ABB Multiwave™ process photometers

ABB Analytical - PUV3402, PIR3502 and PFO3372 process photometers
Applications, technology and data

Process photometers PUV3402 and PIR3502

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 Schematic).

The brushless chopper motor rotates the multichannel 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.

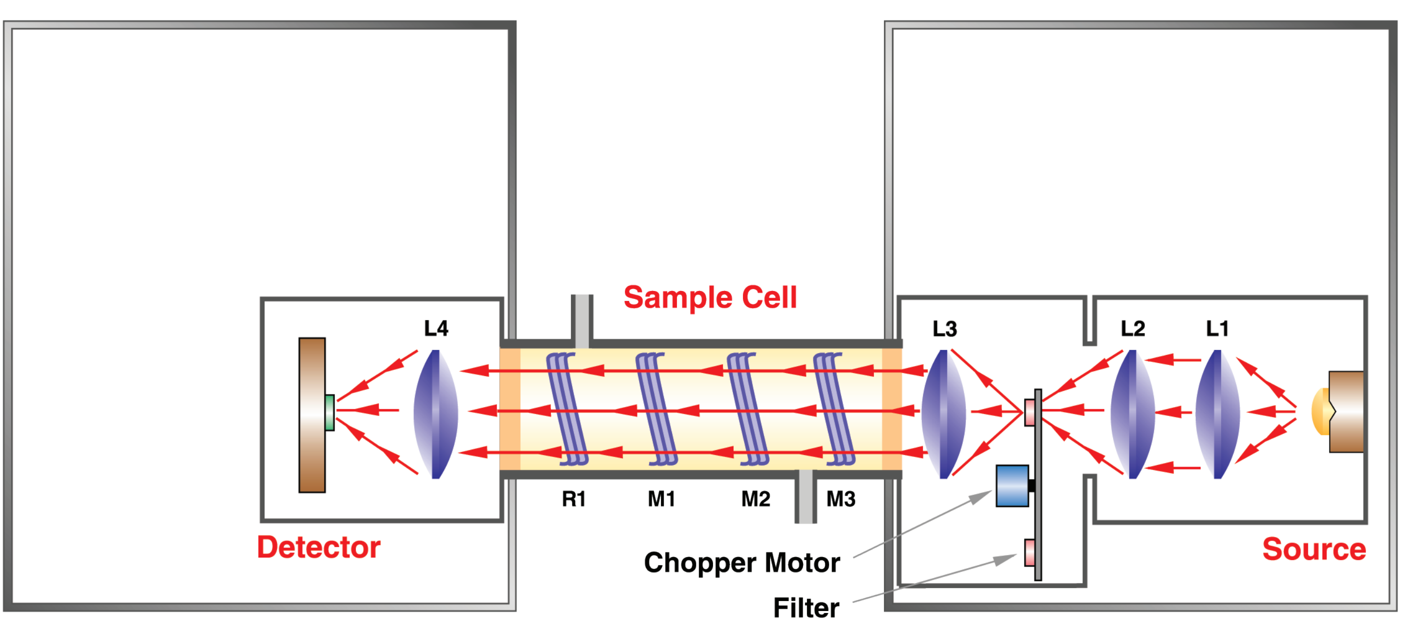
On a multichannel photometer, a reference wavelength is chosen where the stream components have little or no absorbance. The measure wavelength or wavelengths are chosen where the measured components have absorbance. The microprocessor will then use matrix algebra and apply the proper response factor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

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.



Optical schematic

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.

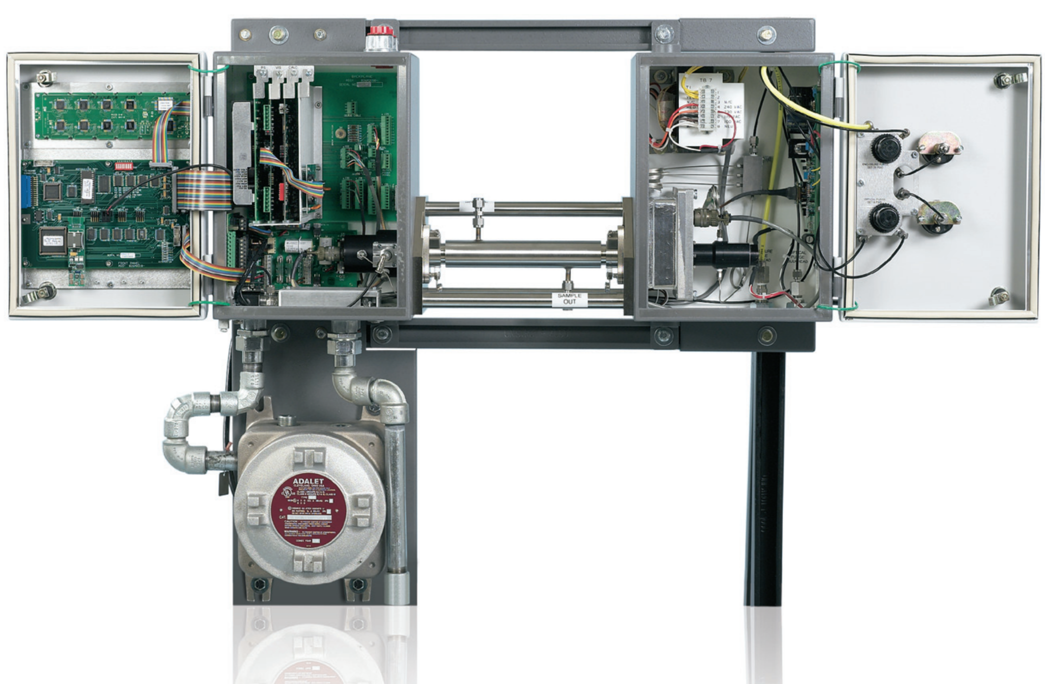
Finally, this multichannel evolution of the fixed filter photometer allows measurements in streams where there are several interfering compounds; and it has the ability to measure multiple components in many applications.

