

# Process Photometers – PUV3402 and PIR3502

## Applications, Technology and Data



- Continuous Measurements
- VistaNET™ Connectivity
- Multiple Component Samples
- Measures Vapor or Liquid Samples
- Operates in IR, NIR, UV and VIS Regions
- Fiber Optic Option for NIR Applications
- Multiple Interference Compensation Capability

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## Principle of Operation

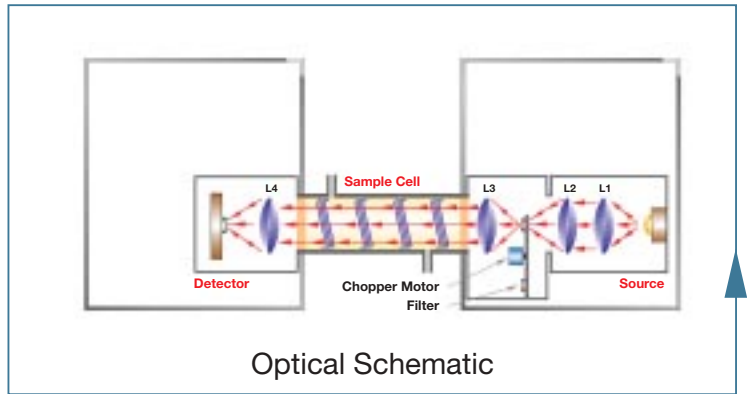
The PUV3402 and PIR3502 Process Photometers optical path consists of an IR or UV source, a brushless chopper motor, a multichannel filter wheel, lenses, cell with windows, and a solid state IR or UV detector. (See Optical Bench Schematic).

The brushless chopper motor rotates the multi-channel filter wheel reference and measure filters, alternately and continuously, into and out of the optical path. The lenses, L1 through L4, focus and collimate the source radiation through the sample cell path to the detector.

On a multichannel photometer, a reference wavelength is chosen where the stream components have little or no absorbance. The measure wavelength or wavelengths are chosen where the measured components have absorbance. The micro-processor will then use matrix algebra and apply the proper response factor to each filter to eliminate interferences on the desired component and convert the absorbance to a component concentration.



Multiwave™ Process Photometer



## Advantages of the Design

The PUV3402 and PIR3502 Process Photometers use a fixed wavelength filter, single beam, multichannel principle. This design concept offers several advantages:

- Produces a simple mechanical design that promotes easier service and maintenance.
- Compensates for obstruction of cell windows.
- Compensates for source and detector aging.
- Permits the sample cell to be isolated from the electronics.
- Enable multicomponent analysis.

As illustrated by the Optical Schematic, the simple mechanical design has a single optical path, from the source directly to the detector. The source energy is focused and collimated straight to the detector. It does not require optical mirrors or internal reflections.

This enables hardware components to be configured for self-alignment, making all components in the system easy to remove and replace. It also ensures a more reliable and stable long term performance.

The cell windows can be obscured by up to 50% without affecting measurement accuracy, because the single cell, multichannel design measures the ratio of the transmitted energy between the reference and measure wavelengths.

Problems normally associated with dual chamber detectors and cells such as gas leaks, optical alignments, vibrations, pitting and corrosion of cell walls, are eliminated by the single beam multichannel design. Also, aging problems typically associated with two sources or two detectors are eliminated. Again, this design concept enhances long term stability and reliability.

The ABB Process Photometer's single source, single detector design also enables the use of an isolated sample cell. An isolated sample cell has many advantages for on-line process measurements. Contact between flammable or corrosive streams and system electronics is prevented. Access to sample lines is made easier, and cell removal is simplified.

Finally, this multichannel evolution of the fixed filter photometer allows measurements in streams where there are several interfering compounds; and it has the ability to measure multiple components in many applications.

## General Applications

ABB PUV3402 and PIR3502 Process Photometers provide on-line measurements of gas or liquid components, in simple or complex process streams for:

- Process Efficiency
- Catalyst Protection
- Product Quality
- Environmental Concerns
- Safety
- Process Control

ABB Process Photometers provide reliable performance in the Petrochemical, Chemical, Refining, Gas Processing and Product Pipeline industries.



