OPUS Optics and Photonics Up-Skilling

User-driven Photonics SKills Improvement via Lifelong Learning

Getting Light tO Work - GLOW

OPUS 1

Principles of Photonics

QUICKER with Light – QUality In Creative Kinetic Experience Resonating with Light

1.1 Observations in Light to reveal SEEING Solutions

1.2 Investigations in Light to reveal Empirical Evidence

1.3 Measurements in Light to reveal Precision Accuracy

1.4 Designing in Light to reveal Imaginative Ingenuity

1.5 Testing in Light to reveal Quality of Reliability

1.6 Reporting in Light to reveal Clarity of Insight

1.7 Presenting in Light to reveal Communication Competence

WORK BASED LEARNING PROGRAMME RHAGLEN DYSGU SEILIEDIG AR WAITH

ESF Llywodraeth Cymru Welsh Government

Ewrop & Chymru: Buddsoddi yn eich dyfodol
Cronfa Gymdeithasol Ewrop
Europe & Wales: Investing in your future
European Social Fund

Linking Light With Yare Design Development Opportunities - LLWYDDO

academi FFOTONEG PHOTONICS academy

Academi Ffotoneg Cymru @ Bangor
Photonics Academy of Wales @ Bangor (PAWB)
Photonics is the Science of the Harnessing of Light

PRIFYSGOL BANGOR UNIVERSITY

1.1 Observations in Light to reveal SEEING Solutions

1.1.1 It is possible to make an OBSERVATION – but to SEE at different Levels of SEEING

Making Observations - but what level of SEEING is involved ?

"Oh – I **See** what you mean" is certainly a very frequent response, during an exchange of some information which perhaps does not prompt an immediately obvious level of comprehension when that particular information is first encountered.

Having the opportunity of **Seeing** some form of Information is often a crucially important input factor in the transition of that Information into becoming some form of personal knowledge or memory capable of being retrieved at some stage.

The ability to **See** requires an appropriate Light Sensor / Detector, which, in turn, needs to be tuned to the appropriate resonant and range of "Frequency" levels which are compatible with the format of the incoming Observation Information.

The ability to **See** is a personal skill which, like all skills, can be acquired at various Levels of personal ability and proficiency.

Observations require some level of Involvement in **Seeing** by an Observer, with several different Levels being possible.

PAWB identifies at least 7 different **Potential Levels of Seeing** Involvements, when Observations are in progress.

Seven Potential Levels of Seeing Involvements when Observing

Level 0 = **Missing** the entire content of the **available Observation Information** - quite a normal, and easy, reality !

Level 1 = **Watching**, but non-registering of any of the **available Observation Information** for future use.

Level 2 = **Witnessing** but no direct involvement in producing, or creating, any of the **available Observed Information**.

