Owlstone ultraFAIMS-DK1 Developer Kit: Guidance for Developers

Contents

Copyright

Disclaimer

Owlstone Ltd makes no representations or warranties, either expressed or implied, with respect to the contents hereof and specifically disclaims any warranties, merchantability or fitness for any particular purpose. Furthermore, Owlstone Ltd reserves the right to revise this publication and to make changes from time to time in the contents hereof without obligation of Owlstone Ltd to notify any person of such revision or changes.

Notice of Proper Use of Owlstone Ltd Instruments

The supplied system is in compliance with international regulations. If this system is used in a manner not specified by Owlstone Ltd, the protection provided by the system could be impaired

Safety notice

Always observe the following safety precautions

- Use only the mains adaptor and leads supplied.
- This equipment is for use in moderate climates only (see Appendix). Do not use the equipment in damp or wet conditions.
- Avoid excessive heat, humidity, dust & vibration.
- Do not use where the equipment may be subjected to dripping or splashing liquids.
- Do not block the cooling duct whilst system is in operation.

Ensure the system is properly installed on the mass spectrometer according to the enclosed instructions before attempting to power on. Never operate the system unless properly installed on the mass spectrometer.

Ensure the safety earth cable is connected to a suitable earth point on the mass spectrometer chassis before powering on and operating the system.

Do not operate the ultraFAIMS system without an ultraFAIMS chip or test load attached.

Caution: risk of electric shock. Remove power from system before disconnecting from the mass spectrometer. Do not remove covers.

The ultraFAIMS control unit is rated 24VDC, 60W max. It is fitted with a fuse of type F3.15AH 250VAC fast-acting. Replace only with a fuse of the same type and rating.

PLEASE READ THIS DOCUMENT BEFORE SETTING UP AND POWERING THE SYSTEM

Contacting OWLSTONE

Visit the OWLSTONE support website (http://support.owlstonenanotech.com) for up to date contact details and service support.

For general inquires please email ultrafaims@owlstone.co.uk.

UK Office:
127 Cambridge Science Park,
Milton Road,
Cambridge
CB4 0GD
Tel: +44 (0)1223 428 200
Fax: +44 (0)1223 428 201

US Office:
Owlstone Inc.
761 Main Avenue
Norwalk, CT 06851

Tel: +1 203-908-4848
Fax: +1 845-533-4232

1. System Description

The Owlstone ultraFAIMS products are field-asymmetric waveform ion mobility (FAIMS) pre-separators for use on Mass Spectrometers. They are used to separate or filter ions before they enter the mass spectrometer. This may provide a reduction in chemical noise or allow observation of ions that would otherwise be difficult to resolve in the mass spectrum.

The ultraFAIMS Developer Kit (ultraFAIMS-DK1) is a variant of the standard ultraFAIMS system that is supplied to instrument developers who wish to customize the system for use on a Mass Spectrometer for which an off-the-shelf Owlstone interface is not yet available. These notes are provided to assist with understanding how to use the system safely and how to develop a custom interface. Please note that ultimate responsibility for safety of the customized system lies with the developer.

See the *Owlstone ultraFAIMS user interface software manual* for further information on FAIMS separation.

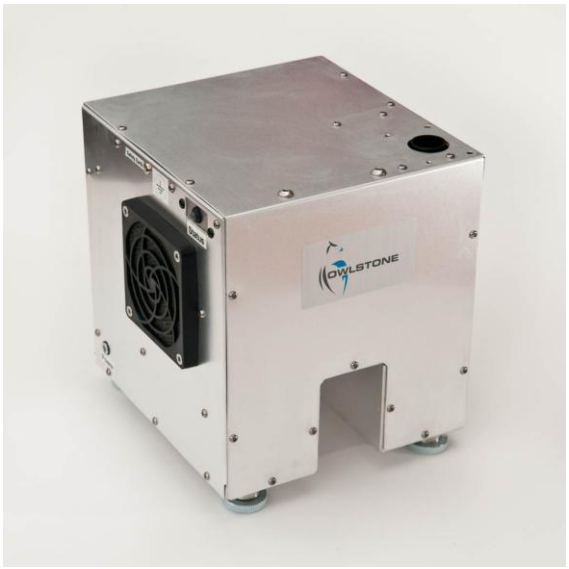
2. System Familiarization

The ultraFAIMS-DK1 is not an “off-the-shelf” system; it is an integration kit that can be used to interface the ultraFAIMS chip to a mass spectrometer and ionisation source. The kit includes the ultraFAIMS chip, the electronics to drive the chip, and the software to control the system. The user will need to design and manufacture a bespoke mechanical interface that holds the chip in the required position on their instrument and allows electrical connections to be routed to the chip from the control electronics.

