Operating Manual

Quantus® LP100+

Gas Analysis System

074-831-P1-C

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3 Safety Information

All work described in this document may only be carried out by persons who have suitable technical training and the necessary experience or who have been instructed by the end user of the product.

3.1 Definition of Safety and Informational Messages

When using this document, please pay attention to the safety and informational messages found throughout. For the purposes of this manual they are defined as follows:

⚠ DANGER

This type of message indicates a hazardous situation that will result in death or serious injury if proper precautions are not taken.

⚠ WARNING

This type of message indicates a hazardous situation that could result in death or serious injury if proper precautions are not taken.

⚠ WARNING

This type of message indicates that dangerous electrical voltages are present that could result in personal injury if proper precautions are not taken.

⚠ WARNING

This type of message indicates that high temperatures are present that could result in personal injury if proper precautions are not taken.

⚠ WARNING

This type of message warns against actions that could cause extensive equipment and/or environmental damage.

⚠ CAUTION

This type of message indicates a hazardous situation that could result in minor or moderate injury if proper precautions are not taken.

⚠ CAUTION

This type of message cautions against actions that may cause an instrument malfunction, minor equipment damage, and/or the loss of data.

NOTICE

This type of message indicates information that is considered important but is not related to any type of hazard.

This type of message indicates information that is considered important but is not related to any type of hazard.

3.2 Liability and Warranty

INFICON assumes no liability and the warranty becomes null and void if the custodian or third parties: (1) disregard the information in this document, (2) use the product in a non-conforming manner, (3) make any kind of changes (modifications, alterations, etc.) to the product, or (4) use the product with accessories not listed in the corresponding product documentation.

The custodian assumes the responsibility in conjunction with the process media used.

3.3 Training

For the optimal use of this product, INFICON offers application, operation, and maintenance courses. Your INFICON partner would be glad to provide the information.

3.4 Safety Precautions When Using Instrument

Misuse of the instrument can damage the instrument and may cause bodily harm. The safety messages in this document are provided to protect the user, as well as to optimize instrument performance. Before operating the instrument, the user must read and understand all safety messages and take adequate precautions to mitigate hazards or equipment damage.

3.4.1 Before You Begin

1. Review the installation process thoroughly before beginning work.
2. Confirm that the sensor materials of construction and surfaces are compatible with the exposed process environment.
3. Confirm that the sensor is installed in an approved manner.

3.4.2 General Warnings and Cautions

⚠ WARNING

Never operate the sensor without its protective enclosures. The sensor should only be powered when fully mounted using the KF vacuum flange interface to an appropriate system to be monitored.

⚠ WARNING

Never install or power the sensor in a position where a user can physically access or view directly the microplasma.

⚠ WARNING

Never touch the microplasma source or its assembly within its containment cavity.

⚠ WARNING

Never view directly the microplasma discharge.

⚠ CAUTION

Never operate the sensor when the interior of the microplasma sensor cell is exposed to ambient or other sources of light, such as another process. Exposure to external light sources will interfere with system performance.

⚠ CAUTION

Never power the sensor with an unapproved power supply.

⚠ CAUTION

When installing the product, make sure it is properly secured in case of a seismic event.

⚠ CAUTION

Do not replace the power cord with an inadequately rated cord. The cord must be rated 10 A or higher.

⚠ CAUTION

Never prevent airflow by blocking the vent holes or the cooling fan on the sensor; doing so could cause damage to the sensor and unpredictable results or loss of data could occur.

4 Introduction

4.1 Overview and Purpose

The Quantus LP100+ gas analysis system detects changes in gas characteristics such as composition, pressure, or concentration. Detecting such changes allows the user to perform critical tasks including, but not limited to, leak detection, endpoint detection, and etch rate monitoring.

Quantus LP100+ operates using the principal of optical emission spectroscopy. A gas sample, flow, or chamber of interest is presented to a proprietary Microplasma Sensor Cell (MSC) inside the sensor that excites the gas, causing it to produce a plasma. The light emitted by the plasma has a spectrum that provides information about the atoms and molecules present. The optical emission spectrum is acquired by a spectrometer in the sensor. The resulting spectra are analyzed by INFICON FabGuard® analysis software on a control computer. The acquisition and analysis are performed as a function of time and typically are coordinated in relation to tool communication and process information.

4.2 Description of Quantus LP100+

The Quantus LP100+ gas analysis system monitors changes in gas composition over the pressure range of 10 mTorr to 1 Torr. In some cases, Quantus LP100+ may function beyond this pressure range. However, the ability to ignite plasma may be affected by the species of gas present. Therefore, the pressure range for plasma ignition, or for sustaining the plasma, may be greater or lesser depending on the application. For application specific support, please contact INFICON.

4.2.1 Quantus LP100+ Sensor Overview

Quantus LP100+ is designed for applications that operate between 10 mTorr and 1 Torr. Exact pressure range is application dependent. The range 10 mTorr to 1 Torr is tested with argon. Quantus LP100+ has two main function blocks: an Electronic Control Module (ECM) and an MSC. The ECM occupies the larger portion of the housing while the MSC occupies the smaller portion of the housing.

4.2.2 Quantus LP100+ Microplasma Sensor Cell

Quantus LP100+ creates a plasma by coupling energy into the gas utilizing a patented planar antenna in the MSC. The antenna is protected by a sapphire window so it is not exposed to the process chamber or gas sample. This provides the LP100+ its unique operating capabilities that allow the sensor to operate in corrosive and aggressive environments. The planar antenna is built using PCB techniques that provide tight tolerances and high performance. The MSC can be replaced in the field.

4.2.3 Quantus LP100+ Wetted Materials

The Quantus LP100+ MSC materials that are exposed to the vacuum chamber are summarized in the table below.