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.



Multiwave™ process photometer, left side: detector, right side: source

Ranges and regions

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 um
Fingerprint Region	8.0 to 15 um

The fingerprint region from 8 – 15 um is very useful because there is a high level of specificity in this region.

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*

*Higher pressures available upon request – consult manufacturer.

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.

Field-proven PUV3402 and PIR3502 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	Maximize process yield
	Water 0 –20% in Reactor Outlet	Distillation tower control
	Water 0 –10% in Drying Column Inlet	2nd half of distillation tower control and determining expected life of drying column
	Water 0 –1500 ppm in Drying Column Outlet	Drying column efficiency
	*Methyl Iodide 0 –1000 ppm	Scrubber efficiency and safety
Ammonia	CO 0 –500ppm	Catalyst protection
	CH_4 0–0.5%	Safety
	NH_3 0–100%	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%	Hydrogenation reactor inlet continuous control
	Acetylene 0 – 0.5%	Hydrogenation reactor mid-bed continuous control
Ethylene Dichloride	CO 0 –10%, CO_2 0–5%, and Ethylene 0 –5%	Process efficiency and safety
	*Chlorine 0 –2000 ppm in EDC with Sparger System	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_2 0–2.5%, Butane 0 – 0.5%, and Maleic Anhydride 0 –2%	Reactor outlet – process efficiency
	Butane 0 –2% and Water Vapor 0 –5%	Reactor inlet – LEL control
Phosgene	CO 0 –10%	Process control
	*Chlorine 0 –200 ppm	Process control
	Phosgene 0 –100 ppm	Safety
Product Pipeline	CO_2 0–1000 ppm	Prevent freezing of natural gas lines
Sulfur Recovery	H_2S 0 –100%, CO2 0–100%,	Acid gas feed
	Water 0 – 30%, THC 0 –10%	Forward control
	H_2S 0 –100%, NH3 0–50%,	Sour gas feed
	Water 0 – 30%, THC 0 –10%	Forward control
Vinyl Chloride	Water 0 –50 ppm in EDC	Catalyst protection, corrosion protection of reactors
	Vinyl chloride 0 –200 ppm, 0 –2% in HCl	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_2; and 0 –5% CH_4 (3 components)
0–55% propane and 0 –20% propylene (2 components)
0–1000 ppm CH_4 and 0 –250 ppm ethane in ethylene @ 100 psig (2 components)
0–100 ppm CO and 0 –100 ppm CO_2 in H_2 @ 200 psig (2 components)
0–200 ppm fluorobenzene; 0 –200 ppm chlorine; and 0 –200 ppm SO_2 in carbon bed vent gas (3 components)
0–5% CO_2; 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_2; 0 –2000 ppm NO; 0 –2000 ppm NO_2 and 0 –2000 ppm NOx (4 components)
0–5000 ppm ethane; 0 –5000 ppm ethylene and 0 – 80% methane (3 components)
0–40% CO_2; 0 – 40% CO and 0 –25% water vapor in air (3 components)
0–80% ethylene and 0 –15% CO_2 in mixed HC stream as a vapor (2 components)
0–100% CO; 0 – 60% ethylene; 0 –20% CO_2; 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 monochlorobenzene
0–50 ppm water in ethylene dichloride
0–250 ppm water in chlorine @ 75psig (vapor)
0–0.5% water in ethylene diamine
0–100 ppm water in vinylidene chloride
0–500 ppm water in propylene glycol
0–200 ppm water in methyl ethyl ketone (MEK)
0–500 ppm water in dimethylacetamide
0–200 ppm water in allyl chloride
0–0.5% water in acetone
0–1500 ppm water in methanol
0–100 ppm water in benzene
0–300 ppm water in toluene diamine
0–1000 ppm water in MEK & alcohols

