an environmentally friendly way, and in accordance with existing regulations for electronic waste.

Please contact your FLIR Systems representative for more details.

3.5 Training

To read about infrared training, visit:

- <http://www.infraredtraining.com>
- <http://www.irtraining.com>
- <http://www.irtraining.eu>

3.6 Documentation updates

Our manuals are updated several times per year, and we also issue product-critical notifications of changes on a regular basis.

To access the latest manuals and notifications, go to the Download tab at:

<http://support.flir.com>

It only takes a few minutes to register online. In the download area you will also find the latest releases of manuals for our other products, as well as manuals for our historical and obsolete products.

3.7 Important note about this manual

FLIR Systems issues generic manuals that cover several cameras within a model line.

This means that this manual may contain descriptions and explanations that do not apply to your particular camera model.

FLIR Customer Support Center

[Home](#)
[Answers](#)
[Ask a Question](#)
[Product Registration](#)
[Downloads](#)
[My Stuff](#)
[Service](#)

FLIR Customer support

Get the most out of your FLIR products

Get Support for Your FLIR Products

Welcome to the FLIR Customer Support Center. This portal will help you as a FLIR customer to get the most out of your FLIR products. The portal gives you access to:

- The FLIR Knowledgebase
- Ask our support team (requires registration)
- Software and documentation (requires registration)
- FLIR service contacts

Find Answers

We store all resolved problems in our solution database. Search by product, category, keywords, or phrases.

Search by Keyword

[Search All Answers](#)

[See All Popular Answers](#)

To find a datasheet for a current product, click on a picture.
To find a datasheet for a legacy product, click [here](#).

FLIR Ex

FLIR Exx

FLIR Kxx

FLIR T4xx

FLIR T6xx

FLIR G3xx

ThermaCAM™ GasFindIR

FLIR GF3xx

FLIR AX

FLIR Ax5

FLIR A3xx

More...

Product catalog

Please right-click the links below and select Save Target As... to save the file.

US Letter (28 Mb)

A4 (27.4 Mb)

[Important legal disclaimer, dangers, warnings, and cautions](#)

Accessories

4.1 General

For customer help, visit:

<http://support.flir.com>

4.2 Submitting a question

To submit a question to the customer help team, you must be a registered user. It only takes a few minutes to register online. If you only want to search the knowledgebase for existing questions and answers, you do not need to be a registered user.

When you want to submit a question, make sure that you have the following information to hand:

- The camera model
- The camera serial number
- The communication protocol, or method, between the camera and your device (for example, HDMI, Ethernet, USB, or FireWire)
- Device type (PC/Mac/iPhone/iPad/Android device, etc.)
- Version of any programs from FLIR Systems
- Full name, publication number, and revision number of the manual

4.3 Downloads

On the customer help site you can also download the following:

- Firmware updates for your infrared camera.
- Program updates for your PC/Mac software.
- Freeware and evaluation versions of PC/Mac software.
- User documentation for current, obsolete, and historical products.
- Mechanical drawings (in *.dxf and *.pdf format).
- Cad data models (in *.stp format).
- Application stories.
- Technical datasheets.
- Product catalogs.



The FLIR Ax5 cameras have features and functions that make them the natural choice for anyone who uses PC software to solve problems. Available resolutions include 80×64 , 160×128 , and 320×256 pixels.

Among their main features are GigE Vision and GenICam compliance, which makes them plug-and-play when used with software packages such as IMAQ Vision and Halcon.

Key features:


- Very affordable.
- Compact ($40 \times 43 \times 106$ mm/ $1.57 \times 1.69 \times 4.17$ in.).
- GigE Vision and GenICam compliant.
- GigE Vision lockable connector.
- PoE (power over Ethernet).
- 8-bit monochrome image streaming.
- 14-bit radiometric image streaming.
- High frame rates (60 Hz).
- Synchronization between cameras possible.
- 1x+1x GPIO.
- Compliant with any software that supports GenICam, including National Instruments IMAQ Vision, Stemmers Common Vision Blox, and COGNEX Vision Pro.
- Lenses: 5° , 9° , 13° , 19° , and 25° (model-dependent).

Typical applications:

- Automation, thermal machine vision.
- Entry-level “high-speed” R&D.

Part number	Product name
T198349	Base support
T198348	Cable kit Mains (UK,EU,US)
T127605ACC	Cable M12 Pigtail
T127606ACC	Cable M12 Sync
T951004ACC	Ethernet cable CAT-6, 2m/6.6 ft.
DSW-10000	FLIR IR Camera Player
T198584	FLIR Tools
T198583	FLIR Tools+ (license only)
T198342ACC	Focus adjustment tool
T911183	Gigabit PoE injector 16 W, with multi-plugs
ITC-ADV-3021	ITC Advanced General Thermography Course - attendance, 1 pers.
ITC-ADV-3029	ITC Advanced General Thermography Course-group of 10 pers.
ITC-CON-1001	ITC conference fee
ITC-EXP-1041	ITC Customized workshop - per person (per day)
ITC-EXP-1021	ITC In-house training - additional attendance 1 pers. (per day)
ITC-EXP-1029	ITC In-house training - group up to 10 pers. (per day)
ITC-EXP-1050	ITC Infrared application and system consultancy (per day)
ITC-CER-5105	ITC Level 1 Thermography Course - additional student to on site class, 1 pers
ITC-CER-5101	ITC Level 1 Thermography Course - attendance, 1 pers.
ITC-CER-5109	ITC Level 1 Thermography Course – group of 10 pers.
ITC-CER-5205	ITC Level 2 Thermography Course - additional student to on site class, 1 pers
ITC-CER-5201	ITC Level 2 Thermography Course - attendance, 1 pers.
ITC-CER-5209	ITC Level 2 Thermography Course – group of 10 pers.
ITC-EXP-2036	ITC R&D basics for industry users - group up to 6 pers. (2 days)
ITC-EXP-2025	ITC Short course Fever Screening - additional student to on site class (2 days)
ITC-EXP-2021	ITC Short course Fever Screening - attendance 1 pers. (2 days)
ITC-EXP-2029	ITC Short course Fever Screening - inclusive 10 pers. (2 days)
ITC-EXP-1019	ITC Short course Introduction to thermography - inclusive 10 pers. (1 day)
ITC-EXP-1011	ITC Short course Introduction to thermography -attendance 1 pers. (1 day)
ITC-SOW-0001	ITC Software course - attendance 1 pers. (per day)
ITC-SOW-0009	ITC Software course - group up to 10 pers. (per day)

Part number	Product name
ITC-EXP-1001	ITC Training 1 day - attendance 1 pers.
ITC-EXP-1009	ITC Training 1 day - group up to 10 pers.
ITC-EXP-2001	ITC Training 2 days - attendance 1 pers.
ITC-EXP-2009	ITC Training 2 days - group up to 10 pers.
ITC-EXP-3001	ITC Training 3 days - attendance 1 pers.
ITC-EXP-3009	ITC Training 3 days - group up to 10 pers.
ITC-TFT-0100	ITC travel time for instructor
T911112	PoE injector
T198392	Table stand kit
T198371	Transport case Ax5
ITC-TOL-1003	Travel and lodging expenses instructor (Center and South Africa)
ITC-TOL-1001	Travel and lodging expenses instructor (Europe, Balcans, Turkey, Cyprus)
ITC-TOL-1005	Travel and lodging expenses instructor (other)
ITC-TOL-1002	Travel and lodging expenses instructor (Russia/ GUS, Middle East, North Africa)
ITC-TOL-1004	Travel and lodging expenses instructor (various)

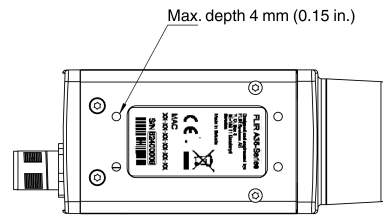
	NOTE
FLIR Systems reserves the right to discontinue models, parts or accessories, and other items, or to change specifications at any time without prior notice.	

The camera unit has been designed to allow it to be mounted in any position. It has a mounting interface on the bottom with four metric M3 holes.



WARNING

Do not use screws that are too long. Using screws that are too long will damage the camera. The maximum depth of the M3 holes is 4 mm (0.15 in.).



NOTE

The camera generates a considerable amount of heat during operation. This is normal. In order to transfer this heat, it is recommended that the camera is mounted on a base support or a heat sink made of a material that has a high capacity to transfer heat, e.g., aluminum. FLIR Systems provides P/N T198349 (base support) for this purpose, but other base supports or heat sinks can be used.

The use of the base support is also strongly recommended in order to minimize temperature drift of the infrared detector in the camera.

If the camera unit is to be permanently mounted on the application site, certain steps have to be taken. The camera unit might need to be enclosed in a protective housing and, depending on the ambient conditions (e.g., temperature), the housing may need to be cooled by means of water or air. In very dusty conditions the installation might also need to have a stream of pressurized air directed at the lens, in order to prevent dust build-up.

When mounting the camera unit in harsh environments, every precaution should be taken when it comes to securing the unit. If the environment exposes the unit to severe vibrations, there may arise a need to secure the mounting screws by means of Loctite or another industrial brand of thread-locking liquid, as well as to dampen the vibrations by mounting the camera unit on a specially designed mounting base.

For further information regarding mounting recommendations and environmental enclosures, contact FLIR Systems.

The camera is typically powered using PoE (Power over Ethernet). A PoE injector and cable kit are available from FLIR Systems. See the part numbers below.

- T198348, Cable kit mains (UK, EU, US).
- T911112, PoE injector.
- T951004ACC, Ethernet cable CAT-6, 2 m/6.6 ft.

8.1 Focusing cameras with 5, 9, 13, and 19 mm lenses

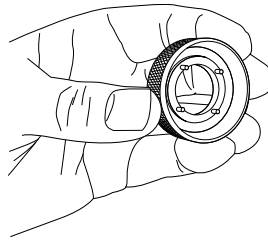
8.1.1 Necessary tools

Focus adjustment tool (included in the package for cameras with 5, 9, 13, and 19 mm lenses).

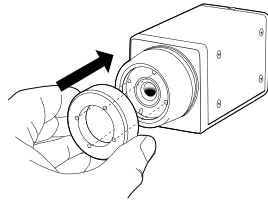
8.1.2 Procedure

Follow this procedure:

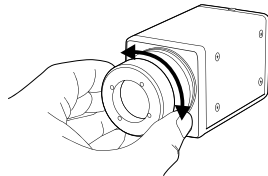
1. Note the four pegs on the inside of the focus adjustment tool.



2. Align the four pegs with the corresponding slots on the front of the lens, and push the focus adjustment tool into position.



3. Rotate the lens.



8.2 Focusing cameras with 25 mm lenses

**CAUTION**

Do not use the focus adjustment tool when focusing cameras with a 25 mm lens.

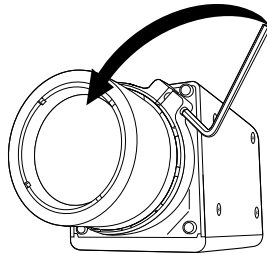
8.2.1 Necessary tools

Allen wrench, 1.5 mm.

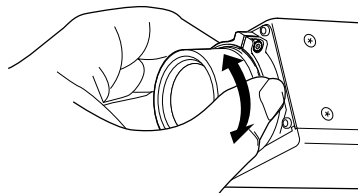
8.2.2 Procedure

Follow this procedure:

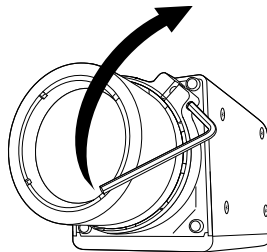
1. Unlock the clamp by loosening the Allen screw.



2. Focus the camera by rotating the lens.



3. Lock the clamp by tightening the Allen screw.



The principal software used to configure and control the camera is FLIR GEV Demo 1.3.0. This software is based on the PleoraBus SDK and the runtime Pleora GEVPlayer that comes with the SDK.

Downloads:

- <http://support.flir.com/Ax5-software>
- Link to download PureGEV SDK Sample (source code): <http://support.flir.com/SwDownload/app/RssSWDownload.aspx?ID=133>
- Link to download FLIR GEV Demo 1.3.0 (installer): <http://support.flir.com/SwDownload/app/RssSWDownload.aspx?ID=155>

The camera is compliant with the following standards. Additional software and documentation resources can be downloaded from these sites.

- GeniCAM: <http://www.genicam.org>
- Gigabit Ethernet: <http://www.ieee802.org/3>

10.1 FLIR Ax5 General Purpose I/O

The FLIR Ax5 camera has one general-purpose input line and one output line that can be used in control applications.

Typical usage:

- The output line is asserted when an alarm condition is met.
- The input line is used to trigger an action, for example saving an image.

The output line GPO+ is controlled by the register *UserOutputValue*. Set this register to *True* to assert (level equal to GPIO_PWR) the GPO+ signal, and set to *False* to de-assert (level is equal to GPIO_GND).

You can monitor the input line by reading the *LineStatus* register on a regular basis. The *LineStatus* register will return *True* if the input level is asserted (level equal to GPIO_PWR voltage), and it will return *False* if the input line is de-asserted (level is equal to GPIO_GND).

Another option is to configure the camera to send a GigEVision event when the input line state is changed. In order to configure the camera for event transmission you need to modify the following registers:

PLC_Q7_Variable0	Enum	Set this register to PLC_I0 (enumeration value 2) to route the GPI signal
EventSelector	Enum	Set this register to PLC_Interrupt_FIFO0_Q7 (enumeration value 5)
EventNotification	Enum	Set this register to GigEVisionEvent (enumeration value 3)

To de-bounce the input signal you also might want to configure the *LineDebounceFactor* register. This register controls the width of the window during which spurious transitions from the input line are filtered out (in increments of ~480 ns). This register is 0 by default, which means that the de-bouncing is disabled. The maximum value for this register is 65535, which corresponds to a maximum holding time of ~31 ms.

The FLIR GEV Demo 1.3 sample illustrates how to setup the event transmission. C++ source code is available in PureGEV SDK Sample.

Applicable downloads:

- Link to download PureGEV SDK Sample (source code): <http://support.flir.com/SwDownload/app/RssSWDownload.aspx?ID=133>
- Link to download FLIR GEV Demo 1.3.0 (installer): <http://support.flir.com/SwDownload/app/RssSWDownload.aspx?ID=155>

10.2 FLIR Ax5 synchronization

The camera provides an external sync channel that can be used to synchronize the frame start between two cameras, one configured as the master and the other configured as the slave. It can also be used to synchronize the frame start of a camera with that of another product.

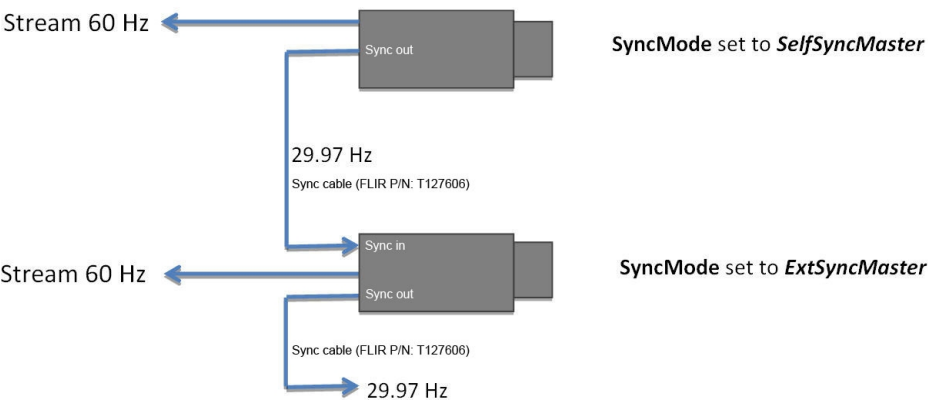



Figure 10.1 Master/slave synchronization between two FLIR Ax5 cameras (NTSC).


 **NOTE**

External synchronization can be applied but only by using an input signal with a frequency of 29.97 Hz (NTSC).

- The signal voltage (relative to digital GND) is 3.3 V.
- The pulse width (minimum) is 100 ns (will be extended to 1 μs).

Note that the synchronization mode is not persistent. The camera will always return to *SyncMode Disabled* after reset or power cycling.

For slow configurations (9 Hz), the output frame rate is a fraction of the sync pulse rate. Because there is ambiguity as to which received pulse triggers the frame timing, FLIR does not recommend using the external sync interface with a slow-configured camera.

 **NOTE**

The only difference between *ExtSyncMaster* and *SelfSyncSlave* mode is that the incoming sync signal is relayed to the SYNC_OUT port if set to *ExtSyncMaster*.

10.3 FLIR Ax5 measurement

The FLIR Ax5 camera has an option to output 14-bit digital video that is temperature linear.

Each count in the temperature-linear video corresponds to either 0.04 K or 0.4 K in 14-bit video, depending on the selected resolution.

Temperature-linear output is enabled or disabled with the feature register:

TemperatureLinearMode: On (1) or Off (0)

Temparture-linear resolution is determined with the feature register:

TemperatureLinearResolution: Low 0.4 K (0) or High 0.04 K (1)

If **TemperatureLinearMode** is On, the signal-to-temperature mapping is calculated using the equations

$T_{[K]} = 0.04 \times S$ (for high resolution)

$T_{[K]} = 0.4 \times S$ (for low resolution)

S corresponds to the 14-bit pixel value.

If the **TemperatureLinearMode** is Off, then the camera provides registers that can be used to convert signal values to temperature. For each measurement range (or gain mode) there is a set of register values that is used for this conversion.

The conversion from the corrected signal S to the temperature $T_{[K]}$ is performed using the external RBFO values for the selected lens and gain mode. The signal-to-temperature mapping is calculated using the equation

$$T_{[K]} = \frac{B}{\ln\left(\frac{R}{S-O} + F\right)}$$

$\ln(x)$ is the base-e logarithm of the x parameter, and S corresponds to the 14-bit pixel value.

Register name	Type
R	Integer
B	Float
F	Float
O	Float (handles only positive vales)
OInt	Integer (same as O but handles negative values)

Please note that these registers will be automatically updated when switching between the high gain mode and the low gain mode.

The FLIR GEV Demo sample illustrates how to use this conversion formula.

You also have the option to do your own one-point calibration by adjusting the offset value (register **OInt**) by pointing the camera at an accurately known temperature. Knowing the temperature, you can then calculate the offset value and update the **OInt** register.

$$OInt = S - \left(R / \left(\exp\left(B / T_{KNOWN} \right) - F \right) \right)$$

The FLIR GEV Demo sample illustrates how to perform this kind of calibration. Please note that you will need to save the current settings if you want the new offset value to be persistent. Use the command register **SensorSetDefaults** to set all current settings as power on defaults.

There are additional registers that also affect the temperature linear output. These registers are grouped together as Object Parameter registers. These registers only affect the transformation of detector signal values to temperature values when the camera is in temperature linear mode.

ReflectedTemperature: The estimated reflected background temperature for the target scene.

ObjectEmissivity: The target scene emissivity factor. The default value is 1.0.

WindowTransmission: The estimated transmission factor for the protective window. The default value is 1.0.

WindowTemperature: The external window temperature T_{win} (in kelvin).

AtmosphericTransmission: The estimated transmission factor for the atmosphere between the camera and the scene.

AtmosphericTemperature: The estimated temperature T_{atm} for the atmosphere between the camera and the scene.

The correction for scene parameters is extended to include the following parameters:

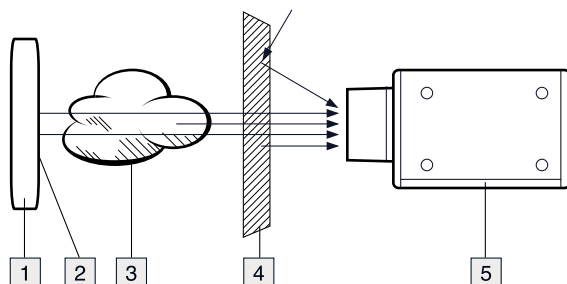


Figure 10.2 1: Scene, T_{scene} ; 2: Reflected background temperature; 3: Atmosphere, T_{Atm} ; 4: External window, T_{win} ; 5: Infrared camera.

**NOTE**

The default values for the object parameters are set to values that will have no impact on the conversion between detector signal values and corrected signal values.

11.1 Online field-of-view calculator

Please visit <http://support.flir.com> and click the FLIR Ax5 camera for field-of-view tables for all lens-camera combinations in this camera series.

11.2 Note about technical data

FLIR Systems reserves the right to change specifications at any time without prior notice. Please check <http://support.flir.com> for latest changes.

11.3 FLIR A15 f=19 mm

P/N: 62319-0101

Rev.: 22369

General description	
<p>The FLIR A15 has features and functions that make it the natural choice for anyone who uses PC software to solve problems and for whom 160 × 128 pixel resolution is sufficient.</p> <p>Among its main features are GigE Vision and GenICam compliance, which makes it plug-and-play when used with software packages such as IMAQ Vision and Halcon.</p>	
Key features:	
<ul style="list-style-type: none"> • Very affordable. • Compact (40 mm × 43 mm × 106 mm). • GigE Vision and GenICam compliant. • GigE Vision lockable connector. • PoE (power over Ethernet). • 8-bit 160 × 128 pixel images streamed at 60 Hz, signal linear. • 14-bit 160 × 128 pixel images streamed at 60 Hz, signal and temperature linear. • High frame rates (60 Hz). • Synchronization between cameras possible. • 1x+1x GPIO. • Compliant with any software that supports GenICam, including National Instruments IMAQ Vision, Stemmers Common Vision Blox, and COGNEX Vision Pro. 	
Typical applications:	
<ul style="list-style-type: none"> • Automation and thermal machine vision. • Entry level "high-speed" R&D. 	
Imaging and optical data	
IR resolution	160 × 128 pixels
Thermal sensitivity/NETD	< 0.05°C @ +30°C (+86°F) / 50 mK
Field of view (FOV)	25° × 19°
Focal length	19 mm (0.75 in.)
Spatial resolution (IFOV)	2.63 mrad
F-number	1.25
Image frequency	60 Hz
Focus	Fixed
Detector data	
Detector type	Focal Plane Array (FPA), Uncooled VOX microbolometer
Spectral range	7.5–13 μm
Detector pitch	50 μm
Detector time constant	Typical 12 ms
Measurement	
Object temperature range	<ul style="list-style-type: none"> • -25 to +135°C (-13 to 275°F) • -40 to +550°C (-40 to +1022°F)
Accuracy	±5°C (±9°F) or ±5% of reading
Ethernet	
Ethernet	Control and image
Ethernet, type	Gigabit Ethernet
Ethernet, standard	IEEE 802.3
Ethernet, connector type	RJ-45

Ethernet	
Ethernet, communication	GigE Vision ver. 1.2 Client API GenICam compliant
Ethernet, image streaming	8-bit monochrome @ 60 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Automatic/ Manual • Flip H&V 14-bit 160 × 128 pixels @ 60 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Temperature linear GigE Vision and GenICam compatible
Ethernet, power	Power over Ethernet, PoE IEEE 802.3af class 0 Power
Ethernet, protocols	TCP, UDP, ICMP, IGMP, DHCP, GigEVision
Digital input/output	
Digital input, purpose	General purpose
Digital input	1× opto-isolated, "0" <2, "1"=2-12 VDC. NOTE: Maximum input 12 VDC. If the input is above 12 VDC without a resistor in series there is a risk of damaging the input. If the input is 24 VDC use a 1.2 kΩ resistor in series. In that case "1" = 3-24 VDC.
Digital output, purpose	General purpose Output to ext. device (programmatically set)
Digital output	1× opto-isolated, 2-40 VDC, max 185 mA
Digital I/O, isolation voltage	500 VRMS
Digital I/O, supply voltage	2-40 VDC, max 200 mA
Digital I/O, connector type	12-pole M12 connector (shared with Digital Synchronization and External power)
Synchronization In, purpose	Frame sync In to control camera
Synchronization In	1×, non-isolated
Synchronization In, type	LVC Buffer @ 3.3V, "0" <0.8 V, "1" >2.0 V.
Synchronization Out, purpose	Frame sync Out to control another Ax5 camera
Synchronization Out	1×, non-isolated
Synchronization Out, type	LVC Buffer @ 3.3V, "0"=24 mA max, "1"= -24 mA max.
Digital Synchronization, connector type	12-pole M12 connector (shared with Digital I/O and External power)
Power system	
External power operation	12/24 VDC, < 3.5 W nominal < 6.0 W absolute max
External power, connector type	12-pole M12 connector (shared with Digital I/O and Digital Synchronization)
Voltage	Allowed range 10-30 VDC
Environmental data	
Operating temperature range	-15°C to +50°C (+5°F to +122°F)
Storage temperature range	-40°C to +70°C (-40°F to +158°F)
Humidity (operating and storage)	IEC 60068-2-30/24 h 95% relative humidity +25°C to +40°C (+77°F to +104°F)

Environmental data	
EMC	<ul style="list-style-type: none"> • EN 61000-6-2 (Immunity) • EN 61000-6-3 (Emission) • FCC 47 CFR Part 15 Class B (Emission)
Encapsulation	IP 40 (IEC 60529) with base support mounted
Shock	25 g (IEC 60068-2-27)
Vibration	2 g (IEC 60068-2-6)
Physical data	
Weight	0.200 kg (0.44 lb.)
Camera size (L × W × H)	106 × 40 × 43 mm (4.2 × 1.6 × 1.7 in.)
Tripod mounting	UNC ¼"-20 (on three sides)
Base mounting	4 × M3 thread mounting holes (bottom)
Housing material	Magnesium and aluminum
Shipping information	
Packaging, type	Cardboard box
List of contents	<ul style="list-style-type: none"> • Infrared camera with lens • FLIR Tools download card • Focus adjustment tool • Printed documentation • User documentation CD-ROM
Packaging, weight	
Packaging, size	295 × 200 × 105 mm (11.6 × 7.9 × 4.1 in.)
EAN-13	7332558003992 4743254000605 (Estonia plant)
UPC-12	845188003555
Country of origin	Sweden

Supplies & accessories:

- T951004ACC; Ethernet cable CAT-6, 2m/6.6 ft.
- T198349; Base support
- T198348; Cable kit Mains (UK,EU,US)
- T911112; PoE injector
- T198392; Table stand kit
- T911183; Gigabit PoE injector 16 W, with multi-plugs
- T127605ACC; Cable M12 Pigtail
- T127606ACC; Cable M12 Sync
- T198342ACC; Focus adjustment tool
- T198584; FLIR Tools
- T198583; FLIR Tools+ (license only)
- DSW-10000; FLIR IR Camera Player

11.4 FLIR A15 f=19 mm (7.5 Hz)

P/N: 64319-0101

Rev.: 22369

General description	
<p>The FLIR A15 has features and functions that make it the natural choice for anyone who uses PC software to solve problems and for whom 160 × 128 pixel resolution is sufficient.</p> <p>Among its main features are GigE Vision and GenICam compliance, which makes it plug-and-play when used with software packages such as IMAQ Vision and Halcon.</p>	
Key features:	
<ul style="list-style-type: none"> • Very affordable. • Compact (40 mm × 43 mm × 106 mm). • GigE Vision and GenICam compliant. • GigE Vision lockable connector. • PoE (power over Ethernet). • 8-bit 160 × 128 pixel images streamed at 7.5 Hz, signal linear. • 14-bit 160 × 128 pixel images streamed at 7.5 Hz, signal and temperature linear. • Synchronization between cameras possible. • 1x+1x GPIO. • Compliant with any software that supports GenICam, including National Instruments IMAQ Vision, Stemmers Common Vision Blox, and COGNEX Vision Pro. 	
Typical applications:	
<ul style="list-style-type: none"> • Automation and thermal machine vision. • Entry level "high-speed" R&D. 	
Imaging and optical data	
IR resolution	160 × 128 pixels
Thermal sensitivity/NETD	< 0.05°C @ +30°C (+86°F) / 50 mK
Field of view (FOV)	25° × 19°
Focal length	19 mm (0.75 in.)
Spatial resolution (IFOV)	2.63 mrad
F-number	1.25
Image frequency	7.5 Hz
Focus	Fixed
Detector data	
Detector type	Focal Plane Array (FPA), Uncooled VOX microbolometer
Spectral range	7.5–13 μm
Detector pitch	50 μm
Detector time constant	Typical 12 ms
Measurement	
Object temperature range	<ul style="list-style-type: none"> • -25 to +135°C (-13 to 275°F) • -40 to +550°C (-40 to +1022°F)
Accuracy	±5°C (±9°F) or ±5% of reading
Ethernet	
Ethernet	Control and image
Ethernet, type	Gigabit Ethernet
Ethernet, standard	IEEE 802.3
Ethernet, connector type	RJ-45
Ethernet, communication	GigE Vision ver. 1.2 Client API GenICam compliant

Ethernet	
Ethernet, image streaming	8-bit monochrome @ 7.5 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Automatic/ Manual • Flip H&V 14-bit 160 × 128 pixels @ 7.5 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Temperature linear GigE Vision and GenICam compatible
Ethernet, power	Power over Ethernet, PoE IEEE 802.3af class 0 Power
Ethernet, protocols	TCP, UDP, ICMP, IGMP, DHCP, GigEVision
Digital input/output	
Digital input, purpose	General purpose
Digital input	1× opto-isolated, "0" <2, "1"=2-12 VDC. NOTE: Maximum input 12 VDC. If the input is above 12 VDC without a resistor in series there is a risk of damaging the input. If the input is 24 VDC use a 1.2 kΩ resistor in series. In that case "1" = 3-24 VDC.
Digital output, purpose	General purpose Output to ext. device (programmatically set)
Digital output	1× opto-isolated, 2-40 VDC, max 185 mA
Digital I/O, isolation voltage	500 VRMS
Digital I/O, supply voltage	2-40 VDC, max 200 mA
Digital I/O, connector type	12-pole M12 connector (shared with Digital Synchronization and External power)
Synchronization In, purpose	Frame sync In to control camera
Synchronization In	1×, non-isolated
Synchronization In, type	LVC Buffer @3.3V, "0" <0.8 V, "1">2.0 V.
Synchronization Out, purpose	Frame sync Out to control another Ax5 camera
Synchronization Out	1×, non-isolated
Synchronization Out, type	LVC Buffer @ 3.3V, "0"=24 MA max, "1"= -24 mA max.
Digital Synchronization, connector type	12-pole M12 connector (shared with Digital I/O and External power)
Power system	
External power operation	12/24 VDC, < 3.5 W nominal < 6.0 W absolute max
External power, connector type	12-pole M12 connector (shared with Digital I/O and Digital Synchronization)
Voltage	Allowed range 10-30 VDC
Environmental data	
Operating temperature range	-15°C to +50°C (+5°F to +122°F)
Storage temperature range	-40°C to +70°C (-40°F to +158°F)
Humidity (operating and storage)	IEC 60068-2-30/24 h 95% relative humidity +25°C to +40°C (+77°F to +104°F)
EMC	<ul style="list-style-type: none"> • EN 61000-6-2 (Immunity) • EN 61000-6-3 (Emission) • FCC 47 CFR Part 15 Class B (Emission)
Encapsulation	IP 40 (IEC 60529) with base support mounted