## Spectral Range and Regions

### Spectral Range:

Gas and Liquids with absorbance in the 0.2 to 15 micrometer region of the electromagnetic spectrum.

### Spectral Regions:

Ultraviolet and Visible	200 to 800 nm
Near Infrared (Overtone Region)	800-2500 nm
Fundamental Infrared (Rotation-Vibration)	2.5 to 15 $\mu\text{m}$
Fingerprint Region	8.0 to 15 $\mu\text{m}$

The fingerprint region from 8 – 15  $\mu\text{m}$  is very useful because there is a high level of specificity in this region.

## ABB Process Photometer Field-Proven Applications

The following chart is a partial listing of field-proven applications. These applications are grouped by process. Measured components and key benefits are indexed for each application.



## Temperature and Pressure Ranges

### Temperature Ranges:

Ambient	32° to 113°F (0 – 45 °C)
Sample Cell Operating Temperature	32° to 392°F (0 – 200 °C)

### Pressure Range:

Sample Cell	5 to 500 PSIG (0.3 – 34 BAR) standard*
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\*Higher pressures available upon request – consult manufacturer.

## Field-Proven PUV3402 and PIR3502 Process Photometer Applications

Process	Measurement	Benefits
Acid Gas Scrubbers	Sodium Hydroxide 0–15%	Improved scrubber efficiency and reduced cost
Acetic Acid	CO 80–100% in Reactor Feed Water 0–20% in Reactor Outlet Water 0–10% in Drying Column Inlet Water 0–1500 ppm in Drying Column Outlet *Methyl Iodide 0–1000 ppm	Maximize process yield Distillation Tower control 2nd half of Distillation Tower control and determining expected life of Drying Column Drying Column efficiency Scrubber efficiency and safety
Ammonia	CO 0–500 ppm CH <sub>4</sub> 0–0.5% NH <sub>3</sub> 0–100%	Catalyst Protection Safety Safety
Area Monitoring	Ethyl Benzene 0–200 ppm, Styrene 0–100 ppm, Isooctane 0–2500 ppm, Divinylbenzene 0–300 ppm	Safety, Leak Detection
Crude Unit	ASTM color 0–8	Product quality
Ethylene	Acetylene 0–2% Acetylene 0–0.5%	Hydrogenation reactor inlet continuous control Hydrogenation reactor mid-bed continuous control
Ethylene Dichloride	CO 0–10%, CO <sub>2</sub> 0–5%, and Ethylene 0–5% *Chlorine 0–2000 ppm in EDC with Sparger System	Process efficiency and safety Process efficiency
Ethylene Glycol	*Percent Transmittance at 4 discrete UV wavelengths	On-line quality control of Ethylene Glycol purity
Maleic Anhydride	CO 0–2.5%, CO <sub>2</sub> 0–2.5%, Butane 0–0.5%, and Maleic Anhydride 0–2% Butane 0–2% and Water Vapor 0–5%	Reactor Outlet – Process Efficiency Reactor Inlet – LEL Control
Phosgene	CO 0–10% *Chlorine 0–200 ppm Phosgene 0–100 ppm	Process Control Process Control Safety
Product Pipeline	CO <sub>2</sub> 0–1000 ppm	Prevent freezing of natural gas Lines
Sulfur Recovery	H <sub>2</sub> S 0–100%, CO <sub>2</sub> 0–100%, Water 0–30%, THC 0–10% H <sub>2</sub> S 0–100%, NH <sub>3</sub> 0–50%, Water 0–30%, THC 0–10%	Acid Gas Feed Forward Control Sour Gas Feed Forward Control
Vinyl Chloride	Water 0–50 ppm in EDC Vinyl chloride 0–200 ppm, 0–2% in HCl	Catalyst protection, corrosion protection of reactors Condenser efficiency