Quantus LP100+ MSC Component	Wetted Materials
Cell body	Stainless steel
Window	Sapphire
O-rings	Viton®
High-voltage pin	Stainless steel, Kovar, alumina

4.2.4 Quantus LP100+ Electronic Control Module

The ECM includes an optical spectrometer and control electronics. It is powered by a 24 V (DC) power supply, has a cooling fan, and has six status indicators. Primary communication is through a USB port. Auxiliary I/O is available through a 15-pin D-sub male connector.

4.3 Computer System Requirements

Quantus LP100+ utilizes INFICON FabGuard analysis software with the following computer system requirements.

	Minimum Requirement	Recommended
Processor	Intel® Pentium 4, 3 GHz	Intel® Core 2 or greater
Memory	8 GB	16 GB or greater
Hard drive	80 GB	160 GB or greater
Resolution	15 in. (1024 × 768)	17 in. (1280 × 1024)
Operating system	Windows® 10	Windows® 10 or 11

Quantus LP100+ requires the Java™ Runtime Environment (JRE), version 6 or higher. Many computers already have Java installed. If necessary, Java can be downloaded from www.java.com. Note that 32-bit operating systems require the 32-bit JRE, while 64-bit operating systems require the 64-bit JRE.

4.4 AUX I/O Connector

4.4.1 AUX I/O Specifications

The auxiliary (AUX) I/O connector on the ECM is a 15-pin D-sub male connector. A 15-pin D-sub female connector is required for connection.

4.4.1.1 Digital I/O

Signals I/O 0 to I/O 3 can be set or read by Quantus LP100+. These four (input or output) bidirectional autosensing level shifters are TTL-compatible I/O connections rated for 0–5 V (DC) with 10 kΩ pull-up impedance. As digital output connections, each can source a maximum of 0.5 mA. As digital input connections, each can sink a maximum of 1.0 mA. The user is responsible for limiting the input current to the 1.0 mA maximum.

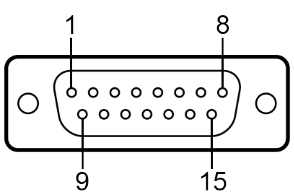
4.4.1.2 Relay

A contact-closure single-pole double-throw (SPDT) relay is included in the Quantus LP100+ ECM. Maximum current is 0.5 A, and maximum voltage is 50 V (AC). The relay is controlled by FabGuard software. The normal (inactive) state is electrical continuity between pins 1 and 3, with pin 2 open. The active state switches to continuity between pins 2 and 3, with pin 1 open.

4.4.1.3 Valve Driver

The 24 V valve driver is powered by the ECM and is controlled by FabGuard analysis software. The valve is open when the circuit is active, which is when pin 7 is grounded by the ECM.

4.4.2 AUX I/O Pin Designations



Pin #	Signal	Pin #	Signal
1	Relay NC	9	I/O 3
2	Relay NO	10	No connection
3	Relay common	11	No connection
4	I/O 2	12	GND
5	I/O 1	13	GND
6	I/O 0	14	GND
7	Valve control return	15	GND
8	Valve + 24 V (DC)		

4.5 Environmental Requirements

4.5.1 Use

The instrument is for indoor use only. IP rating is IPX0.

4.5.2 Altitude Range

The instrument can be used up to an altitude of 2000 m (6561 ft.).
Contact INFICON for operation instructions at higher altitudes.

4.5.3 Maximum Humidity

The instrument can be used up to 80% relative humidity (no condensation).

4.5.4 Pollution Degree

Pollution degree of 2 (per EN61010-1:2010).

4.5.5 Maximum Operating Temperature

The maximum ambient operating temperature is 50°C (122°F).

4.5.6 Minimum Operating Temperature

The minimum operating temperature is 0°C (32°F).

4.5.7 Clean Room Requirements

The instrument is clean room compatible.

