VIT

Station for testing VIS-SWIR image sensors

Fig. 1. VIT test station

BASIC INFORMATION:

Image electronic sensors sensitive in visible, near infrared, and short wavelength infrared spectral bands have found mass applications in many different fields: industry, defense, security, science, environmental protection, and medicine. Image sensors sensitive in VIS-NIR range are almost exclusively silicon chips manufactured using a series of technologies: CCD, CMOS. ICCD, EMCCD, EBAPS, sCMOS in color or monochromatic versions. Most common SWIR image sensors are InGaAs sensors of several spectral bands: non cooled sensors of range from about 900nm to 1700nm; cooled sensors from about 1000nm to about 2000nm; and broadband sensors from about 600nm to about 1700nm. Both silicon and InGaAs image sensors are typically offered on international market in form of camera cores: raw image sensor integrated with control electronics that generates output image in one of electronic image standards. Raw image sensors are used exclusively by manufacturers of VIS-SWIR camera cores.

VIT is a station for expanded testing of VIS-SWIR camera cores/image sensors. The station enables measurement of all important parameters of virtually all VIS-SWIR camera cores/image sensors available on international market. The station is used by a series of top world manufacturers of VIS-SWIR camera cores/ image sensors.

TEST CAPABILITIES:

Majority of VIS-SWIR imaging sensors/camera cores is used as parts of surveillance imaging systems in defense, security or automotive applications. The main task of such imagers is to deliver high quality image of scenery of interest. Two other important markets of VIS-SWIR imaging sensors/camera cores are industrial machine vision and mass consumer market (photography, phone cameras etc.).

Testing of VIS-SWIR imaging sensors/camera cores for surveillance applications is not standardized. List of typically measured parameters of VIS-SWIR imaging sensors/camera cores can be treated as industry consensus of main manufacturers of test equipment. In detail this list is a copy of parameters typically used for testing thermal imagers. It should be also noted that people working with SWIR technology are often familiar with thermal imagers. Therefore VIT station offers measurement of a traditional set of parameters that are equivalent to similar set used to characterize IR FPA/thermal camera cores. However, new VIT stations offer also measurement of parameters of VIS-NIR camera cores recommended for measurement in EMVA Standard 1288 Standard for Characterization of Image Sensors and Cameras. This standard generally is used for characterization of camera cores used in machine vision but EMVA 1288 parameters are useful to characterize camera cores to be used in any applications.

In such situation combination of ability to measure both traditional set of parameters and EMVA1288 set of parameters makes VIT station a totally unique due to ultra expanded test capabilities.

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Traditional set of parameters:

1. Radiometric parameters: relative spectral sensitivity, normalized detectivity D*, quantum efficiency QE, sensitivity, dynamic range, linearity, Noise Equivalent Illuminance/Irradiance, Fixed Pattern Noise, Non Uniformity, Signal to Noise Ratio, dead pixels, 3D Noise. Measurements can be done at 16 wavelengths.
2. Imaging parameters: MTF, resolution, Minimal Resolvable Contrast, crosstalk, blooming, FOV

EMVA1288 set of parameters:

Quantum efficiency, Gain, Temporal Dark Noise, DSNU1288, SNR_{max}, PRNU1288, LE nonlinearity, Absolute Sensitivity Threshold, Saturation capacity, Dynamic Range, Dark current, relative spectral sensitivity

It should be also noted that due to existing proper standardization Inframet can deliver a reference VIS-NIR camera core of known parameters as part of VIT station. Data sheet of reference VIS-NIR camera core can be obtained from EMVA approved test laboratory.

HOW IT WORKS?

VIT works as a dual channel image projector capable of projecting reference images of regulated light intensity and light spectrum to the plane where the image sensor is located. Tested camera core generates output electronic image that is captured by a frame a grabber card. Finally the test software installed on PC set calculates parameters of tested camera core on basis of captured images.

Optional CON controller that delivers necessary control/timing input signals to the tested image sensor is offered when raw image sensors are to be tested. The image sensor integrated with the CON controller can be treated as a camera core. Therefore later this data sheet talks about testing VIS-SWIR camera cores.

VIT can project uniform images in at least 16 narrow spectral bands and broadband VIS-SWIR range. These uniform images are used to measure radiometric parameters.

Next, VIT can project image quality targets at three switchable wavelengths. These images are used to measure imaging parameters.

HOW IS BUILT?

VIT station is a modular system built from five main blocks: Dual Image Projector, set of frame grabbers, PC set, test software and optional CON electronic controller of tested raw image sensors.

Dual Image Projector is the main block of VIT test station. DIP block is built as two quasi independent projectors: a)radiometric projector, b)image projector.

Radiometric projector block is built as a calibrated broadband light source integrated with a spectral selector that projects uniform image of regulated light intensity and light spectrum. The spectral selector regulates spectrum of transmitting light using a set of sixteen narrow band optical filters and one broadband VIS-SWIR window. Light intensity of projected uniform images can be regulated at very wide range and this feature makes possible to simulate extreme lighting conditions from very dark nights in Afghanistan mountains to ultra bright days in Arabian desert.