To reduce the number of bespoke parts that the user will need to design, the kit also includes an example interface (which in some cases may be suitable to use directly) and a duplicate set of parts for that interface. These parts have been designed to facilitate integration with other mechanical parts, and so some may be directly usable as part of the custom interface.

The DK1 system consists of the following items:

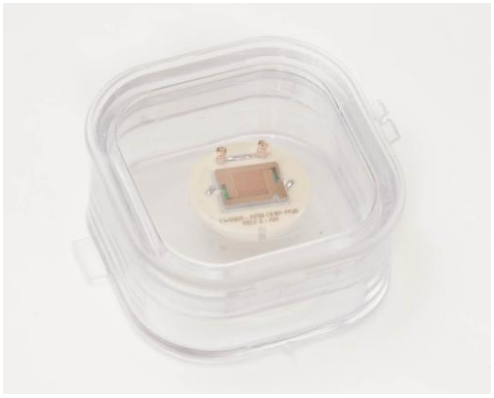
1. UltraFAIMS control unit



The control unit generates the FAIMS waveforms needed to drive the FAIMS chip. It is controlled by the PC software supplied.

2. UltraFAIMS chip

The chip is the core of the ultraFAIMS system – this is the FAIMS device that produces the separation of ions as they pass through the fields applied across the channel.



3. Chip holder (example)

The chip holder is part of the mechanical interface between the chip and the downstream instrument. The holder supplied is an example, but part or all may be usable in the custom interface design.

4. Waveform feeder kit

The waveform feeder connects the chip to the control unit so that the FAIMS waveforms can be applied.

This part may be useable as supplied, or may need modifications to suit the specific interface design. Two versions are supplied:

- Assembled example feeder attached to example chip holder (shown above): may be useable without modifications in some cases, or may need modifications.
- Waveform feeder kit of parts: supplied part-assembled, but can be easily dis-assembled into component parts, to allow any suitable components to be built into the custom interface design.

Design drawings for the waveform feeder kit parts are available on the Owlstone support website.

5. Benchtop power supply and power cable

We recommend that the DK1 system is powered from the current-limited variable power supply in order to protect the control unit.

6. Door Interlock kit (left) and Safety Earth cable (right)

See section 3 for notes on system safety and interlocks.

7. Reference voltage input cable

See section 3 for information on reference voltage requirements.

8. External trigger cable

Information on how to use the external trigger cable is available on the Owlstone support website.

9. USB cable

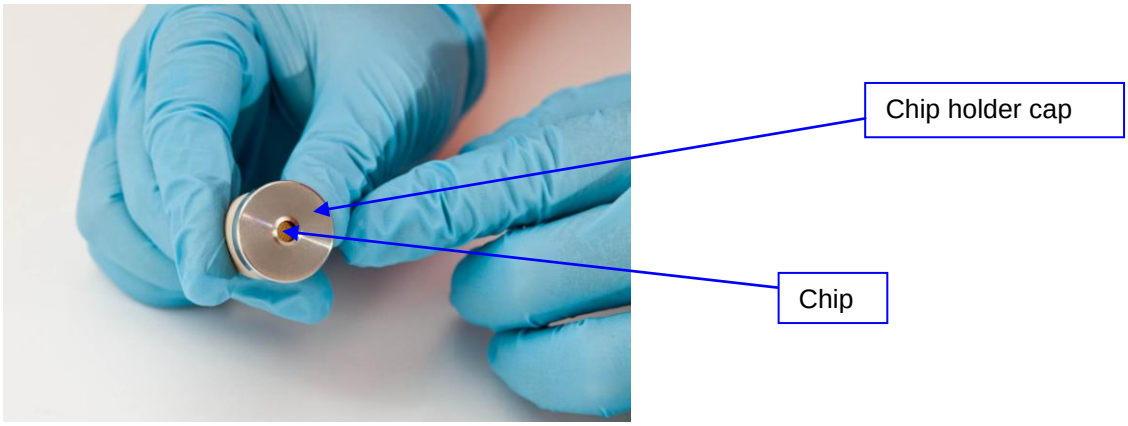
A standard USB A-to-B cable is used to connect the control unit to a PC.

