FT test system

System for testing thermal camera cores and IR FPA sensors

Fig. 1. FT-N configuration of FT test system (measurement of noise/responsivity parameters in static flood mode)

Fig. 2. FT-I configuration of FT test system (measurement of image quality parameters)

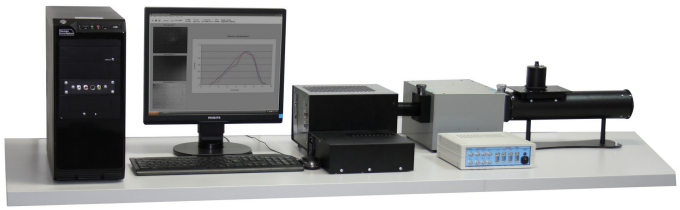

Fig. 3. FT-S configuration of FT test system (measurement of spectral parameters)

BASIC INFORMATION:

Thermal imagers are typically built using two ways:

a) thermal camera core generating output image in a standard electronic format is purchased and later integrated with IR optics, external case and other optional electronic modules;

b) raw IR FPA sensor is purchased, sensor control electronics is developed and later integrated with IR optics and other modules.

Knowledge of precise parameters of thermal camera cores is needed because these parameters determine performance limits of complete thermal imagers. Next, parameters of IR FPA sensors are needed to verify quality of these crucial electronic chips. Further on, tests of camera cores enable improvement of algorithms to reduce spatial noise of IR FPA sensors.

FT is a turnkey system that generates IR radiation of precisely controlled spatial and temporal distribution to the input plane of IR FPA, controls the tested IR FPA; and finally carries out semi-automatic analysis of the output signal necessary to perform characterization of the tested IR FPA sensors (or a thermal camera core). The system enables measurement of all important parameters (noise/sensitivity, image quality, and spectral parameters) of camera cores and IR FPA sensors. Sensors of different spectral bands (LWIR or MWIR), cooled or non cooled can be tested.

FT test system is targeted to two groups of potential users. First, manufacturers of thermal imagers who want to test thermal camera cores or raw IR FPA sensors. Second, manufacturers of IR FPA sensors or scientific institutes working in field of IR FPA technology interested to determine performance limits of these imaging sensors.

FT system can be delivered in a series of versions optimized for different test range of thermal camera cores and IR FPA sensors. Next, FT system can be optionally delivered in ultra expanded version that enable also testing complete thermal imagers.

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SYSTEM STRUCTURE

Total system for testing raw IR FPA sensors is built from three main blocks: radiation emitters (REB), sensor control electronics (CON), and signal acquisition/analysis (SAB) block.

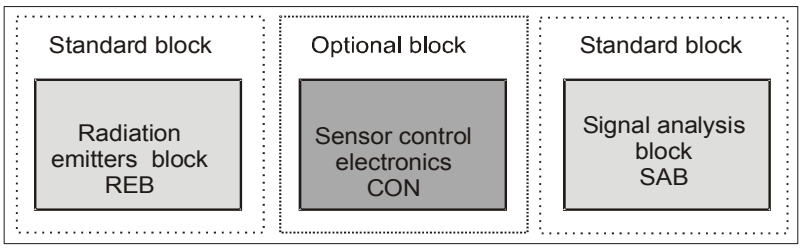

Fig. 4. Main blocks of FT test system

The first block generates the necessary radiometric stimulus to the tested IR FPA sensor. This block is built from a series of exchangeable modules (blackbodies, IR sources, collimators, optics, mechanical stages, monochromators) that make possible to create several configurations that generate different radiometric signals.

The control block provides input electronics signals to the tested IR FPA sensor needed to make sensor to generate proper output signal (signals). The control block can be treated as optional because is not needed when only camera cores are to be tested or customer has its own control electronic.

The signal acquisition block enables analysis of the output signal from the IR FPA and determination of sensor parameters. The latter block is basically a PC set with several frame grabbers and software capable to acquire and analyze signals generated by tested IR FPA/camera core.

In case of testing camera cores only two blocks are needed: RE radiometric emitters and SAT signal analysis block. Camera core is practically sensor integrated with control electronics that generates images in standard electronic formats and therefore additional CON block is not needed.

FT test system is basically a system built from two blocks (REB and SAB) with optional third block: CON.

SENSOR CONTROL BLOCK

Sensor control electronics is an optional block needed when raw IR FPA sensors are to be tested. This block is basically electronics needed to control tested IR FPA sensor and to convert output signals generated by such a sensor into one of standards of electronic imaging: analog video, CameraLink, USB 2.0, GigE etc.

In past Inframet offered sensor control block in two versions versions:

A) Specialized control electronics optimized for a precisely IR FPAs sensor,
B) Universal, reprogramable IR FPA controller developed by Inframet that can be used to control majority of IR FPA sensors offered on market.

