intellevation

White Light Optical Monitor

Model IL553
User Manual

IL553 OPTICAL MONITOR SYSTEM

Instruction Manual
This documentation is provided as an instruction manual to Intellevation customers and potential customers only.

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1. Introduction

Copyright Notice

Declaration of Conformity

Declaration of Conformity

We, Intellemetrics Ltd,
35 Cable Depot Road,
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Glasgow, G81 1UY, UK

Declare under our sole responsibility that the product(s)

White Light Optical Monitor (WLOM)
IL551
IL552
IL554

to which this declaration relates is in conformity with the following standard(s) or other normative document(s)

EN61326 (Industrial Location, Class A Emissions)	Electrical Equipment for Measurement, Control and Laboratory Use - EMC Requirements.

following the provisions of

73 / 023 / EEC	Low Voltage Directive.
89 / 336 / EEC	Electromagnetic Compatibility Directive.

Russell King
Russell king, Technical Manager

8/9/2004 (Eastbourne)
Date and Place

This product has been manufactured under a quality system registered to ISO9001

Intellemetrics Ltd (Part of the BOC Group plc)

Symbols on the OMS Computer

⚠ (lightning)	Electric shock hazard
⚠	Warning and Caution
⏚	Earth (ground) terminal
|	START

Certification and Compliance

⚠	*Warning*	If this equipment is used in a manner not specified by Intellevation, the protection may be compromised

Scope and Definitions

This manual provides installation, operation and maintenance instructions for the Intellevation IL553 Optical Monitor, abbreviated to IL553 in the remainder of this manual.
Read this manual before you install and use the IL553. Important safety information is highlighted as WARNING and CAUTION instructions: You must obey these instructions. The use of WARNINGS and CAUTIONS is defined below.

⚠	*Warning*	Warnings are given when failure to observe could result in injury.

⚠	*Caution*	Cautions are given where failure to observe the instruction could result in damage to the equipment, associated equipment and process

.

Description

The IL553 optical monitoring system (OMS) is designed to be integrated onto a coating deposition system to provide accurate termination of the coating deposition process.

A typical IL553 OMS system layout (in reflection mode) is shown in Figure 1 below.

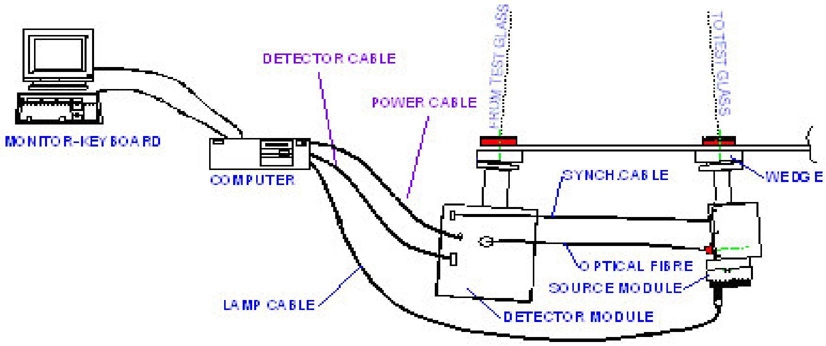


Figure1. Schematic layout of IL553 OMS (in reflection mode)

The IL553 comprises separate Source and Detector modules, a computer with keyboard, an optical fibre and all connecting cabling. The mouse, keyboard and display to complete the installation are NOT provided by Intellevation.
The IL553 OMS is made up of the following modules: a broad waveband white light source, a detector module (IL553), and a computer running Intellemetrics Film*Maker* and Film*Director* software in a Windows 2000 environment.

The Source Module provides a broadband collimated beam. The beam is mechanically chopped in the source module at high speed to provide a four phase synchronous output.

The detector module is fitted with a monochromator to select the process monitoring wavelength. A solid state detector, synchronised with the mechanical chopper, provides signal/dark/reference/dark phases, which when processed by a synchronous detection technique yields a low noise signal representing the optical interference signal from the film developing in the chamber.

The signal is digitised and sent to the computer where further processing of the signal is undertaken and a CUT signal provided through I/O to the process.
The computer also features a programmable I/O capability for two-way communication with the customer process.

A key feature of the IL553 is the provision of an optical reference light path by means of an optical fibre connecting the Intellevation Source and Detector modules. This feature ensures that any temporal variations in the output of the tungsten halogen source are mimicked down the reference path.

Sequential processing of monitor and reference signals is achieved by means of a "stepped" mechanical chopper design and synchronisation of the chopper position with the detector output. This allows each phase (monitor/dark and reference/dark) to be alternately recognised and processed in a single detector amplifier chain.

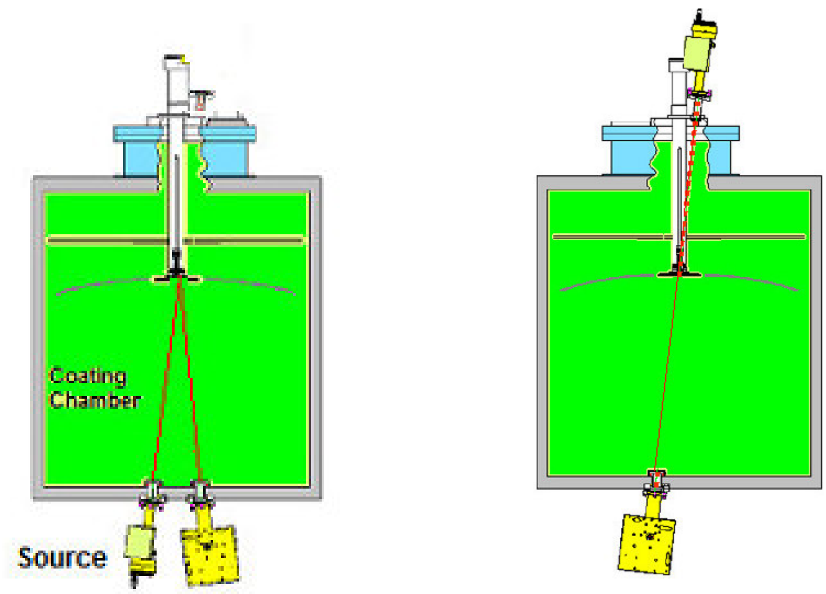
This approach has three main benefits offering improved photometric accuracy.

- Short-term variations in the source output are corrected through the reference.
- Single amplifier--single noise source
- Single detector--single noise source

Intellemetrics Film*Maker* and Film*Director* software are pre-installed on the computer at the factory. The software, which operates in a Windows 2000 environment, enables creation, testing and storage of the OMS coating schism associated with the customer coating stack (design) through Film*Maker* (FM) and real time operation and provision of CUT output of the monitor process via Film*Director* (FD). FD also communicates through the IO with the customer system, and stores all data from the process.

The Source and Detector Modules are designed with free space broadband optics to provide a highly collimated beam in the customer chamber. The extremely low divergence of the beam (<2mRad) ensures that the Intellevation OMS can be successfully fitted to chambers with an optical path length of up to 2.0 to 2.5 metres. The high degree of collimation enables both transmission mode and reflection mode monitoring in large chambers. The diameter of the light patch at the test glass is around 10-12mm.
The reference optical path is provided by a combination of free space optics and a single multimode optical fibre linking the source and detector modules to provide flexibility in the positioning of the modules.

Schematics of the options available for T and R monitoring are shown below:



R mode(front surface reflectance) T mode

The Source and Detector modules are attached externally to the vacuum system using specially designed Intellevation mountings and feedthroughs. The fittings have been designed to provide the required amount of fine adjustment of tilt and then lock of the modules to ensure long-term stability of alignment of the light path in the chamber.

Monitoring is usually from a stationary test glass piece in a fixed position in the vapour stream. A single test glass will only provide an acceptable signal swing for a limited number of films, usually less than 10 and sometimes as low as 5 films, and therefore for complex coating the provision of multiple test glasses is essential. This is achieved by the use of a test glass changer where the order of test glass indexing is under the direct control of the optical monitor. Intellevation provided a range of test glass chambers adaptable to all of the common box coater platforms.

The IL553 OMS is fully programmable for automatic deposition of the most complex multi-layer film stacks and provides the capability through I/O to interact with the system controller. The I/O capability, which is fully programmable, is comprehensively covered later in this manual.

Source Module

At the core of the source module is a tungsten halogen lamp, a mechanical light chopper to modulate the beam, a telescope to collimate the output light and a reference optical signal path (multimode low loss optical fibre) to the detector module.

The source module is shown in Figure 2.

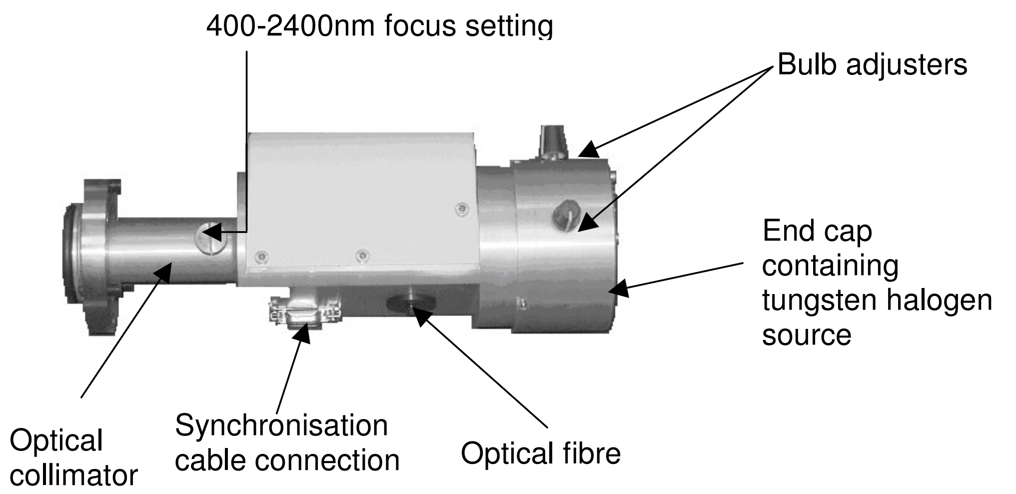


Figure 2. IL550S Source Module

The tungsten halogen lamp is powered from a voltage stabilised source to ensure that the filament temperature provides the required spectral output 300nm to 2400nm. Unfiltered light from the lamp is mechanically chopped and collimation optics provide a narrow parallel beam of light for launch into the coating chamber. The collimation optics have been designed for very low beam divergence over the full waveband, allowing the IL553 to be used successfully even in chambers with a long optical path between the source and detector.
There are two 'switchable' collimator optical configurations covering the UV up to 400nm and the visible through IR (400nm to 2400nm). These two configurations are achieved via the knurled screw in the neck of the Source and Detector Module. The adjuster should be positioned at its extreme position (away from the chamber) for UV up to 400nm operation and (towards the chamber) for all other monitor wavelengths.