Environmental data	
Shock	25 g (IEC 60068-2-27)
Vibration	2 g (IEC 60068-2-6)
Physical data	
Weight	0.200 kg (0.44 lb.)
Camera size (L × W × H)	106 × 40 × 43 mm (4.2 × 1.6 × 1.7 in.)
Tripod mounting	UNC ¼"-20 (on three sides)
Base mounting	4 × M3 thread mounting holes (bottom)
Housing material	Magnesium and aluminum
Shipping information	
Packaging, type	Cardboard box
List of contents	<ul style="list-style-type: none"> • Infrared camera with lens • FLIR Tools download card • Focus adjustment tool • Printed documentation • User documentation CD-ROM
Packaging, weight	
Packaging, size	295 × 200 × 105 mm (11.6 × 7.9 × 4.1 in.)
EAN-13	7332558005668
UPC-12	845188005870
Country of origin	Sweden

Supplies & accessories:

- T951004ACC; Ethernet cable CAT-6, 2m/6.6 ft.
- T198349; Base support
- T198348; Cable kit Mains (UK,EU,US)
- T911112; PoE injector
- T198392; Table stand kit
- T911183; Gigabit PoE injector 16 W, with multi-plugs
- T127605ACC; Cable M12 Pigtail
- T127606ACC; Cable M12 Sync
- T198342ACC; Focus adjustment tool
- T198584; FLIR Tools
- T198583; FLIR Tools+ (license only)
- DSW-10000; FLIR IR Camera Player

11.5 FLIR A15 f=9 mm

P/N: 62309-0101

Rev.: 22369

General description	
<p>The FLIR A15 has features and functions that make it the natural choice for anyone who uses PC software to solve problems and for whom 160 × 128 pixel resolution is sufficient.</p> <p>Among its main features are GigE Vision and GenICam compliance, which makes it plug-and-play when used with software packages such as IMAQ Vision and Halcon.</p>	
Key features:	
<ul style="list-style-type: none"> • Very affordable. • Compact (40 mm × 43 mm × 106 mm). • GigE Vision and GenICam compliant. • GigE Vision lockable connector. • PoE (power over Ethernet). • 8-bit 160 × 128 pixel images streamed at 60 Hz, signal linear. • 14-bit 160 × 128 pixel images streamed at 60 Hz, signal and temperature linear. • High frame rates (60 Hz). • Synchronization between cameras possible. • 1x+1x GPIO. • Compliant with any software that supports GenICam, including National Instruments IMAQ Vision, Stemmers Common Vision Blox, and COGNEX Vision Pro. 	
Typical applications:	
<ul style="list-style-type: none"> • Automation and thermal machine vision. • Entry level "high-speed" R&D. 	
Imaging and optical data	
IR resolution	160 × 128 pixels
Thermal sensitivity/NETD	< 0.05°C @ +30°C (+86°F) / 50 mK
Field of view (FOV)	48° × 39°
Focal length	9 mm (0.35 in.)
Spatial resolution (IFOV)	5.56 mrad
F-number	1.25
Image frequency	60 Hz
Focus	Fixed
Detector data	
Detector type	Focal Plane Array (FPA), Uncooled VOX microbolometer
Spectral range	7.5–13 μm
Detector pitch	50 μm
Detector time constant	Typical 12 ms
Measurement	
Object temperature range	<ul style="list-style-type: none"> • -25 to +135°C (-13 to 275°F) • -40 to +550°C (-40 to +1022°F)
Accuracy	±5°C (±9°F) or ±5% of reading
Ethernet	
Ethernet	Control and image
Ethernet, type	Gigabit Ethernet
Ethernet, standard	IEEE 802.3
Ethernet, connector type	RJ-45

Ethernet	
Ethernet, communication	GigE Vision ver. 1.2 Client API GenICam compliant
Ethernet, image streaming	8-bit monochrome @ 60 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Automatic/ Manual • Flip H&V 14-bit 160 × 128 pixels @ 60 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Temperature linear GigE Vision and GenICam compatible
Ethernet, power	Power over Ethernet, PoE IEEE 802.3af class 0 Power
Ethernet, protocols	TCP, UDP, ICMP, IGMP, DHCP, GigE Vision
Digital input/output	
Digital input, purpose	General purpose
Digital input	1× opto-isolated, "0" <2, "1"=2-12 VDC. NOTE: Maximum input 12 VDC. If the input is above 12 VDC without a resistor in series there is a risk of damaging the input. If the input is 24 VDC use a 1.2 kΩ resistor in series. In that case "1" = 3-24 VDC.
Digital output, purpose	General purpose Output to ext. device (programmatically set)
Digital output	1× opto-isolated, 2-40 VDC, max 185 mA
Digital I/O, isolation voltage	500 VRMS
Digital I/O, supply voltage	2-40 VDC, max 200 mA
Digital I/O, connector type	12-pole M12 connector (shared with Digital Synchronization and External power)
Synchronization In, purpose	Frame sync In to control camera
Synchronization In	1×, non-isolated
Synchronization In, type	LVC Buffer @ 3.3V, "0" <0.8 V, "1" >2.0 V.
Synchronization Out, purpose	Frame sync Out to control another Ax5 camera
Synchronization Out	1×, non-isolated
Synchronization Out, type	LVC Buffer @ 3.3V, "0"=24 mA max, "1"= -24 mA max.
Digital Synchronization, connector type	12-pole M12 connector (shared with Digital I/O and External power)
Power system	
External power operation	12/24 VDC, < 3.5 W nominal < 6.0 W absolute max
External power, connector type	12-pole M12 connector (shared with Digital I/O and Digital Synchronization)
Voltage	Allowed range 10-30 VDC
Environmental data	
Operating temperature range	-15°C to +50°C (+5°F to +122°F)
Storage temperature range	-40°C to +70°C (-40°F to +158°F)
Humidity (operating and storage)	IEC 60068-2-30/24 h 95% relative humidity +25°C to +40°C (+77°F to +104°F)

Environmental data	
EMC	<ul style="list-style-type: none"> • EN 61000-6-2 (Immunity) • EN 61000-6-3 (Emission) • FCC 47 CFR Part 15 Class B (Emission)
Encapsulation	IP 40 (IEC 60529) with base support mounted
Shock	25 g (IEC 60068-2-27)
Vibration	2 g (IEC 60068-2-6)
Physical data	
Weight	0.200 kg (0.44 lb.)
Camera size (L × W × H)	106 × 40 × 43 mm (4.2 × 1.6 × 1.7 in.)
Tripod mounting	UNC ¼"-20 (on three sides)
Base mounting	4 × M3 thread mounting holes (bottom)
Housing material	Magnesium and aluminum
Shipping information	
Packaging, type	Cardboard box
List of contents	<ul style="list-style-type: none"> • Infrared camera with lens • FLIR Tools download card • Focus adjustment tool • Printed documentation • User documentation CD-ROM
Packaging, weight	
Packaging, size	295 × 200 × 105 mm (11.6 × 7.9 × 4.1 in.)
EAN-13	7332558003978 4743254000599 (Estonia plant)
UPC-12	845188003548
Country of origin	Sweden

Supplies & accessories:

- T951004ACC; Ethernet cable CAT-6, 2m/6.6 ft.
- T198349; Base support
- T198348; Cable kit Mains (UK,EU,US)
- T911112; PoE injector
- T198392; Table stand kit
- T911183; Gigabit PoE injector 16 W, with multi-plugs
- T127605ACC; Cable M12 Pigtail
- T127606ACC; Cable M12 Sync
- T198342ACC; Focus adjustment tool
- T198584; FLIR Tools
- T198583; FLIR Tools+ (license only)
- DSW-10000; FLIR IR Camera Player

11.6 FLIR A15 f=9 mm (7.5 Hz)

P/N: 64309-0101

Rev.: 22369

General description	
<p>The FLIR A15 has features and functions that make it the natural choice for anyone who uses PC software to solve problems and for whom 160 × 128 pixel resolution is sufficient.</p> <p>Among its main features are GigE Vision and GenICam compliance, which makes it plug-and-play when used with software packages such as IMAQ Vision and Halcon.</p>	
Key features:	
<ul style="list-style-type: none"> • Very affordable. • Compact (40 mm × 43 mm × 106 mm). • GigE Vision and GenICam compliant. • GigE Vision lockable connector. • PoE (power over Ethernet). • 8-bit 160 × 128 pixel images streamed at 7.5 Hz, signal linear. • 14-bit 160 × 128 pixel images streamed at 7.5 Hz, signal and temperature linear. • Synchronization between cameras possible. • 1x+1x GPIO. • Compliant with any software that supports GenICam, including National Instruments IMAQ Vision, Stemmers Common Vision Blox, and COGNEX Vision Pro. 	
Typical applications:	
<ul style="list-style-type: none"> • Automation and thermal machine vision. • Entry level "high-speed" R&D. 	
Imaging and optical data	
IR resolution	160 × 128 pixels
Thermal sensitivity/NETD	< 0.05°C @ +30°C (+86°F) / 50 mK
Field of view (FOV)	48° × 39°
Focal length	9 mm (0.35 in.)
Spatial resolution (IFOV)	5.56 mrad
F-number	1.25
Image frequency	7.5 Hz
Focus	Fixed
Detector data	
Detector type	Focal Plane Array (FPA), Uncooled VOX microbolometer
Spectral range	7.5–13 μm
Detector pitch	50 μm
Detector time constant	Typical 12 ms
Measurement	
Object temperature range	<ul style="list-style-type: none"> • -25 to +135°C (-13 to 275°F) • -40 to +550°C (-40 to +1022°F)
Accuracy	±5°C (±9°F) or ±5% of reading
Ethernet	
Ethernet	Control and image
Ethernet, type	Gigabit Ethernet
Ethernet, standard	IEEE 802.3
Ethernet, connector type	RJ-45
Ethernet, communication	GigE Vision ver. 1.2 Client API GenICam compliant

Ethernet	
Ethernet, image streaming	8-bit monochrome @ 7.5 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Automatic/ Manual • Flip H&V 14-bit 160 × 128 pixels @ 7.5 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Temperature linear GigE Vision and GenICam compatible
Ethernet, power	Power over Ethernet, PoE IEEE 802.3af class 0 Power
Ethernet, protocols	TCP, UDP, ICMP, IGMP, DHCP, GigEVision
Digital input/output	
Digital input, purpose	General purpose
Digital input	1× opto-isolated, "0" <2, "1"=2-12 VDC. NOTE: Maximum input 12 VDC. If the input is above 12 VDC without a resistor in series there is a risk of damaging the input. If the input is 24 VDC use a 1.2 kΩ resistor in series. In that case "1" = 3-24 VDC.
Digital output, purpose	General purpose Output to ext. device (programmatically set)
Digital output	1× opto-isolated, 2-40 VDC, max 185 mA
Digital I/O, isolation voltage	500 VRMS
Digital I/O, supply voltage	2-40 VDC, max 200 mA
Digital I/O, connector type	12-pole M12 connector (shared with Digital Synchronization and External power)
Synchronization In, purpose	Frame sync In to control camera
Synchronization In	1×, non-isolated
Synchronization In, type	LVC Buffer @3.3V, "0" <0.8 V, "1">2.0 V.
Synchronization Out, purpose	Frame sync Out to control another Ax5 camera
Synchronization Out	1×, non-isolated
Synchronization Out, type	LVC Buffer @ 3.3V, "0"=24 MA max, "1"= -24 mA max.
Digital Synchronization, connector type	12-pole M12 connector (shared with Digital I/O and External power)
Power system	
External power operation	12/24 VDC, < 3.5 W nominal < 6.0 W absolute max
External power, connector type	12-pole M12 connector (shared with Digital I/O and Digital Synchronization)
Voltage	Allowed range 10-30 VDC
Environmental data	
Operating temperature range	-15°C to +50°C (+5°F to +122°F)
Storage temperature range	-40°C to +70°C (-40°F to +158°F)
Humidity (operating and storage)	IEC 60068-2-30/24 h 95% relative humidity +25°C to +40°C (+77°F to +104°F)
EMC	<ul style="list-style-type: none"> • EN 61000-6-2 (Immunity) • EN 61000-6-3 (Emission) • FCC 47 CFR Part 15 Class B (Emission)
Encapsulation	IP 40 (IEC 60529) with base support mounted

Environmental data	
Shock	25 g (IEC 60068-2-27)
Vibration	2 g (IEC 60068-2-6)
Physical data	
Weight	0.200 kg (0.44 lb.)
Camera size (L × W × H)	106 × 40 × 43 mm (4.2 × 1.6 × 1.7 in.)
Tripod mounting	UNC ¼"-20 (on three sides)
Base mounting	4 × M3 thread mounting holes (bottom)
Housing material	Magnesium and aluminum
Shipping information	
Packaging, type	Cardboard box
List of contents	<ul style="list-style-type: none"> • Infrared camera with lens • FLIR Tools download card • Focus adjustment tool • Printed documentation • User documentation CD-ROM
Packaging, weight	
Packaging, size	295 × 200 × 105 mm (11.6 × 7.9 × 4.1 in.)
EAN-13	7332558005644
UPC-12	845188005856
Country of origin	Sweden

Supplies & accessories:

- T951004ACC; Ethernet cable CAT-6, 2m/6.6 ft.
- T198349; Base support
- T198348; Cable kit Mains (UK,EU,US)
- T911112; PoE injector
- T198392; Table stand kit
- T911183; Gigabit PoE injector 16 W, with multi-plugs
- T127605ACC; Cable M12 Pigtail
- T127606ACC; Cable M12 Sync
- T198342ACC; Focus adjustment tool
- T198584; FLIR Tools
- T198583; FLIR Tools+ (license only)
- DSW-10000; FLIR IR Camera Player

11.7 FLIR A15 f=9 mm with SC kit

P/N: 62309-0102

Rev.: 22369

General description	
<p>The FLIR A15 has features and functions that make it the natural choice for anyone who uses PC software to solve problems and for whom 160 × 128 pixel resolution is sufficient.</p> <p>Among its main features are GigE Vision and GenICam compliance, which makes it plug-and-play when used with software packages such as IMAQ Vision and Halcon.</p>	
Key features:	
<ul style="list-style-type: none"> • Very affordable. • Compact (40 mm × 43 mm × 106 mm). • GigE Vision and GenICam compliant. • GigE Vision lockable connector. • PoE (power over Ethernet). • 8-bit 160 × 128 pixel images streamed at 60 Hz, signal linear. • 14-bit 160 × 128 pixel images streamed at 60 Hz, signal and temperature linear. • High frame rates (60 Hz). • Synchronization between cameras possible. • 1x+1x GPIO. • Compliant with any software that supports GenICam, including National Instruments IMAQ Vision, Stemmers Common Vision Blox, and COGNEX Vision Pro. 	
Typical applications:	
<ul style="list-style-type: none"> • Automation and thermal machine vision. • Entry level "high-speed" R&D. 	
Imaging and optical data	
IR resolution	160 × 128 pixels
Thermal sensitivity/NETD	< 0.05°C @ +30°C (+86°F) / 50 mK
Field of view (FOV)	48° × 39°
Focal length	9 mm (0.35 in.)
Spatial resolution (IFOV)	5.56 mrad
F-number	1.25
Image frequency	60 Hz
Focus	Fixed
Detector data	
Detector type	Focal Plane Array (FPA), Uncooled VOX microbolometer
Spectral range	7.5–13 μm
Detector pitch	50 μm
Detector time constant	Typical 12 ms
Measurement	
Object temperature range	<ul style="list-style-type: none"> • -25 to +135°C (-13 to 275°F) • -40 to +550°C (-40 to +1022°F)
Accuracy	±5°C (±9°F) or ±5% of reading
Ethernet	
Ethernet	Control and image
Ethernet, type	Gigabit Ethernet
Ethernet, standard	IEEE 802.3
Ethernet, connector type	RJ-45

Ethernet	
Ethernet, communication	GigE Vision ver. 1.2 Client API GenICam compliant
Ethernet, image streaming	8-bit monochrome @ 60 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Automatic/ Manual • Flip H&V 14-bit 160 × 128 pixels @ 60 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Temperature linear GigE Vision and GenICam compatible
Ethernet, power	Power over Ethernet, PoE IEEE 802.3af class 0 Power
Ethernet, protocols	TCP, UDP, ICMP, IGMP, DHCP, GigEVision
Digital input/output	
Digital input, purpose	General purpose
Digital input	1× opto-isolated, "0" <2, "1"=2-12 VDC. NOTE: Maximum input 12 VDC. If the input is above 12 VDC without a resistor in series there is a risk of damaging the input. If the input is 24 VDC use a 1.2 kΩ resistor in series. In that case "1" = 3-24 VDC.
Digital output, purpose	General purpose Output to ext. device (programmatically set)
Digital output	1× opto-isolated, 2-40 VDC, max 185 mA
Digital I/O, isolation voltage	500 VRMS
Digital I/O, supply voltage	2-40 VDC, max 200 mA
Digital I/O, connector type	12-pole M12 connector (shared with Digital Synchronization and External power)
Synchronization In, purpose	Frame sync In to control camera
Synchronization In	1×, non-isolated
Synchronization In, type	LVC Buffer @ 3.3V, "0" <0.8 V, "1" >2.0 V.
Synchronization Out, purpose	Frame sync Out to control another Ax5 camera
Synchronization Out	1×, non-isolated
Synchronization Out, type	LVC Buffer @ 3.3V, "0"=24 mA max, "1"= -24 mA max.
Digital Synchronization, connector type	12-pole M12 connector (shared with Digital I/O and External power)
Power system	
External power operation	12/24 VDC, < 3.5 W nominal < 6.0 W absolute max
External power, connector type	12-pole M12 connector (shared with Digital I/O and Digital Synchronization)
Voltage	Allowed range 10-30 VDC
Environmental data	
Operating temperature range	-15°C to +50°C (+5°F to +122°F)
Storage temperature range	-40°C to +70°C (-40°F to +158°F)
Humidity (operating and storage)	IEC 60068-2-30/24 h 95% relative humidity +25°C to +40°C (+77°F to +104°F)

Environmental data	
EMC	<ul style="list-style-type: none"> • EN 61000-6-2 (Immunity) • EN 61000-6-3 (Emission) • FCC 47 CFR Part 15 Class B (Emission)
Encapsulation	IP 40 (IEC 60529) with base support mounted
Shock	25 g (IEC 60068-2-27)
Vibration	2 g (IEC 60068-2-6)
Physical data	
Weight	0.200 kg (0.44 lb.)
Camera size (L × W × H)	106 × 40 × 43 mm (4.2 × 1.6 × 1.7 in.)
Tripod mounting	UNC ¼"-20 (on three sides)
Base mounting	4 × M3 thread mounting holes (bottom)
Housing material	Magnesium and aluminum
Shipping information	
Packaging, type	Cardboard box
List of contents	<ul style="list-style-type: none"> • Hard transport case • Infrared camera with lens • Base support • Cable tie (2 ea.) • Ethernet cable CAT-6, 2m/6.6 ft (2 ea.) • FLIR ResearchIR Standard 4 • Focus adjustment tool • Gooseneck • Mains cable kit (UK,EU,US) • PoE Injector (power over Ethernet) • Printed documentation • Table stand • User documentation CD-ROM
Packaging, weight	
Packaging, size	370 × 180 × 320 mm (14.6 × 7.1 × 12.6 in.)
EAN-13	7332558003985 4743254000612 (Estonia plant)
UPC-12	845188003562
Country of origin	Sweden

Supplies & accessories:

- T951004ACC; Ethernet cable CAT-6, 2m/6.6 ft.
- T198349; Base support
- T198348; Cable kit Mains (UK,EU,US)
- T911112; PoE injector
- T198371; Transport case Ax5
- T198392; Table stand kit
- T911183; Gigabit PoE injector 16 W, with multi-plugs
- T127605ACC; Cable M12 Pigtail
- T127606ACC; Cable M12 Sync
- T198342ACC; Focus adjustment tool
- T198584; FLIR Tools
- T198583; FLIR Tools+ (license only)
- DSW-10000; FLIR IR Camera Player

11.8 FLIR A15 f=9 mm with SC kit (7.5 Hz)

P/N: 64309-0102

Rev.: 22369

General description	
<p>The FLIR A15 has features and functions that make it the natural choice for anyone who uses PC software to solve problems and for whom 160 × 128 pixel resolution is sufficient.</p> <p>Among its main features are GigE Vision and GenICam compliance, which makes it plug-and-play when used with software packages such as IMAQ Vision and Halcon.</p>	
Key features:	
<ul style="list-style-type: none"> • Very affordable. • Compact (40 mm × 43 mm × 106 mm). • GigE Vision and GenICam compliant. • GigE Vision lockable connector. • PoE (power over Ethernet). • 8-bit 160 × 128 pixel images streamed at 7.5 Hz, signal linear. • 14-bit 160 × 128 pixel images streamed at 7.5 Hz, signal and temperature linear. • Synchronization between cameras possible. • 1x+1x GPIO. • Compliant with any software that supports GenICam, including National Instruments IMAQ Vision, Stemmers Common Vision Blox, and COGNEX Vision Pro. 	
Typical applications:	
<ul style="list-style-type: none"> • Automation and thermal machine vision. • Entry level “high-speed” R&D. 	
Imaging and optical data	
IR resolution	160 × 128 pixels
Thermal sensitivity/NETD	< 0.05°C @ +30°C (+86°F) / 50 mK
Field of view (FOV)	48° × 39°
Focal length	9 mm (0.35 in.)
Spatial resolution (IFOV)	5.56 mrad
F-number	1.25
Image frequency	7.5 Hz
Focus	Fixed
Detector data	
Detector type	Focal Plane Array (FPA), Uncooled VOX microbolometer
Spectral range	7.5–13 μm
Detector pitch	50 μm
Detector time constant	Typical 12 ms
Measurement	
Object temperature range	<ul style="list-style-type: none"> • –25 to +135°C (–13 to 275°F) • –40 to +550°C (–40 to +1022°F)
Accuracy	±5°C (±9°F) or ±5% of reading
Ethernet	
Ethernet	Control and image
Ethernet, type	Gigabit Ethernet
Ethernet, standard	IEEE 802.3
Ethernet, connector type	RJ-45
Ethernet, communication	GigE Vision ver. 1.2 Client API GenICam compliant

Ethernet	
Ethernet, image streaming	8-bit monochrome @ 7.5 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Automatic/ Manual • Flip H&V 14-bit 160 × 128 pixels @ 7.5 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Temperature linear GigE Vision and GenICam compatible
Ethernet, power	Power over Ethernet, PoE IEEE 802.3af class 0 Power
Ethernet, protocols	TCP, UDP, ICMP, IGMP, DHCP, GigE Vision
Digital input/output	
Digital input, purpose	General purpose
Digital input	1× opto-isolated, "0" <2, "1"=2-12 VDC. NOTE: Maximum input 12 VDC. If the input is above 12 VDC without a resistor in series there is a risk of damaging the input. If the input is 24 VDC use a 1.2 kΩ resistor in series. In that case "1" = 3-24 VDC.
Digital output, purpose	General purpose Output to ext. device (programmatically set)
Digital output	1× opto-isolated, 2-40 VDC, max 185 mA
Digital I/O, isolation voltage	500 VRMS
Digital I/O, supply voltage	2-40 VDC, max 200 mA
Digital I/O, connector type	12-pole M12 connector (shared with Digital Synchronization and External power)
Synchronization In, purpose	Frame sync In to control camera
Synchronization In	1×, non-isolated
Synchronization In, type	LVC Buffer @3.3V, "0" <0.8 V, "1">2.0 V.
Synchronization Out, purpose	Frame sync Out to control another Ax5 camera
Synchronization Out	1×, non-isolated
Synchronization Out, type	LVC Buffer @ 3.3V, "0"=24 MA max, "1"= -24 mA max.
Digital Synchronization, connector type	12-pole M12 connector (shared with Digital I/O and External power)
Power system	
External power operation	12/24 VDC, < 3.5 W nominal < 6.0 W absolute max
External power, connector type	12-pole M12 connector (shared with Digital I/O and Digital Synchronization)
Voltage	Allowed range 10-30 VDC
Environmental data	
Operating temperature range	-15°C to +50°C (+5°F to +122°F)
Storage temperature range	-40°C to +70°C (-40°F to +158°F)
Humidity (operating and storage)	IEC 60068-2-30/24 h 95% relative humidity +25°C to +40°C (+77°F to +104°F)
EMC	<ul style="list-style-type: none"> • EN 61000-6-2 (Immunity) • EN 61000-6-3 (Emission) • FCC 47 CFR Part 15 Class B (Emission)
Encapsulation	IP 40 (IEC 60529) with base support mounted

Environmental data	
Shock	25 g (IEC 60068-2-27)
Vibration	2 g (IEC 60068-2-6)
Physical data	
Weight	0.200 kg (0.44 lb.)
Camera size (L × W × H)	106 × 40 × 43 mm (4.2 × 1.6 × 1.7 in.)
Tripod mounting	UNC ¼"-20 (on three sides)
Base mounting	4 × M3 thread mounting holes (bottom)
Housing material	Magnesium and aluminum
Shipping information	
Packaging, type	Cardboard box
List of contents	<ul style="list-style-type: none"> • Hard transport case • Infrared camera with lens • Base support • Cable tie (2 ea.) • Ethernet cable CAT-6, 2m/6.6 ft (2 ea.) • FLIR ResearchIR Standard 4 • Focus adjustment tool • Gooseneck • Mains cable kit (UK,EU,US) • PoE Injector (power over Ethernet) • Printed documentation • Table stand • User documentation CD-ROM
Packaging, weight	
Packaging, size	370 × 180 × 320 mm (14.6 × 7.1 × 12.6 in.)
EAN-13	7332558005651
UPC-12	845188005863
Country of origin	Sweden

Supplies & accessories:

- T951004ACC; Ethernet cable CAT-6, 2m/6.6 ft.
- T198349; Base support
- T198348; Cable kit Mains (UK,EU,US)
- T911112; PoE injector
- T198371; Transport case Ax5
- T198392; Table stand kit
- T911183; Gigabit PoE injector 16 W, with multi-plugs
- T127605ACC; Cable M12 Pigtail
- T127606ACC; Cable M12 Sync
- T198342ACC; Focus adjustment tool
- T198584; FLIR Tools
- T198583; FLIR Tools+ (license only)
- DSW-10000; FLIR IR Camera Player

11.9 FLIR A35 f=19 mm

P/N: 63219-0101

Rev.: 22369

General description	
<p>The FLIR A35 has features and functions that make it the natural choice for anyone who uses PC software to solve problems and for whom 320 × 256 pixel resolution is sufficient.</p> <p>Among its main features are GigE Vision and GenICam compliance, which makes it plug-and-play when used with software packages such as IMAQ Vision and Halcon.</p>	
Key features:	
<ul style="list-style-type: none"> • Very affordable. • Compact (40 mm × 43 mm × 106 mm). • GigE Vision and GenICam compliant. • GigE Vision lockable connector. • PoE (power over Ethernet). • 8-bit 320 × 256 pixel images streamed at 60 Hz, signal linear. • 14-bit 320 × 256 pixel images streamed at 60 Hz, signal and temperature linear. • High frame rates (60 Hz). • Synchronization between cameras possible. • 1x+1x GPIO. • Compliant with any software that supports GenICam, including National Instruments IMAQ Vision, Stemmers Common Vision Blox, and COGNEX Vision Pro. 	
Typical applications:	
<ul style="list-style-type: none"> • Automation and thermal machine vision. • Entry level "high-speed" R&D. 	
Imaging and optical data	
IR resolution	320 × 256 pixels
Thermal sensitivity/NETD	< 0.05°C @ +30°C (+86°F) / 50 mK
Field of view (FOV)	25° × 19°
Focal length	19 mm (0.75 in.)
Spatial resolution (IFOV)	1.32 mrad
F-number	1.25
Image frequency	60 Hz
Focus	Fixed
Detector data	
Detector type	Focal Plane Array (FPA), Uncooled VOX microbolometer
Spectral range	7.5–13 μm
Detector pitch	25 μm
Detector time constant	Typical 12 ms
Measurement	
Object temperature range	<ul style="list-style-type: none"> • -25 to +135°C (-13 to 275°F) • -40 to +550°C (-40 to +1022°F)
Accuracy	±5°C (±9°F) or ±5% of reading
Ethernet	
Ethernet	Control and image
Ethernet, type	Gigabit Ethernet
Ethernet, standard	IEEE 802.3
Ethernet, connector type	RJ-45