Image projector is built as a tri-spectral switchable light source integrated with set of targets and image macro-projector. This block projects images of a set of reference targets (set of variable contrast USAF 1951 targets, edge target, FOV target, spot target) to surface of the tested sensor. User can regulate light intensity, light wavelength, and type of target to be projected.

Set of frame grabbers is a set of commercially available frame grabber cards compatible to Inframet test software installed in PC main unit. Typical set enables capturing video images in following standards: analog video, CameraLink, LVDS and HDMI. Inframet adds also virtual software frame grabber that makes possible to capture images from typical USB 2.0/USB3.0 camera cores. Other frame grabbers can be optionally added.

PC set used in VIT station is in general typical PCs tested for compatibility with frame grabbers and Inframet test software.

Test software controls all functions of DIP block, communicates with optional CON controller, captures images from tested camera cores and finally calculates parameters of tested camera cores.

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VERSIONS

VIT station is a modular station that can be offered in several versions optimized for different applications. Two digit code defined in Table 1 is used define versions of VIT station.

Table 1. Two digit code used to define versions of VIT stations

Code number	Column A Targeted sensor type	Column B Electronic form of tested image sensors
1	VIS-NIR sensors	Only camera cores
2	-InGaAs sensors	Camera cores and up to two raw image sensors
3	both VIS-NIR and InGaAs sensors	Camera cores and raw image sensors

Code VIT-31 means:
Column A row 3- VIT station optimized for testing VIS-NIR and InGaAs sensors integrated with control electronics
Column B row 1 - VIT station is to be used for testing only camera cores capable to generate standard electronics video images.
Detail information on interpretation of codes from Table 1 is presented below.

A. Targeted sensor type

A1. VIS-NIR sensors. In this version wavelength of sixteen narrow band filters used in radiometric projector are located in range 400-1100nm. Image projector can project image quality targets at two wavelengths located in VIS-NIR range: 590nm (VIS), 850nm (NIR).
A2. InGaAs sensors. Wavelength of sixteen narrow band filters used in radiometric projector are located in range 600-2000nm. Image projector can project image quality targets at one wavelength located in SWIIR range: 1050nm.
A3. Both VIS-NIR and InGaAs sensors. Number of available filters is increased to 20 filters (option: more filters). User can manually change from typical set of filters for VIS-NIR range to typical set of filters for VIS-SWIR range. Image projector is offered in expanded version that can project image quality targets at three wavelengths: 590nm (VIS), 850nm (NIR), 1050nm (SWIR).

B. Electronic form of tested image sensors

B1. Only camera cores. In this version it is assumed that only camera cores are to be tested or that customer has his own electronic controller of image sensors. In both cases it is expected that tested device can generate output electronic image in one of electronic standards: analog video, Camera Link, USB2.0/3.0, LVDS, HDMI.
B2. Camera cores and up to two raw image sensors. In this version Inframet deliverers specialized miniaturized control electronics for up to two customer image sensors. In this way two VIS-SWIR camera cores are built and can be tested as typical camera cores. Customer is to deliver detail information or preferably sample image sensors.
B3. Camera cores and raw image sensors. In this version Inframet delivers quasi universal reprogrammable CON electronic controller that can be used to control a series of VIS-SWIR sensors. Customer is to deliver detail information or preferably sample image sensors.

SPECIFICATIONS

Modules	DIP dual image projector, set of frame grabbers, PC set, test software, CON sensor controller
Dual Image-Projector	
Radiometric projector	
Light source diameter	at least 20mm
Light source non-uniformity (spatial uncertainty)	<1% (<0.5% at central circle diameter 16mm)
Spectral band	350nm to 2200 nm
Broadband light spectrum	Color temperature 2856K±100K in most of source spectral band
Light intensity regulation type	continuous (any value can be set within the regulation range)
Regulation stability	better than 1% of the set value
Number of switchable spectral bands	one broadband and 16 narrow bands (17 slots on rotary wheel) -more filters can be delivered to be manually exchanged