A reference signal is also taken from the source module and passed to the detector module through an optical fibre.

Detector Module- IL553

The IL553 detector module combines collimation optics, wavelength selection detection signal amplification and digitisation.
Non-adjustable fixed collimation optics in the detector module focuses the light incident on the test sample.
The reference optical path light is aligned with the test sample path via injection optics built into the detector module.
Wavelength selection is by a grating directly under the control of software.
Detection is via a silicon/indium gallium arsenide dual solid state detector synchronised to the chopper phase to discriminate sample, dark and reference signals. The output signals are then amplified by a close-coupled preamplifier, digitised for noise immunity and passed to the computer for further processing via the detector cable.

A view of the Detector Module is shown in Figure 3.

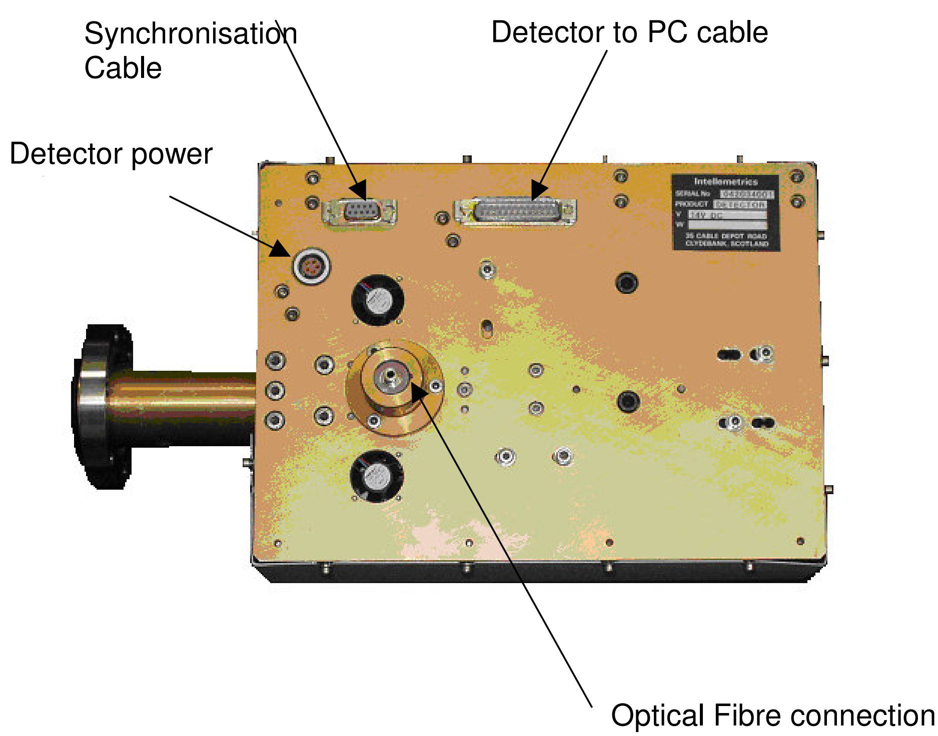


Figure 3. IL553 Detector Module connections.

Computer

The signal processing electronics are contained within a 19" Industrial OM COMPUTER chassis running in a Windows environment.

Figure 4. OMS Computer

Warning	The OMS computer is a dedicated instrument computer and no other programmes can be open when Film*Director* is running.

Software provided are:--

Film*Maker* (FM) with the following features:

- Database format single data input screen to programme
- Materials (including private materials database)
- Films and Recipes.
- Storage of recipes
- Holdoff/Latency
- Filter settings
- Acquisition rate
- Recipe Verify Function
- Signal Modelling Function
- Multiple test glass functionality
- Quarter wave and non quarter capability
- On line help

And including associated software modules

- Film*Simulator*
- Film*Reviewer*
- Film*Character*

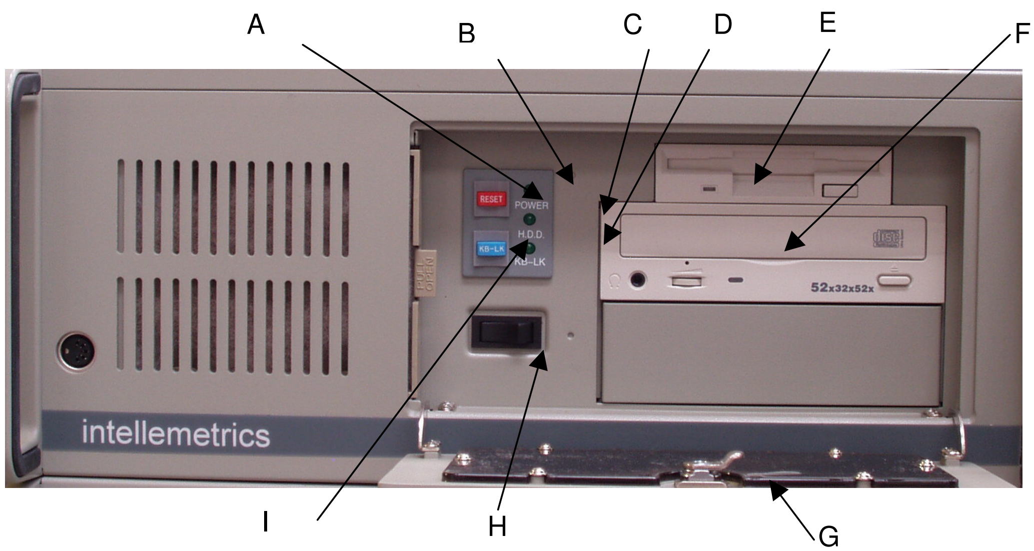
Film*Director* (FD) with the following features:

- Multipanelled screen
- Real time processor
- Data storage and retrieval
- On line help
- DigitalIODataserver (IODS)
- User programmable I/O function
- On line help (not available)
- WLOMDataServer (OMDS)
- Interface between FilmMaker and FilmDirector
- Optical alignment aid
- Diagnostic tools

Controls and Displays

Controls

OMS Computer: The front panel controls associated with the OMS Computer are shown in Figure 5.



A--Reset button
B--Power LED
C--HDD LED
D--Keyboard Lock LED
E--Floppy drive
F--D ROM drive
G-Front door lock
H--n switch
I--keyboard Lock button

Figure 5: OMS Computer front panel controls display

Displays

OMS Computer Monitor (not supplied):
A minimum display resolution of 1280 x1024 is required, type VGA.

2. Technical

General

Dimensions	See Figure 6
Mass	Detector 3.7Kg; Source 1.75Kg; Computer 18.05Kg
Operating temperature range	5°C to 40°C
Electrical supply	100/240VAC 50/60Hz
Electrical Power rating	8A/4A
Pollution Degree	2
Humidity	Maximum 80%RH up to 31°C
Installation category	II

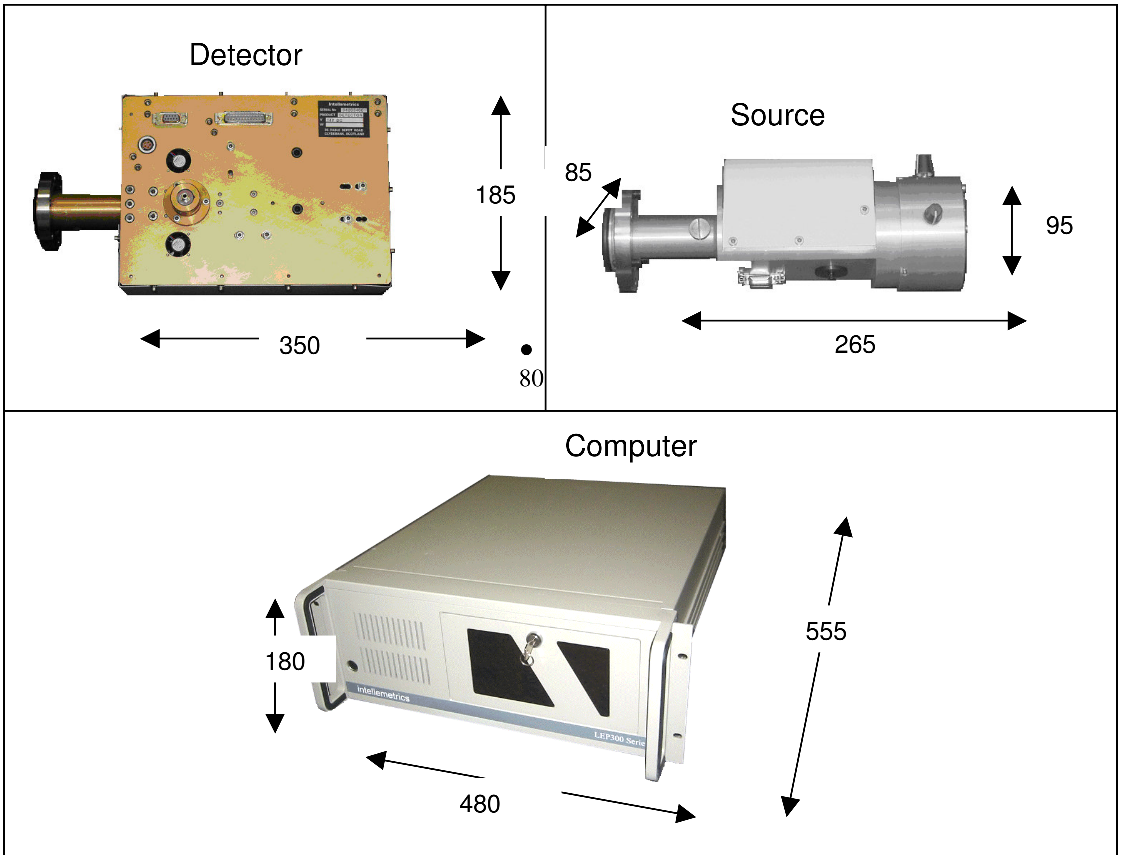


Figure 6. Dimensions in (mm) of Detector and Source Modules and Computer

IL553 Performance

Detector Range	550 to 1650nm
Mechanical chopper period	27mS
Monitor (not supplied) type VGA	Minimum resolution 1280 x1024
Spot size	10-12mm diameter
Optical path length between source and detector	<= 2.5metres
Test glass optical power	0
Monochromator wavelength range	550 to 1650nm
Sampling rate (internal triggering)	<=3Hz

3. Installation

Unpack and Inspect

Remove all packing materials and protective covers and inspect the IL553. A packing list is supplied, see Figure 7. Confirm all parts have been received and none are damaged. If there are any physical signs of damage notify your supplier and carriers in writing within three working days. State the parts affected and your order number and your suppliers invoice number. Retain all packing materials for inspection.