\* = UV Application

## Field-Proven Multicomponent Applications

### Multicomponent Measurements

0–1.2% toluene; 0–2% tetrahydrofuran and 0–100% LEL of gas mix (3 components)  
0–20% CO; 0–20% CO<sub>2</sub>; and 0–5% CH<sub>4</sub> (3 components)  
0–55% propane and 0–20% propylene (2 components)  
0–1000 ppm CH<sub>4</sub> and 0–250 ppm ethane in ethylene @ 100 psig (2 components)  
0–100 ppm CO and 0–100 ppm CO<sub>2</sub> in H<sub>2</sub> @ 200 psig (2 components)  
0–200 ppm fluorobenzene; 0–200 ppm chlorine; and 0–200 ppm SO<sub>2</sub> in carbon bed vent gas (3 components)  
0–5% CO<sub>2</sub>; 0–5% CO; 0–1% toluene and 0–1% benzene in air oxidation vent (4 components)  
0–50 ppm acrylonitrile and 0–50 ppm styrene in air (2 components)  
0–50 ppm ethylene oxide and 0–50 ppm propylene oxide in air (2 components)  
0–70% methyl chloride and 30–55% methylene chloride (2 components)  
0–5000 ppm SO<sub>2</sub>; 0–2000 ppm NO; 0–2000 ppm NO<sub>2</sub> and 0–2000 ppm NO<sub>x</sub> (4 components)  
0–5000 ppm ethane; 0–5000 ppm ethylene and 0–80% methane (3 components)  
0–40% CO<sub>2</sub>; 0–40% CO and 0–25% water vapor in air (3 components)  
0–80% ethylene and 0–15% CO<sub>2</sub> in mixed HC stream as a vapor (2 components)  
0–100% CO; 0–60% ethylene; 0–20% CO<sub>2</sub>; and 0–5% ethyl chloride @ 70 psig (4 components)  
0–1000 ppm water and 0–5% DMSO in monochlorobenzene (2 components)  
0–100% ethylene; 0–10% EDC; 0–50% HCl; and 0–20% ethyl chloride (4 components)  
0–20% propadiene; 0–40% methyl acetylene and 0–60% MAPD (3 components)

### Water Measurements

0–2% water in phenol	0–500 ppm water in dimethylacetamide
0–500 ppm water in monochlorobenzene	0–200 ppm water in allyl chloride
0–50 ppm water in ethylene dichloride	0–0.5% water in acetone
0–250 ppm water in chlorine @ 75psig (vapor)	0–1500 ppm water in methanol
0–0.5% water in ethylene diamine	0–100 ppm water in benzene
0–100 ppm water in vinylidene chloride	0–300 ppm water in toluene diamine
0–500 ppm water in propylene glycol	0–1000 ppm water in MEK & alcohols
0–200 ppm water in methyl ethyl ketone (MEK)	

## Field-Proven Applications

### Various Single Component Measurements

1,3 butadiene 0–50%; in isobutene  
1,3 butadiene 0–70%  
acetic acid 0–2%; in acetic anhydride  
acetylene 0–1%; in methane; ethane and ethylene  
acetylene 0–1.5%  
ammonia 0–250 ppm; in air  
cis-2-butene 0–10%; in butadiene  
CO<sub>2</sub> 0–1%; in CH<sub>4</sub> and C<sub>2</sub>H<sub>6</sub>  
CO<sub>2</sub> 0–1%; in ethane  
CO<sub>2</sub> 0–5000 ppm; in ethane  
CO<sub>2</sub> 0–5000 ppm; in propane  
cyclohexane 0–30%; in cyclohexanol  
cyclohexanone 0–500 ppm; in cyclohexane  
ethane 0–10%; in methane and propane  
ethylene 0–2%; in ethane  
H<sub>2</sub>S 0–15%; in sour fuel gas  
hexamethylene imine 0–400 ppm  
hydrogen cyanide 0–1%  
MEOH 0–20%; in MTBE/TAME  
methane 0–6%; in H<sub>2</sub> and water vapor  
methanol 0–40%; in MTBE  
methyl bromide 0–100 ppm in air  
propane 0–6%; in propylene  
propylene 80–100%  
total hydrocarbons 0–10%; in propylene  
total hydrocarbons 0–300 ppm; as butene-1  
vinyl acetate 0–10%; in ethylene  
vinyl acetate 0–20%; in ethylene