Ethernet	
Ethernet, communication	GigE Vision ver. 1.2 Client API GenICam compliant
Ethernet, image streaming	8-bit monochrome @ 60 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Automatic/ Manual • Flip H&V 14-bit 320 × 256 pixels @ 60 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Temperature linear GigE Vision and GenICam compatible
Ethernet, power	Power over Ethernet, PoE IEEE 802.3af class 0 Power
Ethernet, protocols	TCP, UDP, ICMP, IGMP, DHCP, GigE Vision
Digital input/output	
Digital input, purpose	General purpose
Digital input	1× opto-isolated, "0" <2, "1"=2-12 VDC. NOTE: Maximum input 12 VDC. If the input is above 12 VDC without a resistor in series there is a risk of damaging the input. If the input is 24 VDC use a 1.2 kΩ resistor in series. In that case "1" = 3-24 VDC.
Digital output, purpose	General purpose Output to ext. device (programmatically set)
Digital output	1× opto-isolated, 2-40 VDC, max 185 mA
Digital I/O, isolation voltage	500 VRMS
Digital I/O, supply voltage	2-40 VDC, max 200 mA
Digital I/O, connector type	12-pole M12 connector (shared with Digital Synchronization and External power)
Synchronization In, purpose	Frame sync In to control camera
Synchronization In	1×, non-isolated
Synchronization In, type	LVC Buffer @ 3.3V, "0" <0.8 V, "1" >2.0 V.
Synchronization Out, purpose	Frame sync Out to control another Ax5 camera
Synchronization Out	1×, non-isolated
Synchronization Out, type	LVC Buffer @ 3.3V, "0"=24 mA max, "1"= -24 mA max.
Digital Synchronization, connector type	12-pole M12 connector (shared with Digital I/O and External power)
Power system	
External power operation	12/24 VDC, < 3.5 W nominal < 6.0 W absolute max
External power, connector type	12-pole M12 connector (shared with Digital I/O and Digital Synchronization)
Voltage	Allowed range 10-30 VDC
Environmental data	
Operating temperature range	-15°C to +50°C (+5°F to +122°F)
Storage temperature range	-40°C to +70°C (-40°F to +158°F)
Humidity (operating and storage)	IEC 60068-2-30/24 h 95% relative humidity +25°C to +40°C (+77°F to +104°F)

Environmental data	
EMC	<ul style="list-style-type: none"> • EN 61000-6-2 (Immunity) • EN 61000-6-3 (Emission) • FCC 47 CFR Part 15 Class B (Emission)
Encapsulation	IP 40 (IEC 60529) with base support mounted
Shock	25 g (IEC 60068-2-27)
Vibration	2 g (IEC 60068-2-6)
Physical data	
Weight	0.200 kg (0.44 lb.)
Camera size (L × W × H)	106 × 40 × 43 mm (4.2 × 1.6 × 1.7 in.)
Tripod mounting	UNC ¼"-20 (on three sides)
Base mounting	4 × M3 thread mounting holes (bottom)
Housing material	Magnesium and aluminum
Shipping information	
Packaging, type	Cardboard box
List of contents	<ul style="list-style-type: none"> • Infrared camera with lens • FLIR Tools download card • Focus adjustment tool • Printed documentation • User documentation CD-ROM
Packaging, weight	
Packaging, size	295 × 200 × 105 mm (11.6 × 7.9 × 4.1 in.)
EAN-13	7332558004104 4743254000568 (Estonia plant)
UPC-12	845188003517
Country of origin	Sweden

Supplies & accessories:

- T951004ACC; Ethernet cable CAT-6, 2m/6.6 ft.
- T198349; Base support
- T198348; Cable kit Mains (UK,EU,US)
- T911112; PoE injector
- T198392; Table stand kit
- T911183; Gigabit PoE injector 16 W, with multi-plugs
- T127605ACC; Cable M12 Pigtail
- T127606ACC; Cable M12 Sync
- T198342ACC; Focus adjustment tool
- T198584; FLIR Tools
- T198583; FLIR Tools+ (license only)
- DSW-10000; FLIR IR Camera Player

11.10 FLIR A35 f=9 mm

P/N: 63209-0101

Rev.: 22369

General description	
<p>The FLIR A35 has features and functions that make it the natural choice for anyone who uses PC software to solve problems and for whom 320 × 256 pixel resolution is sufficient.</p> <p>Among its main features are GigE Vision and GenICam compliance, which makes it plug-and-play when used with software packages such as IMAQ Vision and Halcon.</p>	
Key features:	
<ul style="list-style-type: none"> • Very affordable. • Compact (40 mm × 43 mm × 106 mm). • GigE Vision and GenICam compliant. • GigE Vision lockable connector. • PoE (power over Ethernet). • 8-bit 320 × 256 pixel images streamed at 60 Hz, signal linear. • 14-bit 320 × 256 pixel images streamed at 60 Hz, signal and temperature linear. • High frame rates (60 Hz). • Synchronization between cameras possible. • 1x+1x GPIO. • Compliant with any software that supports GenICam, including National Instruments IMAQ Vision, Stemmers Common Vision Blox, and COGNEX Vision Pro. 	
Typical applications:	
<ul style="list-style-type: none"> • Automation and thermal machine vision. • Entry level "high-speed" R&D. 	
Imaging and optical data	
IR resolution	320 × 256 pixels
Thermal sensitivity/NETD	< 0.05°C @ +30°C (+86°F) / 50 mK
Field of view (FOV)	48° × 39°
Focal length	9 mm (0.35 in.)
Spatial resolution (IFOV)	2.78 mrad
F-number	1.25
Image frequency	60 Hz
Focus	Fixed
Detector data	
Detector type	Focal Plane Array (FPA), Uncooled VOX microbolometer
Spectral range	7.5–13 μm
Detector pitch	25 μm
Detector time constant	Typical 12 ms
Measurement	
Object temperature range	<ul style="list-style-type: none"> • -25 to +135°C (-13 to 275°F) • -40 to +550°C (-40 to +1022°F)
Accuracy	±5°C (±9°F) or ±5% of reading
Ethernet	
Ethernet	Control and image
Ethernet, type	Gigabit Ethernet
Ethernet, standard	IEEE 802.3
Ethernet, connector type	RJ-45

Ethernet	
Ethernet, communication	GigE Vision ver. 1.2 Client API GenICam compliant
Ethernet, image streaming	8-bit monochrome @ 60 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Automatic/ Manual • Flip H&V 14-bit 320 × 256 pixels @ 60 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Temperature linear GigE Vision and GenICam compatible
Ethernet, power	Power over Ethernet, PoE IEEE 802.3af class 0 Power
Ethernet, protocols	TCP, UDP, ICMP, IGMP, DHCP, GigE Vision
Digital input/output	
Digital input, purpose	General purpose
Digital input	1× opto-isolated, "0" <2, "1"=2-12 VDC. NOTE: Maximum input 12 VDC. If the input is above 12 VDC without a resistor in series there is a risk of damaging the input. If the input is 24 VDC use a 1.2 kΩ resistor in series. In that case "1" = 3-24 VDC.
Digital output, purpose	General purpose Output to ext. device (programmatically set)
Digital output	1× opto-isolated, 2-40 VDC, max 185 mA
Digital I/O, isolation voltage	500 VRMS
Digital I/O, supply voltage	2-40 VDC, max 200 mA
Digital I/O, connector type	12-pole M12 connector (shared with Digital Synchronization and External power)
Synchronization In, purpose	Frame sync In to control camera
Synchronization In	1×, non-isolated
Synchronization In, type	LVC Buffer @ 3.3V, "0" <0.8 V, "1" >2.0 V.
Synchronization Out, purpose	Frame sync Out to control another Ax5 camera
Synchronization Out	1×, non-isolated
Synchronization Out, type	LVC Buffer @ 3.3V, "0"=24 mA max, "1"= -24 mA max.
Digital Synchronization, connector type	12-pole M12 connector (shared with Digital I/O and External power)
Power system	
External power operation	12/24 VDC, < 3.5 W nominal < 6.0 W absolute max
External power, connector type	12-pole M12 connector (shared with Digital I/O and Digital Synchronization)
Voltage	Allowed range 10-30 VDC
Environmental data	
Operating temperature range	-15°C to +50°C (+5°F to +122°F)
Storage temperature range	-40°C to +70°C (-40°F to +158°F)
Humidity (operating and storage)	IEC 60068-2-30/24 h 95% relative humidity +25°C to +40°C (+77°F to +104°F)

Environmental data	
EMC	<ul style="list-style-type: none"> • EN 61000-6-2 (Immunity) • EN 61000-6-3 (Emission) • FCC 47 CFR Part 15 Class B (Emission)
Encapsulation	IP 40 (IEC 60529) with base support mounted
Shock	25 g (IEC 60068-2-27)
Vibration	2 g (IEC 60068-2-6)
Physical data	
Weight	0.200 kg (0.44 lb.)
Camera size (L × W × H)	106 × 40 × 43 mm (4.2 × 1.6 × 1.7 in.)
Tripod mounting	UNC ¼"-20 (on three sides)
Base mounting	4 × M3 thread mounting holes (bottom)
Housing material	Magnesium and aluminum
Shipping information	
Packaging, type	Cardboard box
List of contents	<ul style="list-style-type: none"> • Infrared camera with lens • FLIR Tools download card • Focus adjustment tool • Printed documentation • User documentation CD-ROM
Packaging, weight	
Packaging, size	295 × 200 × 105 mm (11.6 × 7.9 × 4.1 in.)
EAN-13	7332558004081 4743254000551 (Estonia plant)
UPC-12	845188003500
Country of origin	Sweden

Supplies & accessories:

- T951004ACC; Ethernet cable CAT-6, 2m/6.6 ft.
- T198349; Base support
- T198348; Cable kit Mains (UK,EU,US)
- T911112; PoE injector
- T198392; Table stand kit
- T911183; Gigabit PoE injector 16 W, with multi-plugs
- T127605ACC; Cable M12 Pigtail
- T127606ACC; Cable M12 Sync
- T198342ACC; Focus adjustment tool
- T198584; FLIR Tools
- T198583; FLIR Tools+ (license only)
- DSW-10000; FLIR IR Camera Player

11.11 FLIR A35 f=9 mm with SC kit

P/N: 63209-0102

Rev.: 22369

General description	
<p>The FLIR A35 has features and functions that make it the natural choice for anyone who uses PC software to solve problems and for whom 320 × 256 pixel resolution is sufficient.</p> <p>Among its main features are GigE Vision and GenICam compliance, which makes it plug-and-play when used with software packages such as IMAQ Vision and Halcon.</p>	
Key features:	
<ul style="list-style-type: none"> • Very affordable. • Compact (40 mm × 43 mm × 106 mm). • GigE Vision and GenICam compliant. • GigE Vision lockable connector. • PoE (power over Ethernet). • 8-bit 320 × 256 pixel images streamed at 60 Hz, signal linear. • 14-bit 320 × 256 pixel images streamed at 60 Hz, signal and temperature linear. • High frame rates (60 Hz). • Synchronization between cameras possible. • 1x+1x GPIO. • Compliant with any software that supports GenICam, including National Instruments IMAQ Vision, Stemmers Common Vision Blox, and COGNEX Vision Pro. 	
Typical applications:	
<ul style="list-style-type: none"> • Automation and thermal machine vision. • Entry level "high-speed" R&D. 	
Imaging and optical data	
IR resolution	320 × 256 pixels
Thermal sensitivity/NETD	< 0.05°C @ +30°C (+86°F) / 50 mK
Field of view (FOV)	48° × 39°
Focal length	9 mm (0.35 in.)
Spatial resolution (IFOV)	2.78 mrad
F-number	1.25
Image frequency	60 Hz
Focus	Fixed
Detector data	
Detector type	Focal Plane Array (FPA), Uncooled VOX microbolometer
Spectral range	7.5–13 μm
Detector pitch	25 μm
Detector time constant	Typical 12 ms
Measurement	
Object temperature range	<ul style="list-style-type: none"> • -25 to +135°C (-13 to 275°F) • -40 to +550°C (-40 to +1022°F)
Accuracy	±5°C (±9°F) or ±5% of reading
Ethernet	
Ethernet	Control and image
Ethernet, type	Gigabit Ethernet
Ethernet, standard	IEEE 802.3
Ethernet, connector type	RJ-45

Ethernet	
Ethernet, communication	GigE Vision ver. 1.2 Client API GenICam compliant
Ethernet, image streaming	8-bit monochrome @ 60 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Automatic/ Manual • Flip H&V 14-bit 320 × 256 pixels @ 60 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Temperature linear GigE Vision and GenICam compatible
Ethernet, power	Power over Ethernet, PoE IEEE 802.3af class 0 Power
Ethernet, protocols	TCP, UDP, ICMP, IGMP, DHCP, GigE Vision
Digital input/output	
Digital input, purpose	General purpose
Digital input	1× opto-isolated, "0" <2, "1"=2-12 VDC. NOTE: Maximum input 12 VDC. If the input is above 12 VDC without a resistor in series there is a risk of damaging the input. If the input is 24 VDC use a 1.2 kΩ resistor in series. In that case "1" = 3-24 VDC.
Digital output, purpose	General purpose Output to ext. device (programmatically set)
Digital output	1× opto-isolated, 2-40 VDC, max 185 mA
Digital I/O, isolation voltage	500 VRMS
Digital I/O, supply voltage	2-40 VDC, max 200 mA
Digital I/O, connector type	12-pole M12 connector (shared with Digital Synchronization and External power)
Synchronization In, purpose	Frame sync In to control camera
Synchronization In	1×, non-isolated
Synchronization In, type	LVC Buffer @ 3.3V, "0" <0.8 V, "1" >2.0 V.
Synchronization Out, purpose	Frame sync Out to control another Ax5 camera
Synchronization Out	1×, non-isolated
Synchronization Out, type	LVC Buffer @ 3.3V, "0"=24 mA max, "1"= -24 mA max.
Digital Synchronization, connector type	12-pole M12 connector (shared with Digital I/O and External power)
Power system	
External power operation	12/24 VDC, < 3.5 W nominal < 6.0 W absolute max
External power, connector type	12-pole M12 connector (shared with Digital I/O and Digital Synchronization)
Voltage	Allowed range 10-30 VDC
Environmental data	
Operating temperature range	-15°C to +50°C (+5°F to +122°F)
Storage temperature range	-40°C to +70°C (-40°F to +158°F)
Humidity (operating and storage)	IEC 60068-2-30/24 h 95% relative humidity +25°C to +40°C (+77°F to +104°F)

Environmental data	
EMC	<ul style="list-style-type: none"> • EN 61000-6-2 (Immunity) • EN 61000-6-3 (Emission) • FCC 47 CFR Part 15 Class B (Emission)
Encapsulation	IP 40 (IEC 60529) with base support mounted
Shock	25 g (IEC 60068-2-27)
Vibration	2 g (IEC 60068-2-6)
Physical data	
Weight	0.200 kg (0.44 lb.)
Camera size (L × W × H)	106 × 40 × 43 mm (4.2 × 1.6 × 1.7 in.)
Tripod mounting	UNC ¼"-20 (on three sides)
Base mounting	4 × M3 thread mounting holes (bottom)
Housing material	Magnesium and aluminum
Shipping information	
Packaging, type	Cardboard box
List of contents	<ul style="list-style-type: none"> • Hard transport case • Infrared camera with lens • Base support • Cable tie (2 ea.) • Ethernet cable CAT-6, 2m/6.6 ft (2 ea.) • FLIR ResearchIR Standard 4 • Focus adjustment tool • Gooseneck • Mains cable kit (UK,EU,US) • PoE Injector (power over Ethernet) • Printed documentation • Table stand • User documentation CD-ROM
Packaging, weight	
Packaging, size	370 × 180 × 320 mm (14.6 × 7.1 × 12.6 in.)
EAN-13	7332558004098
UPC-12	845188003524
Country of origin	Sweden

Supplies & accessories:

- T951004ACC; Ethernet cable CAT-6, 2m/6.6 ft.
- T198349; Base support
- T198348; Cable kit Mains (UK,EU,US)
- T911112; PoE injector
- T198371; Transport case Ax5
- T198392; Table stand kit
- T911183; Gigabit PoE injector 16 W, with multi-plugs
- T127605ACC; Cable M12 Pigtail
- T127606ACC; Cable M12 Sync
- T198342ACC; Focus adjustment tool
- T198584; FLIR Tools
- T198583; FLIR Tools+ (license only)
- DSW-10000; FLIR IR Camera Player

11.12 FLIR A5 f=5 mm

P/N: 62205-0101

Rev.: 22369

General description	
<p>The FLIR A5 has features and functions that make it the natural choice for anyone who uses PC software to solve problems and for whom 80 × 64 pixel resolution is sufficient.</p> <p>Among its main features are GigE Vision and GenICam compliance, which makes it plug-and-play when used with software packages such as IMAQ Vision and Halcon.</p>	
Key features:	
<ul style="list-style-type: none"> • Very affordable. • Compact (40 mm × 43 mm × 106 mm). • GigE Vision and GenICam compliant. • GigE Vision lockable connector. • PoE (power over Ethernet). • 8-bit 80 × 64 pixel images streamed at 60 Hz, signal linear. • 14-bit 80 × 64 pixel images streamed at 60 Hz, signal and temperature linear. • High frame rates (60 Hz). • Synchronization between cameras possible. • 1x+1x GPIO. • Compliant with any software that supports GenICam, including National Instruments IMAQ Vision, Stemmers Common Vision Blox, and COGNEX Vision Pro. 	
Typical applications:	
<ul style="list-style-type: none"> • Automation and thermal machine vision. • Entry level "high-speed" R&D. 	
Imaging and optical data	
IR resolution	80 × 64 pixels
Thermal sensitivity/NETD	< 0.05°C @ +30°C (+86°F) / 50 mK
Field of view (FOV)	44° × 36°
Focal length	5 mm (0.20 in.)
Spatial resolution (IFOV)	10.0 mrad
F-number	1.25
Image frequency	60 Hz
Focus	Fixed
Detector data	
Detector type	Focal Plane Array (FPA), Uncooled VOX microbolometer
Spectral range	7.5–13 μm
Detector pitch	50 μm
Detector time constant	Typical 12 ms
Measurement	
Object temperature range	<ul style="list-style-type: none"> • –25 to +135°C (–13 to 275°F) • –40 to +550°C (–40 to +1022°F)
Accuracy	±5°C (±9°F) or ±5% of reading
Ethernet	
Ethernet	Control and image
Ethernet, type	Gigabit Ethernet
Ethernet, standard	IEEE 802.3
Ethernet, connector type	RJ-45

Ethernet	
Ethernet, communication	GigE Vision ver. 1.2 Client API GenICam compliant
Ethernet, image streaming	8-bit monochrome @ 60 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Automatic/ Manual • Flip H&V 14-bit 80 × 64 pixels @ 60 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Temperature linear GigE Vision and GenICam compatible
Ethernet, power	Power over Ethernet, PoE IEEE 802.3af class 0 Power
Ethernet, protocols	TCP, UDP, ICMP, IGMP, DHCP, GigE Vision
Digital input/output	
Digital input, purpose	General purpose
Digital input	1× opto-isolated, "0" <2, "1"=2-12 VDC. NOTE: Maximum input 12 VDC. If the input is above 12 VDC without a resistor in series there is a risk of damaging the input. If the input is 24 VDC use a 1.2 kΩ resistor in series. In that case "1" = 3-24 VDC.
Digital output, purpose	General purpose Output to ext. device (programmatically set)
Digital output	1× opto-isolated, 2-40 VDC, max 185 mA
Digital I/O, isolation voltage	500 VRMS
Digital I/O, supply voltage	2-40 VDC, max 200 mA
Digital I/O, connector type	12-pole M12 connector (shared with Digital Synchronization and External power)
Synchronization In, purpose	Frame sync In to control camera
Synchronization In	1×, non-isolated
Synchronization In, type	LVC Buffer @ 3.3V, "0" <0.8 V, "1" >2.0 V.
Synchronization Out, purpose	Frame sync Out to control another Ax5 camera
Synchronization Out	1×, non-isolated
Synchronization Out, type	LVC Buffer @ 3.3V, "0"=24 mA max, "1"= -24 mA max.
Digital Synchronization, connector type	12-pole M12 connector (shared with Digital I/O and External power)
Power system	
External power operation	12/24 VDC, < 3.5 W nominal < 6.0 W absolute max
External power, connector type	12-pole M12 connector (shared with Digital I/O and Digital Synchronization)
Voltage	Allowed range 10-30 VDC
Environmental data	
Operating temperature range	-15°C to +50°C (+5°F to +122°F)
Storage temperature range	-40°C to +70°C (-40°F to +158°F)
Humidity (operating and storage)	IEC 60068-2-30/24 h 95% relative humidity +25°C to +40°C (+77°F to +104°F)

Environmental data	
EMC	<ul style="list-style-type: none"> • EN 61000-6-2 (Immunity) • EN 61000-6-3 (Emission) • FCC 47 CFR Part 15 Class B (Emission)
Encapsulation	IP 40 (IEC 60529) with base support mounted
Shock	25 g (IEC 60068-2-27)
Vibration	2 g (IEC 60068-2-6)
Physical data	
Weight	0.200 kg (0.44 lb.)
Camera size (L × W × H)	106 × 40 × 43 mm (4.2 × 1.6 × 1.7 in.)
Tripod mounting	UNC ¼"-20 (on three sides)
Base mounting	4 × M3 thread mounting holes (bottom)
Housing material	Magnesium and aluminum
Shipping information	
Packaging, type	Cardboard box
List of contents	<ul style="list-style-type: none"> • Infrared camera with lens • FLIR Tools download card • Focus adjustment tool • Printed documentation • User documentation CD-ROM
Packaging, weight	
Packaging, size	295 × 200 × 105 mm (11.6 × 7.9 × 4.1 in.)
EAN-13	7332558003930 4743254000636 (Estonia plant)
UPC-12	845188003586
Country of origin	Sweden

Supplies & accessories:

- T951004ACC; Ethernet cable CAT-6, 2m/6.6 ft.
- T198349; Base support
- T198348; Cable kit Mains (UK,EU,US)
- T911112; PoE injector
- T198392; Table stand kit
- T911183; Gigabit PoE injector 16 W, with multi-plugs
- T127605ACC; Cable M12 Pigtail
- T127606ACC; Cable M12 Sync
- T198342ACC; Focus adjustment tool
- T198584; FLIR Tools
- T198583; FLIR Tools+ (license only)
- DSW-10000; FLIR IR Camera Player

11.13 FLIR A5 f=5 mm (7.5 Hz)

P/N: 64205-0101

Rev.: 22369

General description	
<p>The FLIR A5 has features and functions that make it the natural choice for anyone who uses PC software to solve problems and for whom 80 × 64 pixel resolution is sufficient.</p> <p>Among its main features are GigE Vision and GenICam compliance, which makes it plug-and-play when used with software packages such as IMAQ Vision and Halcon.</p>	
Key features:	
<ul style="list-style-type: none"> • Very affordable. • Compact (40 mm × 43 mm × 106 mm). • GigE Vision and GenICam compliant. • GigE Vision lockable connector. • PoE (power over Ethernet). • 8-bit 80 × 64 pixel images streamed at 7.5 Hz, signal linear. • 14-bit 80 × 64 pixel images streamed at 7.5 Hz, signal and temperature linear. • Synchronization between cameras possible. • 1x+1x GPIO. • Compliant with any software that supports GenICam, including National Instruments IMAQ Vision, Stemmers Common Vision Blox, and COGNEX Vision Pro. 	
Typical applications:	
<ul style="list-style-type: none"> • Automation and thermal machine vision. • Entry level "high-speed" R&D. 	
Imaging and optical data	
IR resolution	80 × 64 pixels
Thermal sensitivity/NETD	< 0.05°C @ +30°C (+86°F) / 50 mK
Field of view (FOV)	44° × 36°
Focal length	5 mm (0.20 in.)
Spatial resolution (IFOV)	10.0 mrad
F-number	1.25
Image frequency	7.5 Hz
Focus	Fixed
Detector data	
Detector type	Focal Plane Array (FPA), Uncooled VOX microbolometer
Spectral range	7.5–13 μm
Detector pitch	50 μm
Detector time constant	Typical 12 ms
Measurement	
Object temperature range	<ul style="list-style-type: none"> • -25 to +135°C (-13 to 275°F) • -40 to +550°C (-40 to +1022°F)
Accuracy	±5°C (±9°F) or ±5% of reading
Ethernet	
Ethernet	Control and image
Ethernet, type	Gigabit Ethernet
Ethernet, standard	IEEE 802.3
Ethernet, connector type	RJ-45
Ethernet, communication	GigE Vision ver. 1.2 Client API GenICam compliant

Ethernet	
Ethernet, image streaming	8-bit monochrome @ 7.5 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Automatic/ Manual • Flip H&V 14-bit 80 × 64 pixels @ 7.5 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Temperature linear GigE Vision and GenICam compatible
Ethernet, power	Power over Ethernet, PoE IEEE 802.3af class 0 Power
Ethernet, protocols	TCP, UDP, ICMP, IGMP, DHCP, GigEVision
Digital input/output	
Digital input, purpose	General purpose
Digital input	1× opto-isolated, "0" <2, "1"=2-12 VDC. NOTE: Maximum input 12 VDC. If the input is above 12 VDC without a resistor in series there is a risk of damaging the input. If the input is 24 VDC use a 1.2 kΩ resistor in series. In that case "1" = 3-24 VDC.
Digital output, purpose	General purpose Output to ext. device (programmatically set)
Digital output	1× opto-isolated, 2-40 VDC, max 185 mA
Digital I/O, isolation voltage	500 VRMS
Digital I/O, supply voltage	2-40 VDC, max 200 mA
Digital I/O, connector type	12-pole M12 connector (shared with Digital Synchronization and External power)
Synchronization In, purpose	Frame sync In to control camera
Synchronization In	1×, non-isolated
Synchronization In, type	LVC Buffer @3.3V, "0" <0.8 V, "1">2.0 V.
Synchronization Out, purpose	Frame sync Out to control another Ax5 camera
Synchronization Out	1×, non-isolated
Synchronization Out, type	LVC Buffer @ 3.3V, "0"=24 MA max, "1"= -24 mA max.
Digital Synchronization, connector type	12-pole M12 connector (shared with Digital I/O and External power)
Power system	
External power operation	12/24 VDC, < 3.5 W nominal < 6.0 W absolute max
External power, connector type	12-pole M12 connector (shared with Digital I/O and Digital Synchronization)
Voltage	Allowed range 10-30 VDC
Environmental data	
Operating temperature range	-15°C to +50°C (+5°F to +122°F)
Storage temperature range	-40°C to +70°C (-40°F to +158°F)
Humidity (operating and storage)	IEC 60068-2-30/24 h 95% relative humidity +25°C to +40°C (+77°F to +104°F)
EMC	<ul style="list-style-type: none"> • EN 61000-6-2 (Immunity) • EN 61000-6-3 (Emission) • FCC 47 CFR Part 15 Class B (Emission)
Encapsulation	IP 40 (IEC 60529) with base support mounted

Environmental data	
Shock	25 g (IEC 60068-2-27)
Vibration	2 g (IEC 60068-2-6)
Physical data	
Weight	0.200 kg (0.44 lb.)
Camera size (L × W × H)	106 × 40 × 43 mm (4.2 × 1.6 × 1.7 in.)
Tripod mounting	UNC ¼"-20 (on three sides)
Base mounting	4 × M3 thread mounting holes (bottom)
Housing material	Magnesium and aluminum
Shipping information	
Packaging, type	Cardboard box
List of contents	<ul style="list-style-type: none"> • Infrared camera with lens • FLIR Tools download card • Focus adjustment tool • Printed documentation • User documentation CD-ROM
Packaging, weight	
Packaging, size	295 × 200 × 105 mm (11.6 × 7.9 × 4.1 in.)
EAN-13	7332558005620
UPC-12	845188005832
Country of origin	Sweden

Supplies & accessories:

- T951004ACC; Ethernet cable CAT-6, 2m/6.6 ft.
- T198349; Base support
- T198348; Cable kit Mains (UK,EU,US)
- T911112; PoE injector
- T198392; Table stand kit
- T911183; Gigabit PoE injector 16 W, with multi-plugs
- T127605ACC; Cable M12 Pigtail
- T127606ACC; Cable M12 Sync
- T198342ACC; Focus adjustment tool
- T198584; FLIR Tools
- T198583; FLIR Tools+ (license only)
- DSW-10000; FLIR IR Camera Player

11.14 FLIR A5 f=5 mm with SC kit

P/N: 62205-0102

Rev.: 22369

General description	
<p>The FLIR A5 has features and functions that make it the natural choice for anyone who uses PC software to solve problems and for whom 80 × 64 pixel resolution is sufficient.</p> <p>Among its main features are GigE Vision and GenICam compliance, which makes it plug-and-play when used with software packages such as IMAQ Vision and Halcon.</p>	
Key features:	
<ul style="list-style-type: none"> • Very affordable. • Compact (40 mm × 43 mm × 106 mm). • GigE Vision and GenICam compliant. • GigE Vision lockable connector. • PoE (power over Ethernet). • 8-bit 80 × 64 pixel images streamed at 60 Hz, signal linear. • 14-bit 80 × 64 pixel images streamed at 60 Hz, signal and temperature linear. • High frame rates (60 Hz). • Synchronization between cameras possible. • 1x+1x GPIO. • Compliant with any software that supports GenICam, including National Instruments IMAQ Vision, Stemmers Common Vision Blox, and COGNEX Vision Pro. 	
Typical applications:	
<ul style="list-style-type: none"> • Automation and thermal machine vision. • Entry level "high-speed" R&D. 	
Imaging and optical data	
IR resolution	80 × 64 pixels
Thermal sensitivity/NETD	< 0.05°C @ +30°C (+86°F) / 50 mK
Field of view (FOV)	44° × 36°
Focal length	5 mm (0.20 in.)
Spatial resolution (IFOV)	10.0 mrad
F-number	1.25
Image frequency	60 Hz
Focus	Fixed
Detector data	
Detector type	Focal Plane Array (FPA), Uncooled VOX microbolometer
Spectral range	7.5–13 μm
Detector pitch	50 μm
Detector time constant	Typical 12 ms
Measurement	
Object temperature range	<ul style="list-style-type: none"> • -25 to +135°C (-13 to 275°F) • -40 to +550°C (-40 to +1022°F)
Accuracy	±5°C (±9°F) or ±5% of reading
Ethernet	
Ethernet	Control and image
Ethernet, type	Gigabit Ethernet
Ethernet, standard	IEEE 802.3
Ethernet, connector type	RJ-45

