GLOSSARY OF TERMS

General Definitions

$Hg_{1-x}Cd_xTe$

Known also as **M**ercury **C**admium **T**elluride (**MCT**), CdHgTe, (Cd,Hg)Te or **M**er**C**ad**T**el; an alloy of CdTe and HgTe. Change of the CdTe to HgTe ratio (composition or x-value) can be used to tune optical absorption cut-off wavelength in the wide range from ultraviolet (UV) to deep infrared (IR). Cooling shifts the cut-off wavelength towards long wavelengths. Detectors from VIGO System are based on complex graded gap **MCT** structures optimized for **MWIR** (3-6 μm) and **LWIR** (8-14 μm) ranges.

Photovoltaic Detectors (PV, PVM)

Photovoltaic Detectors (photodiodes) are semiconductor structures with one (**PV**) or multiple (**PVM**) homo- or heterojunctions. Absorbed photons produce electron-hole pairs, resulting in external photocurrent. Reverse bias voltage may be applied to increase differential resistance, reduce the shot noise, improve high frequency performance and dynamic range.
Reverse bias may increase responsivity in some devices. Unfortunately, at the expense of flicker noise (1/f) in most cases.
Photovoltaic detectors are more vulnerable to electrostatic discharges than **Photoconductors**.

Detector Formats

Square and **rectangular** formats are used for **PC**, **PV**, **PVM** and **PEM** detectors.
Circular shapes for some **PV** detectors are available upon request.

Photoelectromagnetic Detectors (PEM)

Photovoltaic Detectors based on the **Photoelectromagnetic Effect**. It consists in spatial separation of optically generated electrons and holes in the magnetic field. They do not require electrical bias and show no flicker noise (1/f).
The **PEM** devices are typically used as fast, uncooled detectors of the long wavelength radiation.

Photoconductors (PC)

Photoconductive Detectors based on the **Photoconductive Effect**. Infrared radiation generates charge carriers in the semiconductor active region decreasing its resistance. The resistance change is sensed as a voltage change by applying a constant current bias. The optimum bias current is specified in the **Final Test Report** and depends on the detector size, operating temperature and spectral characteristics

Detector Parameters

Current and Voltage Responsivity: R_i, R_v

$$R_i(\lambda)=\frac{\text{Current Signal}(\lambda)\cdot d\lambda}{\text{Incident Power}(\lambda)\cdot d\lambda} \qquad \left[\frac{A}{W}\right]$$

Current responsivity is typically used for description of **PV** and **PVM** detectors.

$$R_i(\lambda)=\frac{\text{Voltage Signal}(\lambda)\cdot d\lambda}{\text{Incident Power}(\lambda)\cdot d\lambda} \qquad \left[\frac{V}{W}\right]$$

Voltage responsivity is typically used for description of **PC** and **PEM** detectors.

Responsivity-Width Product: $R_i\cdot w$, $R_v\cdot w$

The responsivity of **PC**, **PEM** and **PVM** devices is inversely proportional to the width **w** of the detector.
Therefore, the normalized responsivity can be expressed as the **current** responsivity-width product (**Ri·w**) for **PVM** or **voltage** responsivity-width product (**Rv·w**) for **PC** and **PEM**.

Dark Current: I_{dark}

The current that flows in a photodetector when it is not receiving any light. It may increase as the temperature rises.
The small amount of current that flows through a photonic semiconductor device when it is not operating. Also known as **Leakage Current.**

Maximum Bias Current: I_{max}

The maximum current that can flow through a **Photoconductive** or **Photovoltaic** detector without a risk of its damage.

Bias Current-Width Ratio: I_b/w

Width-normalized photoconductor bias current.
Typical **Photoconductor's** (PC series) bias current **I_b** should be increased proportionally to it's width **w**. Therefore, the normalized bias current can be expressed as the **I_b/w**.

Noise Current and Noise Voltage: I_n, V_n

Root mean square Noise Current or Noise Voltage.

$$I_n=\sqrt{I_n^2(t)} \qquad V_n=\sqrt{U_n^2(t)}$$

Noise Current and Noise Voltage Density: i_n, v_n

$$i_n=\frac{I_n}{\sqrt{\Delta f}} \qquad v_n=\frac{V_n}{\sqrt{\Delta f}}$$

Corner Frequency: 1/f

Flicker noise or **1/f** noise is a frequency dependent noise.

Its power is proportional to $\frac{1}{f^b}$ where b ~ 1.

Below the corner frequency the noise of detectors is dominated by flicker noise.

Normalized Detectivity: D*

The **S**ignal-to-**N**oise **R**atio (**SNR**) at a detector output normalized to 1 W radiant power, a 1 cm^2 detector optical area and a 1 Hz bandwidth.
The higher the **D*** value, the better the detector.

$$D^*=\frac{R_i}{i_n}\sqrt{A}=\frac{R_v}{v_n}\sqrt{A} \qquad \left[\frac{cm\cdot\sqrt{Hz}}{W}\right]$$

Optical Area: A

Active Area (Active Element) - the area from which the incident radiant power is collected.
For immersed detector it is different from physical detector area (see **Optical Immersion** chapter).