3. Safety Considerations for Developers

FAIMS voltages can be hazardous. When designing a custom interface you should consider how to ensure that hazardous live parts of the system are not accessible during operation.

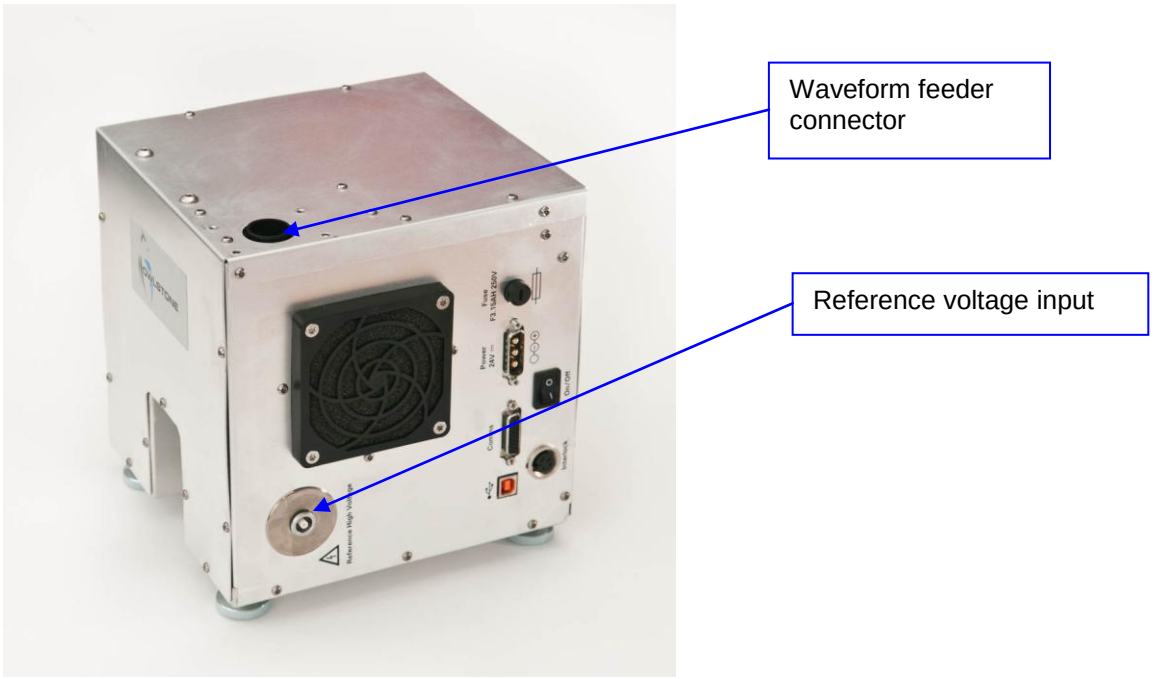
What parts of the system can be hazardous live?

When a FAIMS sweep is underway, the chip, the metal cap on the front of the chip holder (if retained) and the electrical connections to the chip are hazardous live.



The chip carries AC voltages of up to approx 330V AC at 27.12MHz plus a possible DC static bias of up to +/-20V. The metal cap carries only the static bias.

Note: the above voltages are referenced to a floating ground voltage. The level of this floating ground voltage is determined by the voltage supplied to the ground reference voltage input.



A ground reference input cable is supplied. The bare end should be connected to a suitable reference voltage supply. A ground reference of up to +/-6000V can be used, but if a voltage above +/-70V is supplied, be aware that hazardous voltages will become accessible on the landing pads of the waveform feeder connector when the waveform feeder is not connected. See below for information on interlocks.

Please note: this input voltage should be supplied, even if the required reference voltage is 0V.