Ethernet	
Ethernet, communication	GigE Vision ver. 1.2 Client API GenICam compliant
Ethernet, image streaming	8-bit monochrome @ 60 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Automatic/ Manual • Flip H&V 14-bit 80 × 64 pixels @ 60 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Temperature linear GigE Vision and GenICam compatible
Ethernet, power	Power over Ethernet, PoE IEEE 802.3af class 0 Power
Ethernet, protocols	TCP, UDP, ICMP, IGMP, DHCP, GigE Vision
Digital input/output	
Digital input, purpose	General purpose
Digital input	1× opto-isolated, "0" <2, "1"=2-12 VDC. NOTE: Maximum input 12 VDC. If the input is above 12 VDC without a resistor in series there is a risk of damaging the input. If the input is 24 VDC use a 1.2 kΩ resistor in series. In that case "1" = 3-24 VDC.
Digital output, purpose	General purpose Output to ext. device (programmatically set)
Digital output	1× opto-isolated, 2-40 VDC, max 185 mA
Digital I/O, isolation voltage	500 VRMS
Digital I/O, supply voltage	2-40 VDC, max 200 mA
Digital I/O, connector type	12-pole M12 connector (shared with Digital Synchronization and External power)
Synchronization In, purpose	Frame sync In to control camera
Synchronization In	1×, non-isolated
Synchronization In, type	LVC Buffer @ 3.3V, "0" <0.8 V, "1" >2.0 V.
Synchronization Out, purpose	Frame sync Out to control another Ax5 camera
Synchronization Out	1×, non-isolated
Synchronization Out, type	LVC Buffer @ 3.3V, "0"=24 mA max, "1"= -24 mA max.
Digital Synchronization, connector type	12-pole M12 connector (shared with Digital I/O and External power)
Power system	
External power operation	12/24 VDC, < 3.5 W nominal < 6.0 W absolute max
External power, connector type	12-pole M12 connector (shared with Digital I/O and Digital Synchronization)
Voltage	Allowed range 10-30 VDC
Environmental data	
Operating temperature range	-15°C to +50°C (+5°F to +122°F)
Storage temperature range	-40°C to +70°C (-40°F to +158°F)
Humidity (operating and storage)	IEC 60068-2-30/24 h 95% relative humidity +25°C to +40°C (+77°F to +104°F)

Environmental data	
EMC	<ul style="list-style-type: none"> • EN 61000-6-2 (Immunity) • EN 61000-6-3 (Emission) • FCC 47 CFR Part 15 Class B (Emission)
Encapsulation	IP 40 (IEC 60529) with base support mounted
Shock	25 g (IEC 60068-2-27)
Vibration	2 g (IEC 60068-2-6)
Physical data	
Weight	0.200 kg (0.44 lb.)
Camera size (L × W × H)	106 × 40 × 43 mm (4.2 × 1.6 × 1.7 in.)
Tripod mounting	UNC ¼"-20 (on three sides)
Base mounting	4 × M3 thread mounting holes (bottom)
Housing material	Magnesium and aluminum
Shipping information	
Packaging, type	Cardboard box
List of contents	<ul style="list-style-type: none"> • Hard transport case • Infrared camera with lens • Base support • Cable tie (2 ea.) • Ethernet cable CAT-6, 2m/6.6 ft (2 ea.) • FLIR ResearchIR Standard 4 • Focus adjustment tool • Gooseneck • Mains cable kit (UK,EU,US) • PoE Injector (power over Ethernet) • Printed documentation • Table stand • User documentation CD-ROM
Packaging, weight	
Packaging, size	370 × 180 × 320 mm (14.6 × 7.1 × 12.6 in.)
EAN-13	7332558003947 4743254000650 (Estonia plant)
UPC-12	845188003609
Country of origin	Sweden

Supplies & accessories:

- T951004ACC; Ethernet cable CAT-6, 2m/6.6 ft.
- T198349; Base support
- T198348; Cable kit Mains (UK,EU,US)
- T911112; PoE injector
- T198371; Transport case Ax5
- T198392; Table stand kit
- T911183; Gigabit PoE injector 16 W, with multi-plugs
- T127605ACC; Cable M12 Pigtail
- T127606ACC; Cable M12 Sync
- T198342ACC; Focus adjustment tool
- T198584; FLIR Tools
- T198583; FLIR Tools+ (license only)
- DSW-10000; FLIR IR Camera Player

11.15 FLIR A5 f=5 mm with SC kit (7.5 Hz)

P/N: 64205-0102

Rev.: 22369

General description	
<p>The FLIR A5 has features and functions that make it the natural choice for anyone who uses PC software to solve problems and for whom 80 × 64 pixel resolution is sufficient.</p> <p>Among its main features are GigE Vision and GenICam compliance, which makes it plug-and-play when used with software packages such as IMAQ Vision and Halcon.</p>	
Key features:	
<ul style="list-style-type: none"> • Very affordable. • Compact (40 mm × 43 mm × 106 mm). • GigE Vision and GenICam compliant. • GigE Vision lockable connector. • PoE (power over Ethernet). • 8-bit 80 × 64 pixel images streamed at 7.5 Hz, signal linear. • 14-bit 80 × 64 pixel images streamed at 7.5 Hz, signal and temperature linear. • Synchronization between cameras possible. • 1x+1x GPIO. • Compliant with any software that supports GenICam, including National Instruments IMAQ Vision, Stemmers Common Vision Blox, and COGNEX Vision Pro. 	
Typical applications:	
<ul style="list-style-type: none"> • Automation and thermal machine vision. • Entry level "high-speed" R&D. 	
Imaging and optical data	
IR resolution	80 × 64 pixels
Thermal sensitivity/NETD	< 0.05°C @ +30°C (+86°F) / 50 mK
Field of view (FOV)	44° × 36°
Focal length	5 mm (0.20 in.)
Spatial resolution (IFOV)	10.0 mrad
F-number	1.25
Image frequency	7.5 Hz
Focus	Fixed
Detector data	
Detector type	Focal Plane Array (FPA), Uncooled VOX microbolometer
Spectral range	7.5–13 μm
Detector pitch	50 μm
Detector time constant	Typical 12 ms
Measurement	
Object temperature range	<ul style="list-style-type: none"> • -25 to +135°C (-13 to 275°F) • -40 to +550°C (-40 to +1022°F)
Accuracy	±5°C (±9°F) or ±5% of reading
Ethernet	
Ethernet	Control and image
Ethernet, type	Gigabit Ethernet
Ethernet, standard	IEEE 802.3
Ethernet, connector type	RJ-45
Ethernet, communication	GigE Vision ver. 1.2 Client API GenICam compliant

Ethernet	
Ethernet, image streaming	8-bit monochrome @ 7.5 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Automatic/ Manual • Flip H&V 14-bit 80 × 64 pixels @ 7.5 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Temperature linear GigE Vision and GenICam compatible
Ethernet, power	Power over Ethernet, PoE IEEE 802.3af class 0 Power
Ethernet, protocols	TCP, UDP, ICMP, IGMP, DHCP, GigEVision
Digital input/output	
Digital input, purpose	General purpose
Digital input	1× opto-isolated, "0" <2, "1"=2-12 VDC. NOTE: Maximum input 12 VDC. If the input is above 12 VDC without a resistor in series there is a risk of damaging the input. If the input is 24 VDC use a 1.2 kΩ resistor in series. In that case "1" = 3-24 VDC.
Digital output, purpose	General purpose Output to ext. device (programmatically set)
Digital output	1× opto-isolated, 2-40 VDC, max 185 mA
Digital I/O, isolation voltage	500 VRMS
Digital I/O, supply voltage	2-40 VDC, max 200 mA
Digital I/O, connector type	12-pole M12 connector (shared with Digital Synchronization and External power)
Synchronization In, purpose	Frame sync In to control camera
Synchronization In	1×, non-isolated
Synchronization In, type	LVC Buffer @3.3V, "0" <0.8 V, "1">2.0 V.
Synchronization Out, purpose	Frame sync Out to control another Ax5 camera
Synchronization Out	1×, non-isolated
Synchronization Out, type	LVC Buffer @ 3.3V, "0"=24 MA max, "1"= -24 mA max.
Digital Synchronization, connector type	12-pole M12 connector (shared with Digital I/O and External power)
Power system	
External power operation	12/24 VDC, < 3.5 W nominal < 6.0 W absolute max
External power, connector type	12-pole M12 connector (shared with Digital I/O and Digital Synchronization)
Voltage	Allowed range 10-30 VDC
Environmental data	
Operating temperature range	-15°C to +50°C (+5°F to +122°F)
Storage temperature range	-40°C to +70°C (-40°F to +158°F)
Humidity (operating and storage)	IEC 60068-2-30/24 h 95% relative humidity +25°C to +40°C (+77°F to +104°F)
EMC	<ul style="list-style-type: none"> • EN 61000-6-2 (Immunity) • EN 61000-6-3 (Emission) • FCC 47 CFR Part 15 Class B (Emission)
Encapsulation	IP 40 (IEC 60529) with base support mounted

Environmental data	
Shock	25 g (IEC 60068-2-27)
Vibration	2 g (IEC 60068-2-6)
Physical data	
Weight	0.200 kg (0.44 lb.)
Camera size (L × W × H)	106 × 40 × 43 mm (4.2 × 1.6 × 1.7 in.)
Tripod mounting	UNC ¼"-20 (on three sides)
Base mounting	4 × M3 thread mounting holes (bottom)
Housing material	Magnesium and aluminum
Shipping information	
Packaging, type	Cardboard box
List of contents	<ul style="list-style-type: none"> • Hard transport case • Infrared camera with lens • Base support • Cable tie (2 ea.) • Ethernet cable CAT-6, 2m/6.6 ft (2 ea.) • FLIR ResearchIR Standard 4 • Focus adjustment tool • Gooseneck • Mains cable kit (UK,EU,US) • PoE Injector (power over Ethernet) • Printed documentation • Table stand • User documentation CD-ROM
Packaging, weight	
Packaging, size	370 × 180 × 320 mm (14.6 × 7.1 × 12.6 in.)
EAN-13	7332558005675
UPC-12	845188005887
Country of origin	Sweden

Supplies & accessories:

- T951004ACC; Ethernet cable CAT-6, 2m/6.6 ft.
- T198349; Base support
- T198348; Cable kit Mains (UK,EU,US)
- T911112; PoE injector
- T198392; Table stand kit
- T911183; Gigabit PoE injector 16 W, with multi-plugs
- T127605ACC; Cable M12 Pigtail
- T127606ACC; Cable M12 Sync
- T198342ACC; Focus adjustment tool
- T198584; FLIR Tools
- T198583; FLIR Tools+ (license only)
- DSW-10000; FLIR IR Camera Player

11.16 FLIR A5 f=9 mm

P/N: 62209-0101

Rev.: 22369

General description	
<p>The FLIR A5 has features and functions that make it the natural choice for anyone who uses PC software to solve problems and for whom 80 × 64 pixel resolution is sufficient.</p> <p>Among its main features are GigE Vision and GenICam compliance, which makes it plug-and-play when used with software packages such as IMAQ Vision and Halcon.</p>	
Key features:	
<ul style="list-style-type: none"> • Very affordable. • Compact (40 mm × 43 mm × 106 mm). • GigE Vision and GenICam compliant. • GigE Vision lockable connector. • PoE (power over Ethernet). • 8-bit 80 × 64 pixel images streamed at 60 Hz, signal linear. • 14-bit 80 × 64 pixel images streamed at 60 Hz, signal and temperature linear. • High frame rates (60 Hz). • Synchronization between cameras possible. • 1x+1x GPIO. • Compliant with any software that supports GenICam, including National Instruments IMAQ Vision, Stemmers Common Vision Blox, and COGNEX Vision Pro. 	
Typical applications:	
<ul style="list-style-type: none"> • Automation and thermal machine vision. • Entry level "high-speed" R&D. 	
Imaging and optical data	
IR resolution	80 × 64 pixels
Thermal sensitivity/NETD	< 0.05°C @ +30°C (+86°F) / 50 mK
Field of view (FOV)	25° × 20°
Focal length	9 mm (0.35 in.)
Spatial resolution (IFOV)	5.56 mrad
F-number	1.25
Image frequency	60 Hz
Focus	Fixed
Detector data	
Detector type	Focal Plane Array (FPA), Uncooled VOX microbolometer
Spectral range	7.5–13 μm
Detector pitch	50 μm
Detector time constant	Typical 12 ms
Measurement	
Object temperature range	<ul style="list-style-type: none"> • -25 to +135°C (-13 to 275°F) • -40 to +550°C (-40 to +1022°F)
Accuracy	±5°C (±9°F) or ±5% of reading
Ethernet	
Ethernet	Control and image
Ethernet, type	Gigabit Ethernet
Ethernet, standard	IEEE 802.3
Ethernet, connector type	RJ-45

Ethernet	
Ethernet, communication	GigE Vision ver. 1.2 Client API GenICam compliant
Ethernet, image streaming	8-bit monochrome @ 60 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Automatic/ Manual • Flip H&V 14-bit 80 × 64 pixels @ 60 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Temperature linear GigE Vision and GenICam compatible
Ethernet, power	Power over Ethernet, PoE IEEE 802.3af class 0 Power
Ethernet, protocols	TCP, UDP, ICMP, IGMP, DHCP, GigE Vision
Digital input/output	
Digital input, purpose	General purpose
Digital input	1× opto-isolated, "0" <2, "1"=2-12 VDC. NOTE: Maximum input 12 VDC. If the input is above 12 VDC without a resistor in series there is a risk of damaging the input. If the input is 24 VDC use a 1.2 kΩ resistor in series. In that case "1" = 3-24 VDC.
Digital output, purpose	General purpose Output to ext. device (programmatically set)
Digital output	1× opto-isolated, 2-40 VDC, max 185 mA
Digital I/O, isolation voltage	500 VRMS
Digital I/O, supply voltage	2-40 VDC, max 200 mA
Digital I/O, connector type	12-pole M12 connector (shared with Digital Synchronization and External power)
Synchronization In, purpose	Frame sync In to control camera
Synchronization In	1×, non-isolated
Synchronization In, type	LVC Buffer @ 3.3V, "0" <0.8 V, "1" >2.0 V.
Synchronization Out, purpose	Frame sync Out to control another Ax5 camera
Synchronization Out	1×, non-isolated
Synchronization Out, type	LVC Buffer @ 3.3V, "0"=24 mA max, "1"= -24 mA max.
Digital Synchronization, connector type	12-pole M12 connector (shared with Digital I/O and External power)
Power system	
External power operation	12/24 VDC, < 3.5 W nominal < 6.0 W absolute max
External power, connector type	12-pole M12 connector (shared with Digital I/O and Digital Synchronization)
Voltage	Allowed range 10-30 VDC
Environmental data	
Operating temperature range	-15°C to +50°C (+5°F to +122°F)
Storage temperature range	-40°C to +70°C (-40°F to +158°F)
Humidity (operating and storage)	IEC 60068-2-30/24 h 95% relative humidity +25°C to +40°C (+77°F to +104°F)

Environmental data	
EMC	<ul style="list-style-type: none"> • EN 61000-6-2 (Immunity) • EN 61000-6-3 (Emission) • FCC 47 CFR Part 15 Class B (Emission)
Encapsulation	IP 40 (IEC 60529) with base support mounted
Shock	25 g (IEC 60068-2-27)
Vibration	2 g (IEC 60068-2-6)
Physical data	
Weight	0.200 kg (0.44 lb.)
Camera size (L × W × H)	106 × 40 × 43 mm (4.2 × 1.6 × 1.7 in.)
Tripod mounting	UNC ¼"-20 (on three sides)
Base mounting	4 × M3 thread mounting holes (bottom)
Housing material	Magnesium and aluminum
Shipping information	
Packaging, type	Cardboard box
List of contents	<ul style="list-style-type: none"> • Infrared camera with lens • FLIR Tools download card • Focus adjustment tool • Printed documentation • User documentation CD-ROM
Packaging, weight	
Packaging, size	295 × 200 × 105 mm (11.6 × 7.9 × 4.1 in.)
EAN-13	7332558003954 4743254000643 (Estonia plant)
UPC-12	845188003593
Country of origin	Sweden

Supplies & accessories:

- T951004ACC; Ethernet cable CAT-6, 2m/6.6 ft.
- T198349; Base support
- T198348; Cable kit Mains (UK,EU,US)
- T911112; PoE injector
- T198392; Table stand kit
- T911183; Gigabit PoE injector 16 W, with multi-plugs
- T127605ACC; Cable M12 Pigtail
- T127606ACC; Cable M12 Sync
- T198342ACC; Focus adjustment tool
- T198584; FLIR Tools
- T198583; FLIR Tools+ (license only)
- DSW-10000; FLIR IR Camera Player

11.17 FLIR A5 f=9 mm (7.5 Hz)

P/N: 64209-0101

Rev.: 22369

General description	
<p>The FLIR A5 has features and functions that make it the natural choice for anyone who uses PC software to solve problems and for whom 80 × 64 pixel resolution is sufficient.</p> <p>Among its main features are GigE Vision and GenICam compliance, which makes it plug-and-play when used with software packages such as IMAQ Vision and Halcon.</p>	
Key features:	
<ul style="list-style-type: none"> • Very affordable. • Compact (40 mm × 43 mm × 106 mm). • GigE Vision and GenICam compliant. • GigE Vision lockable connector. • PoE (power over Ethernet). • 8-bit 80 × 64 pixel images streamed at 7.5 Hz, signal linear. • 14-bit 80 × 64 pixel images streamed at 7.5 Hz, signal and temperature linear. • Synchronization between cameras possible. • 1x+1x GPIO. • Compliant with any software that supports GenICam, including National Instruments IMAQ Vision, Stemmers Common Vision Blox, and COGNEX Vision Pro. 	
Typical applications:	
<ul style="list-style-type: none"> • Automation and thermal machine vision. • Entry level "high-speed" R&D. 	
Imaging and optical data	
IR resolution	80 × 64 pixels
Thermal sensitivity/NETD	< 0.05°C @ +30°C (+86°F) / 50 mK
Field of view (FOV)	25° × 20°
Focal length	9 mm (0.35 in.)
Spatial resolution (IFOV)	5.56 mrad
F-number	1.25
Image frequency	7.5 Hz
Focus	Fixed
Detector data	
Detector type	Focal Plane Array (FPA), Uncooled VOX microbolometer
Spectral range	7.5–13 μm
Detector pitch	50 μm
Detector time constant	Typical 12 ms
Measurement	
Object temperature range	<ul style="list-style-type: none"> • -25 to +135°C (-13 to 275°F) • -40 to +550°C (-40 to +1022°F)
Accuracy	±5°C (±9°F) or ±5% of reading
Ethernet	
Ethernet	Control and image
Ethernet, type	Gigabit Ethernet
Ethernet, standard	IEEE 802.3
Ethernet, connector type	RJ-45
Ethernet, communication	GigE Vision ver. 1.2 Client API GenICam compliant

Ethernet	
Ethernet, image streaming	8-bit monochrome @ 7.5 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Automatic/ Manual • Flip H&V 14-bit 80 × 64 pixels @ 7.5 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Temperature linear GigE Vision and GenICam compatible
Ethernet, power	Power over Ethernet, PoE IEEE 802.3af class 0 Power
Ethernet, protocols	TCP, UDP, ICMP, IGMP, DHCP, GigEVision
Digital input/output	
Digital input, purpose	General purpose
Digital input	1× opto-isolated, "0" <2, "1"=2-12 VDC. NOTE: Maximum input 12 VDC. If the input is above 12 VDC without a resistor in series there is a risk of damaging the input. If the input is 24 VDC use a 1.2 kΩ resistor in series. In that case "1" = 3-24 VDC.
Digital output, purpose	General purpose Output to ext. device (programmatically set)
Digital output	1× opto-isolated, 2-40 VDC, max 185 mA
Digital I/O, isolation voltage	500 VRMS
Digital I/O, supply voltage	2-40 VDC, max 200 mA
Digital I/O, connector type	12-pole M12 connector (shared with Digital Synchronization and External power)
Synchronization In, purpose	Frame sync In to control camera
Synchronization In	1×, non-isolated
Synchronization In, type	LVC Buffer @3.3V, "0" <0.8 V, "1">2.0 V.
Synchronization Out, purpose	Frame sync Out to control another Ax5 camera
Synchronization Out	1×, non-isolated
Synchronization Out, type	LVC Buffer @ 3.3V, "0"=24 MA max, "1"= -24 mA max.
Digital Synchronization, connector type	12-pole M12 connector (shared with Digital I/O and External power)
Power system	
External power operation	12/24 VDC, < 3.5 W nominal < 6.0 W absolute max
External power, connector type	12-pole M12 connector (shared with Digital I/O and Digital Synchronization)
Voltage	Allowed range 10-30 VDC
Environmental data	
Operating temperature range	-15°C to +50°C (+5°F to +122°F)
Storage temperature range	-40°C to +70°C (-40°F to +158°F)
Humidity (operating and storage)	IEC 60068-2-30/24 h 95% relative humidity +25°C to +40°C (+77°F to +104°F)
EMC	<ul style="list-style-type: none"> • EN 61000-6-2 (Immunity) • EN 61000-6-3 (Emission) • FCC 47 CFR Part 15 Class B (Emission)
Encapsulation	IP 40 (IEC 60529) with base support mounted

Environmental data	
Shock	25 g (IEC 60068-2-27)
Vibration	2 g (IEC 60068-2-6)
Physical data	
Weight	0.200 kg (0.44 lb.)
Camera size (L × W × H)	106 × 40 × 43 mm (4.2 × 1.6 × 1.7 in.)
Tripod mounting	UNC ¼"-20 (on three sides)
Base mounting	4 × M3 thread mounting holes (bottom)
Housing material	Magnesium and aluminum
Shipping information	
Packaging, type	Cardboard box
List of contents	<ul style="list-style-type: none"> • Infrared camera with lens • FLIR Tools download card • Focus adjustment tool • Printed documentation • User documentation CD-ROM
Packaging, weight	
Packaging, size	295 × 200 × 105 mm (11.6 × 7.9 × 4.1 in.)
EAN-13	7332558005637
UPC-12	845188005849
Country of origin	Sweden

Supplies & accessories:

- T951004ACC; Ethernet cable CAT-6, 2m/6.6 ft.
- T198349; Base support
- T198348; Cable kit Mains (UK,EU,US)
- T911112; PoE injector
- T198392; Table stand kit
- T911183; Gigabit PoE injector 16 W, with multi-plugs
- T127605ACC; Cable M12 Pigtail
- T127606ACC; Cable M12 Sync
- T198342ACC; Focus adjustment tool
- T198584; FLIR Tools
- T198583; FLIR Tools+ (license only)
- DSW-10000; FLIR IR Camera Player

11.18 FLIR A65 f=13 mm

P/N: 62613-0101

Rev.: 22369

General description	
<p>The FLIR A65 has features and functions that make it the natural choice for anyone who uses PC software to solve problems and for whom 640 × 512 pixel resolution is sufficient.</p> <p>Among its main features are GigE Vision and GenICam compliance, which makes it plug-and-play when used with software packages such as IMAQ Vision and Halcon.</p>	
Key features:	
<ul style="list-style-type: none"> • Very affordable. • Compact (40 mm × 43 mm × 106 mm). • GigE Vision and GenICam compliant. • GigE Vision lockable connector. • PoE (power over Ethernet). • 8-bit 640 × 512 pixel images streamed at 30 Hz, signal linear • 14-bit 640 × 512 pixel images streamed at 30 Hz, signal and temperature linear • Synchronization between cameras possible. • 1x+1x GPIO. • Compliant with any software that supports GenICam, including National Instruments IMAQ Vision, Stemmers Common Vision Blox, and COGNEX Vision Pro. 	
Typical applications:	
<ul style="list-style-type: none"> • Automation and thermal machine vision. • Entry level "high-speed" R&D. 	
Imaging and optical data	
IR resolution	640 × 512 pixels
Thermal sensitivity/NETD	< 0.05°C @ +30°C (+86°F) / 50 mK
Field of view (FOV)	45° × 37°
Focal length	13 mm (0.5 in.)
Spatial resolution (IFOV)	1.31 mrad
F-number	1.25
Image frequency	30 Hz
Focus	Fixed
Detector data	
Detector type	Focal Plane Array (FPA), Uncooled VOX microbolometer
Spectral range	7.5–13 μm
Detector pitch	17 μm
Detector time constant	Typical 12 ms
Measurement	
Object temperature range	–25 to +135°C (–13 to 275°F)
Accuracy	±5°C (±9°F) or ±5% of reading
Ethernet	
Ethernet	Control and image
Ethernet, type	Gigabit Ethernet
Ethernet, standard	IEEE 802.3
Ethernet, connector type	RJ-45
Ethernet, communication	GigE Vision ver. 1.2 Client API GenICam compliant

Ethernet	
Ethernet, image streaming	8-bit monochrome @ 30 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Automatic/ Manual • Flip H&V 14-bit 640 × 512 pixels @ 30 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Temperature linear GigE Vision and GenICam compatible
Ethernet, power	Power over Ethernet, PoE IEEE 802.3af class 0 Power
Ethernet, protocols	TCP, UDP, ICMP, IGMP, DHCP, GigEVision
Digital input/output	
Digital input, purpose	General purpose
Digital input	1× opto-isolated, "0" <2, "1"=2-12 VDC. NOTE: Maximum input 12 VDC. If the input is above 12 VDC without a resistor in series there is a risk of damaging the input. If the input is 24 VDC use a 1.2 kΩ resistor in series. In that case "1" = 3-24 VDC.
Digital output, purpose	General purpose Output to ext. device (programmatically set)
Digital output	1× opto-isolated, 2–40 VDC, max 185 mA
Digital I/O, isolation voltage	500 VRMS
Digital I/O, supply voltage	2–40 VDC, max 200 mA
Digital I/O, connector type	12-pole M12 connector (shared with Digital Synchronization and External power)
Synchronization In, purpose	Frame sync In to control camera
Synchronization In	1×, non-isolated
Synchronization In, type	LVC Buffer @3.3V, "0" <0.8 V, "1">2.0 V.
Synchronization Out, purpose	Frame sync Out to control another Ax5 camera
Synchronization Out	1×, non-isolated
Synchronization Out, type	LVC Buffer @ 3.3V, "0"=24 MA max, "1"= –24 mA max.
Digital Synchronization, connector type	12-pole M12 connector (shared with Digital I/O and External power)
Power system	
External power operation	12/24 VDC, < 3.5 W nominal < 6.0 W absolute max
External power, connector type	12-pole M12 connector (shared with Digital I/O and Digital Synchronization)
Voltage	Allowed range 10–30 VDC
Environmental data	
Operating temperature range	–15°C to +50°C (+5°F to +122°F)
Storage temperature range	–40°C to +70°C (–40°F to +158°F)
Humidity (operating and storage)	IEC 60068-2-30/24 h 95% relative humidity +25°C to +40°C (+77°F to +104°F)
EMC	<ul style="list-style-type: none"> • EN 61000-6-2 (Immunity) • EN 61000-6-3 (Emission) • FCC 47 CFR Part 15 Class B (Emission)
Encapsulation	IP 40 (IEC 60529) with base support mounted

Environmental data	
Shock	25 g (IEC 60068-2-27)
Vibration	2 g (IEC 60068-2-6)
Physical data	
Weight	0.200 kg (0.44 lb.)
Camera size (L × W × H)	106 × 40 × 43 mm (4.2 × 1.6 × 1.7 in.)
Tripod mounting	UNC ¼"-20 (on three sides)
Base mounting	4 × M3 thread mounting holes (bottom)
Housing material	Magnesium and aluminum
Shipping information	
Packaging, type	Cardboard box
List of contents	<ul style="list-style-type: none"> • Infrared camera with lens • FLIR Tools download card • Focus adjustment tool • Printed documentation • User documentation CD-ROM
Packaging, weight	
Packaging, size	295 × 200 × 105 mm (11.6 × 7.9 × 4.1 in.)
EAN-13	7332558005460
UPC-12	845188005665
Country of origin	Estonia

Supplies & accessories:

- T951004ACC; Ethernet cable CAT-6, 2m/6.6 ft.
- T198349; Base support
- T198348; Cable kit Mains (UK,EU,US)
- T911112; PoE injector
- T198392; Table stand kit
- T911183; Gigabit PoE injector 16 W, with multi-plugs
- T127605ACC; Cable M12 Pigtail
- T127606ACC; Cable M12 Sync
- T198342ACC; Focus adjustment tool
- T198584; FLIR Tools
- T198583; FLIR Tools+ (license only)
- DSW-10000; FLIR IR Camera Player

11.19 FLIR A65 f=13 mm (7.5 Hz)

P/N: 62513-0101

Rev.: 22369

General description	
<p>The FLIR A65 has features and functions that make it the natural choice for anyone who uses PC software to solve problems and for whom 640 × 512 pixel resolution is sufficient.</p> <p>Among its main features are GigE Vision and GenICam compliance, which makes it plug-and-play when used with software packages such as IMAQ Vision and Halcon.</p>	
Key features:	
<ul style="list-style-type: none"> • Very affordable. • Compact (40 mm × 43 mm × 106 mm). • GigE Vision and GenICam compliant. • GigE Vision lockable connector. • PoE (power over Ethernet). • 8-bit 640 × 512 pixel images streamed at 7.5 Hz, signal linear • 14-bit 640 × 512 pixel images streamed at 7.5 Hz, signal and temperature linear • Synchronization between cameras possible. • 1x+1x GPIO. • Compliant with any software that supports GenICam, including National Instruments IMAQ Vision, Stemmers Common Vision Blox, and COGNEX Vision Pro. 	
Typical applications:	
<ul style="list-style-type: none"> • Automation and thermal machine vision. • Entry level "high-speed" R&D. 	
Imaging and optical data	
IR resolution	640 × 512 pixels
Thermal sensitivity/NETD	< 0.05°C @ +30°C (+86°F) / 50 mK
Field of view (FOV)	45° × 37°
Focal length	13 mm (0.5 in.)
Spatial resolution (IFOV)	1.31 mrad
F-number	1.25
Image frequency	7.5 Hz
Focus	Fixed
Detector data	
Detector type	Focal Plane Array (FPA), Uncooled VOX microbolometer
Spectral range	7.5–13 μm
Detector pitch	17 μm
Detector time constant	Typical 12 ms
Measurement	
Object temperature range	–25 to +135°C (–13 to 275°F)
Accuracy	±5°C (±9°F) or ±5% of reading
Ethernet	
Ethernet	Control and image
Ethernet, type	Gigabit Ethernet
Ethernet, standard	IEEE 802.3
Ethernet, connector type	RJ-45
Ethernet, communication	GigE Vision ver. 1.2 Client API GenICam compliant