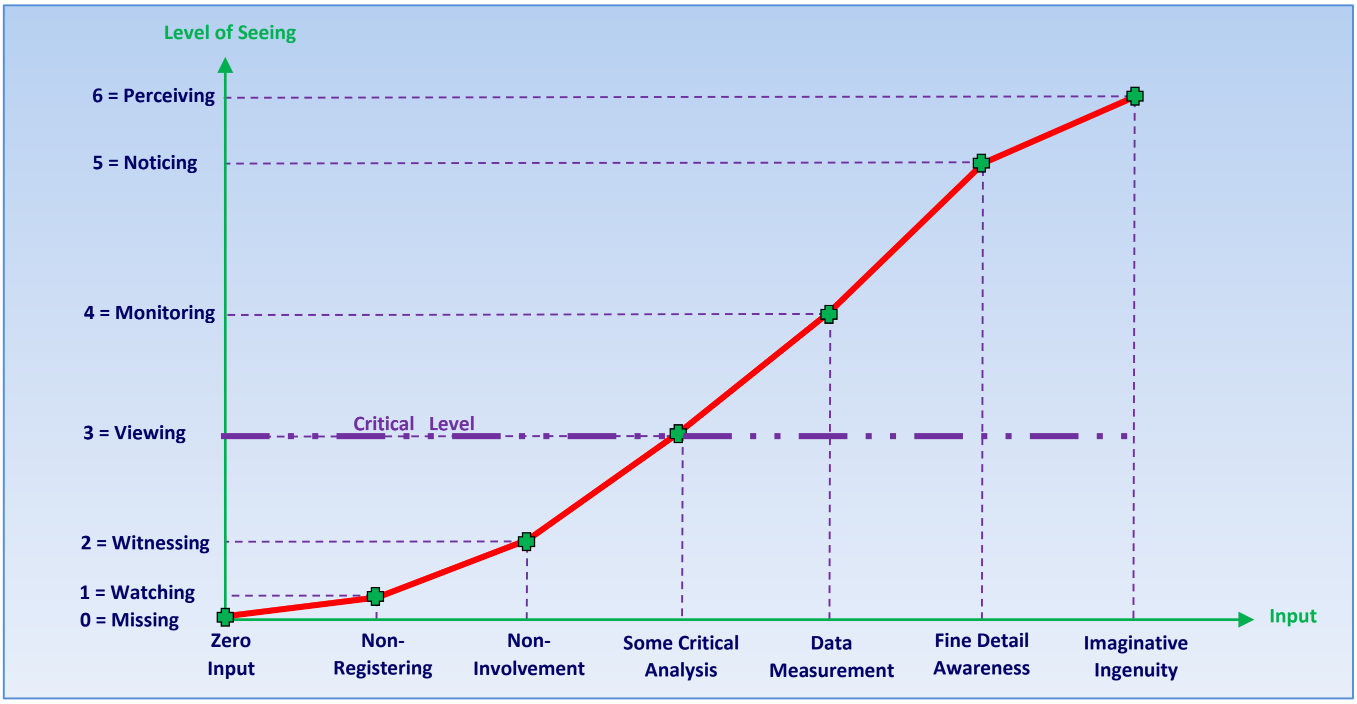
Level 3 = Viewing with some critical analysis of the available Observation Information beginning to happen.

Level 4 = **Monitoring** with some data recording measurement interest in some of the **available Observation Information**.

Level 5 = **Noticing** with an emphasis on an awareness of specific fine detail in the **available Observation Information**.

Level 6 = **Perceiving** with an imaginative vision of some future Ingenuity to create "**What might be achieved**" with the **available Observation Information**.

Perception is derived from the Latin verb "**Percipere**" – meaning "**to seize**" – which is significant !

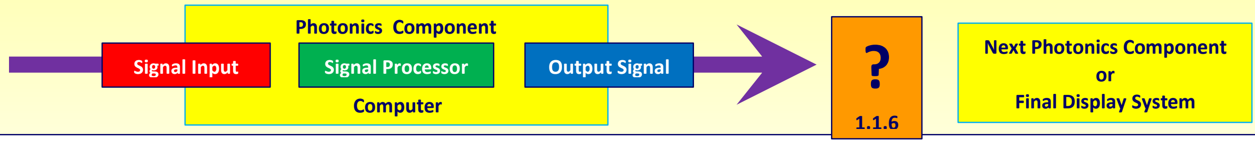


1.1.2 The PAWB Signal Following Approach for Photonics / Optoelectronics

Signal Following Technique - essential in all Optoelectronic Circuit Testing

"What is this . . . ?" Approach to any type of Component

Every Photonics / Optoelectronics Component is a Signal Processing "Computer".