Item	**Quantity**
Computer & two keys	1
Detector Modules (IL553)	1
Reference Optical fibre	1
Detector power cable	1
Detector Cable	1
Synchronisation cable	1
Mounting wedges	2
Fixing kit	2
Source Module	1
Infrasil cover slips for optical feedthroughs	2

Figure 7. Packing List

⚠	*Warning*	Do not use IL553 OMS equipment that is damaged

⚠	*Caution*	Installation can only be carried out by trained personnel

Electrical Supply Voltage

Refer to Figure 8. The computer power supply will operate automatically on supply voltages in the range 100 to 240 VAC 50/60Hz single phase only.

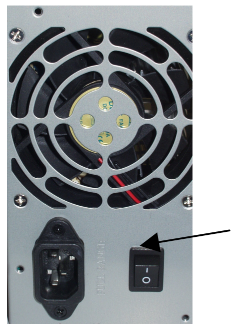
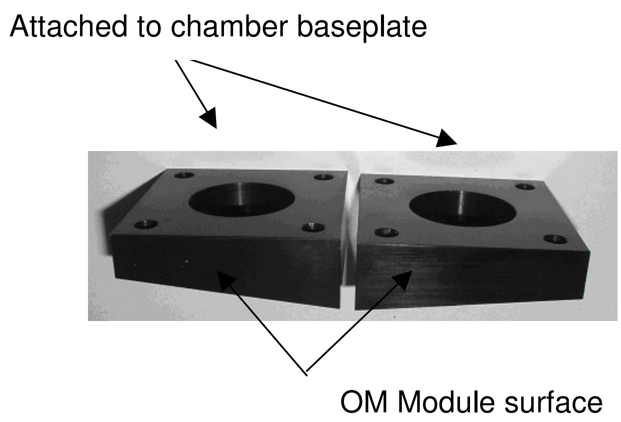


Figure 8.   Computer power supply.

Mounting of Computer
The computer is a standard 19” 4 U high configuration and if possible this should be rack mounted near to the coating chamber, taking into account the length of cabling supplied.
The computer should be mounted away from sources of heat and high humidity and RF radiation.

Mounting of Source and Detector Modules

The Source and Detector Modules are designed with the same mounting arrangement to be compatible with 32mm apertured feedthroughs. The OM modules are mounted on machined angular wedges designed to provide the correct optical path in the chamber.
It is normal practice for the machined angular wedges to be designed and supplied by Intellevation following input from the customers engineering department of the optical path between Source Module-test glass-Detector Module.



The optical feedthroughs shown in Figure 9 are retained in position by a threaded cap, which in conjunction with the inner window 105.934 and "O" ring provides the vacuum seal.

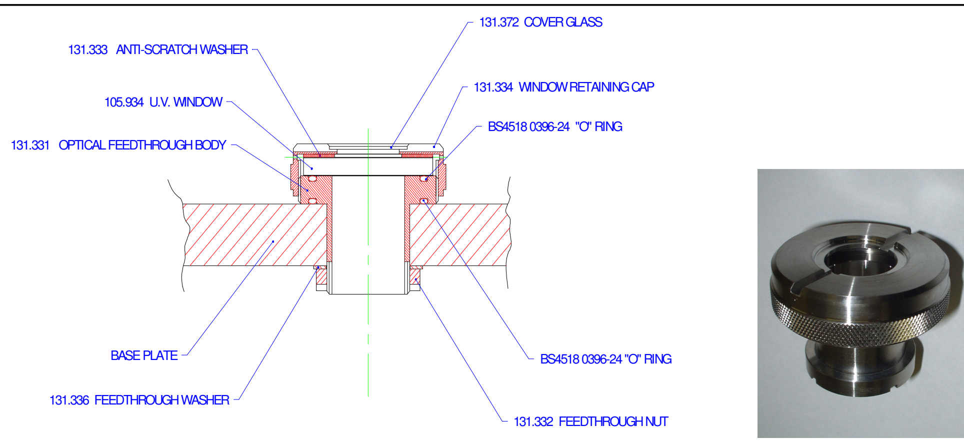


Figure 9. Optical vacuum feedthrough schematic/assembly

The optical path through each feedthrough comprises two uncoated silica windows: The inner window 105.934 forms the permanent seal between atmosphere and

vacuum, whilst the outer cover glass 131.372 is supplied to prevent coating material from being deposited on the inner window. The window rests on an O-ring (vacuum seal) and the upper surface is protected by a PTFE ring.
The vacuum seal window can be removed from inside the vacuum chamber by unscrewing the outer ring. The threaded cap has an integral shoulder that ensures optimum compression of the "O" ring guaranteeing a good vacuum tight seal.

The machined steering wedges are bolted directly onto the chamber baseplate. The angled wedges must be orientated correctly (thick edges towards each other) and then securely bolted onto the underside of the chamber.
The steering wedges are unique to each customer chamber geometry and are intended to provide coarse alignment of the beam from source to detector via the customer fixed test glass position.

To provide fine angular adjustment a compressible O-ring is mounted between the body of each module and the steering wedge.
A flange, which forms part of each module assembly, in combination with the compressible O-ring provides the range of fine angle adjustment necessary.

The adjustable flange is shown in Figure 10.

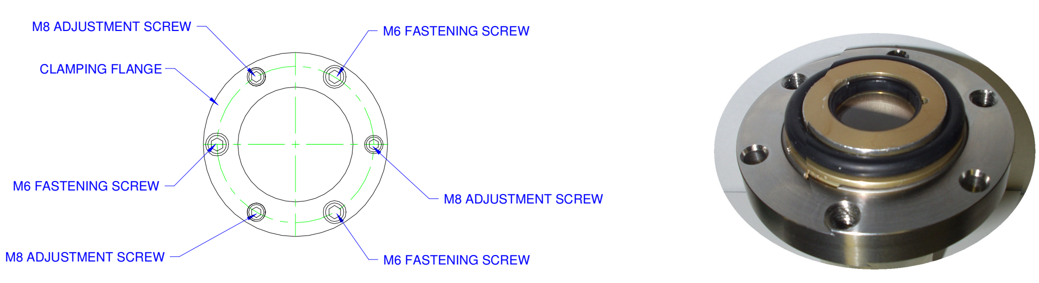
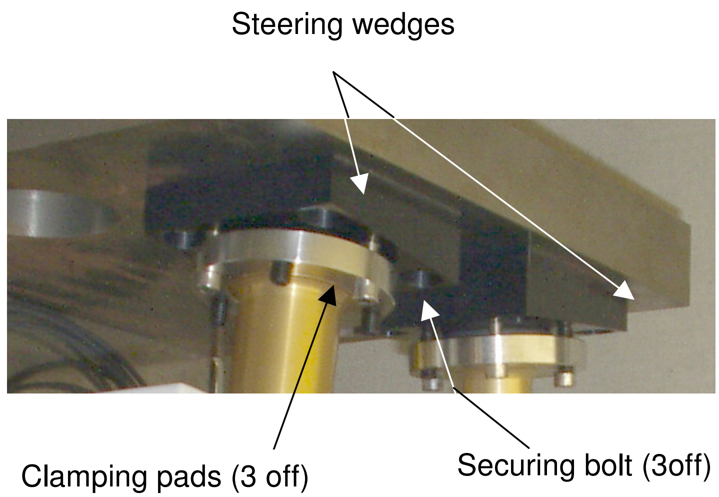


Figure 10 Adjustable flange schematic/actual

The O-ring acts as a compressible joint allowing minor alterations to the alignment of the modules whilst insulating the modules from mechanical vibrations transmitted to the chamber from the pump set.



⚠	*Caution*	Correct installation of the mechanical wedge and flange is essential to low noise operation of the OMS.

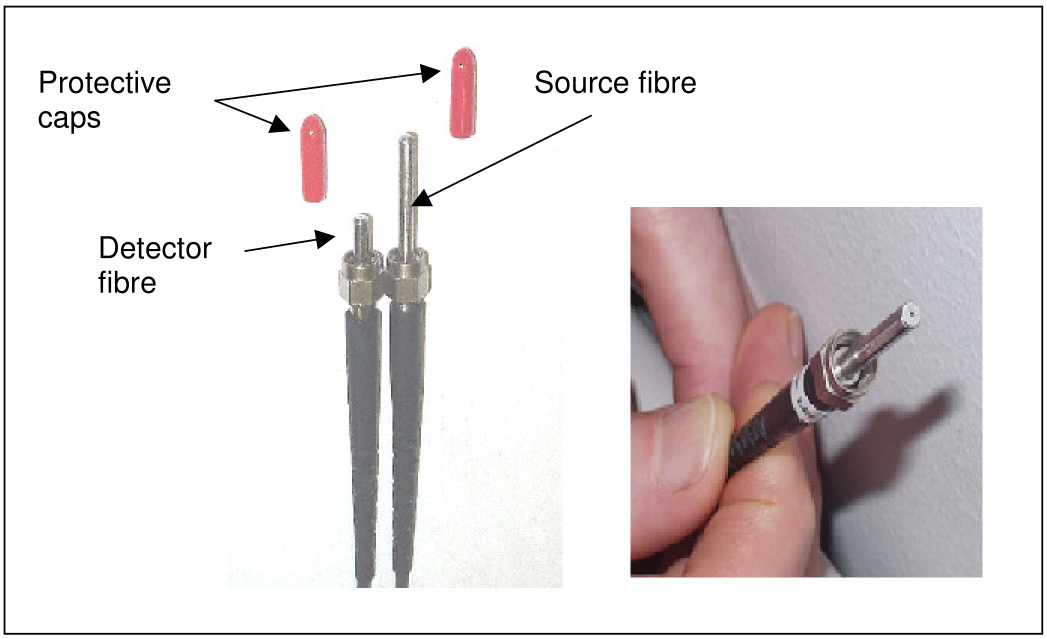
Fitting the Optical Fibre

A reference signal is provided via an optical fibre linking the Source and Detector modules. The optical fibre is a multimode protected fibre terminated at both ends in SMA type connectors.

The optical fibre is terminated in a “short” end and a “long” end. The long end MUST be inserted in the source module and is unmarked.

The optical fibre must be inserted gently and when it reaches the stop gently tightened by screwing in the connector.

If for any reason the fibre is removed it should be stored with the protective end caps in place to prevent entry of dirt or contamination. Avoid touching the end of the fibre. The optical fibre end is flush with the metal outer sheath. If required the end can be cleaned with an alcohol moistened tissue.