Ethernet	
Ethernet, image streaming	8-bit monochrome @ 7.5 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Automatic/ Manual • Flip H&V 14-bit 640 × 512 pixels @ 7.5 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Temperature linear GigE Vision and GenICam compatible
Ethernet, power	Power over Ethernet, PoE IEEE 802.3af class 0 Power
Ethernet, protocols	TCP, UDP, ICMP, IGMP, DHCP, GigEVision
Digital input/output	
Digital input, purpose	General purpose
Digital input	1× opto-isolated, "0" <2, "1"=2-12 VDC. NOTE: Maximum input 12 VDC. If the input is above 12 VDC without a resistor in series there is a risk of damaging the input. If the input is 24 VDC use a 1.2 kΩ resistor in series. In that case "1" = 3-24 VDC.
Digital output, purpose	General purpose Output to ext. device (programmatically set)
Digital output	1× opto-isolated, 2-40 VDC, max 185 mA
Digital I/O, isolation voltage	500 VRMS
Digital I/O, supply voltage	2-40 VDC, max 200 mA
Digital I/O, connector type	12-pole M12 connector (shared with Digital Synchronization and External power)
Synchronization In, purpose	Frame sync In to control camera
Synchronization In	1×, non-isolated
Synchronization In, type	LVC Buffer @3.3V, "0" <0.8 V, "1">2.0 V.
Synchronization Out, purpose	Frame sync Out to control another Ax5 camera
Synchronization Out	1×, non-isolated
Synchronization Out, type	LVC Buffer @ 3.3V, "0"=24 MA max, "1"= -24 mA max.
Digital Synchronization, connector type	12-pole M12 connector (shared with Digital I/O and External power)
Power system	
External power operation	12/24 VDC, < 3.5 W nominal < 6.0 W absolute max
External power, connector type	12-pole M12 connector (shared with Digital I/O and Digital Synchronization)
Voltage	Allowed range 10-30 VDC
Environmental data	
Operating temperature range	-15°C to +50°C (+5°F to +122°F)
Storage temperature range	-40°C to +70°C (-40°F to +158°F)
Humidity (operating and storage)	IEC 60068-2-30/24 h 95% relative humidity +25°C to +40°C (+77°F to +104°F)
EMC	<ul style="list-style-type: none"> • EN 61000-6-2 (Immunity) • EN 61000-6-3 (Emission) • FCC 47 CFR Part 15 Class B (Emission)
Encapsulation	IP 40 (IEC 60529) with base support mounted

Environmental data	
Shock	25 g (IEC 60068-2-27)
Vibration	2 g (IEC 60068-2-6)
Physical data	
Weight	0.200 kg (0.44 lb.)
Camera size (L × W × H)	106 × 40 × 43 mm (4.2 × 1.6 × 1.7 in.)
Tripod mounting	UNC ¼"-20 (on three sides)
Base mounting	4 × M3 thread mounting holes (bottom)
Housing material	Magnesium and aluminum
Shipping information	
Packaging, type	Cardboard box
List of contents	<ul style="list-style-type: none"> • Infrared camera with lens • FLIR Tools download card • Focus adjustment tool • Printed documentation • User documentation CD-ROM
Packaging, weight	
Packaging, size	295 × 200 × 105 mm (11.6 × 7.9 × 4.1 in.)
EAN-13	7332558004067 4743254000537 (Estonia plant)
UPC-12	845188003623
Country of origin	Sweden

Supplies & accessories:

- T951004ACC; Ethernet cable CAT-6, 2m/6.6 ft.
- T198349; Base support
- T198348; Cable kit Mains (UK,EU,US)
- T911112; PoE injector
- T198392; Table stand kit
- T911183; Gigabit PoE injector 16 W, with multi-plugs
- T127605ACC; Cable M12 Pigtail
- T127606ACC; Cable M12 Sync
- T198342ACC; Focus adjustment tool
- T198584; FLIR Tools
- T198583; FLIR Tools+ (license only)
- DSW-10000; FLIR IR Camera Player

11.20 FLIR A65 f=13 mm with SC kit (7.5 Hz)

P/N: 62513-0102

Rev.: 22369

General description	
<p>The FLIR A65 has features and functions that make it the natural choice for anyone who uses PC software to solve problems and for whom 640 × 512 pixel resolution is sufficient.</p> <p>Among its main features are GigE Vision and GenICam compliance, which makes it plug-and-play when used with software packages such as IMAQ Vision and Halcon.</p>	
Key features:	
<ul style="list-style-type: none"> • Very affordable. • Compact (40 mm × 43 mm × 106 mm). • GigE Vision and GenICam compliant. • GigE Vision lockable connector. • PoE (power over Ethernet). • 8-bit 640 × 512 pixel images streamed at 7.5 Hz, signal linear • 14-bit 640 × 512 pixel images streamed at 7.5 Hz, signal and temperature linear • Synchronization between cameras possible. • 1x+1x GPIO. • Compliant with any software that supports GenICam, including National Instruments IMAQ Vision, Stemmers Common Vision Blox, and COGNEX Vision Pro. 	
Typical applications:	
<ul style="list-style-type: none"> • Automation and thermal machine vision. • Entry level "high-speed" R&D. 	
Imaging and optical data	
IR resolution	640 × 512 pixels
Thermal sensitivity/NETD	< 0.05°C @ +30°C (+86°F) / 50 mK
Field of view (FOV)	45° × 37°
Focal length	13 mm (0.5 in.)
Spatial resolution (IFOV)	1.31 mrad
F-number	1.25
Image frequency	7.5 Hz
Focus	Fixed
Detector data	
Detector type	Focal Plane Array (FPA), Uncooled VOX microbolometer
Spectral range	7.5–13 μm
Detector pitch	17 μm
Detector time constant	Typical 12 ms
Measurement	
Object temperature range	–25 to +135°C (–13 to 275°F)
Accuracy	±5°C (±9°F) or ±5% of reading
Ethernet	
Ethernet	Control and image
Ethernet, type	Gigabit Ethernet
Ethernet, standard	IEEE 802.3
Ethernet, connector type	RJ-45
Ethernet, communication	GigE Vision ver. 1.2 Client API GenICam compliant

Ethernet	
Ethernet, image streaming	8-bit monochrome @ 7.5 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Automatic/ Manual • Flip H&V 14-bit 640 × 512 pixels @ 7.5 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Temperature linear GigE Vision and GenICam compatible
Ethernet, power	Power over Ethernet, PoE IEEE 802.3af class 0 Power
Ethernet, protocols	TCP, UDP, ICMP, IGMP, DHCP, GigE Vision
Digital input/output	
Digital input, purpose	General purpose
Digital input	1× opto-isolated, "0" <2, "1"=2-12 VDC. NOTE: Maximum input 12 VDC. If the input is above 12 VDC without a resistor in series there is a risk of damaging the input. If the input is 24 VDC use a 1.2 kΩ resistor in series. In that case "1" = 3-24 VDC.
Digital output, purpose	General purpose Output to ext. device (programmatically set)
Digital output	1× opto-isolated, 2-40 VDC, max 185 mA
Digital I/O, isolation voltage	500 VRMS
Digital I/O, supply voltage	2-40 VDC, max 200 mA
Digital I/O, connector type	12-pole M12 connector (shared with Digital Synchronization and External power)
Synchronization In, purpose	Frame sync In to control camera
Synchronization In	1×, non-isolated
Synchronization In, type	LVC Buffer @3.3V, "0" <0.8 V, "1">2.0 V.
Synchronization Out, purpose	Frame sync Out to control another Ax5 camera
Synchronization Out	1×, non-isolated
Synchronization Out, type	LVC Buffer @ 3.3V, "0"=24 MA max, "1"= -24 mA max.
Digital Synchronization, connector type	12-pole M12 connector (shared with Digital I/O and External power)
Power system	
External power operation	12/24 VDC, < 3.5 W nominal < 6.0 W absolute max
External power, connector type	12-pole M12 connector (shared with Digital I/O and Digital Synchronization)
Voltage	Allowed range 10-30 VDC
Environmental data	
Operating temperature range	-15°C to +50°C (+5°F to +122°F)
Storage temperature range	-40°C to +70°C (-40°F to +158°F)
Humidity (operating and storage)	IEC 60068-2-30/24 h 95% relative humidity +25°C to +40°C (+77°F to +104°F)
EMC	<ul style="list-style-type: none"> • EN 61000-6-2 (Immunity) • EN 61000-6-3 (Emission) • FCC 47 CFR Part 15 Class B (Emission)
Encapsulation	IP 40 (IEC 60529) with base support mounted

Environmental data	
Shock	25 g (IEC 60068-2-27)
Vibration	2 g (IEC 60068-2-6)
Physical data	
Weight	0.200 kg (0.44 lb.)
Camera size (L × W × H)	106 × 40 × 43 mm (4.2 × 1.6 × 1.7 in.)
Tripod mounting	UNC ¼"-20 (on three sides)
Base mounting	4 × M3 thread mounting holes (bottom)
Housing material	Magnesium and aluminum
Shipping information	
Packaging, type	Cardboard box
List of contents	<ul style="list-style-type: none"> • Hard transport case • Infrared camera with lens • Base support • Cable tie (2 ea.) • Ethernet cable CAT-6, 2m/6.6 ft (2 ea.) • FLIR ResearchIR Standard 4 • Focus adjustment tool • Gooseneck • Mains cable kit (UK,EU,US) • PoE Injector (power over Ethernet) • Printed documentation • Table stand • User documentation CD-ROM
Packaging, weight	5.3 kg (11.7 lb.)
Packaging, size	370 × 180 × 320 mm (14.6 × 7.1 × 12.6 in.)
EAN-13	7332558008492
UPC-12	845188008857
Country of origin	Sweden

Supplies & accessories:

- T951004ACC; Ethernet cable CAT-6, 2m/6.6 ft.
- T198349; Base support
- T198348; Cable kit Mains (UK,EU,US)
- T911112; PoE injector
- T198392; Table stand kit
- T911183; Gigabit PoE injector 16 W, with multi-plugs
- T127605ACC; Cable M12 Pigtail
- T127606ACC; Cable M12 Sync
- T198342ACC; Focus adjustment tool
- T198584; FLIR Tools
- T198583; FLIR Tools+ (license only)
- DSW-10000; FLIR IR Camera Player

11.21 FLIR A65 f=25 mm

P/N: 62625-0101

Rev.: 22369

General description	
<p>The FLIR A65 has features and functions that make it the natural choice for anyone who uses PC software to solve problems and for whom 640 × 512 pixel resolution is sufficient.</p> <p>Among its main features are GigE Vision and GenICam compliance, which makes it plug-and-play when used with software packages such as IMAQ Vision and Halcon.</p>	
Key features:	
<ul style="list-style-type: none"> • Very affordable. • Compact (40 mm × 43 mm × 106 mm). • GigE Vision and GenICam compliant. • GigE Vision lockable connector. • PoE (power over Ethernet). • 8-bit 640 × 512 pixel images streamed at 30 Hz, signal linear • 14-bit 640 × 512 pixel images streamed at 30 Hz, signal and temperature linear • Synchronization between cameras possible. • 1x+1x GPIO. • Compliant with any software that supports GenICam, including National Instruments IMAQ Vision, Stemmers Common Vision Blox, and COGNEX Vision Pro. 	
Typical applications:	
<ul style="list-style-type: none"> • Automation and thermal machine vision. • Entry level "high-speed" R&D. 	
Imaging and optical data	
IR resolution	640 × 512 pixels
Thermal sensitivity/NETD	< 0.05°C @ +30°C (+86°F) / 50 mK
Field of view (FOV)	25° × 20°
Focal length	25 mm (0.98 in.)
Spatial resolution (IFOV)	0.68 mrad
F-number	1.25
Image frequency	30 Hz
Focus	Fixed
Detector data	
Detector type	Focal Plane Array (FPA), Uncooled VOX microbolometer
Spectral range	7.5–13 μm
Detector pitch	17 μm
Detector time constant	Typical 12 ms
Measurement	
Object temperature range	–25 to +135°C (–13 to 275°F)
Accuracy	±5°C (±9°F) or ±5% of reading
Ethernet	
Ethernet	Control and image
Ethernet, type	Gigabit Ethernet
Ethernet, standard	IEEE 802.3
Ethernet, connector type	RJ-45
Ethernet, communication	GigE Vision ver. 1.2 Client API GenICam compliant

Ethernet	
Ethernet, image streaming	8-bit monochrome @ 30 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Automatic/ Manual • Flip H&V 14-bit 640 × 512 pixels @ 30 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Temperature linear GigE Vision and GenICam compatible
Ethernet, power	Power over Ethernet, PoE IEEE 802.3af class 0 Power
Ethernet, protocols	TCP, UDP, ICMP, IGMP, DHCP, GigEVision
Digital input/output	
Digital input, purpose	General purpose
Digital input	1× opto-isolated, "0" <2, "1"=2-12 VDC. NOTE: Maximum input 12 VDC. If the input is above 12 VDC without a resistor in series there is a risk of damaging the input. If the input is 24 VDC use a 1.2 kΩ resistor in series. In that case "1" = 3-24 VDC.
Digital output, purpose	General purpose Output to ext. device (programmatically set)
Digital output	1× opto-isolated, 2-40 VDC, max 185 mA
Digital I/O, isolation voltage	500 VRMS
Digital I/O, supply voltage	2-40 VDC, max 200 mA
Digital I/O, connector type	12-pole M12 connector (shared with Digital Synchronization and External power)
Synchronization In, purpose	Frame sync In to control camera
Synchronization In	1×, non-isolated
Synchronization In, type	LVC Buffer @3.3V, "0" <0.8 V, "1">2.0 V.
Synchronization Out, purpose	Frame sync Out to control another Ax5 camera
Synchronization Out	1×, non-isolated
Synchronization Out, type	LVC Buffer @ 3.3V, "0"=24 MA max, "1"= -24 mA max.
Digital Synchronization, connector type	12-pole M12 connector (shared with Digital I/O and External power)
Power system	
External power operation	12/24 VDC, < 3.5 W nominal < 6.0 W absolute max
External power, connector type	12-pole M12 connector (shared with Digital I/O and Digital Synchronization)
Voltage	Allowed range 10-30 VDC
Environmental data	
Operating temperature range	-15°C to +50°C (+5°F to +122°F)
Storage temperature range	-40°C to +70°C (-40°F to +158°F)
Humidity (operating and storage)	IEC 60068-2-30/24 h 95% relative humidity +25°C to +40°C (+77°F to +104°F)
EMC	<ul style="list-style-type: none"> • EN 61000-6-2 (Immunity) • EN 61000-6-3 (Emission) • FCC 47 CFR Part 15 Class B (Emission)
Encapsulation	IP 40 (IEC 60529) with base support mounted

Environmental data	
Shock	25 g (IEC 60068-2-27)
Vibration	2 g (IEC 60068-2-6)
Physical data	
Weight	0.200 kg (0.44 lb.)
Camera size (L × W × H)	106 × 40 × 43 mm (4.2 × 1.6 × 1.7 in.)
Tripod mounting	UNC ¼"-20 (on three sides)
Base mounting	4 × M3 thread mounting holes (bottom)
Housing material	Magnesium and aluminum
Shipping information	
Packaging, type	Cardboard box
List of contents	<ul style="list-style-type: none"> • Infrared camera with lens • FLIR Tools download card • Printed documentation • User documentation CD-ROM
Packaging, weight	
Packaging, size	295 × 200 × 105 mm (11.6 × 7.9 × 4.1 in.)
EAN-13	7332558005453
UPC-12	845188005658
Country of origin	Sweden

Supplies & accessories:

- T951004ACC; Ethernet cable CAT-6, 2m/6.6 ft.
- T198349; Base support
- T198348; Cable kit Mains (UK,EU,US)
- T911112; PoE injector
- T198392; Table stand kit
- T911183; Gigabit PoE injector 16 W, with multi-plugs
- T127605ACC; Cable M12 Pigtail
- T127606ACC; Cable M12 Sync
- T198584; FLIR Tools
- T198583; FLIR Tools+ (license only)
- DSW-10000; FLIR IR Camera Player

11.22 FLIR A65 f=25 mm (7.5 Hz)

P/N: 62525-0101

Rev.: 22369

General description	
<p>The FLIR A65 has features and functions that make it the natural choice for anyone who uses PC software to solve problems and for whom 640 × 512 pixel resolution is sufficient.</p> <p>Among its main features are GigE Vision and GenICam compliance, which makes it plug-and-play when used with software packages such as IMAQ Vision and Halcon.</p>	
Key features:	
<ul style="list-style-type: none"> • Very affordable. • Compact (40 mm × 43 mm × 106 mm). • GigE Vision and GenICam compliant. • GigE Vision lockable connector. • PoE (power over Ethernet). • 8-bit 640 × 512 pixel images streamed at 7.5 Hz, signal linear • 14-bit 640 × 512 pixel images streamed at 7.5 Hz, signal and temperature linear • Synchronization between cameras possible. • 1x+1x GPIO. • Compliant with any software that supports GenICam, including National Instruments IMAQ Vision, Stemmers Common Vision Blox, and COGNEX Vision Pro. 	
Typical applications:	
<ul style="list-style-type: none"> • Automation and thermal machine vision. • Entry level "high-speed" R&D. 	
Imaging and optical data	
IR resolution	640 × 512 pixels
Thermal sensitivity/NETD	< 0.05°C @ +30°C (+86°F) / 50 mK
Field of view (FOV)	25° × 20°
Focal length	25 mm (0.98 in.)
Spatial resolution (IFOV)	0.68 mrad
F-number	1.25
Image frequency	7.5 Hz
Focus	Fixed
Detector data	
Detector type	Focal Plane Array (FPA), Uncooled VOX microbolometer
Spectral range	7.5–13 μm
Detector pitch	17 μm
Detector time constant	Typical 12 ms
Measurement	
Object temperature range	–25 to +135°C (–13 to 275°F)
Accuracy	±5°C (±9°F) or ±5% of reading
Ethernet	
Ethernet	Control and image
Ethernet, type	Gigabit Ethernet
Ethernet, standard	IEEE 802.3
Ethernet, connector type	RJ-45
Ethernet, communication	GigE Vision ver. 1.2 Client API GenICam compliant

Ethernet	
Ethernet, image streaming	8-bit monochrome @ 7.5 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Automatic/ Manual • Flip H&V 14-bit 640 × 512 pixels @ 7.5 Hz <ul style="list-style-type: none"> • Signal linear/ DDE • Temperature linear GigE Vision and GenICam compatible
Ethernet, power	Power over Ethernet, PoE IEEE 802.3af class 0 Power
Ethernet, protocols	TCP, UDP, ICMP, IGMP, DHCP, GigEVision
Digital input/output	
Digital input, purpose	General purpose
Digital input	1× opto-isolated, "0" <2, "1"=2-12 VDC. NOTE: Maximum input 12 VDC. If the input is above 12 VDC without a resistor in series there is a risk of damaging the input. If the input is 24 VDC use a 1.2 kΩ resistor in series. In that case "1" = 3-24 VDC.
Digital output, purpose	General purpose Output to ext. device (programmatically set)
Digital output	1× opto-isolated, 2-40 VDC, max 185 mA
Digital I/O, isolation voltage	500 VRMS
Digital I/O, supply voltage	2-40 VDC, max 200 mA
Digital I/O, connector type	12-pole M12 connector (shared with Digital Synchronization and External power)
Synchronization In, purpose	Frame sync In to control camera
Synchronization In	1×, non-isolated
Synchronization In, type	LVC Buffer @3.3V, "0" <0.8 V, "1">2.0 V.
Synchronization Out, purpose	Frame sync Out to control another Ax5 camera
Synchronization Out	1×, non-isolated
Synchronization Out, type	LVC Buffer @ 3.3V, "0"=24 MA max, "1"= -24 mA max.
Digital Synchronization, connector type	12-pole M12 connector (shared with Digital I/O and External power)
Power system	
External power operation	12/24 VDC, < 3.5 W nominal < 6.0 W absolute max
External power, connector type	12-pole M12 connector (shared with Digital I/O and Digital Synchronization)
Voltage	Allowed range 10-30 VDC
Environmental data	
Operating temperature range	-15°C to +50°C (+5°F to +122°F)
Storage temperature range	-40°C to +70°C (-40°F to +158°F)
Humidity (operating and storage)	IEC 60068-2-30/24 h 95% relative humidity +25°C to +40°C (+77°F to +104°F)
EMC	<ul style="list-style-type: none"> • EN 61000-6-2 (Immunity) • EN 61000-6-3 (Emission) • FCC 47 CFR Part 15 Class B (Emission)
Encapsulation	IP 40 (IEC 60529) with base support mounted

Environmental data	
Shock	25 g (IEC 60068-2-27)
Vibration	2 g (IEC 60068-2-6)
Physical data	
Weight	0.200 kg (0.44 lb.)
Camera size (L × W × H)	106 × 40 × 43 mm (4.2 × 1.6 × 1.7 in.)
Tripod mounting	UNC ¼"-20 (on three sides)
Base mounting	4 × M3 thread mounting holes (bottom)
Housing material	Magnesium and aluminum
Shipping information	
Packaging, type	Cardboard box
List of contents	<ul style="list-style-type: none"> • Infrared camera with lens • FLIR Tools download card • Printed documentation • User documentation CD-ROM
Packaging, weight	
Packaging, size	295 × 200 × 105 mm (11.6 × 7.9 × 4.1 in.)
EAN-13	7332558004074 4743254000544 (Estonia plant)
UPC-12	845188003630
Country of origin	Sweden

Supplies & accessories:

- T951004ACC; Ethernet cable CAT-6, 2m/6.6 ft.
- T198349; Base support
- T198348; Cable kit Mains (UK,EU,US)
- T911112; PoE injector
- T198392; Table stand kit
- T911183; Gigabit PoE injector 16 W, with multi-plugs
- T127605ACC; Cable M12 Pigtail
- T127606ACC; Cable M12 Sync
- T198584; FLIR Tools
- T198583; FLIR Tools+ (license only)
- DSW-10000; FLIR IR Camera Player

Basic dimensions
for cameras with
focal length:
f= 7,5 mm
f= 9 mm
f=13 mm
f=19 mm

4x M3
Depth max 4 mm

Connector GP I/O
M12 12-pin

LED Power indicator

Connector Ethernet
RJ45

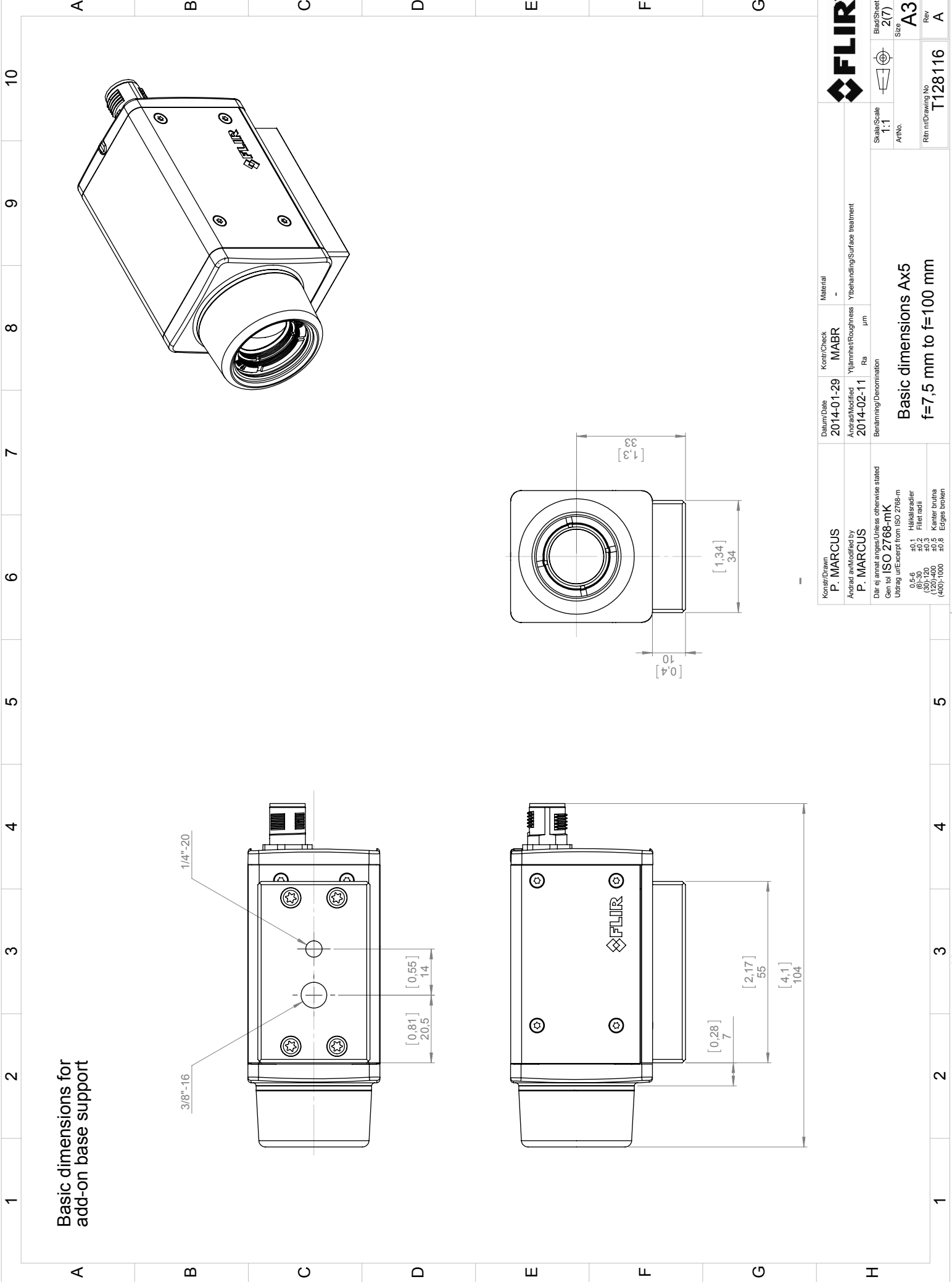
Basic dimensions Ax5
f=7,5 mm to f=100 mm



Konstr/Drawn	2014-01-29	Kontr/Check	Material
P. MARCUS	2014-01-29	MABR	-
Andrad av/Modified by	Andrad/Modified	Ylämäär/Revised	Yrbehandling/Surface treatment
P. MARCUS	2014-02-11	Ra	µm
Benämning/Denomination			

Sheet/Scale	1:1
Size	A3
Rev	A

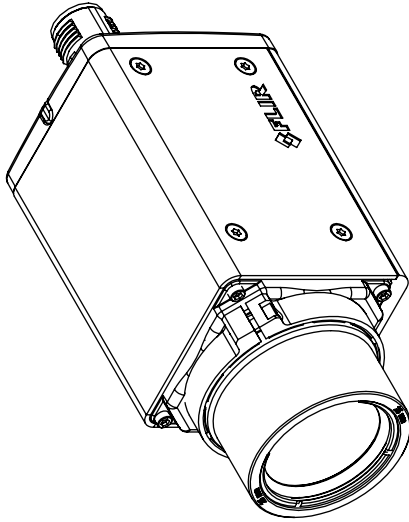
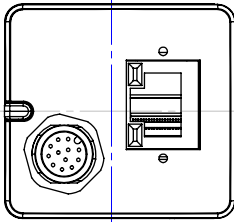
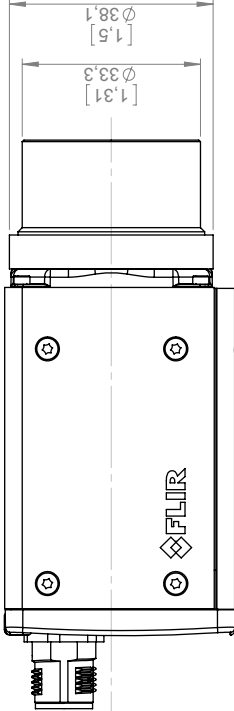
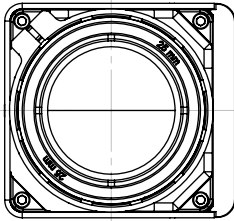
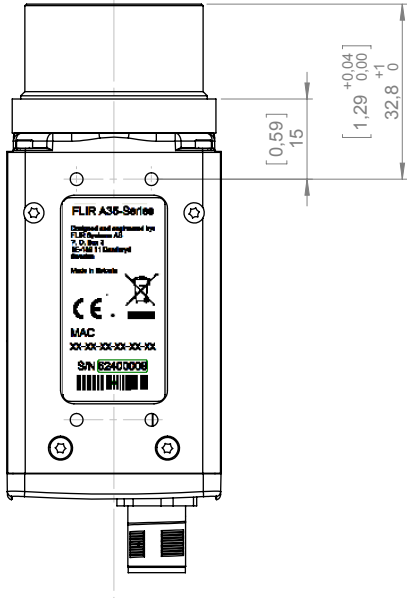
Ritn nr/Drawing No.	T128116
---------------------	---------



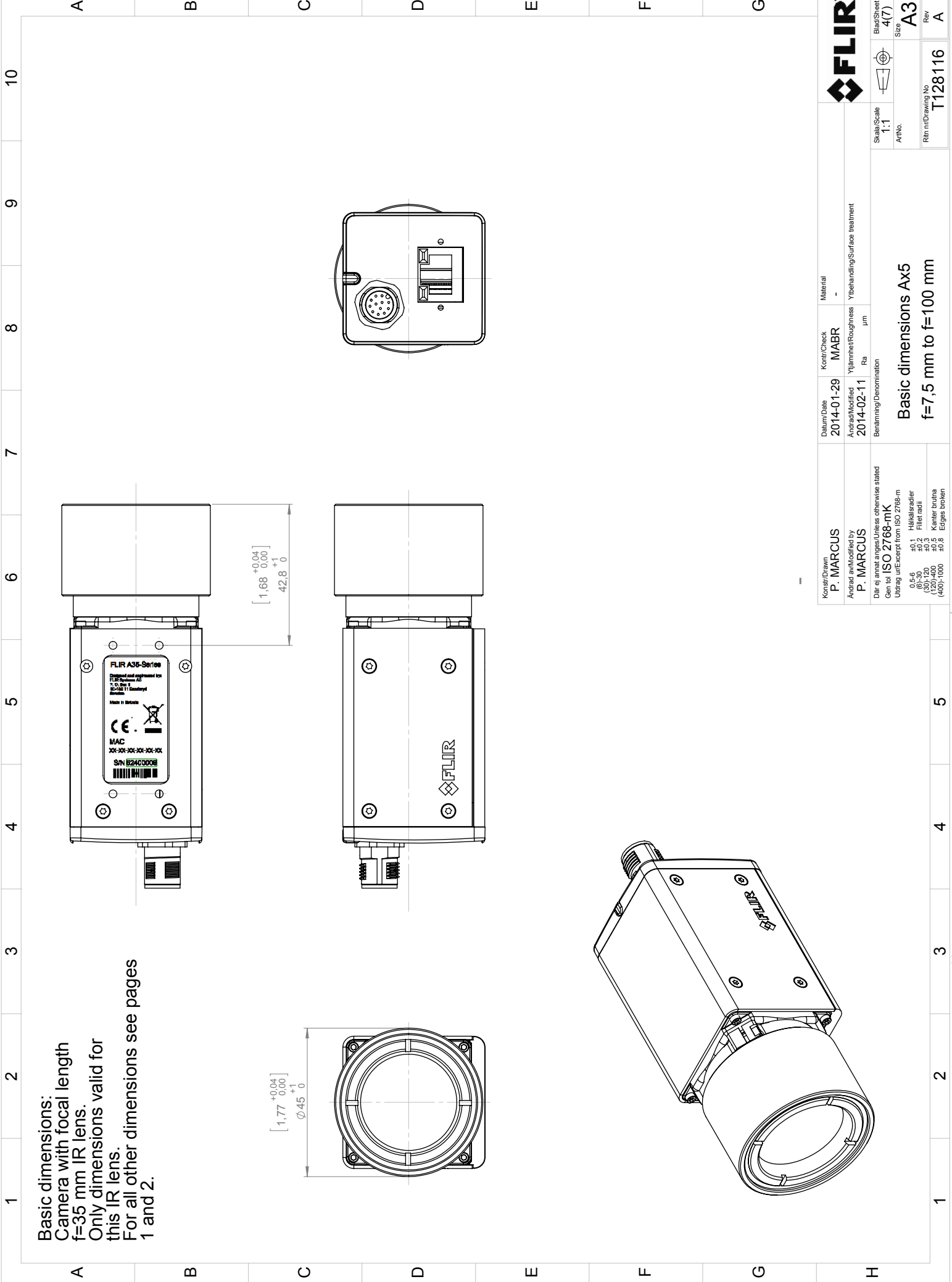
Konstr/Drawn P. MARCUS		Datum/Date 2014-01-29	Kontr/Check MABR	Material -
Ändrad av/Modified by P. MARCUS		Ändrad/Modified 2014-02-11	Ytlämne/Roughness Ra	Ytbehandling/Surface treatment µm
Där ej annat anges/Unless otherwise stated Gen töl ISO 2768-mK Utmått ut/Excerpt from ISO 2768-m		Benämning/Denomination Basic dimensions Ax5 f=7.5 mm to f=100 mm		
0.5-6 ±0.1 Hållisradier (6)-30 ±0.2 Fillet radii (120)-400 ±0.5 Kanter brutna (400)-1000 ±0.8 Edges broken		Skala/Scale 1:1		
		Blad/Sheet 2(7)		
		Rev A		
		Ritning/Drawing No T128116		



Basic dimensions:
Camera with focal length
f=25 mm IR lens.
Only dimensions valid for
this IR lens.
For all other dimensions see pages
1 and 2.