Detector Capacitance: C_d

Parallel capacitance in the detector structure.

Spectral Response

Spectral Responsivity or Spectral Detectivity – in detector data sheets it is presented as **$R_v(\lambda)$**, **$R_i(\lambda)$** or **$D^*(\lambda)$**.
It can be characterized by cut-on, cut-off, optimum and peak wavelength.

Peak Wavelength: λ_{peak}

λ_{peak} is a wavelength of detector maximum responsivity.

Optimum Wavelength: λ_{opt}

The wavelength a device is optimized for. Typically longer than $\lambda_{peak.}$

Cut-On Wavelength: λ_{cut-on}

λ_{cut-on} is the shortest wavelength at which a detector responsivity reaches 10% of the peak value.

Cut-Off Wavelength: $\lambda_{cut-off}$

$\lambda_{cut-off}$ is the longest wavelength at which a detector responsivity reaches 50% of the peak value.

Resistance – Optical Area Product: R·A

Area-normalized detector resistance. Typical photodiodes (PV) resistance decreases proportionally to their area increasing. Therefore, the normalized resistance can be expressed as the **R·A**.
In contrast, the PVM detectors are characterized by **Sheet Resistance**.

Series Resistance: R_s

Parasitic resistance in photodiodes. Its contribution to the total diode resistance may be significant for long wavelength and near room **Operating Temperatures** diodes, especially with large **Optical Area.**

Sheet Resistance: R_{sq}

The normalized resistance expressed in Ω/□. It is used to normalize the resistance for different size devices with non-square active area

$$R_{sq}=\frac{R\cdot w}{l}$$

Time Constant: τ

Typically, detector time response can be described by one pole filter. **Time Constant** is the time it takes detector to reach 1/e ≈ 37% of the initial signal value.
Time Constant is related to the 3dB **High Cut-Off Frequency f_{hi}**:

$$\tau=\frac{1}{(2\pi f_{hi})}$$

Time Constant is related to 10 – 90% **Rise Time t_r**:

$$t_r=2.2\,\tau$$

Operating Temperature: T

Detector active element temperature.

Acceptance Angle: Φ

Acceptance angle is the maximum angle at which incoming radiation can be captured by a detector. Radiation coming from a larger cone angle won't reach the detector.

Field of View: FOV

VIGO defines the **Field of View** as the angle (**FOV**), which is two times the half angle defined by:

- the center of the detector and detector housing - in flat or equipped with hemispherical lens detectors,

and

- the marginal ray in detectors with intermediate or hyperhemispherical (standard) lens.

In systems without external objectives Acceptance Angle and FOV are identical.

F-number: F/#

F/# is related to the image-space acceptance angle when the system is focused at infinity.

Preamplifier Parameters

Output Voltage Responsivity: R_V

The output voltage divided by optical power incident on the detector.

Output Voltage Swing: V_{out}

The maximum and minimum voltages where preamplifier works in linear range.

GND

Point of zero potential. For standard preamplifiers is common power supply and signal ground.

Low Cut-Off Frequency: f_{lo}

A minimum frequency at which a module responsivity (or preamplifier gain) reaches -3dB of the peak value.

High Cut-Off Frequency: f_{hi}

A maximum frequency at which a module responsivity (or preamplifier gain) reaches -3dB of the peak value.

Output Noise

Noise voltage at preamplifier output.

Average Output Noise Density:

$$V_n=\sqrt{\frac{\int_{f_1}^{f_2}V_{out}^2(f)\,df}{f_2-f_1}}$$

Noise Measurement Frequency: f_0

Frequency at which output voltage noise is measured selectively.

Output Noise Density at Specific Frequency: $V_n(f_0)$

Noise voltage density measured at a given frequency.

Transimpedance: K_i

Current to voltage conversion factor (ratio).

$$K_i=\frac{V_{out}}{I_{in}}$$

Preamplifier Input Noise Current: i_n

Noise current generated by equivalent current source in parallel with ideal preamplifier input.

Preamplifier Input Noise Voltage: e_n

Noise voltage generated by equivalent voltage source in series with ideal preamplifier input.

Total Input Noise Current: I_{in}

Parameter taking into consideration all noise sources related to the input.

$$I_{in}=\sqrt{(i_{PA}^2+i_d^2)}=\frac{V_{n0}}{T_r}$$

Output Impedance: R_{out}

Equivalent impedance exhibited by its output terminals.

Load Resistance: R_L

Optimal resistance of the load: amplifier's or the measurement device's.

Output Voltage Offset: V_{off}

DC component of the output voltage.

Power Supply Voltage: V_{sup}

Supply voltage required for correct preamplifier operation. ±20% tolerance is allowed.

Power Supply Current: I_{sup}

Supply current consumption during correct preamplifier operation.

Coupling Type

Preamplifier coupling type. It may be **AC** for alternate current or **DC** for direct current.

Power Supply Input (+) and (-)

Polarity of the power supply related to the ground. Swapping supply connectors may lead to module damage.