1.1.3 QUICKER with Light – QUality In Creative Kinetic Experience Resonant with Light

Observation of Light based Photonics Solutions

1 "Natural Ability" versus the **DISCIPLINE of Acquired Ability**.
2 The **DISCIPLINE of Seeing Photonics Solutions** at the **Level of Perception Seeing**.
3 **Imagination** of the potential variety of the **100+ new Inventions** prompted by the **Photonics Solutions**.
4 Utilization of **New Solution Observations** at **the very instant** of **Seeing the New Solution Information**.
5 **Individual Personality Imprint** imposed on the New Invention – the **Insight** and **Ingenuity Input**.
6 **Fundamental Challenge** for the Creation of **New Inventions** which arise from **New Information**.
7 Importance of **Divergent Thinking** to produce more than one **New Application Output**.
8 Versatility demonstrated by **Personality Input** and **Prototype Design Output**.

Investigations of Light based Photonics Solutions

1 **Investigations** based on the **DISCIPLINE** of **Perception Level Seeing Observations of Solutions**.
2 **Prediction of Empirical Outcomes** – based on earlier, or predicted, theoretical ideas.
3 Acquisition of **Empirical Evidence**.
4 **Pre-eminence of Empirical Evidence** as the only priority.
5 Empirical Evidence must be **repeatable** and **consistently repeatable** – multi-acquisition.
6 The **Output Effect** needs to be confirmed as being the **real Input Cause**.

Scientific Measurements

1 Based on the **DISCIPLINE** of **Investigation of Solutions**.
2 Acquisition of Specific, Precise, Accurate and Useful Empirical Evidence Importance of knowing:-
 2.1 The **Range of Measurements** to be Investigated.
 2.2 How to **achieve Measurements**.
 2.3 How to **Record Measurements**.
 2.4 How to **Interpret Measurements**.
 2.5 How to recognize the **Implications of Measurements**.
 2.6 How to **Utilize Measurements** in the Design Specification.

Design Specification and Engineering Construction

1 **Based on Empirical Evidence** acquired from the Measurement from the Investigation of Solutions.
2 Precise **Purpose of proposed Design** for the Photonics Prototype.
3 **Flow Diagrams**.
4 **Model Making**.
5 Prototype **Design Construction**.
6 Prototype **Design Test Procedures.**
7 Test based **Modifications.**

1.1.4 Low Power LASER, LED, and Optical Component Observations – high Levels of SEEING

Inherent LASER / LED Beam Characteristics – All Potential Solutions to new Applications of Light

Luminous Intensity	Source / Surface	Brightness	Fluence (Jm^{-2})	Distribution	Photometry Units
	Divergence	Convergence	Single Photon	Multi Photon	
Quantum Approach	Hertz (1887) PE	Planck (1900)	Einstein Quanta (1905) – Nobel (1921)		Energy $E = hv = hc/\lambda$
	Millikan e and PE – Nobel (1923)		de Broglie Duality	Momentum, $p = h/\lambda$	
	Feynman QED	1 Photon $f(x_1,t)$ ~ Wave Approach		2 Photons $f(x_1.x_2,t)$ ~ Particle Approach	
	Phasor Vector	Photon Amplitude	Transverse E and B	Wave Function ψ	Maxwell Wave Equ.
	ψ^2 = Photon Probability		Wave Function Collapse		
Wavelength	Frequency	Colour	Resonant Cavity	Quantum Photon	Photon Phase
Photon Velocity	Vacuum	Material	Refractive Index	Dispersion	Birefringence
	Polarization	Dispersion	Polariton	Soliton	
Coherence	Phase	Frequency	Polarization	Spatial / Temporal Coherence	
	Interference	Diffraction	Phase Difference ~ Path Difference		Holography
Polarization	Linear	Circular	Elliptical	Birefringence	Optic Axis
	Photon Velocity	Interference	Crystal Structures	Equal Thickness Colours	

Applied LASER / LED Beam Treatments – All Potential Solutions to new Applications of Light