<div>Konstr/Drawn</div> <div>P. MARCUS</div> <div>Ändrad av/Modified by</div> <div>P. MARCUS</div>	Datum/Date	2014-01-29	Kontr/Check	MABR	Material	Ytbehandling/Surface treatment	
		Ändrad/Modified		Ytämne/Roughness			
		2014-02-11		Ra			µm
		Benämning/Denomination					
	Basic dimensions Ax5						
	f=7,5 mm to f=100 mm						
	Där ej annat anges/Unless otherwise stated						
	Gen töl ISO 2768-mK						
	Utmått utE/Excerpt from ISO 2768-m						
	0,5-6 ±0,1 Hållarsradier						
(6,3-30) ±0,2 Fillet radii							
(30-120) ±0,3							
Kanter brutna							
(120-400) ±0,5							
400-1000 ±0,8 Edges broken							
Scale/Scale		1:1	Blad/Sheet		3(7)		
Art.No.			Size		A3		
Rit nr/Drawing No		T128116	Rev		A		



Basic dimensions:
Camera with focal length
f=35 mm IR lens.
Only dimensions valid for
this IR lens.
For all other dimensions see pages
1 and 2.

This document must not be communicated or
copied completely or in part, without our permission.
FLIR SYSTEMS AB

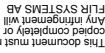
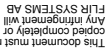
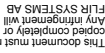
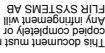
Denna handling får ej delas annan, kopieras i
sin helhet eller delar utan vårt medgivande.
Övertalade härav beivras med stöd av gällande lag.
FLIR SYSTEMS AB

Konstr/Drawn P. MARCUS		Datum/Date 2014-01-29	Kontr/Check MABR	Material -
Ändrad av/Modified by P. MARCUS		Ändrad/Modified 2014-02-11	Ytlämne/Roughness Ra	Ytbehandling/Surface treatment µm
Där ej annat anges/Unless otherwise stated Utdrag ur/Excerpt from ISO 2768-m		Benämning/Denomination Basic dimensions Ax5 f=7.5 mm to f=100 mm		
0.5-6 6.3-30 30-120 120-400 (400)-1000		±0.1 Hållarsradier ±0.2 Fillet radii ±0.5 Kanter brutna ±0.8 Edges broken		
Skala/Scale 1:1		Blad/Sheet 4(7)		
Rev A		Ritning/Drawing No T128116		

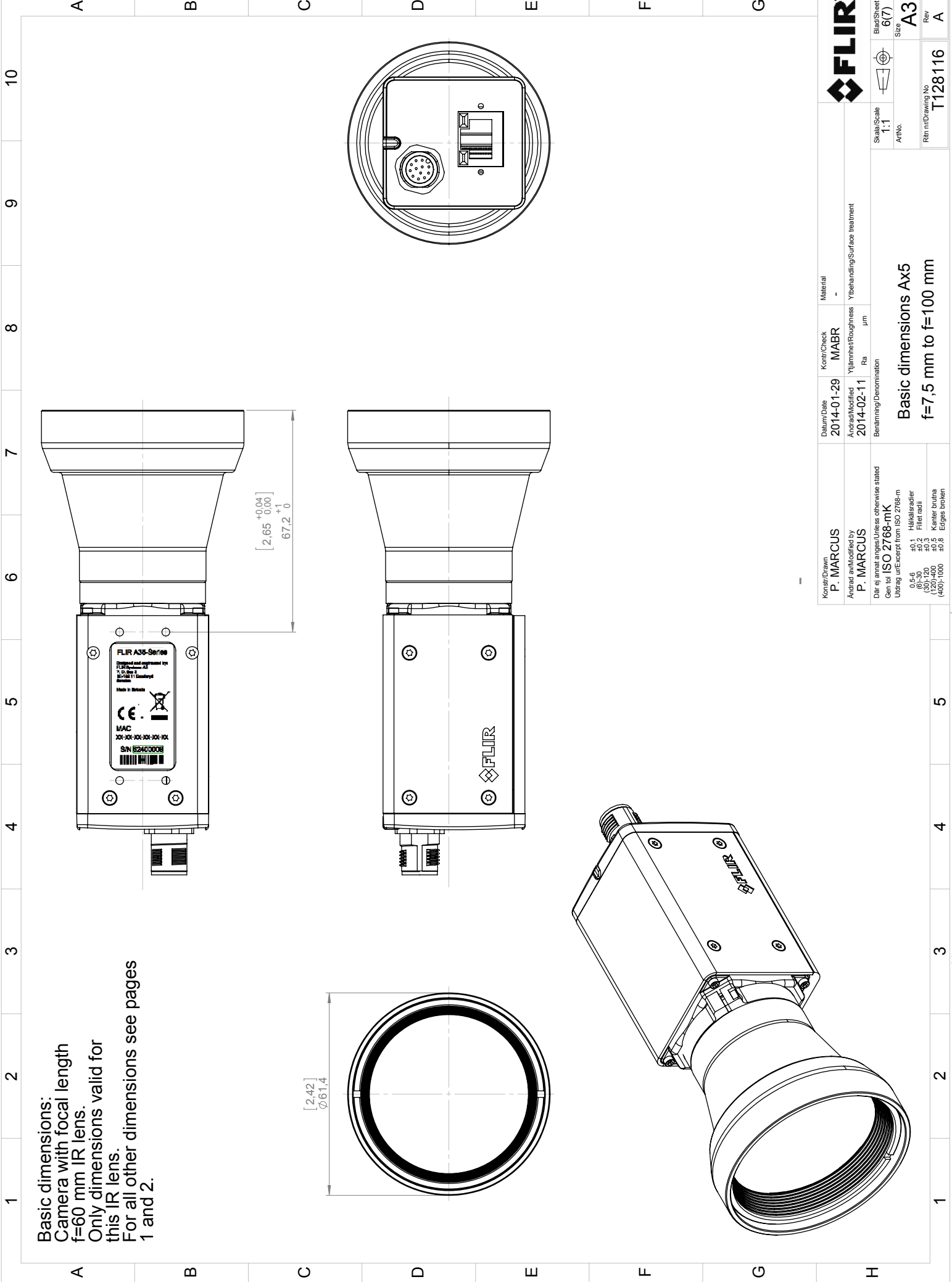


This document must not be copied completely or Any infringement will FLIR SYSTEMS AB

This document must not be copied completely or Any infringement will FLIR SYSTEMS AB



This document must not be copied completely or Any infringement will FLIR SYSTEMS AB



This document must not be communicated or copied completely or in part, without our permission. Any infringement will lead to legal proceedings. FLIR SYSTEMS AB

Denna handling får ej delas annan, kopieras i sin helhet eller delar utan vårt medgivande. Övertagelse härav beivras med stöd av gällande lag. FLIR SYSTEMS AB

Konstr/Drawn P. MARCUS		Datum/Date 2014-01-29	Kontr/Check MABR	Material -
Ändrad av/Modified by P. MARCUS		Ändrad/Modified 2014-02-11	Ytlämne/Roughness Ra	Ytbehandling/Surface treatment µm
Där ej annat anges/Unless otherwise stated Gen töl ISO 2768-mK Utdrag ur/Excerpt from ISO 2768-m		Benämning/Denomination Basic dimensions Ax5 f=7,5 mm to f=100 mm		
0,5-6 60-300 (120)-400 (400)-1000		±0,1 Hållarsradier ±0,2 Fillet radii ±0,5 Kanter brutna ±0,8 Edges broken		
Scale/Scale 1:1		Sheet/Sheet 6(7)		
Rev A		Title/Title T128116		



Basic dimensions:
Camera with focal length
f=100 mm IR lens.
Only dimensions valid for
this IR lens.
For all other dimensions see pages
1 and 2.

This document must not be communicated or
copied completely or in part, without our permission.
FLIR SYSTEMS AB

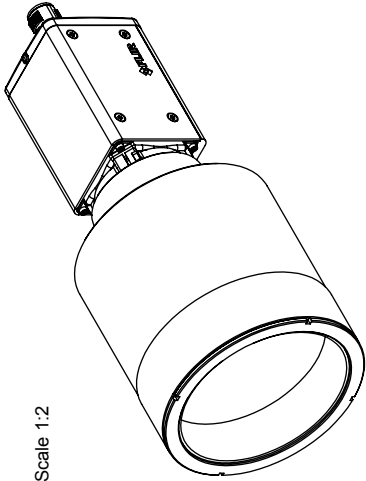
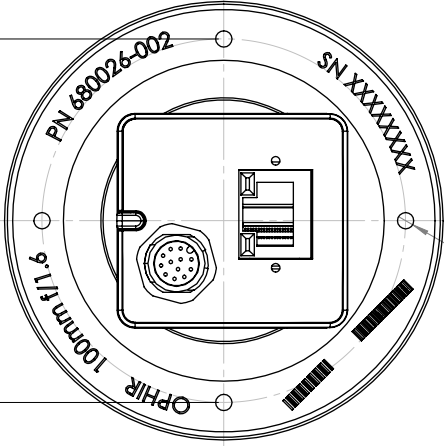
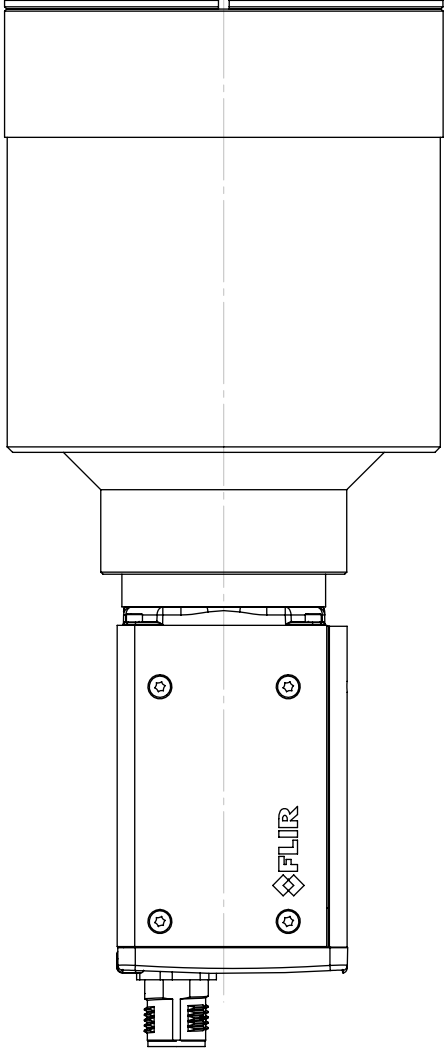
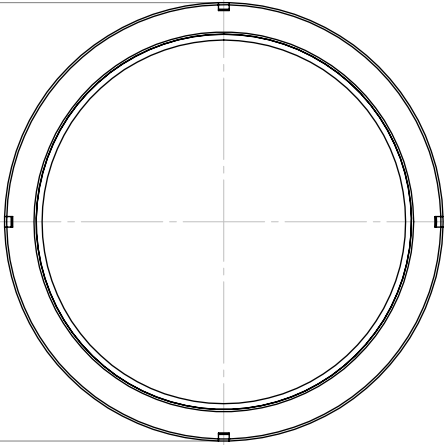


[1,48 +0,04
0,00 +1]
37,5 0

[4,8 +0,04
0,00 +1]
122 0

[3,23]
Ø 82

[2,68]
Ø 68



Scale 1:2



Konstr/Drawn	P. MARCUS	Datum/Date	2014-01-29	Kontr/Check	MABR	Material	-
Ändrad av/Modified by	P. MARCUS	Ändrad/Modified	2014-02-11	Ytlämne/Roughness	Ra	Ytbehandling/Surface treatment	
Där ej annat anges/Unless otherwise stated							

13.1 M12 connector pin configuration

This section specifies the pin configuration for the M12 connector at the rear of the camera.

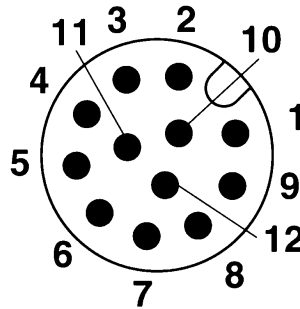


Figure 13.1 Pin assignment M12 male connector: 12 positions, male side view.

Table 13.1 Mapping table, pin to signal

Pin	Signal	Explanation
1	RET_GB	Camera PWR –
2	PWR_GB	Camera PWR +
3	SYNC_OUT	LVC Buffer @ 3.3 V, "0" = 24 mA max, "1" = –24 mA max.
4	SYNC_OUT_GND	= RET_GB = Camera PWR –
5	SYNC_IN	LVC Buffer @ 3.3 V, "0" < 0.8 V, "1" > 2.0 V
6	SYNC_IN_GND	= RET_GB = Camera PWR –
7	GPO+	1 × opto-isolated, 2–40 VDC, max. 185 mA
8	GPO–	= GP Input return
9	GPIO_PWR	GP Output PWR. 2–40 VDC, max. 200 mA
10	GPIO_GND	GP Output PWR return
11	GPI+	1 × opto-isolated, "0" < 2, "1" = 2–40 VDC
12	GPI–	GP Input return

Cables for the M12 connector are available from FLIR Systems. See the part numbers below.

- T127605, Cable M12 pigtail.
- T127606, Cable M12 sync.

13.2 Pig-tail end of cable













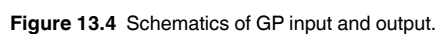
1 RET_GB		BLACK
2 PWR_GB		BROWN
3 SYNC_OUT		BLACK
4 SYNC_OUT_GND		RED
5 SYNC_IN		BLACK
6 SYNC_IN_GND		ORANGE
7 GPO+		BLACK
8 GPO–		YELLOW
9 GPIO_PWR		BLACK
10 GPIO_GND		GREEN
11 GPI+		BLACK
12 GPI–		BLUE

Figure 13.2 Mapping table, signal type to cable color.

The schematic diagram shows two SN74VLC1G373DCKR flip-flops, U7 and U8, connected to a 3.3V power supply and ground. The power supply is connected to the VCC pins (pin 5 for U7, pin 1 for U8) and the ground is connected to the GND pins (pin 4 for U7, pin 2 for U8). The input/output signals are connected to the D and Q pins. The output signals are connected to the Q pins (pin 4 for U7, pin 2 for U8). The circuit includes various resistors (R20, R21, R22, R24, R37, R38, R39) and a capacitor (C20) for timing and signal conditioning.

13.4 GP input/output schematics





July 2, 2013

AQ320030

CE Declaration of Conformity

This is to certify that the System listed below have been designed and manufactured to meet the requirements, as applicable, of the following EU-Directives and corresponding harmonising standards. The systems consequently meet the requirements for the CE-mark.

Directives:

Directive 2004/108/EC; Electromagnetic Compatibility
Directive 2006/95/EC; "Low voltage Directive" (Power Supply)
Directive 2002/96/EC Waste electrical and electronic equipment; WEEE
(As applicable)

Standards:

Emission: EN 61000-6-3; Electromagnetic Compatibility
Generic standards - Emission
Immunity: EN 61000-6-2; Electromagnetic Compatibility;
Generic standards - Immunity
Safety (Power Supply): EN 60950; (or other) Safety of information technology
equipment

System: FLIR AXX series

FLIR Systems AB
Quality Assurance

Björn Svensson
Director

FLIR Systems AB • Antennvägen 6 • P.O. Box 7376 • SE-187 15 Täby • Sweden
Telephone: +46 8 753 25 00 • Telefax: +46 8 753 23 64
Registered No: 556256-6579
www.flir.se

15.1 Camera housing, cables, and other items

15.1.1 Liquids

Use one of these liquids:

- Warm water
- A weak detergent solution

15.1.2 Equipment

A soft cloth

15.1.3 Procedure

Follow this procedure:

1. Soak the cloth in the liquid.
2. Twist the cloth to remove excess liquid.
3. Clean the part with the cloth.



CAUTION

Do not apply solvents or similar liquids to the camera, the cables, or other items. This can cause damage.

15.2 Infrared lens

15.2.1 Liquids

Use one of these liquids:

- A commercial lens cleaning liquid with more than 30% isopropyl alcohol.
- 96% ethyl alcohol (C_2H_5OH).

15.2.2 Equipment

Cotton wool

15.2.3 Procedure

Follow this procedure:

1. Soak the cotton wool in the liquid.
2. Twist the cotton wool to remove excess liquid.
3. Clean the lens one time only and discard the cotton wool.



WARNING

Make sure that you read all applicable MSDS (Material Safety Data Sheets) and warning labels on containers before you use a liquid: the liquids can be dangerous.



CAUTION

- Be careful when you clean the infrared lens. The lens has a delicate anti-reflective coating.
- Do not clean the infrared lens too vigorously. This can damage the anti-reflective coating.

16About FLIR Systems

FLIR Systems was established in 1978 to pioneer the development of high-performance infrared imaging systems, and is the world leader in the design, manufacture, and marketing of thermal imaging systems for a wide variety of commercial, industrial, and government applications. Today, FLIR Systems embraces five major companies with outstanding achievements in infrared technology since 1958—the Swedish AGEMA Infrared Systems (formerly AGA Infrared Systems), the three United States companies Indigo Systems, FSI, and Inframetrics, and the French company Cedip.

Since 2007, FLIR Systems has acquired several companies with world-leading expertise in sensor technologies:

- Exttech Instruments (2007)
- Ifara Tecnologías (2008)
- Salvador Imaging (2009)
- OmniTech Partners (2009)
- Directed Perception (2009)
- Raymarine (2010)
- ICx Technologies (2010)
- TackTick Marine Digital Instruments (2011)
- Aerius Photonics (2011)
- Lorex Technology (2012)
- Traficon (2012)
- MARSS (2013)
- DigitalOptics micro-optics business (2013)

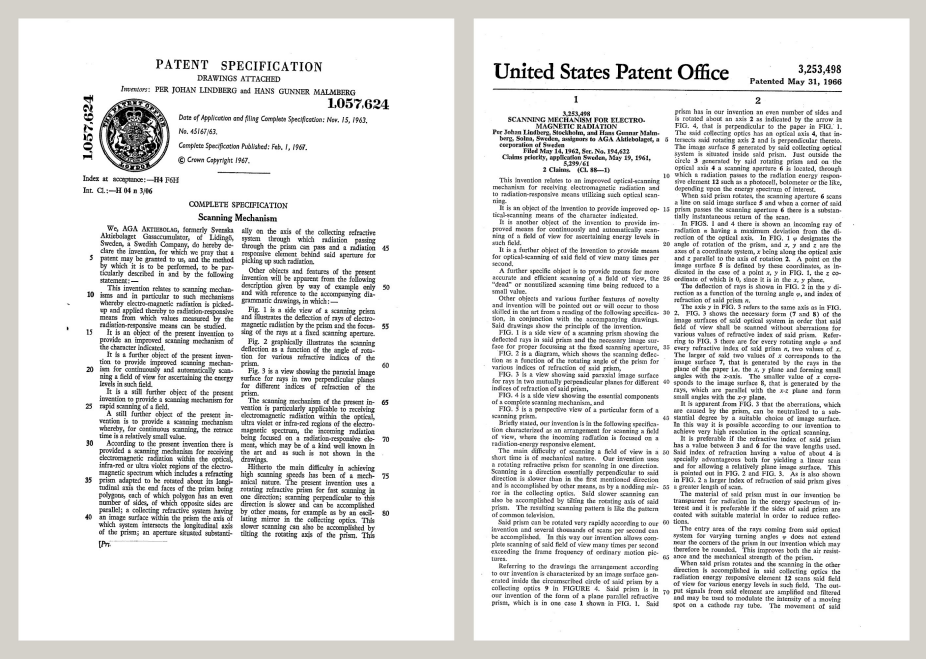


Figure 16.1 Patent documents from the early 1960s

The company has sold more than 350,000 infrared cameras worldwide for applications such as predictive maintenance, R & D, non-destructive testing, process control and automation, and machine vision, among many others.

FLIR Systems has three manufacturing plants in the United States (Portland, OR, Boston, MA, Santa Barbara, CA) and one in Sweden (Stockholm). Since 2007 there is also a manufacturing plant in Tallinn, Estonia. Direct sales offices in Belgium, Brazil, China, France, Germany, Great Britain, Hong Kong, Italy, Japan, Korea, Sweden, and the USA—together with a worldwide network of agents and distributors—support our international customer base.

FLIR Systems is at the forefront of innovation in the infrared camera industry. We anticipate market demand by constantly improving our existing cameras and developing new ones. The company has set milestones in product design and development such as the introduction of the first battery-operated portable camera for industrial inspections, and the first uncooled infrared camera, to mention just two innovations.

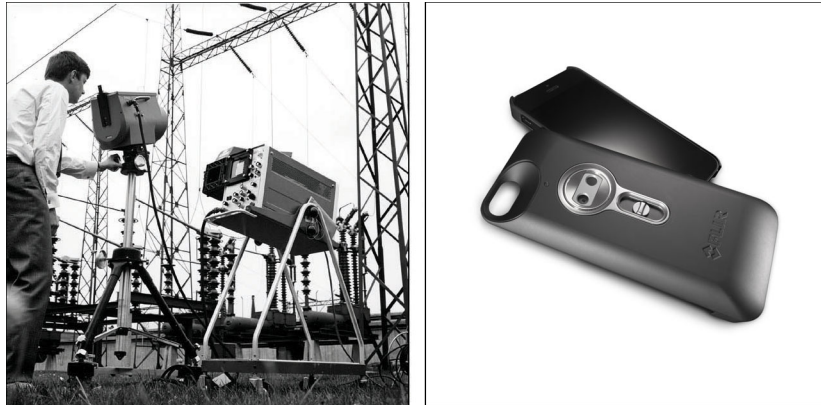


Figure 16.2 LEFT: Thermovision Model 661 from 1969. The camera weighed approximately 25 kg (55 lb.), the oscilloscope 20 kg (44 lb.), and the tripod 15 kg (33 lb.). The operator also needed a 220 VAC generator set, and a 10 L (2.6 US gallon) jar with liquid nitrogen. To the left of the oscilloscope the Polaroid attachment (6 kg/13 lb.) can be seen. RIGHT: FLIR One, which was launched in January 2014, is a slide-on attachment that gives iPhones thermal imaging capabilities. Weight: 90 g (3.2 oz.).

FLIR Systems manufactures all vital mechanical and electronic components of the camera systems itself. From detector design and manufacturing, to lenses and system electronics, to final testing and calibration, all production steps are carried out and supervised by our own engineers. The in-depth expertise of these infrared specialists ensures the accuracy and reliability of all vital components that are assembled into your infrared camera.

16.1 More than just an infrared camera

At FLIR Systems we recognize that our job is to go beyond just producing the best infrared camera systems. We are committed to enabling all users of our infrared camera systems to work more productively by providing them with the most powerful camera–software combination. Especially tailored software for predictive maintenance, R & D, and process monitoring is developed in-house. Most software is available in a wide variety of languages.

We support all our infrared cameras with a wide variety of accessories to adapt your equipment to the most demanding infrared applications.

16.2 Sharing our knowledge

Although our cameras are designed to be very user-friendly, there is a lot more to thermography than just knowing how to handle a camera. Therefore, FLIR Systems has founded the Infrared Training Center (ITC), a separate business unit, that provides certified training courses. Attending one of the ITC courses will give you a truly hands-on learning experience.

The staff of the ITC are also there to provide you with any application support you may need in putting infrared theory into practice.

16.3 Supporting our customers

FLIR Systems operates a worldwide service network to keep your camera running at all times. If you discover a problem with your camera, local service centers have all the equipment and expertise to solve it within the shortest possible time. Therefore, there is no need to send your camera to the other side of the world or to talk to someone who does not speak your language.