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_2 0–1%; in CH_4 and C_2H_6
CO_2 0–1%; in ethane
CO_2 0–5000 ppm; in ethane
CO_2 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_2S 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_2 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_20
chlorine 0 –2%; in HCl
chlorine 0 –200 ppm; SO_2 0–200 ppm; in vent gas (2 components)
chlorine 0 –30%; in propylene
dimethyl aniline 0–2000 ppm; in N_2 saturated with water
DMAC 0–1000 ppm; in water
H_2S 0 –10%; in H_2
H_2S 0 – 4%; in N_2
Saybolt color -30 to +15
SO_2 0–500 ppm
SO_2 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_20

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

Partial list of UV absorbing compounds (potential measurements)

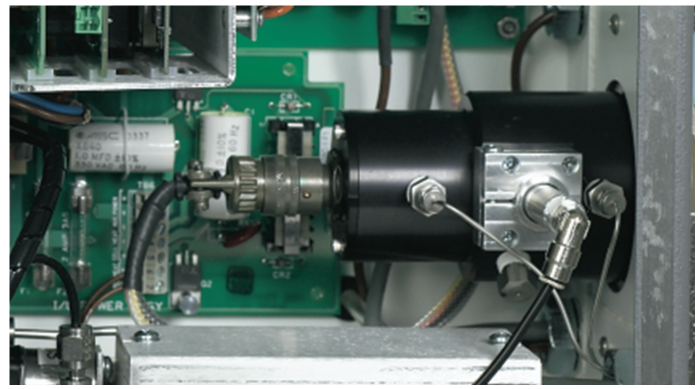
Acetic acid
Acetone
Ammonia
Aniline
Anthracene
Benzene
Bromine
Carbon disulfide
Carbon tetrachloride
Chlorine
Chlorine dioxide
Chlorophenol (o,m,p)
Dioxane
Ethylbenzene
Ferric chloride
Fluorine
Furfural
Hydrogen peroxide
Hydrogen sulfide
Iodine
Mercury
Methyl mercaptan
Naphthalene
Nickel carbonyl
Nitrobenzene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

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.



Optical span filter

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

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 remote sample 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.

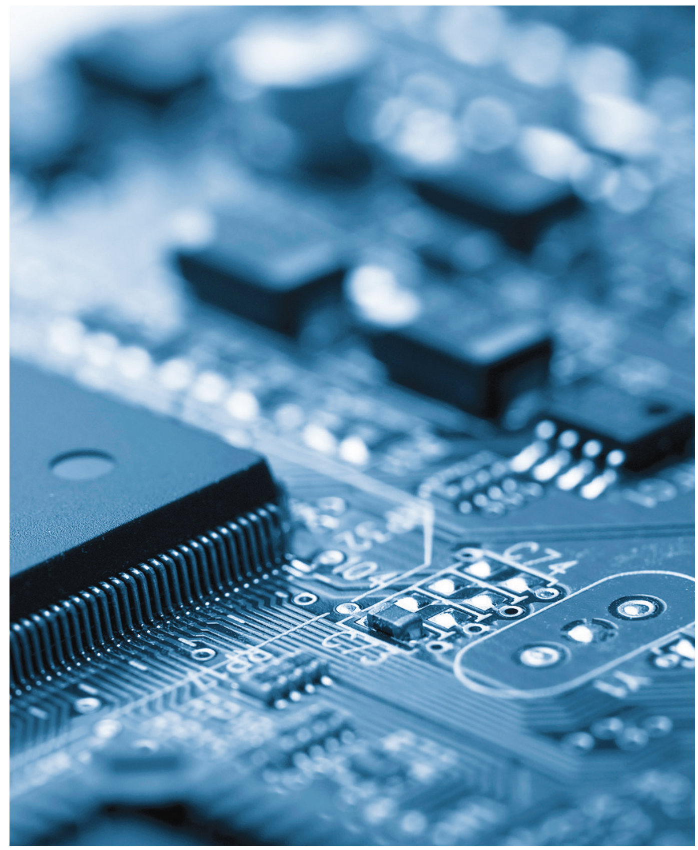
Fiber Optics is an effective option in applications where ...
- the sample stream is highly toxic
- highly corrosive products are analyzed
- streams are at high temperature
- streams are at high pressure
- the sample is at high vacuum
- the sample needs to remain sanitary
- a fast response time is required
- 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 VIstaNET) 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 and 0–50 ppm Stryrene
0–25 ppm Ethylene Oxide and 0–25 ppm Propylene Oxide
0–50 ppm Phosgene
0–25 ppm Carbon Tetrachloride and 0–25 ppm Chloroform
0–100 ppm Divinylbenzene and 0–100 ppm Ethylbenzene
0-200 ppm

Contact us

ABB Inc.
843 N. Jefferson Street
Lewisburg, WV 24901
USA
Phone: 1 304 647 4358
Fax: 1 304 645 4236
E-Mail: analyzeIt@us.abb.com

www.abb.com/analytical

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