Pulsed Modulation	Amplitude	Frequency	Pulse Width Modulation		Ambient Light
	Astable	Monostable	3 Signals in a Pulse	Bounce Signals	
Placement	Optic Fibre	Step / Graded Index	Speckle Effect	Random / Ordered Interference	
Protraction	Rough Surface	Mirror	Spherical Lens	Cylindrical Lens	Beam Steering
	Tweakability	Lens Mounts	Mirror Mounts	Base Board	Beam Height
Polarization	Polarizing Filters	Intensity Control	Birefringent Colours	Observable Interference Fringes	
	Coloured Filters	¼ Wave Plate	½ Wave Plate	Sellotape	

LASER / LED Photon Beam Encounters with Orbital Electron Inter-actions - All Potential Innovative Solutions

Beam Analysis	Photodiode	Optoelectronics	Oscilloscope	Multimeter	LED
Optical Media	Lens	Mirror	Apertures	Diffraction Grating	Filters
Photon / Electron	Photoelectric Effect	Absorption	Scattering	Surface Colour	Spectra
	Boundary Edges	Diffraction	Photovoltaic	Transmission	Polariton
Photon Effects	Photosynthesis	Phosphorescence	Fluorescence	Luminescence	
	Persistence of vision				

1.1.5 Radiometry and Photometry Units

Radiometry – Measurement of the Properties of Radiant Energy		
Quantity	**Meaning**	**Symbol**
Radiant Energy	The total amount of Energy Radiated by a Source.	J
Radiant Flux	The amount of Energy Radiated by the Source per second	W
Radiant Intensity	Radiant Flux leaving a point on the Source per unit solid angle	W sr^{-1}
Irradiance	Radiant Flux incident from all directions on a surface per unit area	W m^{-2}
Radiance	Radiant Flux Emitted ~ Scattered by unit area of a Surface relative to the solid angle subtended by a sensing entrance pupil	W m^{-2} sr^{-1}
Photometry – Measurement of the Properties of Optical Energy		
	Meaning	
Luminous Energy	Depends on the response of the detector (the eye) to different wavelengths	lm.s = talbot
Luminous Flux	One Lumen is defined as the Luminous Flux of Light produced by a Light Source that emits 1 Candela of Luminous Intensity over a solid angle of 1 Steradian	lm = lumen 1 lm = 1 cd.sr
Luminous Intensity	The Candela is the Luminous Intensity, in a given direction, of a Light Source that emits monochromatic radiation of frequency 540 x 10^{12} Hertz which has a Radiant Intensity in that direction of 1/683 Watt per Steradian.	Cd
Illuminance	Luminous Flux per unit area	1 lm m^{-2} = 1 Lx
Luminance	Luminous Intensity per unit area	Cd m^{-2}

1.1.6 Coupling – An Essential and Practical Consideration – a Reprise Section

Signal Following Technique - essential in all Optoelectronic Circuit Testing

"What is this . . . ?" Approach to any type of Component.

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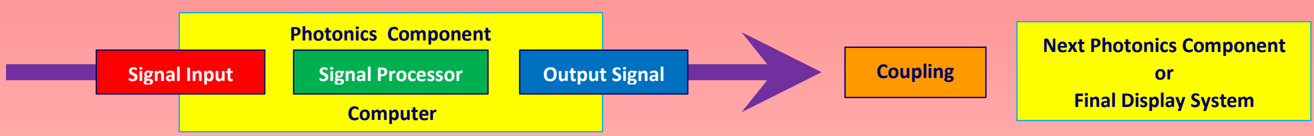

The Coupling of one Optical / Optoelectronics Signal Output to the Input of the next Photonics Component / Display requires very precise considerations.

The Coupling of one Optical / Optoelectronics Signal Output to the Input of the next Photonics Component / Display forms and essential consideration in the role of Investigations – Measurements – Design.

Coupling of Signals forms an essential consideration through:-

1. In Optoelectronics Circuits – the use of Voltage Follower Buffers.
2. In Photonics Situations – the use of Optical Fibres.
3. In Optical Fibre situations – the use of Lenses for Launch or Collection of Optical Signals.