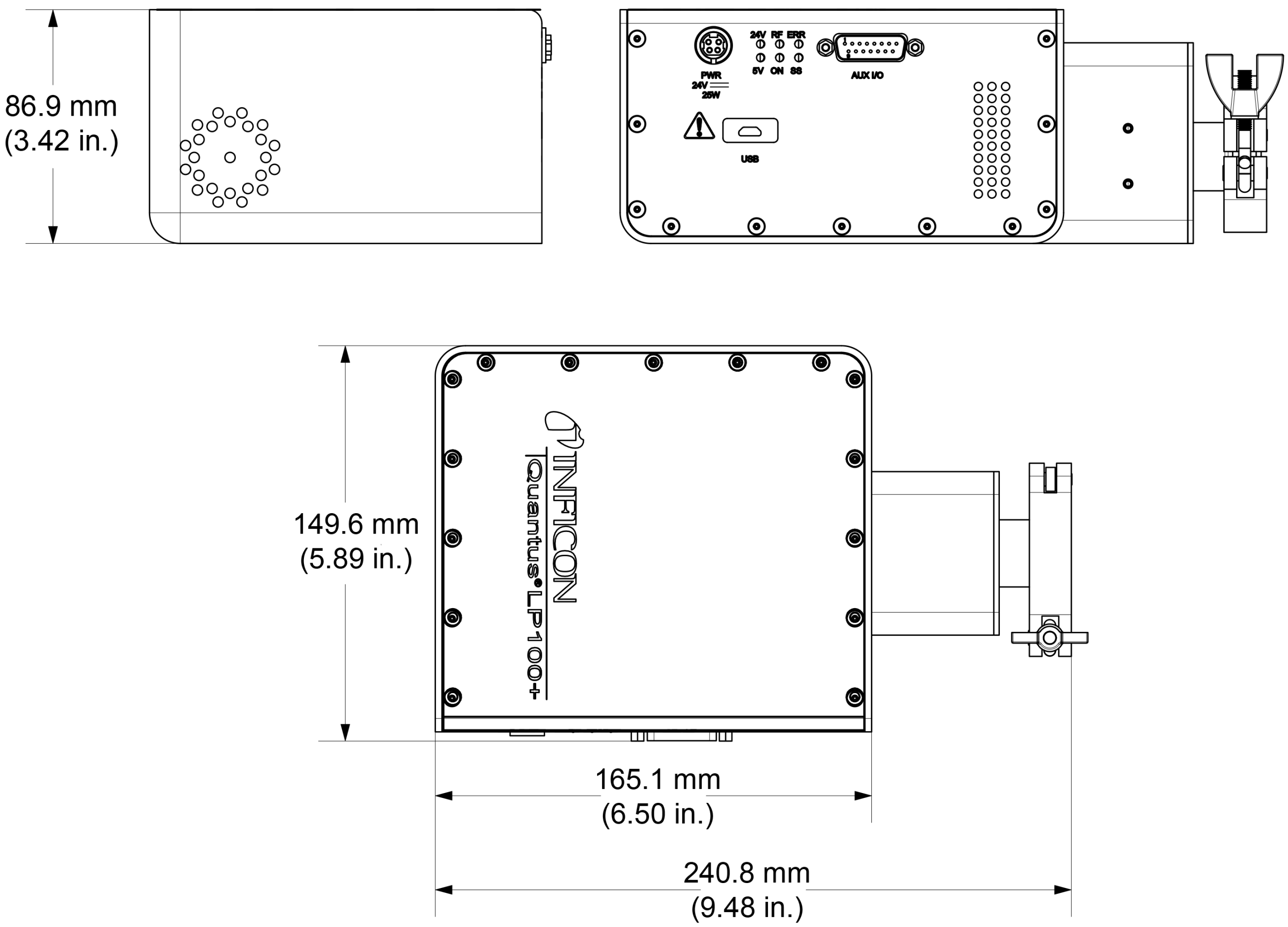
4.5.8 Anti-Static Conditions

The instrument passes standard EN 61326-1:2020.

4.6 Physical Specifications

4.6.1 Physical Dimensions and Weight

Dimensions (H × W × L):	Without clamp and O-ring: 86.9 mm × 149.6 mm × 233.7 mm (3.42 in. × 5.89 in. × 9.20 in.) With clamp and O-ring: 86.9 mm × 149.6 mm × 240.8 mm (3.42 in. × 5.89 in. × 9.48 in.)
Approximate weight:	Without clamp and O-ring: 2.52 kg (5.55 lb.) With clamp and O-ring: 2.7 kg (5.9 lb.)



4.6.2 Physical Properties

Performance

Parameter	LP100+
Technology	Optical emission spectroscopy using proprietary and integrated ICP microplasma, spectrometer, and RF power supply
Spectrometer performance	200–850 nm wavelengths (UV-Vis) 16-bit full-scale resolution, 3648 pixels
Integration time	Minimum of 1 ms
Detection limit	To low PPM levels (application dependent)

Gas Sampling Interface

Parameter	LP100+
Process environment[1)]	10 mTorr to 1 Torr (application dependent)
Vacuum fitting	KF25
Maximum flange temperature	80°C
Serviceability	Sensor cell is field replaceable

1) Pressure range for argon. Pressure range may differ per application.

Facilities

Parameter	LP100+
Operating temperature range	0–50°C (noncondensing, sensor cell 80°C)
Power requirements	24 V (DC) @ 2.5 A (AC/DC converter provided)
Power consumption	<25 W (typical, steady-state operation)
Carrier gases	None required
Mounting options	Direct mount via KF25 flange

5 Installation

Before you begin:

- CONFIRM that use of a microplasma will not adversely affect the gases, processes, or equipment being monitored.
- FOLLOW all safety precautions.
- REVIEW the installation process thoroughly before beginning work.

⚠ WARNING

DO NOT operate the sensor without its protective enclosure.

⚠ WARNING

DO NOT touch the microplasma within the microplasma source cell's cavity.

⚠ WARNING

The Quantus LP100+ system must be electrically grounded through the KF25 connection flange to the vacuum chamber or system to which it is installed. Failure to ensure proper electrical grounding could result in a shock hazard and/or personal injury.

⚠ CAUTION

DO NOT block the fan or vent holes on the Electronic Control Module.

5.1 Quantus LP100+ Precautions

⚠ WARNING

The gas sensors utilize radio-frequency power supplies and high-voltage power supplies, and in their intended use may generate light emission from the ultraviolet to the infrared. High-voltage, radio-frequency, and ultraviolet exposure may be hazardous. It is the responsibility of the user to only operate the sensor when it is installed properly.

A proper installation meets the following criteria:

- Ensures that the environment is appropriate for operation of the sensors. The Quantus LP100+ wetted materials are stainless steel, sapphire, Viton, Kovar, and alumina. The user should evaluate if any chemicals, gases, or their byproducts to which the sensor may be exposed present the potential for corrosion of these materials and if such corrosion would present a safety hazard. Should such a hazard exist, the user should ensure that proper safety monitoring capabilities are installed at the process tool and/or facility level (for example, facility toxic or hazardous gas monitoring).

- Ensures that users cannot physically access the internal portions of the sensor in which the microplasma operates. Typically, the sensor is installed on a vacuum system whose containment vessel prevents access.
- Ensures that the user cannot directly view the microplasma, as UV emission may be present.
- Is protected from exposure of the interior of the microplasma sensor cell to other sources of light, including ambient light or light generated elsewhere in the process equipment. Any other light sources seen by the Quantus LP100+ spectrometer will make data analysis difficult or impossible.