⚠	*Caution*	The “long” end of the optical fibre MUST be inserted in the Source module

Test glass Specification (stationary)

If Intellevation are providing a test glass changer then the instructions for installation and commissioning are explained in the Intellevation user manual supplied with the test glass changer.

The following general specification applies to test glasses.

- The test glass must present a clear aperture of 16mm to ensure that the OM beam is not truncated by the test glass. Taking into account the need to support the test glass around the edge this translates to a test glass of around 20mm diameter or 20mm square minimum.
- The test glass must have optically polished parallel-sided surfaces for Transmission mode monitoring.
- The test glass material must be of a high quality, have highly reproducible and known optical dispersion in the band of operation of the OMS.
- Only the surface receiving coating needs to be polished and flat for Reflectance mode monitoring. The rear surface can be greyed to suppress reflectance. However if the rear face is polished then both faces must be parallel.
- In the event that the customer uses a non Intellevation test glass changer, the reproducibility of seating of the test glasses must be tested, particularly for Reflectance Mode monitoring to ensure compatibly with the optical design of the Intellevation OMS.

In the event that the customer has an Intellevation test glass changer, then the specification of compatible test glasses is defined in the Intellevation supplied test glass changer user manual.

Cabling

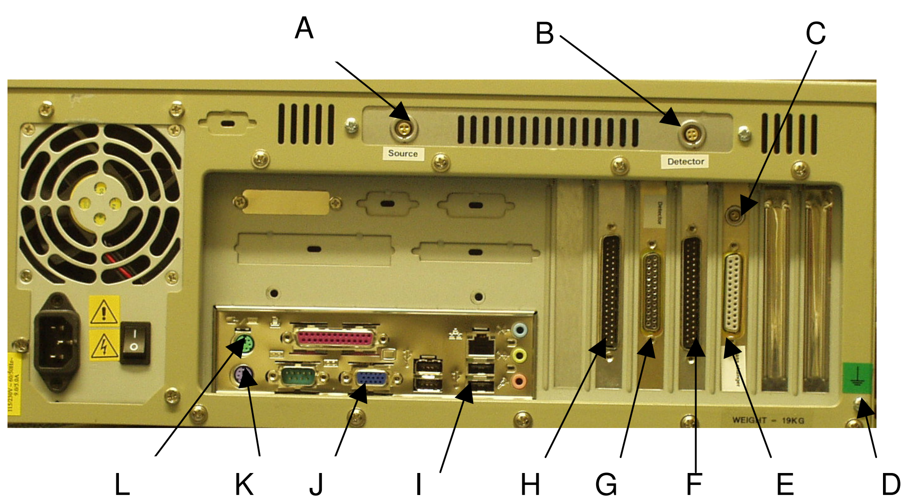
The cabling required to operate an OMS are:--

- The Lamp/Source cable. This is a 5 metre cable (part number WLOM3W), which plugs into the rear end cap of the Source Module and provides the low voltage power for the quartz halogen bulb. The cable connects to the rear of the OMS Computer, as shown at Figure 11 position A.
- The Detector cable (part number WLOM25W). This cable is 5 metres in length and links the Detector Module to the rear of the OMS Computer. The cable carries the returned detector signal to the computer. The connection at the Detector Module is shown in Figure 11c and at the rear of the OMS Computer in Figure 11 position E.
- Synchronisation cable (part number WLOM9W). This cable is 3 metres in length and links the detector module to the source module and provides the phasing information from the mechanical chopper required to synchronise the detector output to chopper phase.

- Detector power cable (part number WLOM4W-5W). This cable is 5 metres in length and provides the low voltage power required for operation of the mechanical actuators in the detector module and detector amplification and digitisation boards.
- Power cable for the OMS Computer. This must be connected to an earthed wall socket (3pin) of a minimum rating as specified in Section 2.1
- There is a single earthing screw at the rear panel of the OMS Computer, see Figure 11 position D. This point MUST be connected to a good system earth point in the customer installation.
- The detector body should be earthed to the customer system.

⚠	*Caution*	Only use the cables supplied with the IL552 as these are specifically manufactured for this application. Using other cables may result in damage to the IL552 and/or the digital I/O card. Always power down the OM COMPUTER before connecting or disconnecting cables.

⚠	*Warning*	Ensure that all of the electrical wiring to minimise a trip hazard. If you do not it may cause injury.



A--Source lamp power
B--Detector Module power
C--TGC power
D--Earth ground
E--TGC connector
F--Unused

G--Detector signal connector
H--I/O connector
I--USB (Deskey)
J--Video output
K--Keyboard
L--Mouse

Figure 11a Connections to the Computer

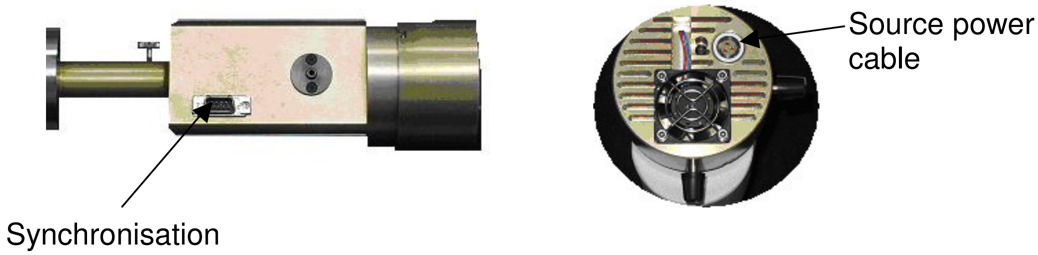


Figure 11b. Connections to Source

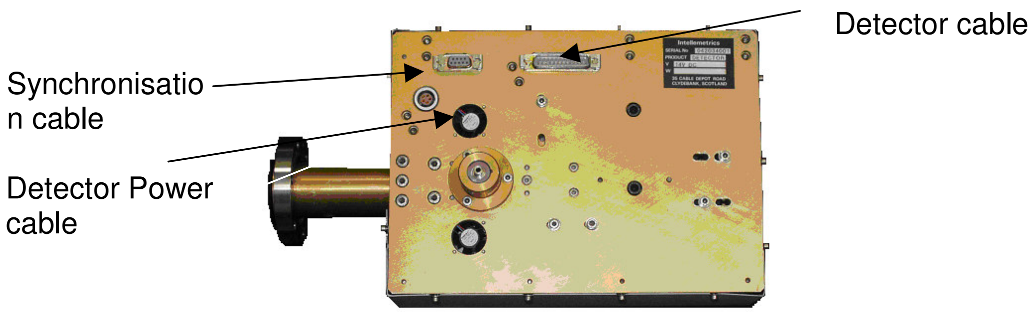


Figure 11c. Connections to the Detector

DesKey

The IL553 OMS computer is supplied with a DesKey software key which must be fitted to the USB port on the computer. Intellemetrics proprietary software will not run unless this is fitted.

Windows Licence

A Windows 2000 user licence is provided.
The Intellemetrics software is provided with a timeout, which will require the user after an agreed period by mutual agreement, to contact Intellevation to re-enable the software for a further agreed period. This process also enables Intellevation to revalidate the software provided and provide updates to software as per any previous agreement in place between the two parties.

Test the Installation

Coarse Optical Alignment procedure

This check is undertaken to ensure that the optical path Source-test glass-Detector is in alignment.

The most common configuration of the IL553 is monitoring in the reflection (R) mode, although the IL553 can be readily configured for transmission (T) mode monitoring. Instructions for the alignment of both modes are given below.

Place a highly reflecting sample (95 to 100%) in the test glass position, if the IL553 is configured in R mode or an uncoated glass (94%) if the IL553 is configured in T mode. Ensure that the test glass is seated correctly.

Also ensure that the telescope optics on the Source and Detector modules are correctly configured. To do this locate the knurled knob on the body of the source module at the forward end of the slot (ie towards the chamber). To reposition the knob, slacken move the knob along to the required end of the slot and then lightly tighten.

Switch on the OMS computer by unlocking the front access door and pressing the non-toggling ON switch.

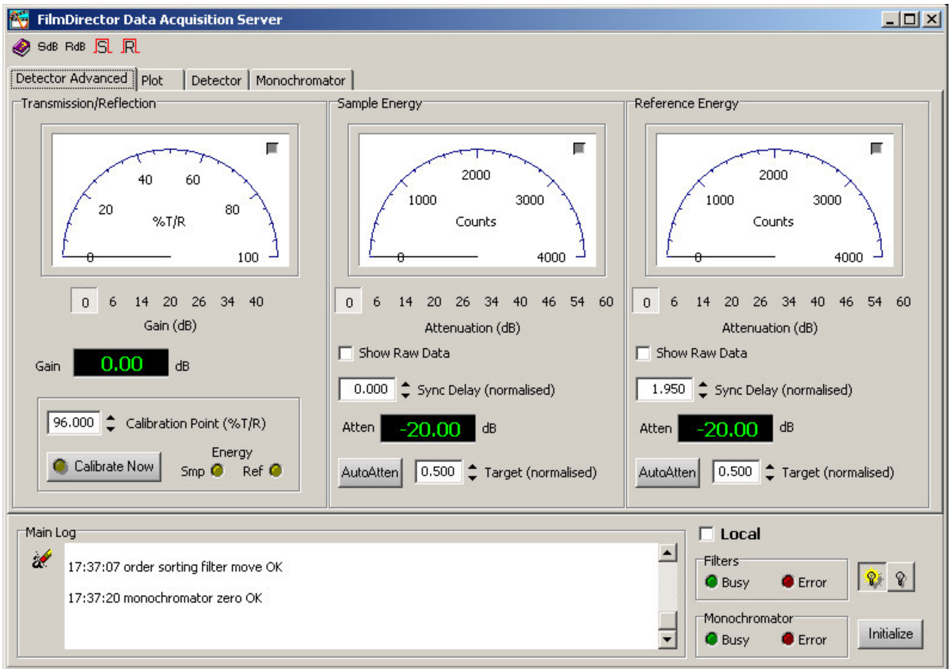
This will boot up the OM computer and activate the internal power supply which in turn will switch on the source lamp.

Double click on the Film*Director* (FD) icon on the desktop. FD will open up and WLWLOMDataServer (OMDS) and DigitalIODataserver (IODS) will minimise automatically to the bottom right system tray. (In certain setups you may see a shortcut on the screen to the OMDS without having to open FD). The process of opening FD also starts up the OMS, and power is automatically applied to the detector module, which in turn supplies the power for the source module electronics and mechanical chopper.

In the background the source will activate and the detector module will start a process of initialisation including re-setting of the monochromator and associated filters.

Click on the OMDS icon in the system tray to open it. In the illustration below, the righthand icon is the hardware data server, and the lefthand icon the IODS.