16.4 A few images from our facilities

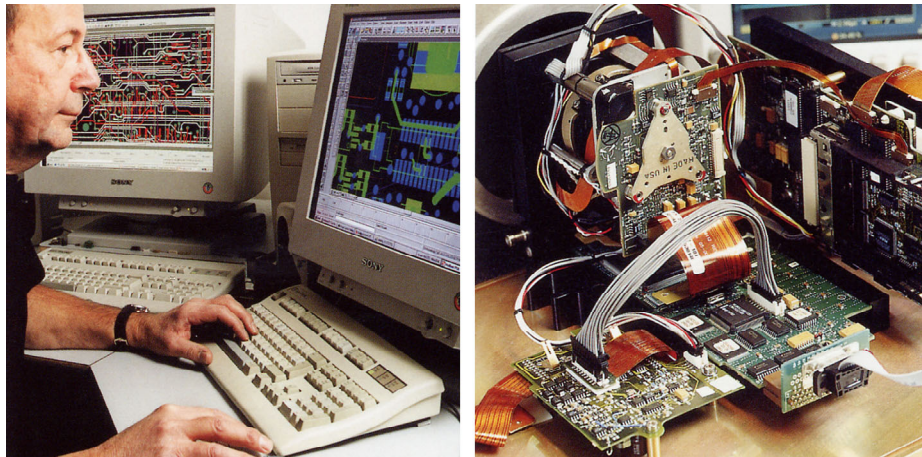


Figure 16.3 LEFT: Development of system electronics; RIGHT: Testing of an FPA detector

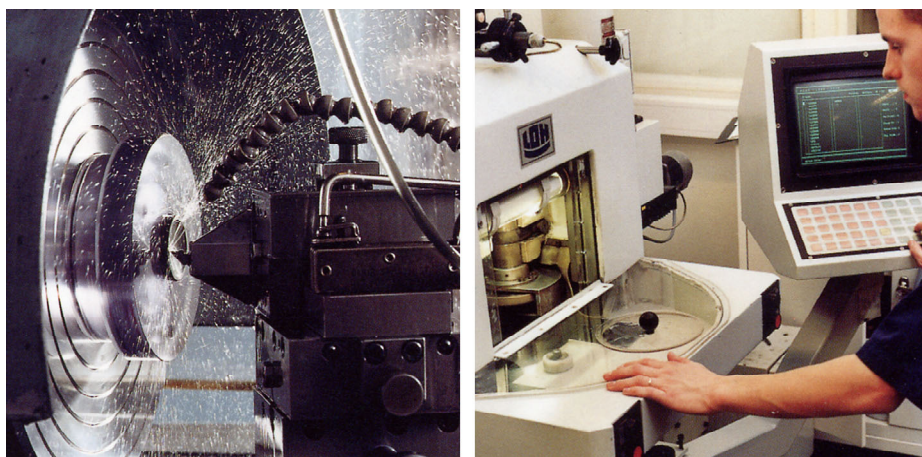


Figure 16.4 LEFT: Diamond turning machine; RIGHT: Lens polishing

absorption (absorption factor)	The amount of radiation absorbed by an object relative to the received radiation. A number between 0 and 1.
atmosphere	The gases between the object being measured and the camera, normally air.
autoadjust	A function making a camera perform an internal image correction.
autopalette	The IR image is shown with an uneven spread of colors, displaying cold objects as well as hot ones at the same time.
blackbody	Totally non-reflective object. All its radiation is due to its own temperature.
blackbody radiator	An IR radiating equipment with blackbody properties used to calibrate IR cameras.
calculated atmospheric transmission	A transmission value computed from the temperature, the relative humidity of air and the distance to the object.
cavity radiator	A bottle shaped radiator with an absorbing inside, viewed through the bottleneck.
color temperature	The temperature for which the color of a blackbody matches a specific color.
conduction	The process that makes heat diffuse into a material.
continuous adjust	A function that adjusts the image. The function works all the time, continuously adjusting brightness and contrast according to the image content.
convection	Convection is a heat transfer mode where a fluid is brought into motion, either by gravity or another force, thereby transferring heat from one place to another.
dual isotherm	An isotherm with two color bands, instead of one.
emissivity (emissivity factor)	The amount of radiation coming from an object, compared to that of a blackbody. A number between 0 and 1.
emittance	Amount of energy emitted from an object per unit of time and area (W/m^2)
environment	Objects and gases that emit radiation towards the object being measured.
estimated atmospheric transmission	A transmission value, supplied by a user, replacing a calculated one
external optics	Extra lenses, filters, heat shields etc. that can be put between the camera and the object being measured.
filter	A material transparent only to some of the infrared wavelengths.
FOV	Field of view: The horizontal angle that can be viewed through an IR lens.
FPA	Focal plane array: A type of IR detector.
graybody	An object that emits a fixed fraction of the amount of energy of a blackbody for each wavelength.
IFOV	Instantaneous field of view: A measure of the geometrical resolution of an IR camera.

image correction (internal or external)	A way of compensating for sensitivity differences in various parts of live images and also of stabilizing the camera.
infrared	Non-visible radiation, having a wavelength from about 2–13 μm .
IR	infrared
isotherm	A function highlighting those parts of an image that fall above, below or between one or more temperature intervals.
isothermal cavity	A bottle-shaped radiator with a uniform temperature viewed through the bottleneck.
Laser LocatIR	An electrically powered light source on the camera that emits laser radiation in a thin, concentrated beam to point at certain parts of the object in front of the camera.
laser pointer	An electrically powered light source on the camera that emits laser radiation in a thin, concentrated beam to point at certain parts of the object in front of the camera.
level	The center value of the temperature scale, usually expressed as a signal value.
manual adjust	A way to adjust the image by manually changing certain parameters.
NETD	Noise equivalent temperature difference. A measure of the image noise level of an IR camera.
noise	Undesired small disturbance in the infrared image
object parameters	A set of values describing the circumstances under which the measurement of an object was made, and the object itself (such as emissivity, reflected apparent temperature, distance etc.)
object signal	A non-calibrated value related to the amount of radiation received by the camera from the object.
palette	The set of colors used to display an IR image.
pixel	Stands for <i>picture element</i> . One single spot in an image.
radiance	Amount of energy emitted from an object per unit of time, area and angle ($\text{W}/\text{m}^2/\text{sr}$)
radiant power	Amount of energy emitted from an object per unit of time (W)
radiation	The process by which electromagnetic energy, is emitted by an object or a gas.
radiator	A piece of IR radiating equipment.
range	The current overall temperature measurement limitation of an IR camera. Cameras can have several ranges. Expressed as two blackbody temperatures that limit the current calibration.
reference temperature	A temperature which the ordinary measured values can be compared with.
reflection	The amount of radiation reflected by an object relative to the received radiation. A number between 0 and 1.
relative humidity	Relative humidity represents the ratio between the current water vapour mass in the air and the maximum it may contain in saturation conditions.
saturation color	The areas that contain temperatures outside the present level/span settings are colored with the saturation colors. The saturation colors contain an 'overflow' color and an 'underflow' color. There is also a third red saturation color that marks everything saturated by the detector indicating that the range should probably be changed.

span	The interval of the temperature scale, usually expressed as a signal value.
spectral (radiant) emittance	Amount of energy emitted from an object per unit of time, area and wavelength ($\text{W/m}^2/\mu\text{m}$)
temperature difference, or difference of temperature.	A value which is the result of a subtraction between two temperature values.
temperature range	The current overall temperature measurement limitation of an IR camera. Cameras can have several ranges. Expressed as two blackbody temperatures that limit the current calibration.
temperature scale	The way in which an IR image currently is displayed. Expressed as two temperature values limiting the colors.
thermogram	infrared image
transmission (or transmittance) factor	Gases and materials can be more or less transparent. Transmission is the amount of IR radiation passing through them. A number between 0 and 1.
transparent isotherm	An isotherm showing a linear spread of colors, instead of covering the highlighted parts of the image.
visual	Refers to the video mode of a IR camera, as opposed to the normal, thermographic mode. When a camera is in video mode it captures ordinary video images, while thermographic images are captured when the camera is in IR mode.

18.1 Introduction

An infrared camera measures and images the emitted infrared radiation from an object. The fact that radiation is a function of object surface temperature makes it possible for the camera to calculate and display this temperature.

However, the radiation measured by the camera does not only depend on the temperature of the object but is also a function of the emissivity. Radiation also originates from the surroundings and is reflected in the object. The radiation from the object and the reflected radiation will also be influenced by the absorption of the atmosphere.

To measure temperature accurately, it is therefore necessary to compensate for the effects of a number of different radiation sources. This is done on-line automatically by the camera. The following object parameters must, however, be supplied for the camera:

- The emissivity of the object
- The reflected apparent temperature
- The distance between the object and the camera
- The relative humidity
- Temperature of the atmosphere

18.2 Emissivity

The most important object parameter to set correctly is the emissivity which, in short, is a measure of how much radiation is emitted from the object, compared to that from a perfect blackbody of the same temperature.

Normally, object materials and surface treatments exhibit emissivity ranging from approximately 0.1 to 0.95. A highly polished (mirror) surface falls below 0.1, while an oxidized or painted surface has a higher emissivity. Oil-based paint, regardless of color in the visible spectrum, has an emissivity over 0.9 in the infrared. Human skin exhibits an emissivity 0.97 to 0.98.

Non-oxidized metals represent an extreme case of perfect opacity and high reflexivity, which does not vary greatly with wavelength. Consequently, the emissivity of metals is low – only increasing with temperature. For non-metals, emissivity tends to be high, and decreases with temperature.

18.2.1 Finding the emissivity of a sample

18.2.1.1 Step 1: Determining reflected apparent temperature

Use one of the following two methods to determine reflected apparent temperature:

18.2.1.1.1 Method 1: Direct method

Follow this procedure:

1. Look for possible reflection sources, considering that the incident angle = reflection angle ($a = b$).

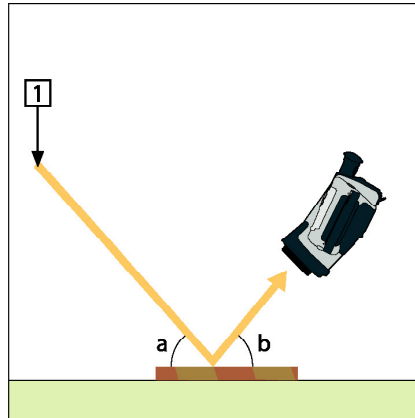


Figure 18.1 1 = Reflection source

2. If the reflection source is a spot source, modify the source by obstructing it using a piece of cardboard.

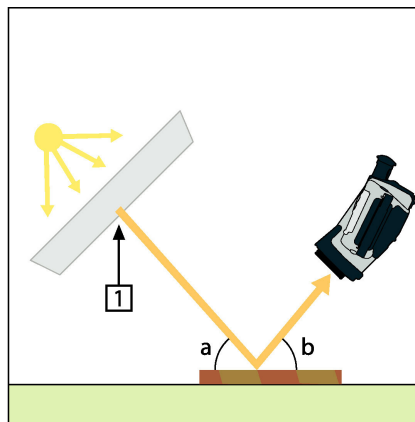


Figure 18.2 1 = Reflection source

3. Measure the radiation intensity (= apparent temperature) from the reflecting source using the following settings:

- Emissivity: 1.0
- D_{obj} : 0

You can measure the radiation intensity using one of the following two methods:

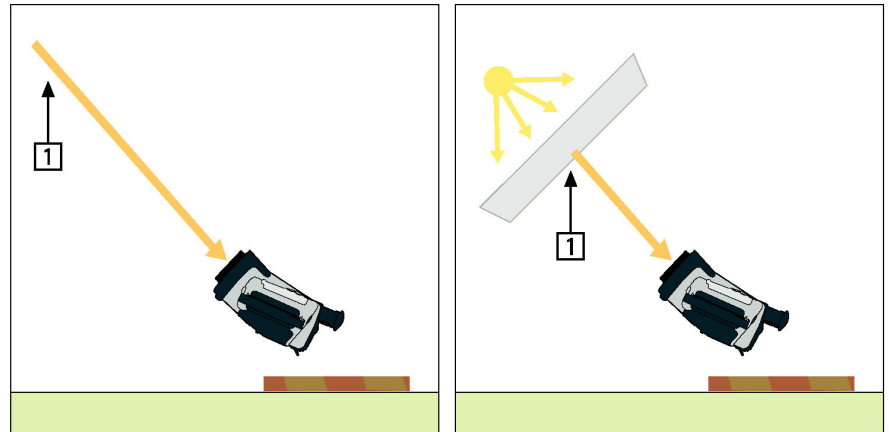


Figure 18.3 1 = Reflection source



NOTE

Using a thermocouple to measure reflected apparent temperature is not recommended for two important reasons:

- A thermocouple does not measure radiation intensity
- A thermocouple requires a very good thermal contact to the surface, usually by gluing and covering the sensor by a thermal isolator.

18.2.1.1.2 Method 2: Reflector method

Follow this procedure:

1. Crumble up a large piece of aluminum foil.
2. Uncrumple the aluminum foil and attach it to a piece of cardboard of the same size.
3. Put the piece of cardboard in front of the object you want to measure. Make sure that the side with aluminum foil points to the camera.
4. Set the emissivity to 1.0.
5. Measure the apparent temperature of the aluminum foil and write it down.

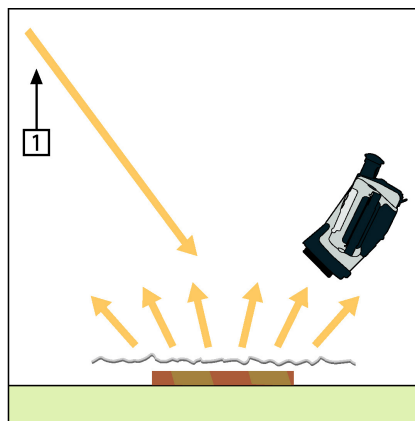


Figure 18.4 Measuring the apparent temperature of the aluminum foil.

18.2.1.2 Step 2: Determining the emissivity

Follow this procedure:

1. Select a place to put the sample.
2. Determine and set reflected apparent temperature according to the previous procedure.
3. Put a piece of electrical tape with known high emissivity on the sample.
4. Heat the sample at least 20 K above room temperature. Heating must be reasonably even.
5. Focus and auto-adjust the camera, and freeze the image.
6. Adjust *Level* and *Span* for best image brightness and contrast.
7. Set emissivity to that of the tape (usually 0.97).
8. Measure the temperature of the tape using one of the following measurement functions:
 - *Isotherm* (helps you to determine both the temperature and how evenly you have heated the sample)
 - *Spot* (simpler)
 - *Box Avg* (good for surfaces with varying emissivity).
9. Write down the temperature.
10. Move your measurement function to the sample surface.
11. Change the emissivity setting until you read the same temperature as your previous measurement.
12. Write down the emissivity.



NOTE

- Avoid forced convection
- Look for a thermally stable surrounding that will not generate spot reflections
- Use high quality tape that you know is not transparent, and has a high emissivity you are certain of
- This method assumes that the temperature of your tape and the sample surface are the same. If they are not, your emissivity measurement will be wrong.

18.3 Reflected apparent temperature

This parameter is used to compensate for the radiation reflected in the object. If the emissivity is low and the object temperature relatively far from that of the reflected it will be important to set and compensate for the reflected apparent temperature correctly.

18.4 Distance

The distance is the distance between the object and the front lens of the camera. This parameter is used to compensate for the following two facts:

- That radiation from the target is absorbed by the atmosphere between the object and the camera.
- That radiation from the atmosphere itself is detected by the camera.

18.5 Relative humidity

The camera can also compensate for the fact that the transmittance is also dependent on the relative humidity of the atmosphere. To do this set the relative humidity to the correct value. For short distances and normal humidity the relative humidity can normally be left at a default value of 50%.

18.6 Other parameters

In addition, some cameras and analysis programs from FLIR Systems allow you to compensate for the following parameters:

- Atmospheric temperature – *i.e.* the temperature of the atmosphere between the camera and the target
- External optics temperature – *i.e.* the temperature of any external lenses or windows used in front of the camera

- External optics transmittance – *i.e.* the transmission of any external lenses or windows used in front of the camera

Before the year 1800, 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.

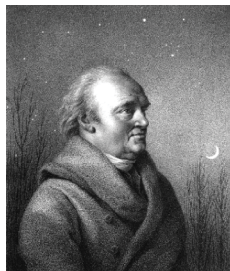


Figure 19.1 Sir William Herschel (1738–1822)

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.



Figure 19.2 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.



Figure 19.3 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 $0.2\text{ }^{\circ}\text{C}$ ($0.036\text{ }^{\circ}\text{F}$), and later models were able to be read to $0.05\text{ }^{\circ}\text{C}$ ($0.09\text{ }^{\circ}\text{F}$)). 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 three meters away.

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'.



Figure 19.4 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.

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.

20.1 Introduction

The subjects of infrared radiation and the related technique of thermography are still new to many who will use an infrared camera. In this section the theory behind thermography will be given.

20.2 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.

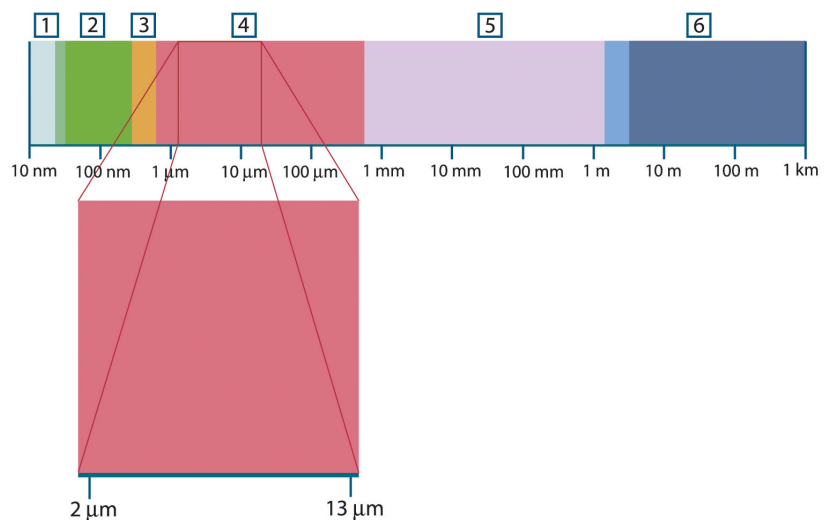


Figure 20.1 The electromagnetic spectrum. 1: X-ray; 2: UV; 3: Visible; 4: IR; 5: Microwaves; 6: Radiowaves.

Thermography 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:

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

20.3 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.

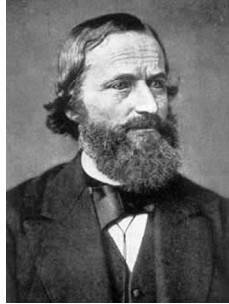


Figure 20.2 Gustav Robert Kirchhoff (1824–1887)

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. Such cavity radiators are commonly used as sources of radiation in temperature reference standards in the laboratory for calibrating thermographic instruments, such as a FLIR Systems camera for example.

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.

20.3.1 Planck's law



Figure 20.3 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:

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

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/m², μm .

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.

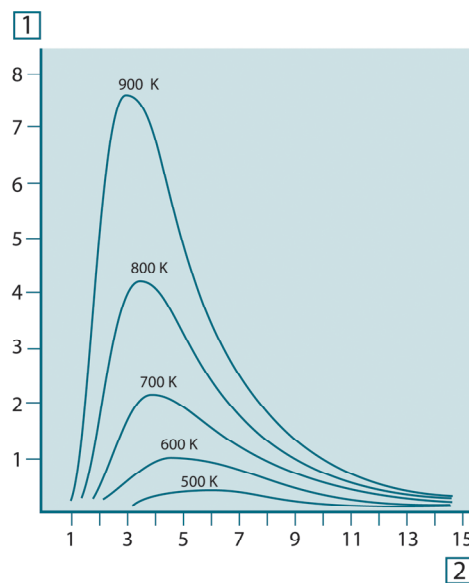


Figure 20.4 Blackbody spectral radiant emittance according to Planck's law, plotted for various absolute temperatures. 1: Spectral radiant emittance (W/cm² × 10³(μm)); 2: Wavelength (μm)

20.3.2 Wien's displacement law

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

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

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 .

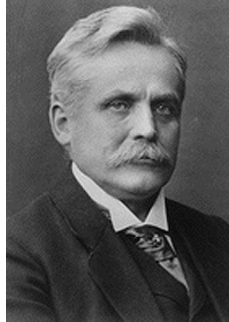


Figure 20.5 Wilhelm Wien (1864–1928)

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 infra-red, 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.

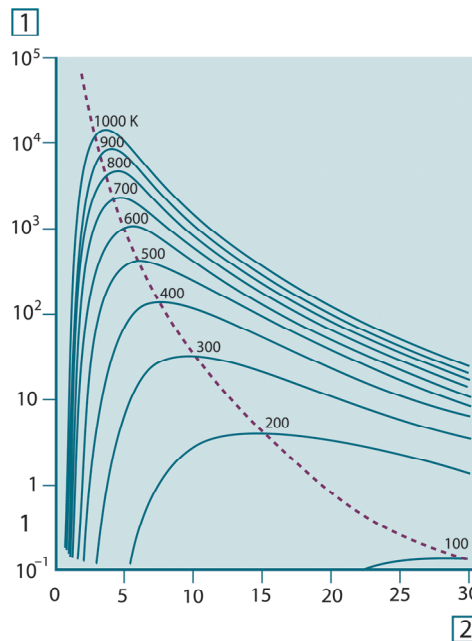


Figure 20.6 Planckian curves plotted on semi-log scales from 100 K to 1000 K. The dotted line represents the locus of maximum radiant emittance at each temperature as described by Wien's displacement law. 1: Spectral radiant emittance (W/cm^2 (μm)); 2: Wavelength (μm).

20.3.3 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:

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

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.



Figure 20.7 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 m², 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.

20.3.4 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:

$$\epsilon_\lambda + \rho_\lambda = 1$$

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:

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

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 $\epsilon_\lambda = \epsilon = 1$
- A graybody, for which $\epsilon_\lambda = \epsilon = \text{constant less than } 1$

- 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:

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

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.

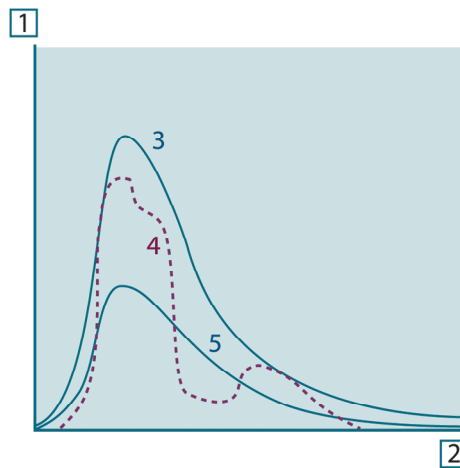


Figure 20.8 Spectral radiant emittance of three types of radiators. 1: Spectral radiant emittance; 2: Wavelength; 3: Blackbody; 4: Selective radiator; 5: Graybody.

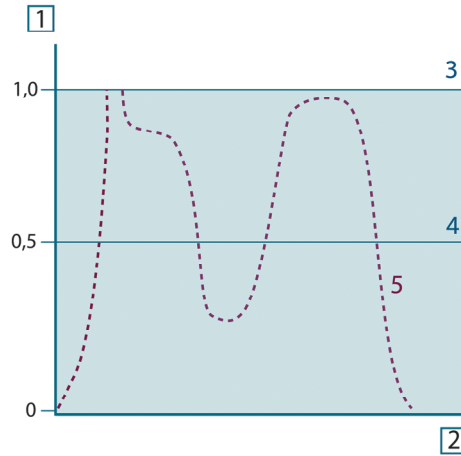


Figure 20.9 Spectral emissivity of three types of radiators. 1: Spectral emissivity; 2: Wavelength; 3: Black-body; 4: Graybody; 5: Selective radiator.

20.4 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.

As already mentioned, when viewing an object, the camera receives radiation not only from the object itself. It also collects radiation from the surroundings reflected via the object surface. Both these radiation contributions become attenuated to some extent by the atmosphere in the measurement path. To this comes a third radiation contribution from the atmosphere itself.

This description of the measurement situation, as illustrated in the figure below, is so far a fairly true description of the real conditions. What has been neglected could for instance be sun light scattering in the atmosphere or stray radiation from intense radiation sources outside the field of view. Such disturbances are difficult to quantify, however, in most cases they are fortunately small enough to be neglected. In case they are not negligible, the measurement configuration is likely to be such that the risk for disturbance is obvious, at least to a trained operator. It is then his responsibility to modify the measurement situation to avoid the disturbance e.g. by changing the viewing direction, shielding off intense radiation sources etc.

Accepting the description above, we can use the figure below to derive a formula for the calculation of the object temperature from the calibrated camera output.

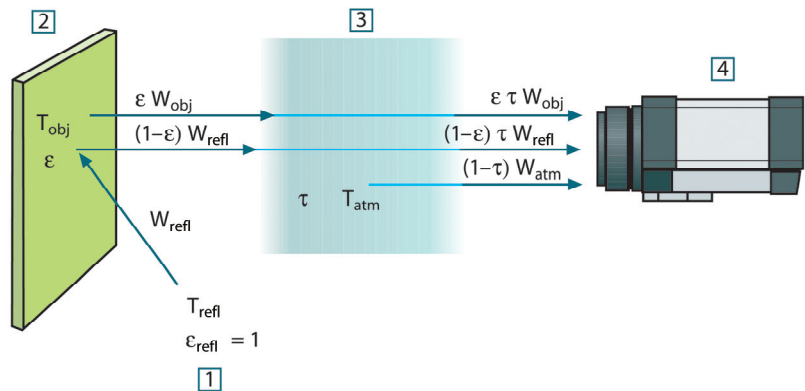


Figure 21.1 A schematic representation of the general thermographic measurement situation. 1: Surroundings; 2: Object; 3: Atmosphere; 4: Camera

Assume that the received radiation power W from a blackbody source of temperature T_{source} on short distance generates a camera output signal U_{source} that is proportional to the power input (power linear camera). We can then write (Equation 1):

$$U_{\text{source}} = CW(T_{\text{source}})$$

or, with simplified notation:

$$U_{\text{source}} = CW_{\text{source}}$$

where C is a constant.

Should the source be a graybody with emittance ϵ , the received radiation would consequently be $\epsilon W_{\text{source}}$.

We are now ready to write the three collected radiation power terms:

1. *Emission from the object* = $\epsilon \tau W_{\text{obj}}$, where ϵ is the emittance of the object and τ is the transmittance of the atmosphere. The object temperature is T_{obj} .

2. *Reflected emission from ambient sources* = $(1 - \varepsilon)\tau W_{\text{refl}}$, where $(1 - \varepsilon)$ is the reflectance of the object. The ambient sources have the temperature T_{refl} .

It has here been assumed that the temperature T_{refl} is the same for all emitting surfaces within the hemisphere seen from a point on the object surface. This is of course sometimes a simplification of the true situation. It is, however, a necessary simplification in order to derive a workable formula, and T_{refl} can – at least theoretically – be given a value that represents an efficient temperature of a complex surrounding.

Note also that we have assumed that the emittance for the surroundings = 1. This is correct in accordance with Kirchhoff's law: All radiation impinging on the surrounding surfaces will eventually be absorbed by the same surfaces. Thus the emittance = 1. (Note though that the latest discussion requires the complete sphere around the object to be considered.)

3. *Emission from the atmosphere* = $(1 - \tau)\tau W_{\text{atm}}$, where $(1 - \tau)$ is the emittance of the atmosphere. The temperature of the atmosphere is T_{atm} .

The total received radiation power can now be written (Equation 2):

$$W_{\text{tot}} = \varepsilon\tau W_{\text{obj}} + (1 - \varepsilon)\tau W_{\text{refl}} + (1 - \tau)W_{\text{atm}}$$

We multiply each term by the constant C of Equation 1 and replace the CW products by the corresponding U according to the same equation, and get (Equation 3):

$$U_{\text{tot}} = \varepsilon\tau U_{\text{obj}} + (1 - \varepsilon)\tau U_{\text{refl}} + (1 - \tau)U_{\text{atm}}$$

Solve Equation 3 for U_{obj} (Equation 4):

$$U_{\text{obj}} = \frac{1}{\varepsilon\tau} U_{\text{tot}} - \frac{1 - \varepsilon}{\varepsilon} U_{\text{refl}} - \frac{1 - \tau}{\varepsilon\tau} U_{\text{atm}}$$

This is the general measurement formula used in all the FLIR Systems thermographic equipment. The voltages of the formula are:

Table 21.1 Voltages

U_{obj}	Calculated camera output voltage for a blackbody of temperature T_{obj} i.e. a voltage that can be directly converted into true requested object temperature.
U_{tot}	Measured camera output voltage for the actual case.
U_{refl}	Theoretical camera output voltage for a blackbody of temperature T_{refl} according to the calibration.
U_{atm}	Theoretical camera output voltage for a blackbody of temperature T_{atm} according to the calibration.

The operator has to supply a number of parameter values for the calculation:

- the object emittance ε ,
- the relative humidity,
- T_{atm}
- object distance (D_{obj})
- the (effective) temperature of the object surroundings, or the reflected ambient temperature T_{refl} , and
- the temperature of the atmosphere T_{atm}

This task could sometimes be a heavy burden for the operator since there are normally no easy ways to find accurate values of emittance and atmospheric transmittance for the actual case. The two temperatures are normally less of a problem provided the surroundings do not contain large and intense radiation sources.

A natural question in this connection is: How important is it to know the right values of these parameters? It could though be of interest to get a feeling for this problem already here by looking into some different measurement cases and compare the relative

magnitudes of the three radiation terms. This will give indications about when it is important to use correct values of which parameters.

The figures below illustrates the relative magnitudes of the three radiation contributions for three different object temperatures, two emittances, and two spectral ranges: SW and LW. Remaining parameters have the following fixed values:

- $\tau = 0.88$
- $T_{\text{refl}} = +20^{\circ}\text{C}$ ($+68^{\circ}\text{F}$)
- $T_{\text{atm}} = +20^{\circ}\text{C}$ ($+68^{\circ}\text{F}$)

It is obvious that measurement of low object temperatures are more critical than measuring high temperatures since the 'disturbing' radiation sources are relatively much stronger in the first case. Should also the object emittance be low, the situation would be still more difficult.

We have finally to answer a question about the importance of being allowed to use the calibration curve above the highest calibration point, what we call extrapolation. Imagine that we in a certain case measure $U_{\text{tot}} = 4.5$ volts. The highest calibration point for the camera was in the order of 4.1 volts, a value unknown to the operator. Thus, even if the object happened to be a blackbody, i.e. $U_{\text{obj}} = U_{\text{tot}}$, we are actually performing extrapolation of the calibration curve when converting 4.5 volts into temperature.

Let us now assume that the object is not black, it has an emittance of 0.75, and the transmittance is 0.92. We also assume that the two second terms of Equation 4 amount to 0.5 volts together. Computation of U_{obj} by means of Equation 4 then results in $U_{\text{obj}} = 4.5 / 0.75 / 0.92 - 0.5 = 6.0$. This is a rather extreme extrapolation, particularly when considering that the video amplifier might limit the output to 5 volts! Note, though, that the application of the calibration curve is a theoretical procedure where no electronic or other limitations exist. We trust that if there had been no signal limitations in the camera, and if it had been calibrated far beyond 5 volts, the resulting curve would have been very much the same as our real curve extrapolated beyond 4.1 volts, provided the calibration algorithm is based on radiation physics, like the FLIR Systems algorithm. Of course there must be a limit to such extrapolations.

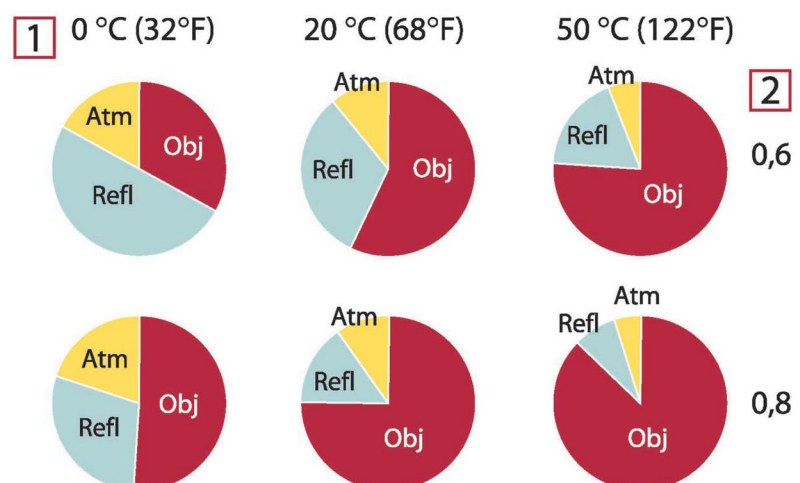


Figure 21.2 Relative magnitudes of radiation sources under varying measurement conditions (SW camera). 1: Object temperature; 2: Emittance; Obj: Object radiation; Refl: Reflected radiation; Atm: atmosphere radiation. Fixed parameters: $\tau = 0.88$; $T_{\text{refl}} = 20^{\circ}\text{C}$ ($+68^{\circ}\text{F}$); $T_{\text{atm}} = 20^{\circ}\text{C}$ ($+68^{\circ}\text{F}$).