### UV Field-Proven Applications

APHA color 0–50  
ASTM color 0–8 ASTM units  
benzene 0–100 ppm; in water  
Bisphenol A 0–25 ppm and 0–100 ppm; in water  
chlorine 0–30%; in propane  
chlorine 0–10%; in NaOH+H<sub>2</sub>O  
chlorine 0–2%; in HCl  
chlorine 0–200 ppm; SO<sub>2</sub> 0–200 ppm; in vent gas (2 components)  
chlorine 0–30%; in propylene  
dimethyl aniline 0–2000 ppm; in N<sub>2</sub> saturated with water  
DMAC 0–1000 ppm; in water  
H<sub>2</sub>S 0–10%; in H<sub>2</sub>  
H<sub>2</sub>S 0–4%; in N<sub>2</sub>  
Saybolt color -30 to +15  
SO<sub>2</sub> 0–500 ppm  
SO<sub>2</sub> 0–5000 ppm; in stack gas  
styrene 0–20 ppm; butadiene in water  
total aminobenzenes as aniline 0–50 ppm  
total phenols as 2-chlorophenol 0–25 ppm; in 33% HCl in H<sub>2</sub>O

## Partial List of IR and UV Absorbing Compounds

The following lists are provided as a general reference for determining potential IR and UV applications. Other considerations will be the remaining stream matrix, stream temperature, stream pressure, and stream phase. The sample must be homogeneous, single phase in order to apply the method. Please provide the needed information on your application to our customer service group so that application engineers can determine the feasibility of your application.

### Partial List of IR Absorbing Compounds (Potential Measurements)

Butadiene (1,3)	Ethane	Nitric Acid
Butane (n)	Ethyl alcohol	Nitric oxide
Carbon dioxide	Ethyl chloride	Nitroethane
Carbon monoxide	Freon-13B	Nitrogen dioxide
Carbon tetrachloride	Freon-14	Nitrogen pentoxide
Chloroform	Freon-C-318	Nitromethane
Cyanogen	Hydrazine	Nitropropane (1 & 2)
Cyclopropane	Hydrogen bromide	Nitrosyl chloride
Diazomethane	Hydrogen chloride	Nitrous Oxide
Dichloroethane (1,1 and 1,2)	Hydrogen cyanide	Phosgene
Dichloromethane	Hydrogen sulfide	Propane
Dimethyl amine	Isobutane	Propylene
Dimethyl ether	Methane	Trimethylhydrazine
Dimethyl hydrazine	Methyl alcohol	Trimethylamine
	Methyl azide	Vinyl chloride
	Methyl chloride	Water
	Methyl mercaptan	

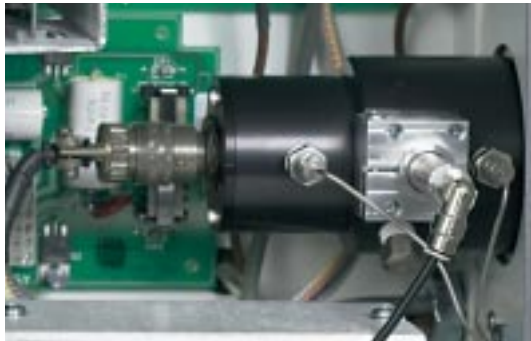
### Partial List of UV Absorbing Compounds (Potential Measurements)

Acetic acid	Dioxane	Ozone
Acetone	Ethylbenzene	Perchloroethane
Ammonia	Ferric chloride	Phenol
Aniline	Fluorine	Phosgene
Anthracene	Furfural	Pyridine
Benzene	Hydrogen peroxide	Sodium sulfide
Bromine	Hydrogen sulfide	Styrene
Carbon disulfide	Iodine	Sulfur
Carbon tetrachloride	Mercury	Sulfur dioxide
Chlorine	Methyl mercaptan	Toluene
Chlorine dioxide	Naphthalene	Xylene (o, m, p)
Chlorophenol (o,m,p)	Nickel carbonyl	
	Nitrobenzene	

## Enhanced Applications Capability

To enhance the application capability of the Multiwave Photometer, six options are available.