The following screen will pop up:---



Check the *Local* box which transfers control from Film*Director* (automatic) to manual control which will be required to perform the OMS optical alignment checks and system interaction checks to ensure that the OMS installation is sound.
The *Sample Energy* and *Reference energy* meters function is self-explanatory. The *Transmission/Reflection* meter attempts to achieve the pre-set calibration set point value. If the value read off the meter is significantly different from the calibration point this needs to be investigated

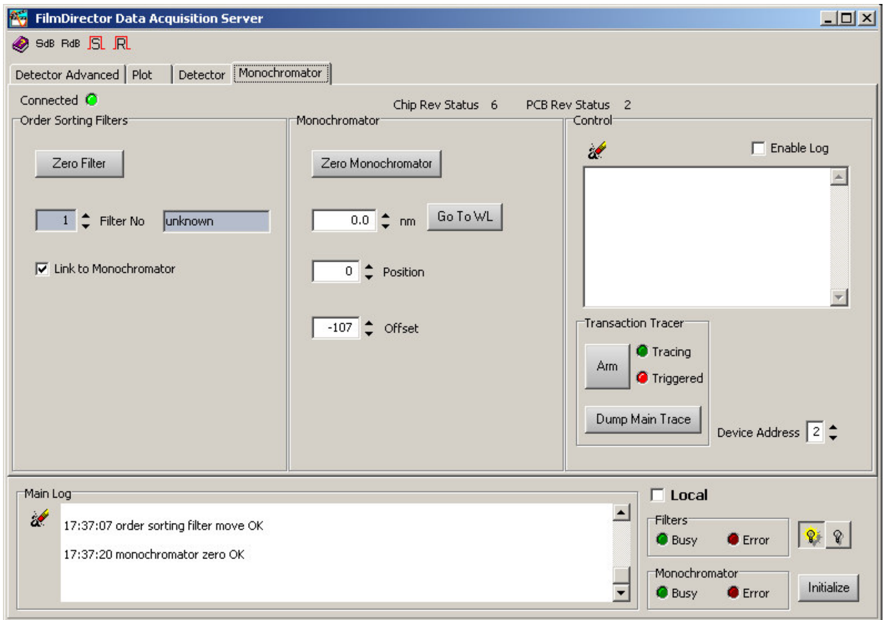
⚠	*Caution*	Note that in this screen the majority of functions are for diagnostic purposes only, and must not be changed

The ONLY manual interactions allowed on this screen are:--

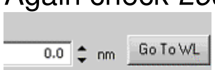
- Setting the *Calibration Point*.
- Checking (√) the *Show raw Data* box
- Checking (√) the *Local* box
- Using the *Calibrate Now* button.

Always remember to uncheck the *Local* box prior to closing the Dataserver in manual mode as this resets the link between the Dataserver and Film*Director* required for OMS automatic process operation.
Note at this point that the *Main Log* will indicate the current status of readiness of the detector module.

Click on the *Monochromator* tab, and the following screen will pop up;--

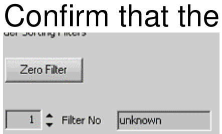


Again check *Local*. Insert a value of 1000nm in the *Monochromator* window



and press the *GoToWL* button. This will set the monochromator to the midband value suitable for the alignment process, and you will see a status report in the *Main Log*.

Confirm that the filter number on the left of the screen. This should not read



'*unknown'*. This indicates an error and you should exit the OMDS and reopen and start again.

Also confirm that the *Link to Monochromator* box is checked (√**)**.

⚠	*Caution*	Note that in this screen the majority of functions are for diagnostic purposes only, and must not be changed

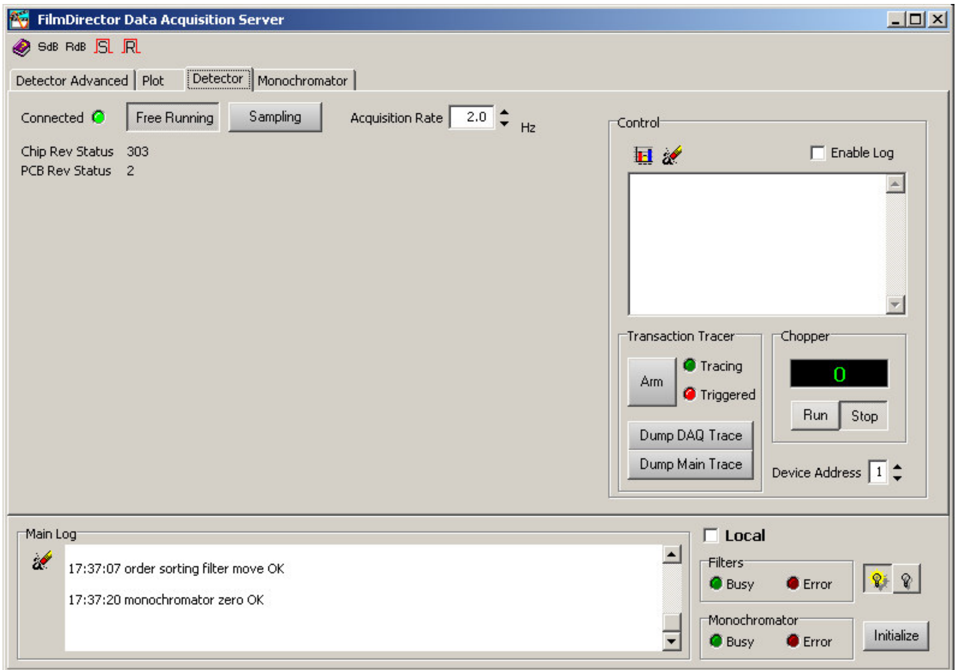
The ONLY manual interactions allowed on this screen are:--

- Using the *Go To WL* button.
- Checking the *Local* box
- Lamp *ON/OFF* buttons
- Post a value into the monochromator box (in the operational range 550-1600nm)

The OMS resets itself to zero on each start up. It is essential, that this screen is not exited before a value is posted into the wavelength screen and the *Go To WL* buttons is activated. There is a possibility that if this is not done the synchronisation between the monochromator and the filters will be lost. This is a problem with the current operation of the software which will be addressed in the next release.

Note you must remember to uncheck the *Local* box, to transfer control back over to FD after then manual operations are completed, otherwise FD will throw up an error in subsequent operation.

Click on the *Detector* Tab, and the following screen will pop up;--



Again check *Local* (√)
Make sure that the *Free Running* tab is selected. Set the *Acquisition Rate* to 2Hz

	*Caution*	Note that in this screen the majority of functions are for diagnostic purposes only, and must not be changed

The ONLY manual interactions allowed on this screen are:--

- Checking the *Local* box
- *Lamp ON/OFF* buttons
- Posting a value in the Acquisition rate box. (The maximum acquisition rate is 3Hz).
- The *Free Running* and *Sampling* tabs can be used. Ensure that the Free Running tab is activated before close down of this window.

Note you must remember to uncheck the *Local* box, to transfer control back over to FD after then manual operations are completed, otherwise FD will throw up an error in subsequent operation.

Return to the *Detector Advanced* screen.

At this point, with the source lit, you should be getting a reading on the reference meter. If there is no reading you should confirm that the optical fibre is correctly fitted. If it is fitted then remove the optical fibre carefully at the Detector module. Point the fibre at a card and you should readily see a patch of light. If there is no patch of light then open the chamber door and confirm that the Source module is operating by viewing obliquely to the axis of the Source module. If the lamp is operating then the problem is probably misalignment of the bulb and this will require adjustment of the bulb as described in Section 5.

Having completed the bulb alignment we can now proceed to optimising the Source to test glass to Detector alignment.

This is best done in subdued lighting and using a piece of tracing paper you should be able to locate the light patch from the Source. The patch should be between 10-12mm in diameter and evenly illuminated across the full area.

If the illumination is uneven or the shape is non-circular, this needs to be investigated before progressing further with the alignment procedure, and will require the bulb to be realigned to provide a circular uniformly illuminated patch exiting from the Source module.
Before resorting to bulb realignment confirm that the poor shape is not caused by shadowing from objects in the optical path or by debris collected on the vacuum windows. The sacrificial cover slip which rests on the inside of each optical feedthrough can be removed if required to help trace the light path during the alignment operation, but must be replaced before coating is undertaken.

Trace the light path from the IL550S module. Obtain the correct light path by adjustment of the body flange to the feedthrough at the Source module. The flange screws, which are all hex head, are shown in Figure 12.

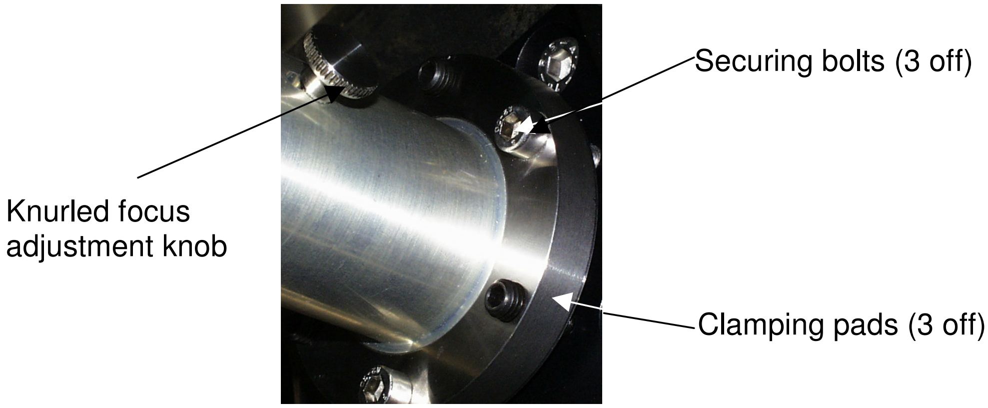


Figure 12 Source & Detector flange connector to chamber.

The flange rests against an O-ring which in turn seats on the face of a precision metal wedge to provide coarse optical alignment in the coater.
All securing screws should be backed off slightly, and the clamping pads withdrawn from contact with the mechanical wedge to allow the Source module to be moved to achieve the correct alignment of the beam centrally onto the test glass. The module should then held as closely as possible to the correct alignment and the securing screws adjusted progressively to take up any free movement and to put the O ring under a reasonable degree of compression. The clamping pads are then tightened progressively against the face of the wedge to provide very fine adjustment.

At this point check the alignment and if necessary back off the screws slightly and make small adjustments. Finally the locking screws can now be progressively tightened in turn until the Source module is locked.

Warning	Over tightening adjusters will have an effect of distorting the O-ring and may potentially reduce the OMS's isolation from mechanically induced noise.

