Thermal Target Detection Using Vigo Detectors

The appropriateness of a detector for use in pyrometry or thermal imaging is a function of its spectral response, its absolute sensitivity within the wavelength region of its spectral response, and the temperature of the target.

For example, the Vigo PD-10.6-series devices cover the region 1 to 11+ microns. A 300K body radiates ~35% of its energy in this band. The weighted average D* of the PD-10.6-3 in this region is >4 x 10^6, so we can compute that the effective D* of the PD-10.6-3 against a 300K target is 35% of >4 x 10^6 ≥ 1.4 x 10^6. This is the "300K blackbody D*" of the detector. The fraction of energy radiated by a 500K body that the PD-10.6-series will see is ~65%. For a 1000K body the fraction is ~93%. With these values we can make a table of 'black body D*' for the PD-10.6-3 as follows.

Target temp	Fraction of energy in spectral range of PD-10.6-series	Average D* of PD-10.6-3 in spectral range	Blackbody D* of PD-10.6-3
300K	35%	>4 x 10^6	>1.4 x 10^6
500K	65%		>2.6 x 10^6
1000K	93%		>3.7 x 10^6

Table 1.

This is an interesting result, since it is not intuitively obvious that in absolute terms this relatively long wavelength detector is better against hot targets than against room temperature targets. This result can easily be extended to other devices in the PD-10.6-3 series and to any other device with this spectral response such as the PDI-10.6, PDI-2TE-10.6, etc by simply substituting appropriate values of D* into the above table.

Pursuing this further, we have computed these figures for detectors with other cutoff wavelengths such as the PDI-n-series, PCI-n-series, and their TE-cooled variations. See **Table 2** following.

Table 1 clearly shows that as the target gets hotter the detector blackbody D* improves even for a detector seemingly matched to longer wavelengths. **Table 2** shows that, in the Vigo product line, the 6-micron cutoff devices are the most sensitive against real-world thermal targets. **Our recommendation is to use the PDI-2TE-6 for best system performance against targets at or above ambient temperature.**

For 300K body detection				
Detector Model	**Spectral Range**	**Fraction of energy in spectral range of this model**	**Average D* of this model in spectral range**	**300K Blackbody D* of this model**
	(microns)		($cm.Hz^{1/2}W^{-1}$)	
PDI-4	1.5 to 4	0.25%	$>1.6 \times 10^{9}$	$>4 \times 10^{6}$
PCI-M-4			$>7 \times 10^{9}$	$>1.7 \times 10^{7}$
PDI-2TE-4			$>5 \times 10^{10}$	$>1.7 \times 10^{8}$
PCI-2TE-4			$>8 \times 10^{10}$	$>2 \times 10^{8}$
PDI-5	1.5 to 5	1.4%	$>6 \times 10^{8}$	$>8 \times 10^{6}$
PCI-M-5			$>3 \times 10^{9}$	$>4 \times 10^{7}$
PDI-2TE-5			$>3 \times 10^{10}$	$>4 \times 10^{8}$
PCI-2TE-5			$>3 \times 10^{10}$	$>4 \times 10^{8}$
PDI-6	**1.5 to 6**	**4.3%**	$>4 \times 10^{8}$	$>1.7 \times 10^{7}$
PCI-M-6			$>6 \times 10^{8}$	$>2.5 \times 10^{7}$
PDI-2TE-6			**$>1.3 \times 10^{10}$**	**$>5 \times 10^{8}$**
PCI-2TE-6			**$>1.3 \times 10^{10}$**	**$>5 \times 10^{8}$**
PDI-8	1.5 to 8	15%	$>2 \times 10^{8}$	$>3 \times 10^{7}$
PDI-2TE-8			$>1 \times 10^{9}$	$>1.5 \times 10^{8}$
PCI-2TE-9	1.5 to 9	21%	$>7 \times 10^{8}$	$>1.4 \times 10^{8}$
PDI-10.6	1 to 11	35%	$>4 \times 10^{7}$	$>1.4 \times 10^{7}$
PDI-2TE-10.6			$>2 \times 10^{8}$	$>7 \times 10^{7}$
PD-10.6-3			$>4 \times 10^{6}$	$>1.4 \times 10^{6}$
PCI-2TE-12	1 to 13	42%	$>1 \times 10^{8}$	$>4 \times 10^{7}$

Table 2.

Additional Notes and Comments:

1. Atmospheric transmission effects usually can be ignored at target distances less than 100 meters.
2. 1/f 'flicker' noise in photoconductive versions of these devices will degrade sensitivity in many instances. Therefore, photovoltaic types will be generally preferred.
3. The D* usually quoted is 'spectral D*' "D^*_{λ}", whereas this discussion is about 'Black Body D*', "D^*_{BB}", and the calculations are primarily D^*_{300K}. For a more rigorous discussion see Optical Radiation Detectors by Dereniak & Crowe, Wiley & Sons, 1984.
4. Fractions of blackbody energy in the various wavelength bands were taken from a GE Radiation Calculator slide rule.
5. The military thermal imaging community thinks that the sensitivity of thermal imagers operating in the 3 to 5 and 8 to 12 micron regions are roughly equal. They are correct. The large difference between 6-micron and 11 or 12-micron cut off devices indicated above for Vigo devices derives from the fact that Vigo's best 6-micron devices are very nearly as sensitive as the best LN_2 cooled types the military community uses, while the room temperature long wavelength Vigo devices are as much as 10^4 less sensitive than military-quality LN_2 cooled types (though 10^4 times faster).

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