⚠ WARNING

Power SHOULD NOT be connected to the sensor unless the above conditions are met. It is the responsibility of the user to ensure that the above conditions are met, including thorough training.

⚠ CAUTION

Do not replace the power cord with an inadequately rated cord. The cord must be 10 A or higher.

⚠ CAUTION

The DC power connector is intended to be used to remove power from the system. Ensure there is enough room to disconnect the power cord when needed.

Quantus LP100+ requires a Class 1, limited DC power supply with a minimum rating of 24 V @ 2.5 A. INFICON offers a 100–240 V (AC) to 24 V (DC) power converter which meets all power supply requirements. Should the user supply power independently, the user must ensure that the supply has at least the minimum capability and is short-circuit and overcurrent protected. At a minimum, the supply should be compliant with UL/CSA 60950-1.

Quantus LP100+ sensors are intended to be used in clean, protected environments and are not to be used in outdoor or indoor installations where significant amounts of dust, oil, or other vapors are present, unless a separate provision is made to provide a suitable environmental enclosure. The sensors are intended to be used in clean room environments.

⚠ WARNING

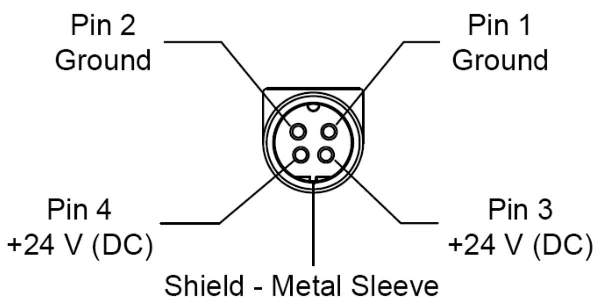
There are no user-serviceable parts in either the ECM or MSC, and the user should not attempt to open, disassemble, or tamper with these components. Doing so will void the warranty and may either (1) render the product noncompliant with safety certifications and/or (2) expose the user to hazardous voltages or emissions.

5.2 Quantus LP100+ Installation Requirements

Power[1)]	24 V (DC) @ 2.5 A; includes 100–240 V (AC) to 24 V (DC) converter with connector, 50/60 Hz compatible (provided)
Vacuum chamber interface	KF25 flange and clamp (provided)
Communications	15 ft or 30 ft USB 2.0 A to Micro-B cable (provided)
Approximate weight	2.7 kg (5.9 lb.)
Computer interface	PC with Microsoft Windows 10 or 11 is required to run FabGuard
Auxiliary I/O	15-pin D-sub male interface

[1)] Connector pin designations:

Pin #	Connection
1	Ground
2	Ground
3	+24 V (DC)
4	+24 V (DC)



Connect 24 V (DC) to the power connector using the provided power supply or a user-supplied power supply with a minimum power rating of 24 V (DC) at 15 W.

If a user-supplied power supply is used, INFICON recommends the power connection to Quantus LP100+ use a Kycon connector, part number KPPX-4P. Pins 3 and 4 carry +24 V (DC); pins 1 and 2 are ground. Whenever a user-supplied power supply is used, the connector shield on the 24 V cable must be connected to the mains protective earth ground terminal through the user-supplied power supply.

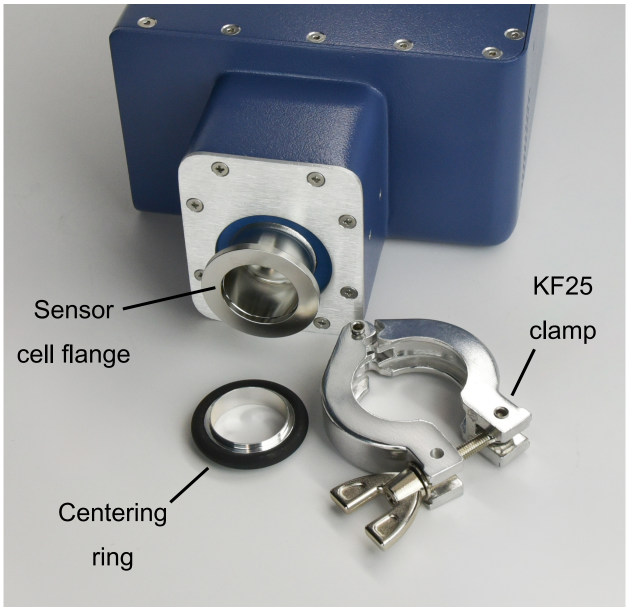
⚠ CAUTION

Never use a power source that does not meet the systems voltage and power requirements.

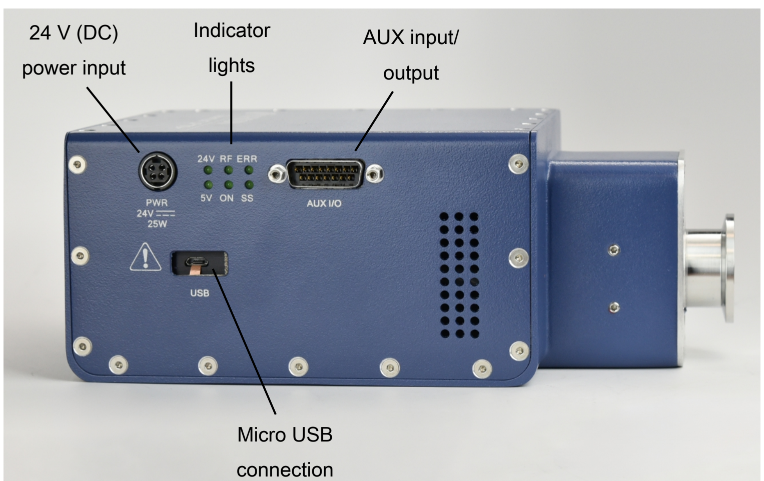
5.3 Installing Quantus LP100+

Quantus LP100+ installs quickly and easily. Listed below are the typical steps required to install Quantus LP100+. Please note that your installation requirements may differ.