Note at this point that the light patch size at the test glass should be around 10-12mm. The open clear aperture of the test glass should a minimum of 18mm (the clear aperture on Intellevation supplied test glass changers is a minimum of 18mm). Although the beam diameter is 12mm, there must be some allowance built-in for a small misalignment of the beam as a result of coating chamber dynamics, since any overspill of the light onto the metalwork of the test glass changer for example will cause a significant loss in OM signal and therefore error in monitoring. The light patch must be centralised on the test glass and any overspill onto the metalwork eliminated during the set up phase.

The light patch from the test glass (either in reflectance or transmittance depending on configuration) now needs to be traced onto the entrance port of the detector module, and centred on this port. A useful aid at this point is a circular disc of paper with the same internal diameter as the optical part of the feedthrough (and with a central scribed circle of around 15mm diameter). By placing this aid in the entrance window of the detector module it is possible to accurately centre the beam. The centration is achieved by adjusting the tilt of the test glass (or in the case where an Intellevation test glass changer is fitted by use of the external tilt adjuster provided).

Coarse alignment is achieved when the light patch centred on the test glass also falls in the centre of the detector module window.

Remove the centration aid.

Fine Optical Alignment Procedure

Having completed the visual alignment in the chamber, the next stage is to review the on screen display.
At this stage, on the *Detector Advanced* screen, the *log* will display the following messages (or something similar).

> ***9:13:48 PM lamp on***
> ***9:13:59 PM order sorting filter move OK***
> ***9:13:59 PM monochromator move OK***

Change to the monochromator control page by clicking the *monochromator* tab.
Enter 1000nm in the wavelength edit control and click the *GoToWL* button.

When the system indicates it has reached wavelength by extinguishing the *busy* LED, click on the *Detector Advanced* tab to reopen the *Main Detector* page.

Set the *Calibration point* to the value you expect from the test glass in the chamber (eg 4% for a single surface uncoated glass with a greyed rear surface, 96% to 100% for a front surface metal coated reflector).

Now click the *Calibrate now* button, and wait for approximately 10 seconds. You will be advised in the dialogue box when the calibration is complete.
If the energy throughput is adequate for both signal and reference meters then both the *energy* LEDs will be lit green.

At this point the detector module needs to be fully aligned and this is done by checking the meter display for maximum reading. With the *Detector Advanced* screen in view, make small adjustments to the detector flange securing screws and the clamping pads on the detector module ONLY, as was previously undertaken on the source module, to optimise the signal path as seen on the meter display.

Both channel (reference and signal) LED's should be lit green. (Note the reference signal should not change during this alignment procedure). If either channel LED is red then the cause will have to be investigated.

At this point recheck the calibration value is correct and press the *Calibrate Now* button.
Wait for the meters to settle down and note the Signal and Reference attenuation.
Intellevation completed a similar calibration in the factory and by comparison with the factory results you can ensure that the basic operation and alignment of the OMS is correct.
If the attenuation value is very small (eg <=-2dB), indicating a poor optical signal in that path, you should recheck the bulb alignment, using the procedure in Sections 6 of this manual, and if this does not improve matters contact Intellevation for support.

If the reference level is OK, but the signal is inadequate then –

Check for and remove any obstructions in the optical light path. If the above measures fail, it will be necessary to contact Intellevation for support.

At this point it is recommended that the customer repeat the calibration at detector module band edge wavelengths (say 550nm and 1600nm) to ensure that Signal and Reference energies are adequate at these extremes. It would be expected following calibration at these wavelengths that the attenuation in each path will be much reduced but usable. A qualitative assessment of the noise present can also be judged by viewing the meter stability.

Optimising the alignment under vacuum

This stage of alignment will require that the operator be able to view the signal traces on the *Detector Advanced* screen on the monitor screen.

The signal at atmosphere should be noted and monitored as the chamber is pumped down. Inevitably there will be some change in the signal path caused by flexing of the chamber walls. The effect is much more pronounced where the OMS is fitted in Reflection mode and will be much less for Transmission mode.
In the reflection mode configuration therefore it may be necessary to make minor adjustments to the test glass changer orientation externally to bring the signal back to the original value. This will cause a slight offset of the beam when the chamber is at atmosphere, but there should still be a usable signal. If the signal disappears completely at atmosphere then the most likely cause is poor mechanical fixing of the test glass holder or poor reproducibility of indexing of the test glass, which need to be investigated. After the test glass changer has been reset to give optimum signal under vacuum. The reproducibility of shift should be checked by cycling the chamber to atmosphere and noting the signal reading on each cycle.
In transmission mode it is unlikely that there will be a significant signal swing between atmosphere and vacuum. If there is a significant change in signal then the security of the fixings of the of the transmission mode detector module should be checked and a module realignment performed if necessary.

Confirming system integration factors

Test1: The change in signal under vacuum when the test glass changer is indexed should also be noted and this will confirm the reproducibility of the seating of the test glass.

Test 2: The effect on the signal of the rotation of the calotte should be checked by noting the signal change for a fixed test glass, when the calotte is off at half speed and run at full speed.

Test 3: The effect on the signal of running plasma sources and quartz heaters should be checked by switching these sources on and running up to full power while monitoring the OMS signal. There should be no change to the monitor signal.

Note: That although the OMS is highly immune to background light sources that it is possible that the detector may be seeing a very high background which will limit the dynamic range of the detector and cause saturation during monitoring. For this reason it is recommended that the background light sources are pointed away from the detector module where possible.

4. Digital I/O Interface

Introduction

Intellevation provides extensive programmable I/O capability on the computer. The rear connection of the IO is shown in Figure 13. There is one I/O card fitted output to a 37 way ‘D’ type connector. Additional OM computer IO card/s can be fitted by the customer onto the motherboard, where additional IO is required. The software automatically identifies additional cards, which are programmed in the same way as for the Intellevation supplied card.

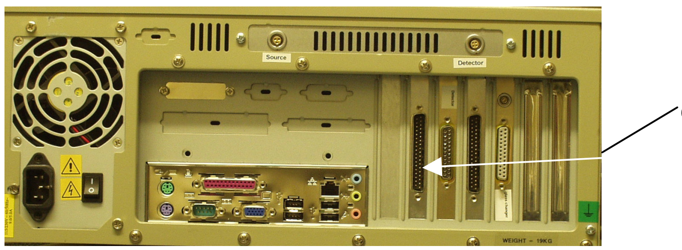


Figure 13. Rear view of Computer

The I/O pin configuration is shown in Figure 14.

The I/O is programmable through the IODS executable.

The dedicated pins used by are also shown in Figure 14. These are pins 6,7,8,9,10,11, 18 and 19.

The remaining pins are programmable by the user.

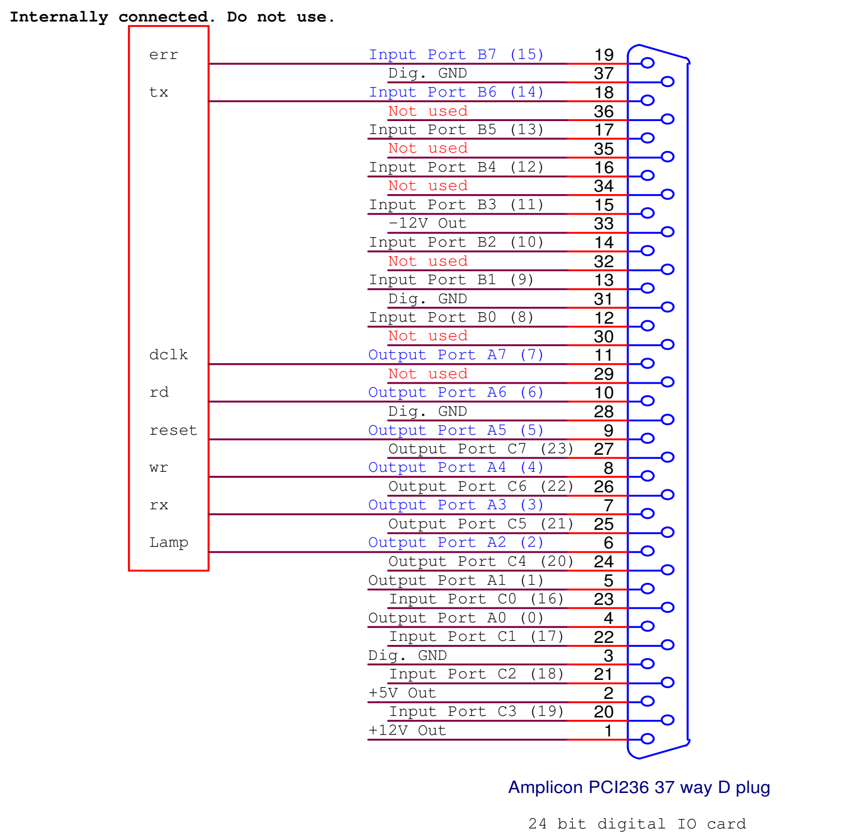


Figure 14. Digital I/O interface for the IL541 computer

Digital I/O Data Server (IODS)

The IODS provides a user interface around the digital in/out ports. It allows the user to verify the operation of the digital I/O hardware. It also provides an editor for modifying the properties, and the mappings associated with the I/O hardware. In normal operation, this module is minimised to the system tray and the WLOMDataServer interfaces to it without the need for user intervention. However, it can be opened at any time by clicking on the icon in the system tray.

An aid to programming the digital I/O is provided by Film*Director* 's main control state diagram

Only a subset of the controller's states and commands are made accessible to the outside world. Commands and Status's intended for the IODS are mapped to the tags of its virtual ports. A virtual port tag can be freely associated with one or more physical ports within the restrictions imposed by hardware, eg a hardware port which is fixed in direction as an input, cannot be mapped with virtual port tag which is an output by nature.
The IODS groups all digital I/O resources provided by the cards it finds installed on the OMS computer bus. It provides a drop down list of the virtual port tokens and configuration allowable for each digital I/O line.
The IODS handles the logical sense of each line. Thus *mcGo* is always asserted or negated , and whether this represents 0V input or 5V input depends upon the configuration set for the line in the IODS.
The IODS also configures whether an input line is either edge or level sensitive, and whether an output is steady state or monostable. It also provides configurable deglitch timing for inputs, and minimum pulse width for outputs on a line per line basis.