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Calibration of light source	lx - for broadband mode; W/m^2 - for narrow spectral band mode
Illumination range at broadband mode	1 µlx to 10 000lx (10^{10} dynamic)
Regulation resolution of illuminance	1 µlx (at low intensity range)
Typical wavelengths of light in narrow band mode	A1 version: 350; 400, 450; 500, 550; 600, 650; 700, 750; 800, 850; 900, 950; 1000, 1050; 1100nm A2 version: 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000nm A3 version: user gets 25 filters and can manually change filters to achieve A1 version or A2 version. Additional filters are optional.
Width of narrow spectral bands	From 10 nm to 20nm depending on wavelength
Irradiance range at the narrow band mode	400nm: 5nW/m^2 – 3mW/m^2 500nm: 10nW/m^2– 40mW/m^2 600nm: 50nW/m^2 – 150mW/m^2 700nm: 50nW/m^2 – 260mW/m^2 800nm: 70nW/m^2 – 330mW/m^2 900nm: 90nW/m^2 – 400mW/m^2 1000nm: 90nW/m^2 – 450mW/m^2 1100nm: 90nW/m^2 – 460mW/m^2 1200nm: 90nW/m^2 – 460mW/m^2 1300nm: 90nW/m^2– 430mW/m^2 1400nm: 90nW/m^2 – 380mW/m^2 1500nm: 80nW/m^2 – 340mW/m^2 1600nm: 70nW/m^2 – 320mW/m^2 1700nm: 60nW/m^2 – 290mW/m^2 18000nm: 50nW/m^2 – 240mW/m^2 1900nm: 50 nW/m^2– 220mW/m^2 2000nm: 50nW/m^2– 200mW/m^2 other wavelengths – mean values from the neighbor wavelengths
Regulation resolution of irradiance	10 nW/m^2 (at low intensity range)
Image projector	
Spectral band of image projector	400-1100nm
Resolution of image projector	at least 400 lp/mm at 590nm; 300 lp/mm at 850nm, 200 lp/mm at 1050nm
Diameter of max image area	20mm
Light non-uniformity in image area (spatial uncertainty)	<2.5% (<1% at central circle diameter 16mm)
Switchable wavelengths of light source	B1 version: 590nm (VIS), 850nm (NIR) B2 version: 1050nm (SWIR) B3 version: 590nm (VIS), 850nm (NIR), 1050nm (SWIR)
Irradiance at sensor plane	590nm: 10nW/m^2 to 1W/m^2 850nm: 10nW/m^2 to 0.5W/m^2 1050nm: 10nW/m^2 to 0.1W/m^2
Targets	set of five variable contrast USAF 1951 targets (contrast at least from 3% to 100%), edge target, FOV target, pinhole target
Spatial frequency range of USAF1951 targets	at least 1-228 lp/mm for 100% contrast at least 1-128 lp/mm for other contrasts
CON controller	
Basic description	B2 version: specialized miniaturized control electronics for up to two customer image sensors B3 version: universal reprogrammable controller that can be used to control a wide group of VIS-NIR sensors
Set of frame grabbers	
Number of frame grabbers	at least four frame grabbers (including virtual USB 2.0/USB3.0 grabber)
Types of acceptable image interfaces	Typical configuration: analog video, CameraLink, USB 2.0/USB3.0, LVDS and HDMI - virtually all camera cores can be tested (attention: camera software driver compatible with MS DirectX is required when testing USB 2.0/3.0 cameras)
PC	
Basic description	typical desktop PC tested for compatibility with frame grabbers and test software
Test software	
List of computer programs	VIT Control, VIT Display, TAS-V, SUB-V, CON control program
Functions of VIT Control	control of spectrum and irradiance at exit of radiometric channel
Functions of VIT Display	Measurement and display of irradiance at exit of image channel

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VIS-V test program	a)acquisition video image generated by tested image sensor, b)measurement of parameters of tested sensor: relative spectral sensitivity, Quantum Efficiency, sensitivity, dynamic range, linearity, Noise Equivalent Illuminance/Irradiance, Fixed Pattern Noise, Non Uniformity, Signal to Noise Ratio, dead pixels, 3D Noise, Modulation Transfer Function, resolution, Minimal Resolvable Contrast, crosstalk, blooming, FOV
SUB-V	software support for MRC measurement
CON control program	control of functions of CON controller
Power	230/110 VAC 50/60 Hz power < 800W
Operating temperature	10°C to 40°C
Dimensions	About 163x63x73 cm
Mass	About 91 kg (without PC set)

*specifications are subject to change without prior notice

COMPARISON TO OTHER SYSTEMS:

Inframet offers three stations for testing VIS-SWIR imaging sensors: VIT, SIT and SOL. VIT test station enables measurement of radiometric and imaging parameters at a dozen spectral bands of VIS-SWIR range; SIT- measurement of radiometric parameters at continuously regulated wavelength in VIS-SWIR range; SOL - measurement of radiometric parameters at step regulated wavelength or at broadband VIS-SWIR range. VIT offers to measure more parameters of VIS-SWIR camera cores/image sensors and offers also tests at extremely wide light intensity range.

WHY VIT STATION?

VIT is the only test station optimized for testing VIS-SWIR image sensors that is offered as commercially available product at international market. Technical parameters of blocks of this station (light sources, image projector, spectral selector) significantly exceed performance of similar blocks offered on international market.

The station has been developed as a product of a scientific project in 2014 year and has been significantly improved since that time. The design concept and test capabilities of VIT station have been positively verified by a series of top world manufacturers of VIS-SWIR camera core/image sensors who presented ultra high requirements on station performance.

Version 4.1

CONTACT:

Tel: +48 22 6668780 Fax: +48 22 3987244 Email: info@inframet.com

• INFRAMET