1. Remove KF25 clamp, protective cap, and centering ring from sensor cell flange.
2. Attach sensor cell flange to mating flange on system using KF25 centering ring and clamp.



3. Attach 24 V (DC) power at the PWR connection point. Quantus LP100+ is electrically grounded through the KF25 connection flange to the vacuum chamber or system to which it is installed. No other ground connections are necessary.
4. Attach micro USB cable at the USB connection point.



5.3.1 Connecting the USB Interface

USB communications between the Controller and Quantus LP100+ are established using the 15 ft or 30 ft USB cable provided with the system.

6 Operation

6.1 Introduction

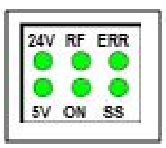
Operation of Quantus LP100+ is controlled by FabGuard analysis software. Refer to FabGuard Help for user documentation or contact INFICON applications support for more information regarding sensor setup and operation.

Quantus LP100+ is designed to ignite its plasma over a pressure range from 10 mTorr to 1 Torr. However, the ability to ignite plasma can be affected by the species of gas present. Therefore, the pressure range for plasma ignition, or for sustaining the plasma, may be greater or lesser depending on the application.

Optical spectra acquired by the Quantus LP100+ are analyzed by FabGuard analysis software.

6.2 Sensor Status Indicators

Quantus LP100+ is equipped with six green indicator lights to indicate sensor status. When 24 V (DC) power is applied to the sensor, the 24 V and 5 V indicators illuminate. During initial power-up, the other four indicators will flash several times to indicate that they are functioning.



Indicator Label	Description
24 V	24 V (DC) power present
5 V	5 V (DC) power present
RF	RF amplifier enabled: RF power being delivered to the antenna to start, or sustain, the microplasma
ON	Microplasma on: Light is being detected from the microplasma
ERR	Hardware error
SS	Spread spectrum (dithering): Frequency modulation, as described in Spread Spectrum (SS) [▸ 21]

NOTICE

If no indicators illuminate after power is applied, then a fault in the sensor is likely to have occurred. Contact INFICON for assistance.

6.3 Spread Spectrum (SS)

The indicator labeled SS indicates, when lit, that the instrument is operating in spread-spectrum mode, a form of frequency modulation also known as dithering. Spread spectrum is the default mode of operation for Quantus LP100+. In this mode, the sensor modulates the RF drive frequency about the nominal frequency for a given MSC. While SS is the default mode of operation, it can be disabled through the FabGuard software. With SS disabled, the sensor will operate over a wider pressure range and produce higher signal values. However, with SS disabled, Quantus LP100+ may not operate entirely within conformity of all standards listed in the Declaration of Conformity [▸ 31].

7 Maintenance

7.1 Cleaning

Should cleaning be required, clean the enclosure exterior with mild detergents or alcohol applied with a towel or cloth. Cleaning of the interior portions of the MSC cannot be performed and the user should instead install a new MSC assembly.

7.2 Replacing the Microplasma Sensor Cell (MSC)

The MSC contains components for igniting and sustaining the microplasma, including a planar antenna. The MSC also contains two sapphire windows. One window isolates the antenna from the vacuum chamber, process gases, and microplasma. The second window allows light generated in the microplasma to pass out of the cell to be gathered by the collection optics for analysis by the Quantus LP100+ system.

The MSC can be replaced when necessary. In order to replace the MSC, vacuum must be broken. The frequency of the new MSC, if different from the previous MSC, must be updated at the Sensor Configuration Screen for this sensor using FabGuard software. The MSC can be returned to INFICON for refurbishment for subsequent reuse on either the same Quantus LP100+ or another Quantus LP100+.

⚠ CAUTION

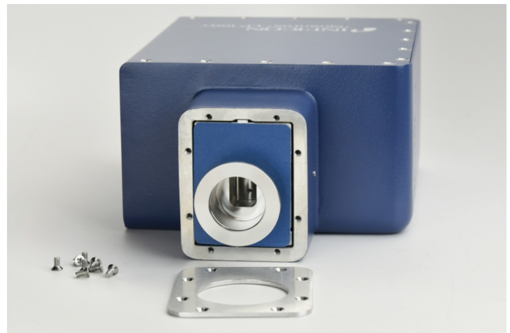
Keep the inside of the MSC clean. Do not contaminate the inside of the MSC because it will be exposed to the process chamber or pump line to which it is connected.

Required Tools and Equipment

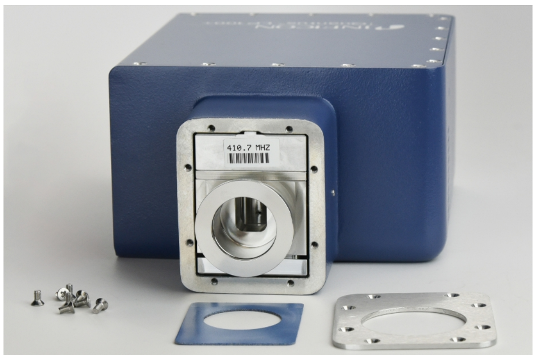
- 2 mm hex driver
- #2 Phillips head screwdriver
- Spare Quantus microplasma sensor cell (962-221-G1S)

1 To remove Quantus LP100+ from the chamber or system it is installed upon, turn the wingnut on the clamp counterclockwise to loosen, then remove the KF25 clamp and centering ring. Keep the clamp and centering ring for reinstallation of Quantus LP100+. Keep the centering ring clean.