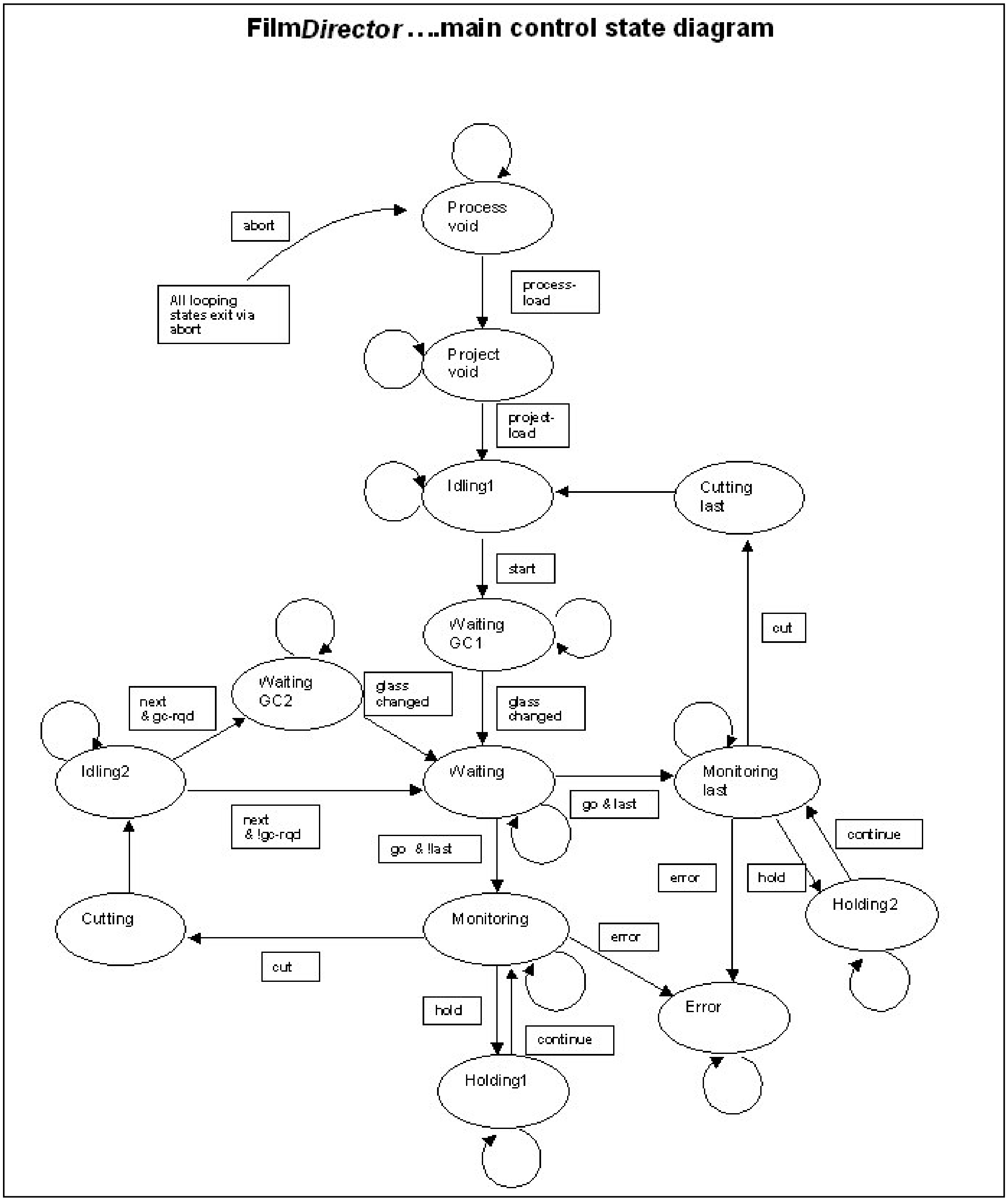
Inputs

State Input	Button Name	DIGIO Tag
Process-load	None	not mapped
Project-load	None	not mapped
Start	Start	McStart
Go	Go	McGo
Last	None	Not mapped
Hold	Hold	McHold
Continue	Continue	McContinue
Cut	Cut now	McForceCut
Next	Next	McNext
Abort	Finish	McAbort
Error	None	not mapped
Glass-changed	Glass-changed	McGlassChanged
Gc-rgd	None	Not mapped

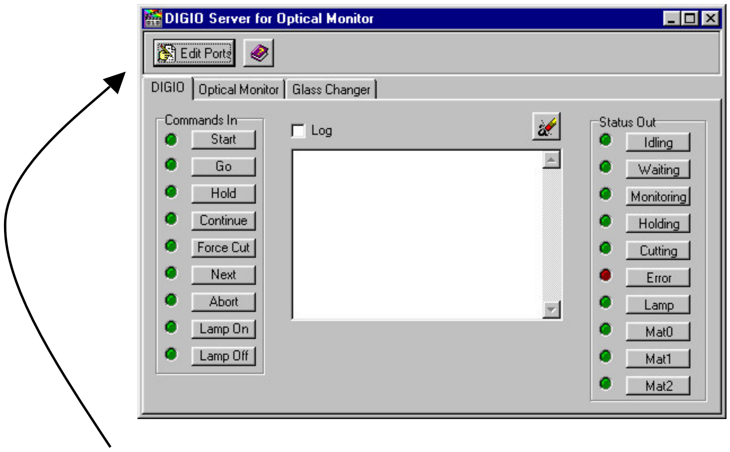
Outputs

Machine State	DIGIO Tag
Process-void	not mapped
Project-void	not mapped
Idling1	MsIdling
Waiting	MsWaitingForGo
Monitoring	MsMonitoring
Monitoring-last	MsMonitoring
Holding1	MsHolding
Holding2	MsHolding
Cutting	MsCutting
Cutting-last	MsCutting
Idling2m	MsIdling
Error	MsError
Waiting-GC1	MsWaitingForGC
Waiting-GC2	MsWaitingForGC

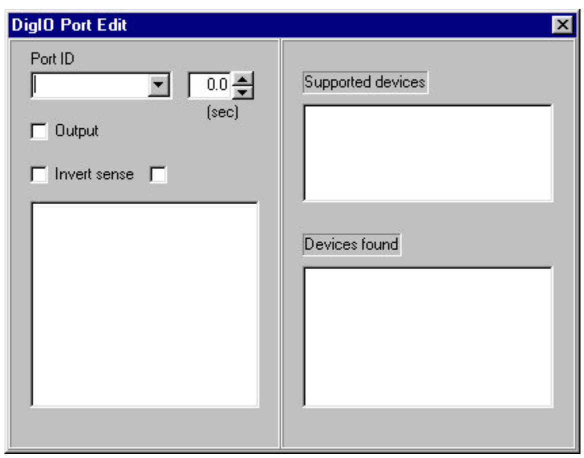
The Film*Director* main state control diagram is an aid to understanding how the state machine functions.



In order to edit the I/O the following sequence must be followed.



Press the ***Edit Ports*** tab.
If permission is denied. Go to ***START: RUN***
Type “regedit” in the field and then press return .
Choose *HKEY_LOCAL_MACHINE\SOFTWARE|Intellemetrics Ltd\DIGIOServer*
Double click on the *PERMISSION to EDIT* field. Type ”0”=inhibited, “1”=OK to edit.
Exit “regedit” and the ***Edit Ports*** is enabled.



The supported device should read Amplicon OM COMPUTERI236

Warning	Please note that when you exit the *Edit Ports* tab the ports will be set to the newly programmed values.

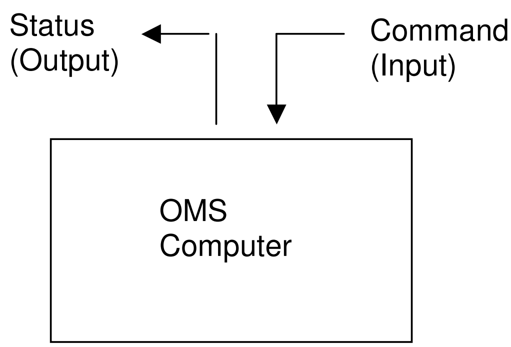
The original configuration of ports set at the factory is on file at Intellevation and can be supplied if required.

Inverse sense changes the signal from positive going to negative going or vice versa. The *(sec)* setting defines the length of the pulse.

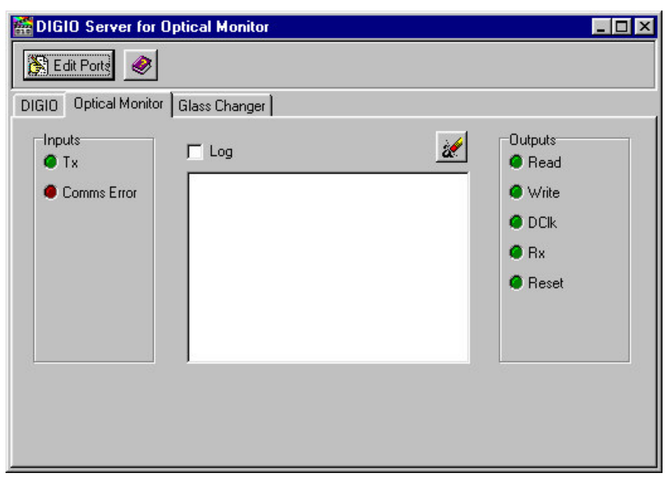
The nomenclature used is as follows.
mc……………... is a "machine Command" INPUT to the OMS.
ms………………is a "machine Status" OUTPUT from the OMS.

The process of allocating ports is achieved by first calling the port ID and then allocating the function to the PORT by checking ✓ the appropriate function.

A definition of the STATUS functions can be found in Film*Maker* help.



Port Identifiers include I/O card connection 0 to 23 in brackets, as shown in the user manual and two character Amplicon designation (eg B0).



5. Operation

Introduction

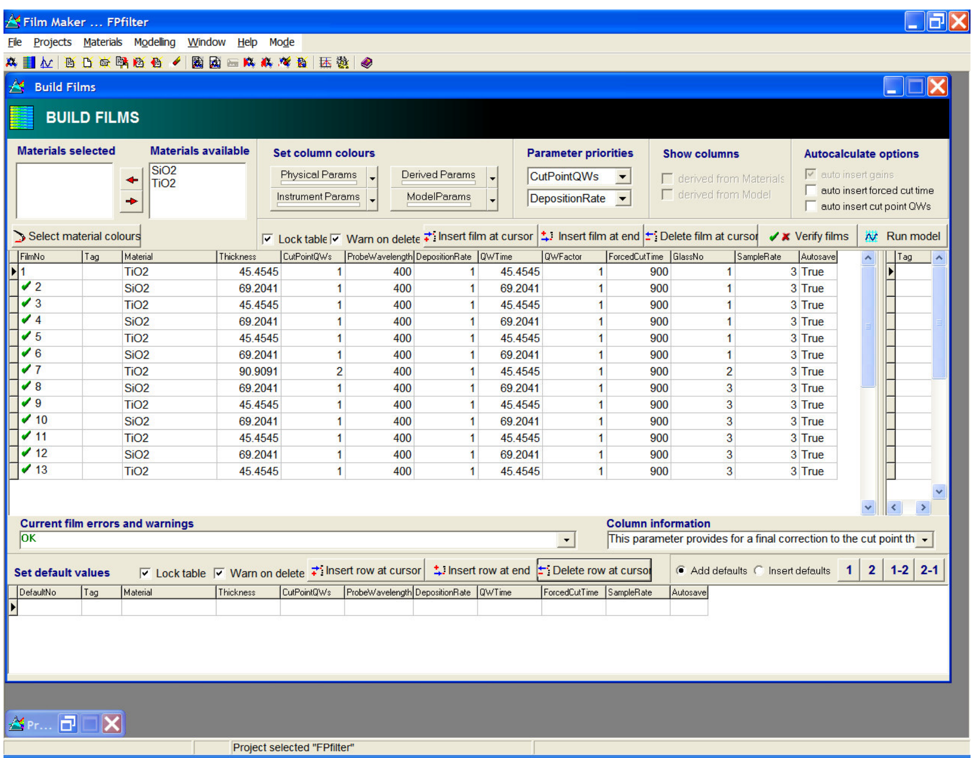
Having completed the installation in Section 3 and completed the IO interconnectivity to the coater the IL553 OMS is now ready to be programmed for a deposition process.