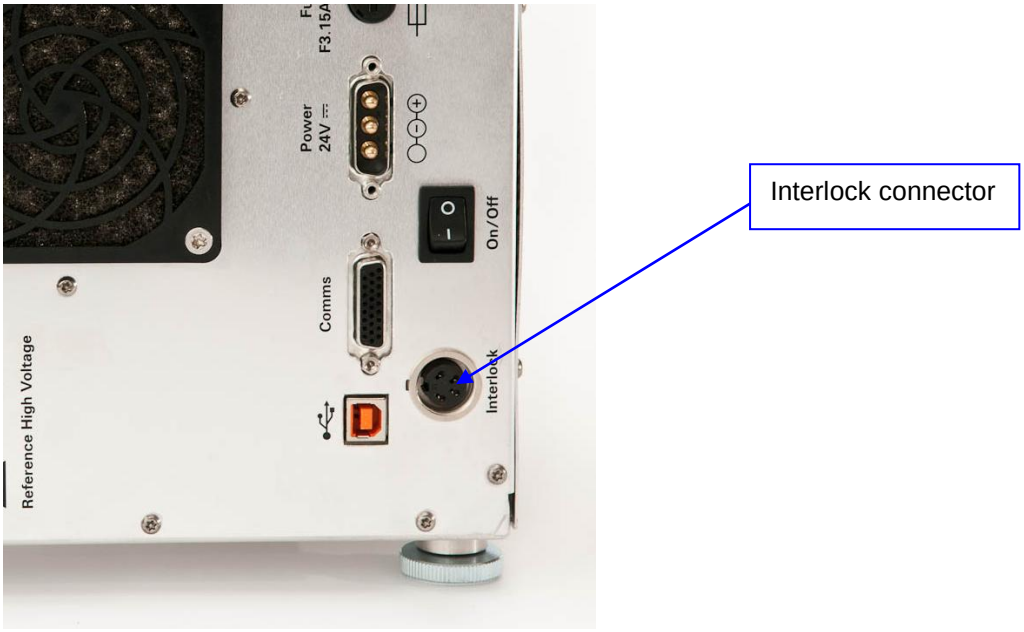
Are the live voltages on the chip, chip holder cap and electrical connections accessible?

This will depend entirely on how you design your mounting interface for the chip. We recommend that you consult safety standard IEC61010-1 for detailed information on how to prevent hazardous live voltages from being accessible, paying particular attention to the requirements for creepage and clearance distances.

Mechanical drawings of the chip and example chip holder are available on the Owlstone support website (http://support.owlstonenanotech.com/categories/20097286-UltraFAIMS-MS-Development-Kit) to aid with confirming dimensions.

How does the interlock work?

An interlock input is required to protect the user from the hazardous voltage generated by the control unit. The door interlock is a dual redundant circuit that will disconnect the 24V DC supply to the parts of the system that internally generate the hazardous live voltages.



To make use of the interlock input, see the cable wiring diagram on the Owlstone support website http://support.owlstonenanotech.com/categories/20097286-UltraFAIMS-MS-Development-Kit. Both reed switches need to be activated (closed) in order activate the FAIMS voltage.

It is recommended that the interlock is arranged so that the 2 reed switches are activated (closed) when the user is physically prevented from accessing the FAIMS chip. When the one or both of the reed switches are not activated (or the interlock cable is disconnected) the control unit remains powered and able to communicate with the PC, **but all FAIMS voltages are disabled.**

Please note: the ground reference voltage will not be disabled by this interlock and will still be applied to the waveform feeder connector pads (if the waveform feeder is disconnected) or to the waveform feeder wires and chip (if the waveform feeder is connected). Consider whether it is necessary to apply a separate interlock to disable the ground reference input voltage when it is accessible to the user.

Safety earth

A safety earth cable is attached to the control unit. The other end of this cable must be connected to a suitable safety earth point on the Mass Spectrometer chassis using an M4 screw before the control unit is powered on.

