BNUC

Sets of blackbodies for two point NUC of thermal imagers

Fig.1. Photo of BNUC-12D-2TCB-TC set for 2 point NUC (including YLS

a) b)

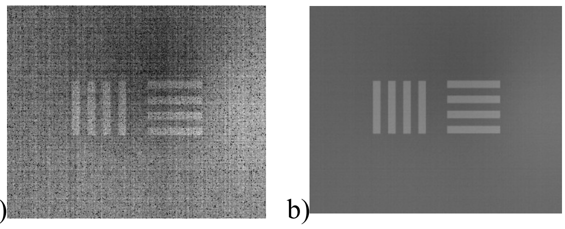

Fig.2. Exemplary images: a)raw image from IR FPA sensor, b) image from thermal imager after two point NUC

1 Methods of two point NUC

Raw image generated by IR FPA sensors used in thermal imagers is typically very noisy, mostly due to high spatial noise generated by significant variation of gain and offset of pixels of this image sensor. Therefore this spatial noise (it varies from pixel to pixel but almost does not depends on time) must be corrected by some image processing. Practically it means that all thermal imagers must be factory-calibrated to generate non-uniformity compensation (NUC) coefficients which are applied automatically by the camera in real time to maintain good image quality. These coefficients are determined during so called two point NUC operation.

NUC coefficients are typically calculated on basis of images of a large area, uniform blackbody that fully fills FOV of tested imager taken at typically two different blackbody temperatures. Because blackbody is uniform then manufacturer knows that any difference in signal from different pixels is spatial noise to be corrected.

Manufacturers use myriad of different mathematical algorithms to correct spatial noise. However, from point of view of test equipment there are three two-point NUC methods:

A) Tests at laboratory ambient temperature (about 20ºC) by capturing images of a hot blackbody (temperature more than about 30ºC over ambient) and of a neutral blackbody (temperature equal to ambient temperature).

B) Tests at laboratory ambient temperature by capturing images of a hot blackbody (temperature more than about 30ºC over ambient temperature) and of a cold blackbody (temperature more than about 10ºC below ambient temperature).

C) Tests at temperature chambers (ambient temperature varies from about -30ºC to about +60ºC) by capturing images of a hot blackbody (temperature more than about 20ºC over ambient temperature) and of a cold blackbody (temperature more than 20ºC below ambient temperature).

Method A is the simplest and most typical. However, it enables to compensate spatial noise only if thermal imager work at temperatures close to typical laboratory temperature and of imagers having symmetric response function. The latter limitation is eliminated in case of method B, especially when blackbody of temperature below about -20ºC ambient temperature is used. However, there are possible problems with vapor condensation on such blackbody when emitter is at sub-zero temperatures.

Method C is the most advanced as it enables to determine a set NUC coefficients for different ambient temperature and to design thermal imagers capable to deliver image almost free from spatial noise at any ambient temperature.

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2 Requirement on blackbodies for two point NUC

Perfect blackbody for two point NUC tests should simulate a large thermal target of thermal non-uniformity and temporal non-stability that are not detectable by tested imager. Practically it means that the blackbody should be characterized by:

1. blackbody emitter must be large enough to fill totally FOV of tested thermal imager (blackbody is typically located at very short distance to optics of the imager),
2. very low and diffuse reflectivity of the blackbody emitter (no detectable reflections on blackbody surface from radiation of hot sources),
3. very good thermal uniformity (uniform emission of thermal radiation),
4. very good temporal uniformity (no detectable temporal variations of emitted thermal radiation),
5. ability to work at extreme ambient conditions from about -40ºC to about +60ºC.

3 Inframet offer for two point NUC

There are many low cost blackbodies offered on international market that can be used potentially for two point NUC applications. However, due to significant and specular reflectivity, noticeable thermal uniformity and temporal stability, and not ability to work in temperature chambers these blackbodies are not suitable for professional applications. Inframet BNUC sets are optimized for the latter applications.

Inframet sets of BNUC sets for two point NUC are built as sets of two blackbodies with optional YLP linear platform and YLP Control program. The latter two blocks are needed to enable to enable fast movement of tested imager from one blackbody to another blackbody in order to increase NUC accuracy.