### Optical Span Filter



The optical span filter for the Multiwave Photometer provides the operator with an alternate means of checking the analyzer performance. It is most often used when the process makes it difficult to readily acquire a calibration standard, and when normal calibration methods would be difficult to accomplish or unsafe.

## Temperature and Pressure Compensation – Gas Samples

**Temperature Compensation** is available on analyzers that do not have cell heat. It is intended to be used for vapor applications. There are two types of temperature compensation available:

- **Gas Law Compensation** – Temperature Compensation is based upon the Ideal Gas Law and requires no calibration or set up. An example of where Gas Law Compensation may be useful is for streams at ambient temperature.
- **Empirical Compensation** – Temperature Compensation is based on experimental data. It requires calibration in the factory lab.

**Pressure Compensation** is used on vapor applications only. It is recommended on suppressed range applications such as 90–100% Chlorine. Two types of pressure compensation are available:

- **Gas Law Compensation** – Pressure Compensation is based on the Ideal Gas Law and requires no calibration. It is used in selected applications where the gas sample does not have a fine line spectrum. Some common compounds with fine line spectra are carbon monoxide, carbon dioxide, methane, and ammonia.
- **Empirical Compensation** – Pressure Compensation is based on experimental data. It requires calibration in the factory lab. This type of compensation is recommended on suppressed ranges and on applications susceptible to pressure broadening effects.



## PFO3372 Fiber Optic Process Photometer

This option involves interfacing with the Multiwave Photometer. The **Fiber Optic Waveguide** eliminates the need to transport sample to the analyzer. With this option, the light is transmitted via one waveguide to the sample. Then, a second waveguide returns the sample-modified light from the sample cell to the detector.

**Fiber Optics** is an effective option in applications where ...

- the sample stream is highly toxic
- highly corrosive products are analyzed
- streams are at high temperature
- streams are at high pressure
- the sample is at high vacuum
- the sample needs to remain sanitary
- a fast response time is required
- all of the above, or any combination of the above conditions apply

Moisture applications such as water in acids, water in methanol, water in hydrocarbons, or hydrocarbons in water are good candidates for the fiber optic option. Applications that require a fast response time, such as monitoring the Lower Explosive Limit (LEL) for hydrocarbons in air, should also be considered.

**NOTE:** Current applications of fiber optics are limited to the UV/Visible (250-800 nm) and NIR (800-2100 nm).



## VN2300 Communications Board

The ABB Process Photometer features a VN2300 (formerly VStaNET) Communications Board option. The VN2300 Remote User Interface (RUI) presents the user with a graphical interface for operation and configuration at a remote PC. The following operations are available via the RUI at the remote PC:

- Remote Maintenance via modem.
- Direct calculation of Matrix Coefficients
- Direct calculation of Linearity Coefficients.
- Reports, Tables and Applications Data Sheets can be printed and reviewed.



## Ambient Air Applications

The PIR3502 Photometer interfaced with a multi-reflective long path gas cell can be used in ambient air monitoring applications. Multiple stream Sample Handling Systems combined with the ABB Process Photometer have been used to measure up to 20 points for the detection of toxic gases.

- 0–50 ppm Acrylonitrile;  
0–50 ppm Styrene
- 0–25 ppm Ethylene Oxide;  
0–25 ppm Propylene Oxide
- 0–50 ppm Phosgene
- 0–25 ppm Carbon Tetrachloride;  
0–25 ppm Chloroform
- 0–100 ppm Divinylbenzene;  
0–100 ppm Ethylbenzene 0-200 ppm



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