Connect earth cable here and to a suitable protective safety earth point

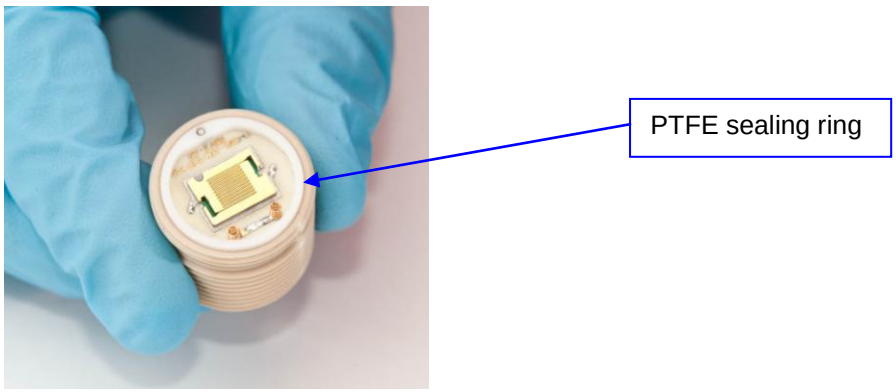
4. Developing a custom chip interface

In order to couple the ultraFAIMS chip to a mass spectrometer, the developer will need to design a suitable mechanical interface. The interface should hold the chip in the correct position, ensure desolvated ions from the ionisation source are efficiently coupled into the chip and from the chip into the mass spectrometer, and route the electrical conditions from the control unit to the chip.

The Developer Kit includes an example interface (chip holder and waveform feeder) that illustrates one possible design. ***This assembled interface is also useful for system testing and troubleshooting, so we recommend that it is not modified.***

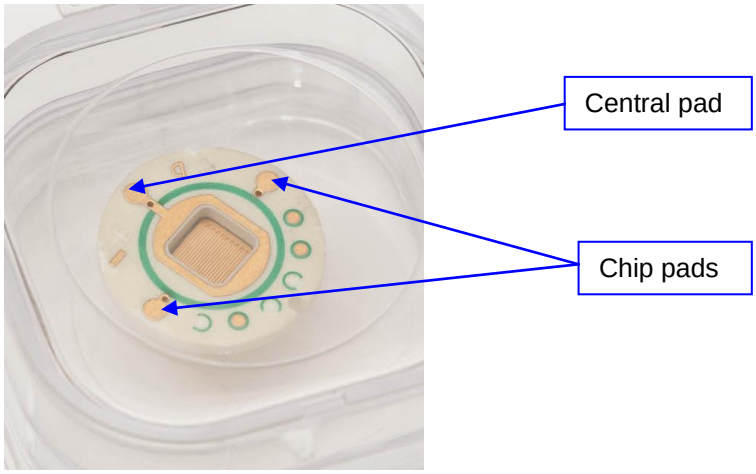
A duplicate set of interface components is included in the kit. These components can be incorporated into the custom design where appropriate. It is likely that some new components, tailored to the specific mass spectrometer to be used, will be needed. Design of the custom components is the responsibility of the developer. However, the following notes are provided for guidance and we encourage you to contact Owlstone to discuss proposed designs.

1. **Desolvation of ions:** ions must be desolvated before they reach the FAIMS chip. Consider where to place the chip relative to the ionisation source so that desolvation happens upstream of the chip. It may be advisable to use a heated counter flow of gas (opposing the flow into the chip holder) to assist desolvation. If the chip is exposed to liquid droplets while FAIMS voltages are applied, the chip and control unit may be permanently damaged.
2. **Gas flow rate (through chip):** this is usually determined by the conductance of the mass spectrometer inlet orifice. The chips provided with the Developer Kit provide optimum performance with a carrier gas flow of around 1.5-2l/min. With higher MS inlet gas flow rates, separation performance will be reduced – this could be alleviated by adding a controlled make-up gas flow downstream of the chip. With lower MS inlet gas flow rates, ion transmission will be reduced. In this case, an alternative chip design may be available – contact Owlstone for details.
3. **Flow sealing:** it is important to ensure good sealing to ensure all carrier gas flow passes through the FAIMS chip and into the MS inlet. In the example chip holder, a PTFE sealing ring between the chip PCB and metal cap is used and the rear aperture of the FAIMS chip holder contains an o-ring.