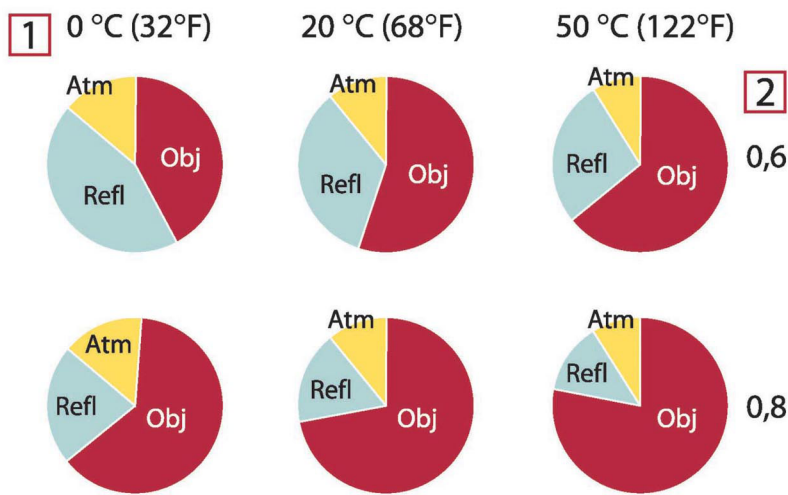


Figure 21.3 Relative magnitudes of radiation sources under varying measurement conditions (LW camera). 1: Object temperature; 2: Emittance; Obj: Object radiation; Refl: Reflected radiation; Atm: atmosphere radiation. Fixed parameters: $\tau = 0.88$; $T_{\text{refl}} = 20^{\circ}\text{C}$ (+68°F); $T_{\text{atm}} = 20^{\circ}\text{C}$ (+68°F).

This section presents a compilation of emissivity data from the infrared literature and measurements made by FLIR Systems.

22.1 References

1. Mikaél A. Bramson: *Infrared Radiation, A Handbook for Applications*, Plenum press, N.Y.
2. William L. Wolfe, George J. Zissis: *The Infrared Handbook*, Office of Naval Research, Department of Navy, Washington, D.C.
3. Madding, R. P.: *Thermographic Instruments and systems*. Madison, Wisconsin: University of Wisconsin – Extension, Department of Engineering and Applied Science.
4. William L. Wolfe: *Handbook of Military Infrared Technology*, Office of Naval Research, Department of Navy, Washington, D.C.
5. Jones, Smith, Probert: *External thermography of buildings...*, Proc. of the Society of Photo-Optical Instrumentation Engineers, vol.110, Industrial and Civil Applications of Infrared Technology, June 1977 London.
6. Paljak, Pettersson: *Thermography of Buildings*, Swedish Building Research Institute, Stockholm 1972.
7. Vlcek, J: *Determination of emissivity with imaging radiometers and some emissivities at $\lambda = 5 \mu\text{m}$* . Photogrammetric Engineering and Remote Sensing.
8. Kern: *Evaluation of infrared emission of clouds and ground as measured by weather satellites*, Defence Documentation Center, AD 617 417.
9. Öhman, Claes: *Emittansmätningar med AGEMA E-Box*. Teknisk rapport, AGEMA 1999. (Emittance measurements using AGEMA E-Box. Technical report, AGEMA 1999.)
10. Mattei, S., Tang-Kwor, E: *Emissivity measurements for Nextel Velvet coating 811-21 between -36°C AND 82°C* .
11. Lohrengel & Todtenhaupt (1996)
12. ITC Technical publication 32.
13. ITC Technical publication 29.



NOTE

The emissivity values in the table below are recorded using a shortwave (SW) camera. The values should be regarded as recommendations only and used with caution.

22.2 Tables

Table 22.1 T: Total spectrum; SW: 2–5 μm ; LW: 8–14 μm , LLW: 6.5–20 μm ; 1: Material; 2: Specification; 3: Temperature in $^{\circ}\text{C}$; 4: Spectrum; 5: Emissivity; 6: Reference

1	2	3	4	5	6
3M type 35	Vinyl electrical tape (several colors)	< 80	LW	≈ 0.96	13
3M type 88	Black vinyl electrical tape	< 105	LW	≈ 0.96	13
3M type 88	Black vinyl electrical tape	< 105	MW	< 0.96	13
3M type Super 33+	Black vinyl electrical tape	< 80	LW	≈ 0.96	13
Aluminum	anodized sheet	100	T	0.55	2
Aluminum	anodized, black, dull	70	SW	0.67	9
Aluminum	anodized, black, dull	70	LW	0.95	9
Aluminum	anodized, light gray, dull	70	SW	0.61	9

Table 22.1 T: Total spectrum; SW: 2–5 μm ; LW: 8–14 μm ; LLW: 6.5–20 μm ; 1: Material; 2: Specification; 3: Temperature in $^{\circ}\text{C}$; 4: Spectrum; 5: Emissivity; 6: Reference (continued)

1	2	3	4	5	6
Aluminum	anodized, light gray, dull	70	LW	0.97	9
Aluminum	as received, plate	100	T	0.09	4
Aluminum	as received, sheet	100	T	0.09	2
Aluminum	cast, blast cleaned	70	SW	0.47	9
Aluminum	cast, blast cleaned	70	LW	0.46	9
Aluminum	dipped in HNO_3 , plate	100	T	0.05	4
Aluminum	foil	27	10 μm	0.04	3
Aluminum	foil	27	3 μm	0.09	3
Aluminum	oxidized, strongly	50–500	T	0.2–0.3	1
Aluminum	polished	50–100	T	0.04–0.06	1
Aluminum	polished plate	100	T	0.05	4
Aluminum	polished, sheet	100	T	0.05	2
Aluminum	rough surface	20–50	T	0.06–0.07	1
Aluminum	roughened	27	10 μm	0.18	3
Aluminum	roughened	27	3 μm	0.28	3
Aluminum	sheet, 4 samples differently scratched	70	SW	0.05–0.08	9
Aluminum	sheet, 4 samples differently scratched	70	LW	0.03–0.06	9
Aluminum	vacuum deposited	20	T	0.04	2
Aluminum	weathered, heavily	17	SW	0.83–0.94	5
Aluminum bronze		20	T	0.60	1
Aluminum hydroxide	powder		T	0.28	1
Aluminum oxide	activated, powder		T	0.46	1
Aluminum oxide	pure, powder (alumina)		T	0.16	1
Asbestos	board	20	T	0.96	1
Asbestos	fabric		T	0.78	1
Asbestos	floor tile	35	SW	0.94	7
Asbestos	paper	40–400	T	0.93–0.95	1
Asbestos	powder		T	0.40–0.60	1
Asbestos	slate	20	T	0.96	1
Asphalt paving		4	LLW	0.967	8
Brass	dull, tarnished	20–350	T	0.22	1
Brass	oxidized	100	T	0.61	2
Brass	oxidized	70	SW	0.04–0.09	9
Brass	oxidized	70	LW	0.03–0.07	9
Brass	oxidized at 600°C	200–600	T	0.59–0.61	1

Table 22.1 T: Total spectrum; SW: 2–5 µm; LW: 8–14 µm, LLW: 6.5–20 µm; 1: Material; 2: Specification; 3: Temperature in °C; 4: Spectrum; 5: Emissivity; 6: Reference (continued)

1	2	3	4	5	6
Brass	polished	200	T	0.03	1
Brass	polished, highly	100	T	0.03	2
Brass	rubbed with 80-grit emery	20	T	0.20	2
Brass	sheet, rolled	20	T	0.06	1
Brass	sheet, worked with emery	20	T	0.2	1
Brick	alumina	17	SW	0.68	5
Brick	common	17	SW	0.86–0.81	5
Brick	Dinas silica, glazed, rough	1100	T	0.85	1
Brick	Dinas silica, refractory	1000	T	0.66	1
Brick	Dinas silica, unglazed, rough	1000	T	0.80	1
Brick	firebrick	17	SW	0.68	5
Brick	fireclay	1000	T	0.75	1
Brick	fireclay	1200	T	0.59	1
Brick	fireclay	20	T	0.85	1
Brick	masonry	35	SW	0.94	7
Brick	masonry, plastered	20	T	0.94	1
Brick	red, common	20	T	0.93	2
Brick	red, rough	20	T	0.88–0.93	1
Brick	refractory, corundum	1000	T	0.46	1
Brick	refractory, magnesite	1000–1300	T	0.38	1
Brick	refractory, strongly radiating	500–1000	T	0.8–0.9	1
Brick	refractory, weakly radiating	500–1000	T	0.65–0.75	1
Brick	silica, 95% SiO ₂	1230	T	0.66	1
Brick	sillimanite, 33% SiO ₂ , 64% Al ₂ O ₃	1500	T	0.29	1
Brick	waterproof	17	SW	0.87	5
Bronze	phosphor bronze	70	SW	0.08	9
Bronze	phosphor bronze	70	LW	0.06	9
Bronze	polished	50	T	0.1	1
Bronze	porous, rough	50–150	T	0.55	1
Bronze	powder		T	0.76–0.80	1
Carbon	candle soot	20	T	0.95	2
Carbon	charcoal powder		T	0.96	1
Carbon	graphite powder		T	0.97	1
Carbon	graphite, filed surface	20	T	0.98	2
Carbon	lampblack	20–400	T	0.95–0.97	1

Table 22.1 T: Total spectrum; SW: 2–5 µm; LW: 8–14 µm, LLW: 6.5–20 µm; 1: Material; 2: Specification; 3: Temperature in °C; 4: Spectrum; 5: Emissivity; 6: Reference (continued)

1	2	3	4	5	6
Chipboard	untreated	20	SW	0.90	6
Chromium	polished	50	T	0.10	1
Chromium	polished	500–1000	T	0.28–0.38	1
Clay	fired	70	T	0.91	1
Cloth	black	20	T	0.98	1
Concrete		20	T	0.92	2
Concrete	dry	36	SW	0.95	7
Concrete	rough	17	SW	0.97	5
Concrete	walkway	5	LLW	0.974	8
Copper	commercial, burnished	20	T	0.07	1
Copper	electrolytic, carefully polished	80	T	0.018	1
Copper	electrolytic, polished	–34	T	0.006	4
Copper	molten	1100–1300	T	0.13–0.15	1
Copper	oxidized	50	T	0.6–0.7	1
Copper	oxidized to blackness		T	0.88	1
Copper	oxidized, black	27	T	0.78	4
Copper	oxidized, heavily	20	T	0.78	2
Copper	polished	50–100	T	0.02	1
Copper	polished	100	T	0.03	2
Copper	polished, commercial	27	T	0.03	4
Copper	polished, mechanical	22	T	0.015	4
Copper	pure, carefully prepared surface	22	T	0.008	4
Copper	scraped	27	T	0.07	4
Copper dioxide	powder		T	0.84	1
Copper oxide	red, powder		T	0.70	1
Ebonite			T	0.89	1
Emery	coarse	80	T	0.85	1
Enamel		20	T	0.9	1
Enamel	lacquer	20	T	0.85–0.95	1
Fiber board	hard, untreated	20	SW	0.85	6
Fiber board	masonite	70	SW	0.75	9
Fiber board	masonite	70	LW	0.88	9
Fiber board	particle board	70	SW	0.77	9
Fiber board	particle board	70	LW	0.89	9
Fiber board	porous, untreated	20	SW	0.85	6
Gold	polished	130	T	0.018	1
Gold	polished, carefully	200–600	T	0.02–0.03	1
Gold	polished, highly	100	T	0.02	2

Table 22.1 T: Total spectrum; SW: 2–5 µm; LW: 8–14 µm, LLW: 6.5–20 µm; 1: Material; 2: Specification; 3: Temperature in °C; 4: Spectrum; 5: Emissivity; 6: Reference (continued)

1	2	3	4	5	6
Granite	polished	20	LLW	0.849	8
Granite	rough	21	LLW	0.879	8
Granite	rough, 4 different samples	70	SW	0.95–0.97	9
Granite	rough, 4 different samples	70	LW	0.77–0.87	9
Gypsum		20	T	0.8–0.9	1
Ice: See Water					
Iron and steel	cold rolled	70	SW	0.20	9
Iron and steel	cold rolled	70	LW	0.09	9
Iron and steel	covered with red rust	20	T	0.61–0.85	1
Iron and steel	electrolytic	100	T	0.05	4
Iron and steel	electrolytic	22	T	0.05	4
Iron and steel	electrolytic	260	T	0.07	4
Iron and steel	electrolytic, carefully polished	175–225	T	0.05–0.06	1
Iron and steel	freshly worked with emery	20	T	0.24	1
Iron and steel	ground sheet	950–1100	T	0.55–0.61	1
Iron and steel	heavily rusted sheet	20	T	0.69	2
Iron and steel	hot rolled	130	T	0.60	1
Iron and steel	hot rolled	20	T	0.77	1
Iron and steel	oxidized	100	T	0.74	4
Iron and steel	oxidized	100	T	0.74	1
Iron and steel	oxidized	1227	T	0.89	4
Iron and steel	oxidized	125–525	T	0.78–0.82	1
Iron and steel	oxidized	200	T	0.79	2
Iron and steel	oxidized	200–600	T	0.80	1
Iron and steel	oxidized strongly	50	T	0.88	1
Iron and steel	oxidized strongly	500	T	0.98	1
Iron and steel	polished	100	T	0.07	2
Iron and steel	polished	400–1000	T	0.14–0.38	1
Iron and steel	polished sheet	750–1050	T	0.52–0.56	1
Iron and steel	rolled sheet	50	T	0.56	1
Iron and steel	rolled, freshly	20	T	0.24	1
Iron and steel	rough, plane surface	50	T	0.95–0.98	1
Iron and steel	rusted red, sheet	22	T	0.69	4
Iron and steel	rusted, heavily	17	SW	0.96	5
Iron and steel	rusty, red	20	T	0.69	1
Iron and steel	shiny oxide layer, sheet,	20	T	0.82	1
Iron and steel	shiny, etched	150	T	0.16	1

Table 22.1 T: Total spectrum; SW: 2–5 μm ; LW: 8–14 μm ; LLW: 6.5–20 μm ; 1: Material; 2: Specification; 3: Temperature in $^{\circ}\text{C}$; 4: Spectrum; 5: Emissivity; 6: Reference (continued)

1	2	3	4	5	6
Iron and steel	wrought, carefully polished	40–250	T	0.28	1
Iron galvanized	heavily oxidized	70	SW	0.64	9
Iron galvanized	heavily oxidized	70	LW	0.85	9
Iron galvanized	sheet	92	T	0.07	4
Iron galvanized	sheet, burnished	30	T	0.23	1
Iron galvanized	sheet, oxidized	20	T	0.28	1
Iron tinned	sheet	24	T	0.064	4
Iron, cast	casting	50	T	0.81	1
Iron, cast	ingots	1000	T	0.95	1
Iron, cast	liquid	1300	T	0.28	1
Iron, cast	machined	800–1000	T	0.60–0.70	1
Iron, cast	oxidized	100	T	0.64	2
Iron, cast	oxidized	260	T	0.66	4
Iron, cast	oxidized	38	T	0.63	4
Iron, cast	oxidized	538	T	0.76	4
Iron, cast	oxidized at 600 $^{\circ}\text{C}$	200–600	T	0.64–0.78	1
Iron, cast	polished	200	T	0.21	1
Iron, cast	polished	38	T	0.21	4
Iron, cast	polished	40	T	0.21	2
Iron, cast	unworked	900–1100	T	0.87–0.95	1
Krylon Ultra-flat black 1602	Flat black	Room temperature up to 175	LW	≈ 0.96	12
Krylon Ultra-flat black 1602	Flat black	Room temperature up to 175	MW	≈ 0.97	12
Lacquer	3 colors sprayed on Aluminum	70	SW	0.50–0.53	9
Lacquer	3 colors sprayed on Aluminum	70	LW	0.92–0.94	9
Lacquer	Aluminum on rough surface	20	T	0.4	1
Lacquer	bakelite	80	T	0.83	1
Lacquer	black, dull	40–100	T	0.96–0.98	1
Lacquer	black, matte	100	T	0.97	2
Lacquer	black, shiny, sprayed on iron	20	T	0.87	1
Lacquer	heat-resistant	100	T	0.92	1
Lacquer	white	100	T	0.92	2
Lacquer	white	40–100	T	0.8–0.95	1
Lead	oxidized at 200 $^{\circ}\text{C}$	200	T	0.63	1
Lead	oxidized, gray	20	T	0.28	1
Lead	oxidized, gray	22	T	0.28	4
Lead	shiny	250	T	0.08	1
Lead	unoxidized, polished	100	T	0.05	4

Table 22.1 T: Total spectrum; SW: 2–5 μm ; LW: 8–14 μm , LLW: 6.5–20 μm ; 1: Material; 2: Specification; 3: Temperature in $^{\circ}\text{C}$; 4: Spectrum; 5: Emissivity; 6: Reference (continued)

1	2	3	4	5	6
Lead red		100	T	0.93	4
Lead red, powder		100	T	0.93	1
Leather	tanned		T	0.75–0.80	1
Lime			T	0.3–0.4	1
Magnesium		22	T	0.07	4
Magnesium		260	T	0.13	4
Magnesium		538	T	0.18	4
Magnesium	polished	20	T	0.07	2
Magnesium powder			T	0.86	1
Molybdenum		1500–2200	T	0.19–0.26	1
Molybdenum		600–1000	T	0.08–0.13	1
Molybdenum	filament	700–2500	T	0.1–0.3	1
Mortar		17	SW	0.87	5
Mortar	dry	36	SW	0.94	7
Nextel Velvet 811-21 Black	Flat black	–60–150	LW	> 0.97	10 and 11
Nichrome	rolled	700	T	0.25	1
Nichrome	sandblasted	700	T	0.70	1
Nichrome	wire, clean	50	T	0.65	1
Nichrome	wire, clean	500–1000	T	0.71–0.79	1
Nichrome	wire, oxidized	50–500	T	0.95–0.98	1
Nickel	bright matte	122	T	0.041	4
Nickel	commercially pure, polished	100	T	0.045	1
Nickel	commercially pure, polished	200–400	T	0.07–0.09	1
Nickel	electrolytic	22	T	0.04	4
Nickel	electrolytic	260	T	0.07	4
Nickel	electrolytic	38	T	0.06	4
Nickel	electrolytic	538	T	0.10	4
Nickel	electroplated on iron, polished	22	T	0.045	4
Nickel	electroplated on iron, unpolished	20	T	0.11–0.40	1
Nickel	electroplated on iron, unpolished	22	T	0.11	4
Nickel	electroplated, polished	20	T	0.05	2
Nickel	oxidized	1227	T	0.85	4
Nickel	oxidized	200	T	0.37	2
Nickel	oxidized	227	T	0.37	4
Nickel	oxidized at 600 $^{\circ}\text{C}$	200–600	T	0.37–0.48	1
Nickel	polished	122	T	0.045	4
Nickel	wire	200–1000	T	0.1–0.2	1
Nickel oxide		1000–1250	T	0.75–0.86	1

Table 22.1 T: Total spectrum; SW: 2–5 μm ; LW: 8–14 μm ; LLW: 6.5–20 μm ; 1: Material; 2: Specification; 3: Temperature in $^{\circ}\text{C}$; 4: Spectrum; 5: Emissivity; 6: Reference (continued)

1	2	3	4	5	6
Nickel oxide		500–650	T	0.52–0.59	1
Oil, lubricating	0.025 mm film	20	T	0.27	2
Oil, lubricating	0.050 mm film	20	T	0.46	2
Oil, lubricating	0.125 mm film	20	T	0.72	2
Oil, lubricating	film on Ni base: Ni base only	20	T	0.05	2
Oil, lubricating	thick coating	20	T	0.82	2
Paint	8 different colors and qualities	70	SW	0.88–0.96	9
Paint	8 different colors and qualities	70	LW	0.92–0.94	9
Paint	Aluminum, vari- ous ages	50–100	T	0.27–0.67	1
Paint	cadmium yellow		T	0.28–0.33	1
Paint	chrome green		T	0.65–0.70	1
Paint	cobalt blue		T	0.7–0.8	1
Paint	oil	17	SW	0.87	5
Paint	oil based, aver- age of 16 colors	100	T	0.94	2
Paint	oil, black flat	20	SW	0.94	6
Paint	oil, black gloss	20	SW	0.92	6
Paint	oil, gray flat	20	SW	0.97	6
Paint	oil, gray gloss	20	SW	0.96	6
Paint	oil, various colors	100	T	0.92–0.96	1
Paint	plastic, black	20	SW	0.95	6
Paint	plastic, white	20	SW	0.84	6
Paper	4 different colors	70	SW	0.68–0.74	9
Paper	4 different colors	70	LW	0.92–0.94	9
Paper	black		T	0.90	1
Paper	black, dull		T	0.94	1
Paper	black, dull	70	SW	0.86	9
Paper	black, dull	70	LW	0.89	9
Paper	blue, dark		T	0.84	1
Paper	coated with black lacquer		T	0.93	1
Paper	green		T	0.85	1
Paper	red		T	0.76	1
Paper	white	20	T	0.7–0.9	1
Paper	white bond	20	T	0.93	2
Paper	white, 3 different glosses	70	SW	0.76–0.78	9
Paper	white, 3 different glosses	70	LW	0.88–0.90	9
Paper	yellow		T	0.72	1
Plaster		17	SW	0.86	5

Table 22.1 T: Total spectrum; SW: 2–5 µm; LW: 8–14 µm, LLW: 6.5–20 µm; 1: Material; 2: Specification; 3: Temperature in °C; 4: Spectrum; 5: Emissivity; 6: Reference (continued)

1	2	3	4	5	6
Plaster	plasterboard, untreated	20	SW	0.90	6
Plaster	rough coat	20	T	0.91	2
Plastic	glass fibre laminate (printed circ. board)	70	SW	0.94	9
Plastic	glass fibre laminate (printed circ. board)	70	LW	0.91	9
Plastic	polyurethane isolation board	70	LW	0.55	9
Plastic	polyurethane isolation board	70	SW	0.29	9
Plastic	PVC, plastic floor, dull, structured	70	SW	0.94	9
Plastic	PVC, plastic floor, dull, structured	70	LW	0.93	9
Platinum		100	T	0.05	4
Platinum		1000–1500	T	0.14–0.18	1
Platinum		1094	T	0.18	4
Platinum		17	T	0.016	4
Platinum		22	T	0.03	4
Platinum		260	T	0.06	4
Platinum		538	T	0.10	4
Platinum	pure, polished	200–600	T	0.05–0.10	1
Platinum	ribbon	900–1100	T	0.12–0.17	1
Platinum	wire	1400	T	0.18	1
Platinum	wire	500–1000	T	0.10–0.16	1
Platinum	wire	50–200	T	0.06–0.07	1
Porcelain	glazed	20	T	0.92	1
Porcelain	white, shiny		T	0.70–0.75	1
Rubber	hard	20	T	0.95	1
Rubber	soft, gray, rough	20	T	0.95	1
Sand			T	0.60	1
Sand		20	T	0.90	2
Sandstone	polished	19	LLW	0.909	8
Sandstone	rough	19	LLW	0.935	8
Silver	polished	100	T	0.03	2
Silver	pure, polished	200–600	T	0.02–0.03	1
Skin	human	32	T	0.98	2
Slag	boiler	0–100	T	0.97–0.93	1
Slag	boiler	1400–1800	T	0.69–0.67	1
Slag	boiler	200–500	T	0.89–0.78	1
Slag	boiler	600–1200	T	0.76–0.70	1
Snow: See Water					
Soil	dry	20	T	0.92	2

Table 22.1 T: Total spectrum; SW: 2–5 µm; LW: 8–14 µm, LLW: 6.5–20 µm; 1: Material; 2: Specification; 3: Temperature in °C; 4: Spectrum; 5: Emissivity; 6: Reference (continued)

1	2	3	4	5	6
Soil	saturated with water	20	T	0.95	2
Stainless steel	alloy, 8% Ni, 18% Cr	500	T	0.35	1
Stainless steel	rolled	700	T	0.45	1
Stainless steel	sandblasted	700	T	0.70	1
Stainless steel	sheet, polished	70	SW	0.18	9
Stainless steel	sheet, polished	70	LW	0.14	9
Stainless steel	sheet, untreated, somewhat scratched	70	SW	0.30	9
Stainless steel	sheet, untreated, somewhat scratched	70	LW	0.28	9
Stainless steel	type 18-8, buffed	20	T	0.16	2
Stainless steel	type 18-8, oxidized at 800°C	60	T	0.85	2
Stucco	rough, lime	10–90	T	0.91	1
Styrofoam	insulation	37	SW	0.60	7
Tar			T	0.79–0.84	1
Tar	paper	20	T	0.91–0.93	1
Tile	glazed	17	SW	0.94	5
Tin	burnished	20–50	T	0.04–0.06	1
Tin	tin-plated sheet iron	100	T	0.07	2
Titanium	oxidized at 540°C	1000	T	0.60	1
Titanium	oxidized at 540°C	200	T	0.40	1
Titanium	oxidized at 540°C	500	T	0.50	1
Titanium	polished	1000	T	0.36	1
Titanium	polished	200	T	0.15	1
Titanium	polished	500	T	0.20	1
Tungsten		1500–2200	T	0.24–0.31	1
Tungsten		200	T	0.05	1
Tungsten		600–1000	T	0.1–0.16	1
Tungsten	filament	3300	T	0.39	1
Varnish	flat	20	SW	0.93	6
Varnish	on oak parquet floor	70	SW	0.90	9
Varnish	on oak parquet floor	70	LW	0.90–0.93	9
Wallpaper	slight pattern, light gray	20	SW	0.85	6
Wallpaper	slight pattern, red	20	SW	0.90	6
Water	distilled	20	T	0.96	2
Water	frost crystals	–10	T	0.98	2
Water	ice, covered with heavy frost	0	T	0.98	1
Water	ice, smooth	0	T	0.97	1

Table 22.1 T: Total spectrum; SW: 2–5 μm ; LW: 8–14 μm , LLW: 6.5–20 μm ; 1: Material; 2: Specification; 3: Temperature in $^{\circ}\text{C}$; 4: Spectrum; 5: Emissivity; 6: Reference (continued)

1	2	3	4	5	6
Water	ice, smooth	–10	T	0.96	2
Water	layer >0.1 mm thick	0–100	T	0.95–0.98	1
Water	snow		T	0.8	1
Water	snow	–10	T	0.85	2
Wood		17	SW	0.98	5
Wood		19	LLW	0.962	8
Wood	ground		T	0.5–0.7	1
Wood	pine, 4 different samples	70	SW	0.67–0.75	9
Wood	pine, 4 different samples	70	LW	0.81–0.89	9
Wood	planed	20	T	0.8–0.9	1
Wood	planed oak	20	T	0.90	2
Wood	planed oak	70	SW	0.77	9
Wood	planed oak	70	LW	0.88	9
Wood	plywood, smooth, dry	36	SW	0.82	7
Wood	plywood, untreated	20	SW	0.83	6
Wood	white, damp	20	T	0.7–0.8	1
Zinc	oxidized at 400 $^{\circ}\text{C}$	400	T	0.11	1
Zinc	oxidized surface	1000–1200	T	0.50–0.60	1
Zinc	polished	200–300	T	0.04–0.05	1
Zinc	sheet	50	T	0.20	1

A note on the technical production of this publication

This publication was produced using XML — the eXtensible Markup Language. For more information about XML, please visit <http://www.w3.org/XML/>

A note on the typeface used in this publication

This publication was typeset using Linotype Helvetica™ World. Helvetica™ was designed by Max Miedinger (1910–1980)

LOEF (List Of Effective Files)

T501003.xml; en-US; 18834; 2014-10-21
T505475.xml; en-US; 15550; 2014-06-30
T505779.xml; en-US; 15550; 2014-06-30
T505783.xml; en-US; ; 18834; 2014-10-21
T505013.xml; en-US; 9229; 2013-10-03
T505085.xml; en-US; 15550; 2014-06-30
T505084.xml; en-US; 18049; 2014-10-01
T505478.xml; en-US; 15549; 2014-06-30
T505507.xml; en-US; 6360; 2013-01-29
T505082.xml; en-US; 15550; 2014-06-30
T505477.xml; en-US; 15536; 2014-06-30
T505081.xml; en-US; 15550; 2014-06-30
T505470.xml; en-US; 12154; 2014-03-06
T505007.xml; en-US; 21877; 2014-12-08
T505004.xml; en-US; 12154; 2014-03-06
T505000.xml; en-US; 12154; 2014-03-06
T505005.xml; en-US; 12154; 2014-03-06
T505001.xml; en-US; 12154; 2014-03-06
T505006.xml; en-US; 12154; 2014-03-06
T505002.xml; en-US; 18260; 2014-10-06



Corporate Headquarters

FLIR Systems, Inc.
27700 SW Parkway Ave.
Wilsonville, OR 97070
USA
Telephone: +1-503-498-3547

Website

<http://www.flir.com>

Customer support

<http://support.flir.com>

Copyright

© 2014, FLIR Systems, Inc. All rights reserved worldwide.

Disclaimer

Specifications subject to change without further notice. Models and accessories subject to regional market considerations. License procedures may apply. Products described herein may be subject to US Export Regulations. Please refer to exportquestions@flir.com with any questions.

Publ. No.: T559770
Commit: 18834
Head: 22369
Language: en-US
Modified: 2014-10-21
Formatted: 2014-12-22