CON block in version A is delivered in form of camera core electronics designed for several precisely defined IR FPA sensor or a small group of similar sensors.

CON block in version B is delivered in form of a single quasi universal camera core electronics controller (coded as CON-B) that can potentially be used to control almost all IR FPA sensors offered at market. Change of mechanical adapters (optimized for different sensors) and reprogramming of CON-B controller is needed to enable control of a new IR FPA sensor. Reprogramming is a crucial operation if CON-B block. It can be done by Inframet staff or advanced users having deep knowledge of IR FPA technology.

In 2016 year Inframet stopped offering CON controller in both versions because of very narrow market, technical problems with reprogramming of COB-B version and export control problems with shipment of IR FPA sensors integrated with CON electronics.

Since that time it is expected that customer has his own control electronics or can acquire IR FPA controller from a a third party. In the latter case Inframet recommends to purchase control electronics from Pulse Instruments http://www.pulseinstruments.com. Control electronics from this company is fully compatible with electronics of FT system.

It should be also noted that Pulse Instruments can deliver not only control electronics of IR FPA sensors but also complete IR FPA test system. However, Inframet claims that can deliver more expanded system for testing IR FPA sensors (more advanded REB and SAB blocks).

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AIM OF TESTS

There are two main aims of tests of thermal camera cores/ raw IR FPA sensors:

1. Determination of parameters that determine performance of thermal camera cores/ raw IR FPA sensors,
2. Determination of data that can be used to develop algorithms of image processing used to improve quality of images generated by thermal camera cores or complete thermal imagers (typically algorithms for reduction of spatial noise).

Sensors of different spectral bands (LWIR or MWIR), cooled or non cooled can be tested.

CONFIGURATIONS

Parameters of IR FPAs can be classified into three main groups:
Noise/sensitivity parameters:

1. Standard noise characteristics: NETD (high frequency temporal noise), FPN (high frequency spatial noise), non-uniformity (low frequency spatial noise),
2. Response parameters: SiTF, linearity, dynamic range, saturation level,
3. Advanced noise parameters: 3D noise model, NPSD, 1/f noise, number of bad pixels and bad pixel localisation,
4. D**(normalized detectivity) and related parameters – optional (if the integration time of the FPA is known).

Image quality parameters:

1. MTF (modulation transfer function),
2. Ensquared power (PVF),
3. Cross-talk.

Spectral parameters:

1. Relative spectral sensitivity (average, deviation, signal dependence).

Companies that buy camera cores and later integrate these modules into thermal imagers are typically interested mostly in measurement of noise/sensitivity parameters. Imaging quality parameters and spectral parameters are out of interest of such teams.
Scientific teams that work on manufacturing or development of IR FPA sensors are interested in measurement of parameters from all three earlier mentioned groups.
Situation in case of teams that buy IR FPAs and develop their own control electronics vary from case to case. Mostly such teams concentrate on measurement of noise parameters, but sometimes prefer to measure image quality and spectral parameters in order to get more detail knowledge of theoretical potential of IR FPA sensors used by them.

FT test system is a modular system can be configured into three semi-independent test stations: FT-N station, FT-I station, FT-S station to carry out following measurements:

1. FT-N - measurement of noise and response parameters;
2. FT-I - measurement of image quality parameters
3. FT-S - measurement of spectral parameters.

FT-N irradiates uniformly the entire area of the tested FPA using a TCB-4D area blackbody located at short distance from tested IR FPA. The distance between the IR FPA and the TCB-4D blackbody is short (no more than a few centimeters) and the whole field of view of the tested IR FPA sensor is filled by the blackbody. Irradiation at the IR FPA plane is regulated by control of the temperature of the TCB-4D blackbody. The output analog (digital) signal from tested IR FPA is recorded at different temperature levels and is later analyzed. On the basis of analysis of the output images the noise and response parameters of the tested IR FPA are determined. Because the entire area of the FPA is irradiated by a static radiation beam the tests made using the FT-N are called static flood mode tests.

Fig. 5. Block diagram of FT-N station

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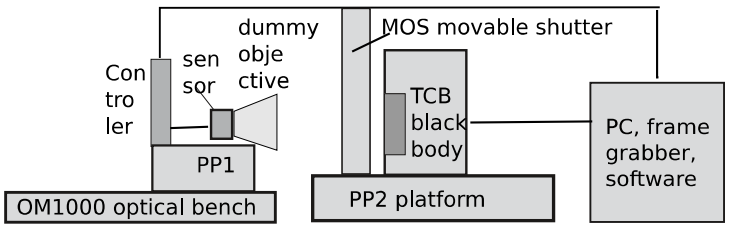

FT-I station projects images of some standard targets (pinhole, slit) placed at a target slider to the tested FPA input plane fixed to a motorized x-y-z axis stage (Fig. 6).
The image projection is done by a set of two optical modules: an off axis reflective collimator and an IR refractive objective. Due to movement of the IR objective placed on a motorized platform the images of the target can be projected to any part of the tested FPA.
Practically the whole area of the tested IR FPA can be scanned pixel by pixel, line by line. Next, the output signal from the tested FPA is recorded by the SAT acquisition block. After that, the recorded sequences of images generated by the tested FPA are analyzed with help of the TAI computer program and finally image quality parameters of the tested FPA are determined.