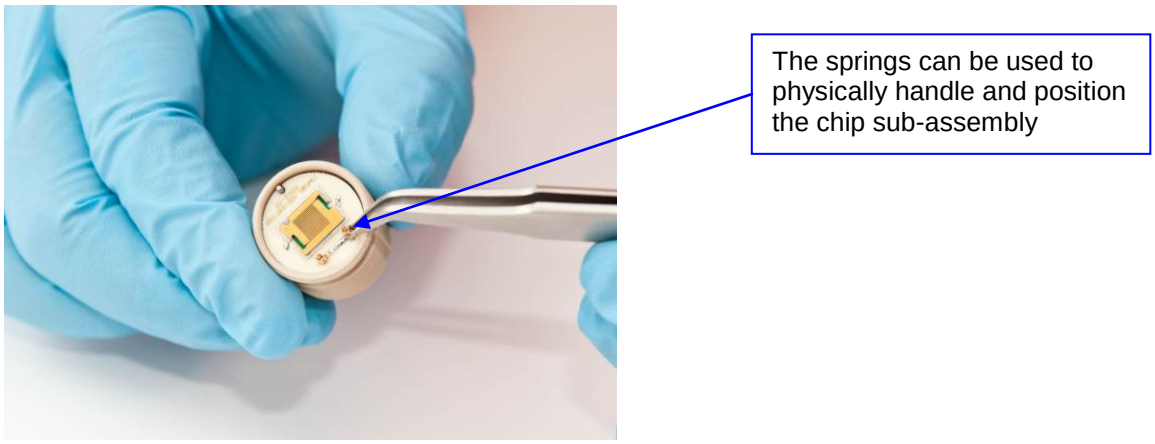
4. **Chip mounting:** the example chip holder is designed to ensure minimum stresses are applied to the FAIMS chip (since this would risk distorting the gaps in the chip, which would affect performance). If you intend to remove the chip PCB from the chip holder and use a different housing, consider how to ensure minimum distortion of the chip PCB.
5. **Chip module temperature:** the chip PCB sub-assembly should not be exposed to sustained temperatures above 150°C or it may be damaged.
6. **Electrical connections to chip PCB:** when connecting the waveform feeder wires to the chip PCB, the marked wire (which carries the ground reference and bias voltage) must be connected to the central pad on the rear of the PCB. This is connected to the two springs on the front of the PCB, which can be used to apply a static bias to the surrounding metalwork (see item 7).

   The other two wires carry the FAIMS waveforms (plus ground reference and bias voltage) are unmarked and must be connected to the chip pads. It does not matter which way round these wires are connected.



The connections to the pads can be made either by soldering the wires directly to the PCB or using the pogo pins provided. Using the pogo pins means the chip can more easily be replaced.

7. **Static electric fields:** the signals to the chip pads and central pad are always at the same DC voltage. These can be offset relative to the ground reference input voltage by up to +/-20V if needed. This bias voltage is controlled using the PC software interface provided - see software user manual. A distance of >=1mm is needed between the chip and any metal parts at the same bias voltage, to prevent breakdown due to the additional RF voltages applied to the chip during FAIMS sweeping.
8. **Parasitic capacitances:** any significant change to the capacitance experienced by the FAIMS chip can affect the shape of the FAIMS separation waveforms. FAIMS performance is very sensitive to waveform shape. It is therefore important to try to avoid adding extra capacitance – e.g. due to any additional metalwork near to the chip or the unshielded wires (a gap of at least 10mm is recommended), or due to extending the length of the wires.
9. **Chip cleanliness:** minimise handling to avoid contamination of chips, especially particulates entering the chip. Chips are physically robust, but any shorting across the gaps (100um width) caused by conductive debris is likely to damage the chip and control unit.



If chemical contamination builds up during use, chip modules can be cleaned by sonicating in water and/or methanol/IPA. Ensure chips are completely dry after cleaning before they are used again.

To avoid unnecessary handling of the chips, a chip PCB with a dummy load has been provided. During interface development & testing, the dummy load can be used instead of a chip to provide the necessary load for the control unit to operate without damage.

We strongly advise contacting Owlstone to request a design review for custom interface designs.