BNUC sets can be divided into four groups coded as below:

1. BNUCxD-2TCB-TC, (xD code for blackbody size)
2. BNUC-xD-2TCB,
3. BNUCxD-TCB+BAB,
4. BNUC-xD-TCB+BPB (old code: DAP).

BNUC-2TCB-TC is actually a set of two TCB series blackbodies (technical specifications as in https://www.inframet.com/Data%20sheets/TCB.pdf) optimized to work in extreme temperatures in temperature chambers. BNUC-2TCB-TC set is recommended for most demanding NUC tests (method C in Section 1). Inframet has delivered a long series of BNUC-2TCB-TC sets to top world manufacturers of thermal imagers.

BNUC-2TCB is a set of two typical TCB series blackbodies optimized to work in typical room temperatures that can simulate large hot/cold target of near perfect thermal uniformity, temporal stability and very good accuracy of measurement of both absolute and differential temperature of the blackbody emitter (method B in Section 1).

Keeping precision and stable absolute temperature of both blackbodies is actually not critical during NUC tests. It is also not needed to achieve precision value of set differential temperature but it is critical to keep stable differential temperature between two blackbodies. Therefore as a cost effective solution Inframet offers BNUC-TCB+BAB set that is built by combining typical TCB blackbody (to be used as cold blackbody) and a simple heated blackbody coded as BAB (active blackbody). The BAB enables only rough regulation of its absolute temperature but differential temperature is measured and stabilized with high accuracy.

BNUC-TCB+BPB is built by combining typical TCB blackbody (to be used as hot blackbody) and a simple passive blackbody coded as BPB (passive blackbody). Temperature of emitter of BPB blackbody is not stabilized electronically. However, because of its good thermal insulation and high thermal inertia temperature of the emitter of PB blackbody changes with very slow speed and can be considered as constant in temporal intervals not longer than several minutes. Next, software that controls TCB blackbody keeps stable temperature difference relative to temperature of BPB. The BNUC-TCB+BPB blackbody set makes possible two point NUC using method A described in Section 1).

It should be noted that even the simplest and cheapest BNUC-TCB+BPB blackbody set is characterized by near perfect Lambertian coating of near zero reflectivity, near perfect temperature uniformity and temporal stability.

All the BNUC blackbody sets can be delivered with emitters of size that vary from 100x100mm (code 4D) to 500x500mm (code 20D). Practically it means that Inframet BNUC sets can be used for NUC of almost any thermal imagers. Size of blackbody emitter is indicated by code in form of XD when X means size in inches.

Table 1. Configurations of BNUC blackbody sets

BNUC set code	Cold blackbody	Hot blackbody
BNUC-xD-2TCB-TC	TCB-xD-TC	TCB-xD-TC
BNUC-xD 2TCB	TCB-xD	TCB-xD

BNUC-xD -TCB+BAB	TCB-xD	BAB-xD
BNUC-xD TCB+BPB (old code: DAP)	TCB-xD	BPB-xD

For example BNUC -6D-2TCB-TC means a set of two TCB-6D blackbodies optimized to work in temperature chamber.

4 Technical specifications

Technical specifications of TCB blackbodies are presented in data sheet at https://www.inframet.com/Data%20sheets/TCB.pdf. Basic parameters of simplified blackbodies are as below:

BAB blackbody: blackbody emitter properties (size, coating, emissivity, reflectivity, diffusivity) and resolution and uncertainty of measurement of temperature of the blackbody are the same as for TCB blackbodies. However, blackbody temperature is regulated manually by changing voltage from external power supply.

BAP blackbody: blackbody emitter properties (size, coating, emissivity, reflectivity, diffusivity) and resolution and uncertainty of measurement of temperature of the blackbody are the same as for TCB blackbodies. However, blackbody temperature is not regulated and is kept at ambient temperature.

5 Options

Inframet can deliver optional YLS railway platform that makes possible fast transport of tested thermal imager from one blackbody to the second blackbody. Option code: YLS. .

Temperature of blackbodies in NUC sets is typically measured with resolution at level of 0.001ºC and uncertainty at level of 0.03ºC. So high resolution and uncertainty are actually not needed in NUC tests. Therefore Inframet offers an option of limited resolution/uncertainty (resolution at level of 0.01ºC and uncertainty at level of 0.1ºC) for situation when budget is critical. Option code: LRU. This option is recommended when blackbodies are to be used only for NUC tests. Please note that high resolution/uncertainty can be useful for other applications (MRTD tests, accuracy tests).

Version 2.3

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