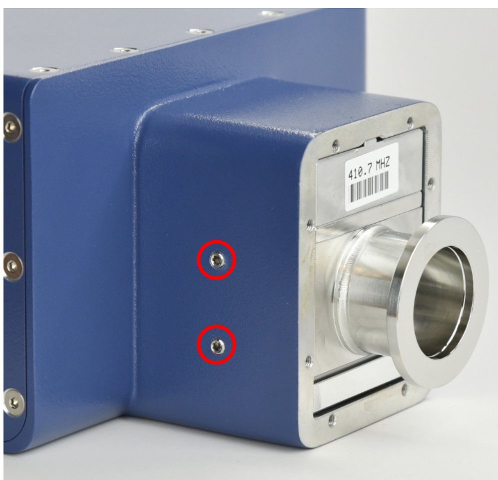
2 Using a #2 Phillips head screwdriver, remove the eight (8) screws holding the sensor cover plate in place. Remove the cover plate. Keep the cover plate and screws for reassembly at the end of this procedure.



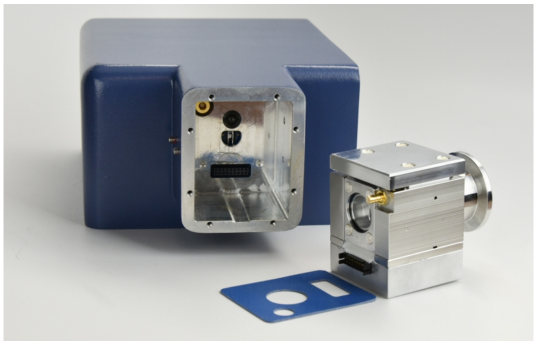
3 Remove the outer gasket by stretching it around the MSC flange.



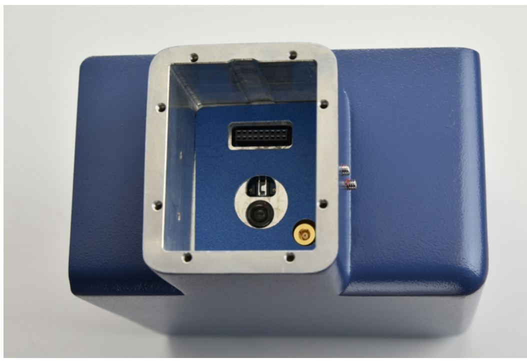
4 Using a 2 mm hex driver, remove the four (4) set screws (two on each side) holding the MSC in place.



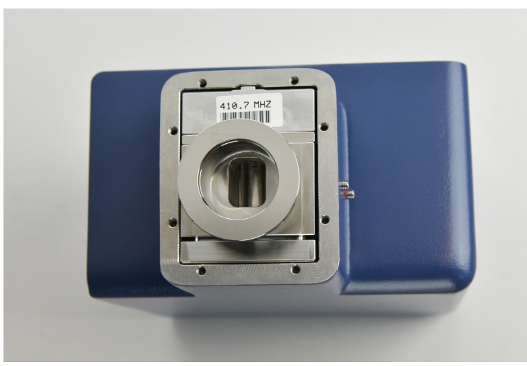
5 Remove the MSC and the inner gasket from the Quantus LP100+ housing by sliding the MSC forward out of the housing. Do not touch the inside of the MSC. Peel the inner gasket off the back of the MSC. If the gasket remains in the housing, tilt the instrument downward so the gasket falls out of the cavity. If the gasket is stuck, use a pair of blunt-tip precision tweezers to peel the gasket out of the cavity.



6 Install the new inner gasket from replacement MSC kit. If a new inner gasket is not available, reuse the original inner gasket. To install the inner gasket, place Quantus LP100+ upright on the work surface so that the gasket can rest at the bottom of the cavity. Leave Quantus LP100+ in this upright position for the next step, installing the new MSC.



7 Carefully install the new MSC by slowly sliding it down into the housing, without too much force, to ensure the connectors are not damaged and are properly mated. Replace the four (4) set screws using a 2 mm hex driver to secure the MSC in the housing.



8 Note the cell frequency, in units of MHz, on the label of the new MSC. The cell frequency will be needed for sensor configuration.

9 Install the new outer gasket from replacement MSC kit. If a new outer gasket is not available, reuse the original outer gasket. To install gasket, gently stretch it around the flange of the MSC.

10 Reinstall the cover plate and use a Phillips head screwdriver to reinstall the eight (8) screws.

11 Update the MSC frequency on the sensor configuration screen in the FabGuard software. Refer to FabGuard Help for user documentation or contact INFICON applications support for more information regarding sensor configuration.

8 Accessories and Spare Parts

Part Number	Description
962-601-G1	Quantus LP100 standard and corrosive environment gas analysis cell
962-401-G1	Power supply: 100–240 V (AC) @ 50–60 Hz to 24 V (DC)
962-020-G1	KF25 right-angle isolation valve kit[1)]
962-437-G1	KF25 in-line isolation valve kit
600-1657	15 ft USB 2.0 A to Micro-B cable
600-1658	30 ft USB 2.0 A to Micro-B cable

[1)] The isolation valve kit includes a pneumatic right-angle valve and a control cable to interface the valve directly to the Quantus LP100+ Electronic Control Module.

9 Service and Technical Support

9.1 How to Contact Customer Support

Worldwide customer support information is available under **Contact** at www.inficon.com:

- Sales and Customer Service
- Technical Support
- Repair Service

When reporting an issue with your instrument, please have the following information readily available:

- the instrument part number(s) and serial number(s)
- a description of the problem
- an explanation of any corrective action already attempted
- the exact wording of any error messages

For technical support, visit www.inficon.com and select **Contact** >> **Service & Support**. Select your region and product to obtain support contact information. To submit a repair request in North America, fill out a Service Request form at https://service.inficon.com/.