5. How to Set Up the System

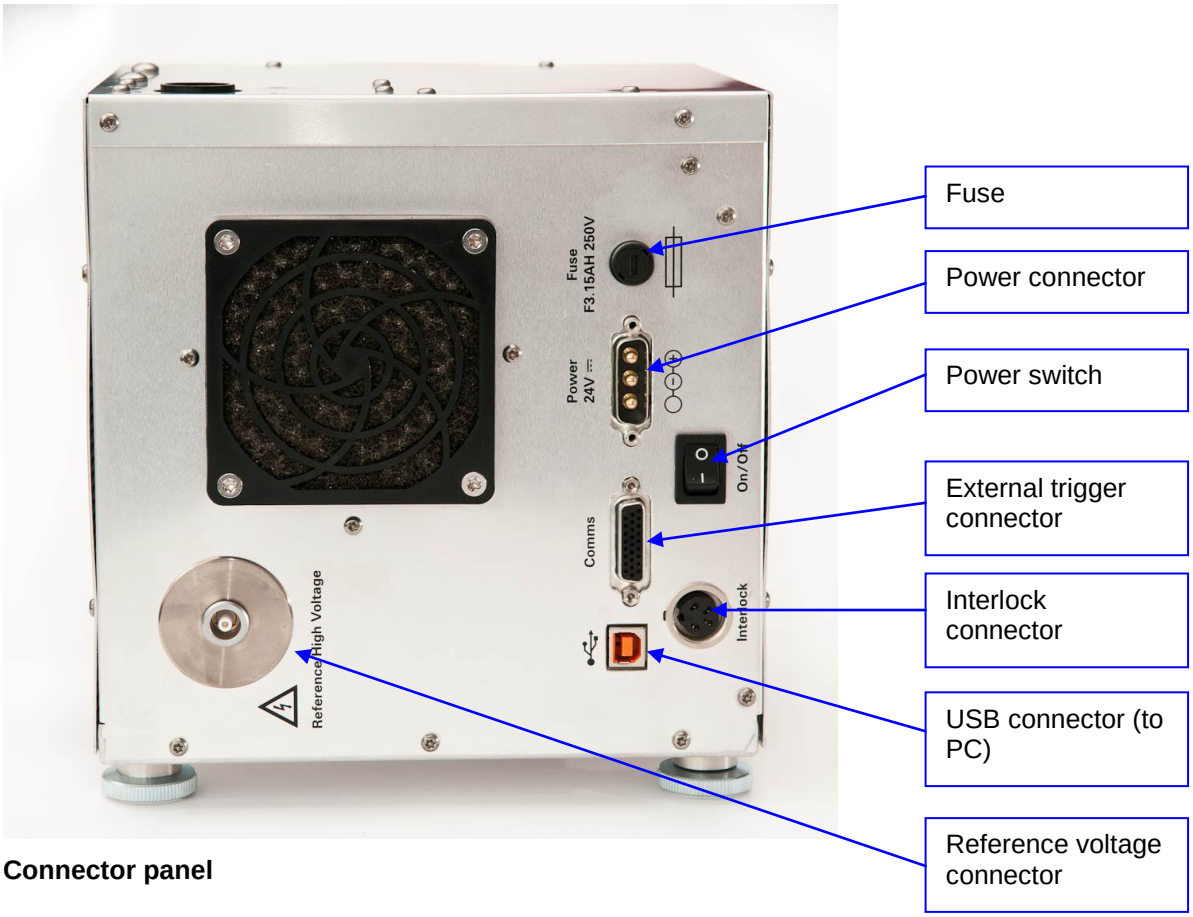
Once you have your custom chip mounting interface ready to go, the system is set up as follows:

1. Install the PC interface software provided (see software user manual for more information).
2. Attach the waveform feeder to the control unit using the 4 screws provided (M3x12). Note: the waveform feeder will only fit when in the correct orientation.

3. Position the control unit suitably close to the mass spectrometer inlet.
4. Install your custom chip mounting interface on the mass spectrometer (with chip inserted).
5. Connect the safety earth cable to a suitable earth point on the mass spectrometer chassis.
6. Connect the ground reference input cable from your reference voltage supply to the control unit.
7. Connect the USB cable from the PC to the control unit.
8. Connect the power cable from the benchtop power supply to the control unit. Set the output voltage to 24V and set a current limit of 2.5 amps (60W).
9. If using the external trigger cable, connect this to the connector labelled “Comms”.
10. Connect the interlock cable and engage the interlocks.
11. Enable the power supply output and switch on the control unit.

Reminder: Do not operate the system without a chip or test load correctly installed, otherwise system faults are likely to occur and there is a risk of permanent damage to the control unit.

See *OW-003401-TM Owlstone ultraFAIMS-MS user interface software manual* (available on the Owlstone support website: http://support.owlstonenanotech.com/categories/20097286-UltraFAIMS-MS-Development-Kit) for instructions on how to operate the system using the PC software.



Connector panel

6. Appendix – Operating Conditions

Type	Specification
Ambient operating temperature	15-35°C
Ambient storage temperature	5-50°C
Humidity	20-85% relative humidity at 35°C
Operating altitude	Up to 2000m