Because the radiation emitted by blackbody comes to the tested IR FPA in a form of a focused beam, the tests carried out using the FT-I are called focused mode tests.

Set of near perfect, diffraction limited refractive objectives optimized for three main spectral bands (LWIR, MWIR and SWIR) can be considered as a crucial module of FT-I station.

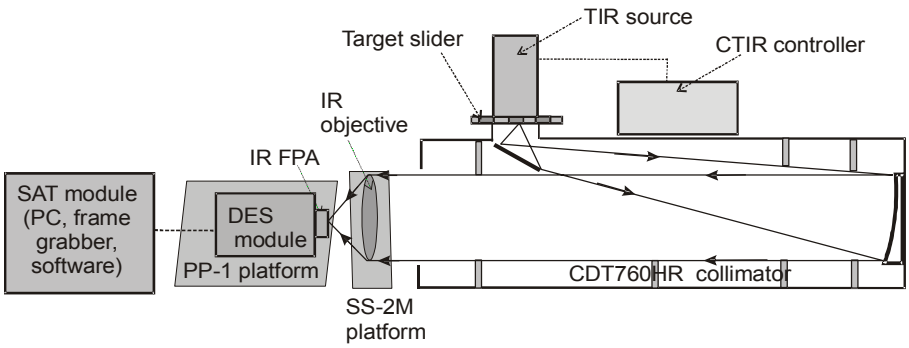

Fig. 6. Block diagram of the FT-I station

FT-S station irradiates the FPA area using variable wavelength radiation and measures the response of the tested IR FPA to the incoming radiation (Fig. 3, Fig. 7). The principle of work of this station is as following. The IR115 source is a small size calibrated source IR radiation integrated with OM optical projector. This source irradiates the input slit of the M250 monochromator used as a variable wavelength selector. The output slit of the M250 monochromator emits radiation of the wavelength controlled by the user. AMP optical amplifier is used to increase irradiance of tested IR FPA sensor. The output images from the IR FPA are captured at different wavelengths. Next, the captured signals from IR FPA are normalized to the output signals from the TM reference broadband module, and finally the relative spectral sensitivity characteristic of the tested FPA is determined by the SPEC software.

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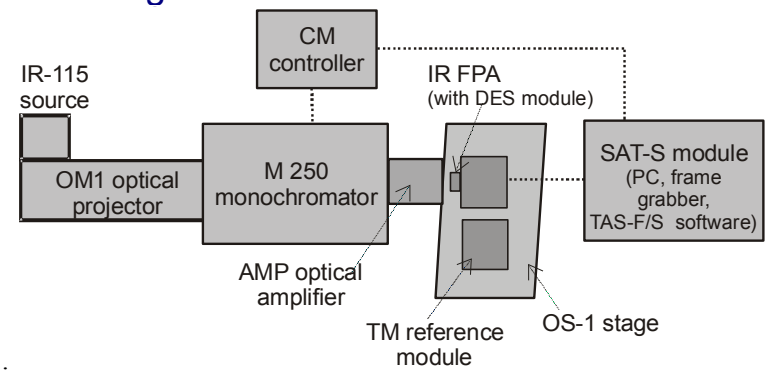

Fig. 7. Basic blocks of the FT-S station

FT system can be also optionally delivered with additional modules that enables to built a new configuration called FT-DT capable to test complete thermal imagers. These additional test capabilities are presented in data sheet of DT systems http://www.inframet.pl/Data%20sheets/DT.pdf

VERSIONS

FT test system can be delivered in different versions of different test capabilities and at different price level. The version can be precisely determined using the five letter code as shown in the table below.

Tab. 1. Versions of FT test system

	A	B
Code	**Test capabilities**	**Testing complete thermal imagers**
1	Noise/response parameters	No
2	Imaging parameters	Yes
3	Spectral parameters	
4	Noise and imaging parameters	
5	All parameters	

*specifications are subject to change without prior notice

Example codes:
Code FT40 – system to measure noise/response and imaging parameters of IR FPA sensors/camera cores. Complete thermal imagers not tested.
Code FT52 – system to measure noise/response, imaging and spectral parameters of IR FPA sensors/camera cores. Complete thermal imagers can be tested, too.

Data sheet version 7.1

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