9.2 Returning an Instrument to INFICON

Do not return any component of your instrument to INFICON without first obtaining a Return Material Authorization (RMA) number from a Customer Support Representative. To obtain an RMA, fill out and submit a Service Request form (refer to How to Contact Customer Support [▸ 26]). Service Request forms must be approved by INFICON before an RMA number is issued.

If you deliver a package to INFICON without an RMA number, your package will be held and you will be contacted. This will result in delays in servicing your instrument.

Prior to being given an RMA number, you may be required to complete a Declaration of Contamination (DOC) form if your instrument has been exposed to certain materials. DOC forms must be approved by INFICON before an RMA number is issued. INFICON may require that the instrument be sent to a designated decontamination facility, not to the factory.

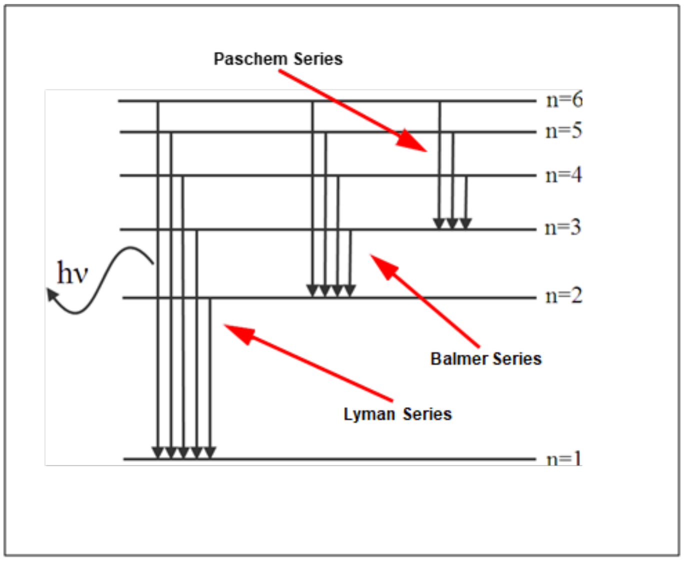
10 Appendix

10.1 Introduction to Optical Emission Spectroscopy

Quantus LP100+ gas analysis system utilizes optical emission spectroscopy to monitor gases present in a chamber, delivery line or pump line. This chapter will discuss the theory behind optical emission spectroscopy and then briefly discuss how Quantus LP100+ utilizes these phenomena for detecting leaks, contaminants, process changes, or process endpoints.

10.2 Origin of Optical Emission Theory

In the early 1900s, Neils Bohr redefined atomic physics with the Bohr model of the atom. His theory stated that atoms had discrete, quantized energy levels where electrons can exist. He also noted that the electrons can excite to higher energy levels if they absorb an energy equivalent to the difference in energy between the two levels. The electron then can exist inside of the "excited" energy level, but will eventually relax to the unexcited state. When the electron drops from the excited energy level to the unexcited level, the energy that was absorbed for the excitation must be released. This energy is released in the form of a single photon that has energy equivalent to the difference between the excited and unexcited energy states. A visual depiction of the different quantum energy levels is illustrated below.



There are three basic series that are defined for the hydrogen atom: the Lyman Series, the Balmer Series, and the Paschen Series. The Lyman Series includes all of the photons generated when electrons go from an excited state back to the most unexcited state, n = 1. The photons generated in the Lyman Series are 94 nm, 95 nm, 97 nm, 103 nm, and 122 nm, which are all in the UV range of the electromagnetic spectrum. The Balmer Series is the more easily measured series and includes all of the photons generated when electrons go from an excited state down to a less excited state, n = 2. The photons generated in the Balmer Series are 410 nm, 434 nm, 486 nm, and 656 nm, which are all in the visible range. A visual representation of the Balmer Series is presented below.

The third series, the Paschen Series, includes all of the photons generated from relaxation from an excited energy state to the *n* = 3 energy state. This produces photons with wavelengths of 1084 nm, 1282 nm, and 1875 nm, which are all in the infrared (IR) range of the electromagnetic spectrum.

The energy of the photon emitted by the gas can be determined by the following equations:

$$E = h\nu \qquad [1]$$

$$\nu = \frac{c}{\lambda} \qquad [2]$$

$$E = \frac{hc}{\lambda} \qquad [3]$$

Where E = energy, ν = frequency, c = the speed of light (3.00E8 m/s), λ= wavelength, and h = Planck's constant (6.626E-34 J·s).

Since the energy is quantized, only a single wavelength of light is emitted for each relaxation. This produces a line in the optical spectrum. Since each element or molecule has a specific set of energy levels, each element or molecule has a unique line spectrum. Also, because each element or molecule produces photons independently, the number of photons of a certain wavelength is related to the concentration of a specific element or molecule.

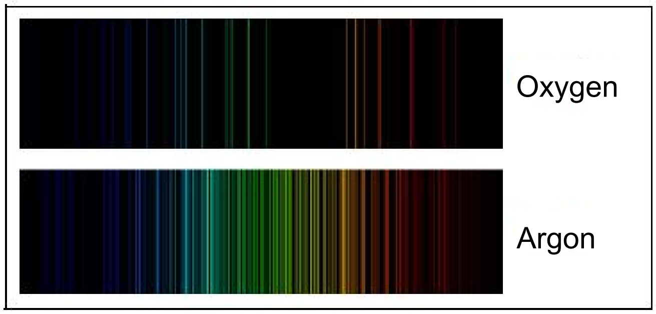
10.3 Complex Optical Emission Spectra

Thus far, the only optical emission spectrum discussed has been that of monatomic hydrogen. Monatomic hydrogen, of course, has a very simple atomic structure including only one electron. As elements increase in complexity or combine with other elements to form molecules, more electrons are given the opportunity to exist in more energy states, producing complex spectra. This section will discuss the two different reasons for complex spectra.

10.3.1 Increasing Numbers of Electrons

Multi-electron systems baffled Neils Bohr during his lifetime, and unfortunately, such is still the case today. Due to this, the underlying physics, mathematics, and chemistry that define emission spectra of multi-electron elements include a multitude of assumptions and estimations. However, that is on the theoretical side of science. For our needs, only one rule is important: as elemental complexity increases, so does the complexity of an element's emission spectrum, or as the atomic number increases, so does the complexity of the atomic emission spectrum.

This can be seen below, which shows emission spectra of both oxygen and argon. When you compare these spectra to the hydrogen spectrum (refer to Origin of Optical Emission Theory [▸ 27]), it is easy to see how the complexity increases.



Remember that each electron can exist in each energy state. Because the electrons have different energy based on spin and ground state configuration, a multitude of different energy photons are released when the electrons relax to a non-excited state.

The other thing to note is that many of these different atomic emission lines have very similar wavelengths (that is, oxygen has lines at 394.729 nm, 394.748 nm, and 394.759 nm). Depending on the resolution of an instrument, these could appear as three distinct lines or just as one line at 394.7 nm, with the intensity of all three lines added together.

Additionally, although each spectrum is unique for a given atom, that does not mean that two elements cannot have overlapping lines. For instance, argon has lines at 394.6097 nm and 394.8979 nm. Again, depending on the instrument, an argon-oxygen mix could show five distinct lines at 394.6097 nm, 394.729 nm, 394.748 nm, 394.759 nm, and 394.8979 nm, or it could show one line at 395 nm that includes the intensity of all five lines.

10.3.2 Molecular Combinations of Atoms

When atoms combine to form molecules, their orbitals combine to form new bonding orbitals. These bonding orbitals create more energy states that electrons can exist in. Since there are more energy states, there are more chances for electrons to excite and relax and then release photons. This can create very complex optical emission spectra. The discussion of the theory is outside of the scope of this manual, but it is worth noting that molecules have more complex spectra than elements.

10.4 Quantus LP100+ and Optical Emission Spectroscopy

Due to each element or molecule producing its own unique spectrum and the amount of photons being related to the concentration of a specific element or molecule, optical emission spectroscopy can be used to detect changes in the relative concentration of gases present in a chamber, gas line, or process. In order to utilize optical emission spectroscopy, the electrons in the gas have to be excited to higher energy states. This is accomplished by the proprietary MSC of Quantus LP100+. Inside the MSC, the gas molecules are energized to excite the electrons to higher energy levels. When the electrons relax, photons of light are emitted as described above. These photons are then divided according to their wavelength and detected by a spectrometer in the Quantus LP100+ system. This allows INFICON FabGuard analysis software to monitor, as a function of time, the intensity versus wavelength optical emission spectra generated in the MSC. Analysis of the optical spectra versus time provides for the detection of leaks, contaminants, process changes, or process endpoints. Note that quantitative determination of concentration is not generally possible because the intensity of different wavelengths in the optical emission spectrum depends on the concentration and energy distribution of electrons in the plasma as well as the concentration of the species of interest.

11 Declaration of Conformity

Declaration of Conformity

This declaration is issued under the sole responsibility of the manufacturer: **INFICON Inc.** Two Technology Place, East Syracuse, NY 13057, USA.

We hereby certify that the equipment described below is in conformity with the applicable legislation and has been constructed in accordance with good engineering practices to ensure the safety of persons, domestic animals, and property when properly installed, maintained, and used as intended.

Equipment Description: Quantus LP100+

Applicable Directives:

Name	Description
2014/35/EU (LVD)	Electrical Equipment (Safety) Regulations 2016 (UK)
2014/30/EU (EMC)	Electromagnetic Compatibility Regulations 2016 (UK)
2015/863/EU (RoHS)	Substances in Electrical and Electronic Equipment Regulations 2012 (AS AMENDED)

Applicable Standards:

Category	Standard	Description	Notations
Safety	IEC 61010-1:2010/AMD1:2016 3rd Ed.	General safety requirements	Listing # E115486
Emissions	EN 61326-1:2020	Radiated and conducted emissions	
	CISPR 11:2015/AMD2:2019	Radio-frequency disturbance limits and measurement methods for industrial, scientific, and medical (ISM) equipment	
	EN 55011:2016/A11:2020	Emission standard for industrial, scientific and medical (ISM) radio RF equipment	
	FCC Title 47 CFR Part 18	USA Class A emission requirements for industrial, scientific and medical (ISM) radio RF equipment	
Immunity	EN 61326:2020	Industrial electromagnetic compatibility for equipment used in the measurement, control, and laboratory environments, per Table 2	
SEMI	SEMI S2-0821 Compliant	Environmental, health, and safety (EHS) guidelines for semiconductor manufacturing equipment	
CE	European Conformity	EU safety, health, and environmental protection standards	Implementation date: August 29, 2022
UKCA	United Kingdom (UK) Conformity	UK safety, health, and environmental protection standards	Implementation date: August 29, 2022

Authorized Representatives:

Paul Grimshaw
Paul Grimshaw
Compliance Manager, ISS

Samuel Carroll
Digitally signed by Samuel Carroll
Date: 2025.06.18 10:00:34 -04'00'
Samuel Carroll
Vice President of Engineering

ANY QUESTIONS RELATIVE TO THIS DECLARATION OR TO THE SAFETY OF INFICON'S PRODUCTS SHOULD BE DIRECTED, IN WRITING, TO THE AUTHORIZED REPRESENTATIVE AT THE ABOVE ADDRESS.

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