The main operational software provided on the IL553 are Film*Maker*  and Film*Director* .

Film*Maker*

The BUILD FILMS screen, shown below, is at the core of the Film*Maker* database software. This screen allows the user to programme the vast majority of the parameters required for operation of the Intellevation OMS.
These parameters are:
The film sequence and optical characteristics of the films and CUT position.
The instrument parameters such as wavelength filters, delays acquisition rates etc.
The test glass changer sequence
Following on from this Film*Maker* will check for valid data, predict the OM signal swings, and allow off line simulation of the process for optimisation of the final project.
The Film*Maker* project is then saved on line for later retrieval.

A Film*Maker* screenshot is shown below:

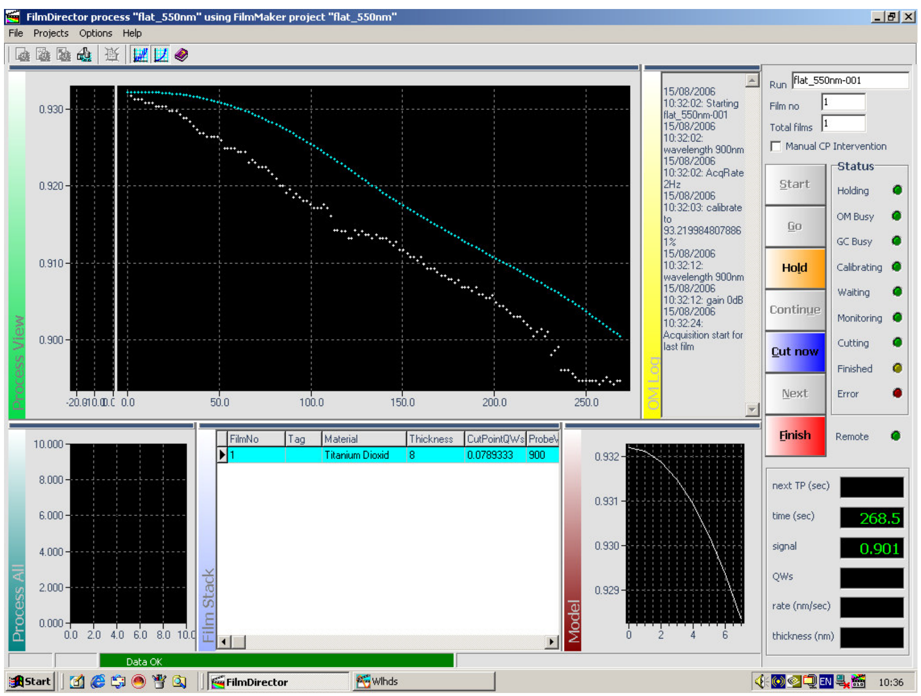


The key features are:--
Film*Maker*

- Database programme providing a single screen for entry of all process variables.
- Provides a logic check on entered data.
- Provides a signal modelling capability.

For a detailed explanation of Film*Maker* software, please read the relevant sections of the Intellevation Software training manual.

Film*Director*
Film*Director* is the real time processor. A Film*Maker* project is loaded into Film*Director* at the point where the coating process requiring optical monitoring is to be undertaken. Through the OMS computer communicating via IO with the process chamber PLC, QC controller and test glass changer where fitted, Film*Director* will initiate the monitor process and provide CUT outputs and progress through the film stack without the need for manual intervention. At the completion of each film the data collected for the film is saved to file for later analysis. At any time during the process through the OM can be commanded to *PAUSE/RESUME*, or *CUT* by manual intervention of the operator.



Film*Director*

- Provides a real time display of process.
- Provides a cut signal at termination.
- Interfaces through programmable I/O with the customer system controller/s.
- Collects run data for subsequent analysis.
- Automatically sequences through to completion of multilayer processes.
- Segmented display, allowing up to five screens

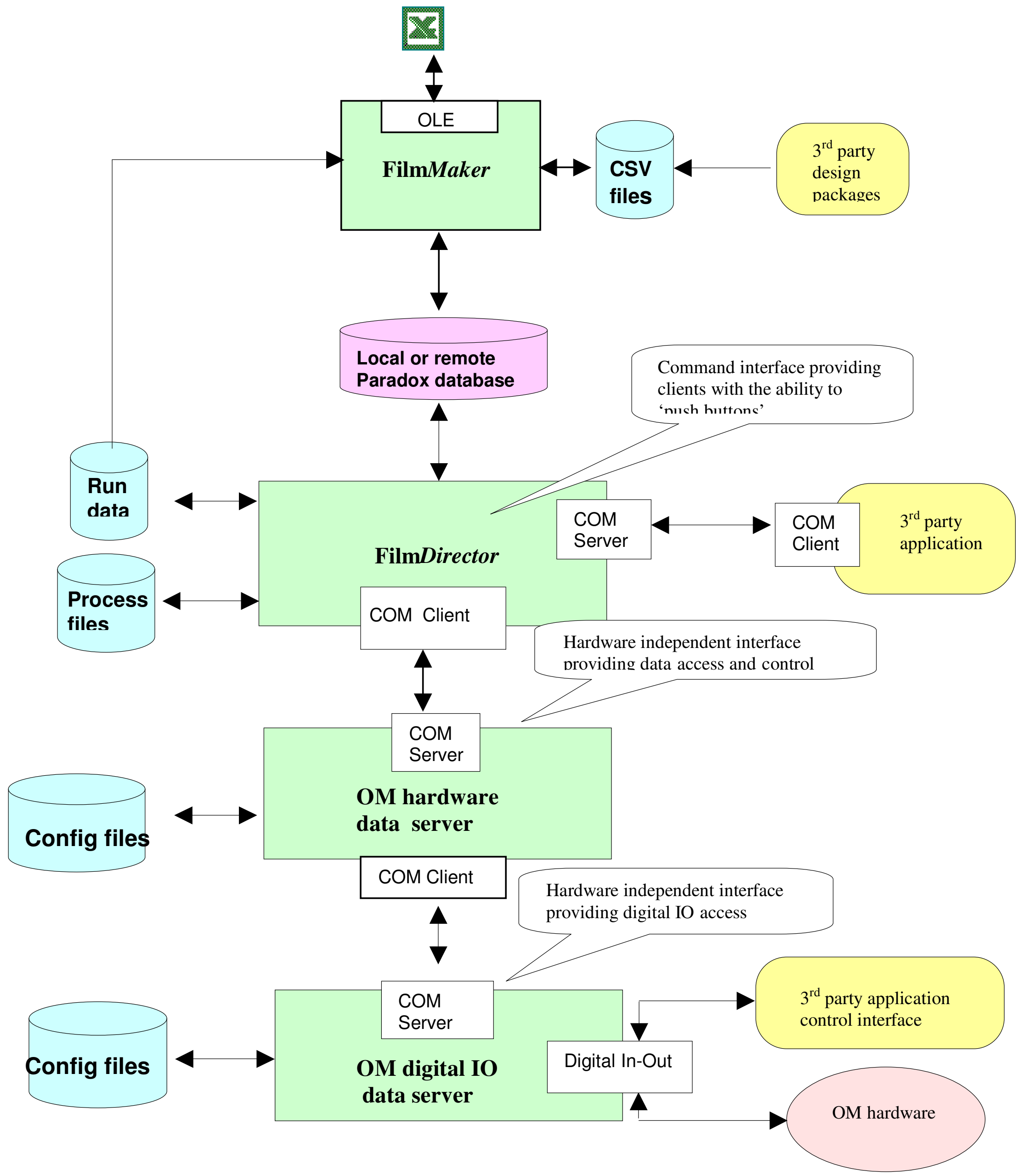
For a detailed explanation of Film*Director*, please read the relevant sections of the Intellevation Software Training manual.

Starting the Optical Monitor Mode

Detailed help is available in the on-line help of Film*Maker* and is in process of being written for Film*Director*.
The start-up process is as follows:

- Switch on the computer by pressing the ON/OFF button inside the front panel and wait for computer to boot up.
- If there are any errors follow the on-screen prompts.
- Open Film*Maker* by clicking on the icon  in the centre of the screen.
- Start a new project, and programme-in a recipe (coating design).
- Verify the project by clicking on the **verify films** button.
- Model the project by clicking on the run model button.
- Close Film*Maker*.
- Open Film*Director* by clicking on the icon  in the centre of the screen.
- Create a *New Process*, and associate it with the Film*Maker* project just created.
- Click the *Start* button and the parameters for the first film will be loaded.
- Click the *Go* button and the optical monitor will commence data acquisition displaying the optical signal to the *Process View* window.
- If the IL553 has been connected to the main system controller, then step 10 and 11 will be carried out automatically, as will be the final cut when the film has achieved the required thickness.

Software Structure



Apart from Film*Maker* and Film*Director* there are two other executables that make up the working software –

WLWLOMDataServer (OMDS) provides a user interface around the optical monitor hardware itself. Basically this module acts as a 'virtual instrument' front panel by means of which the user can directly interact with the hardware. In normal operation, this module is minimised to the system tray, and Film*Director* interfaces to it, without the need for user intervention. However, it can be opened at any time by clicking on the icon in the system tray.

DigitalIODataserver (IODS) provides a user interface around the digital in/out ports. It allows the user to verify the operation of the digital IO hardware. It also provides an editor for modifying the properties, and the mappings associated with the I/O hardware. In normal operation, this module is minimised to the system tray and the WLOMDataServer interfaces to it without the need for user intervention. However, it can be opened at any time by clicking on the icon in the system tray.

Film*Maker* can be opened or closed as required in order to create a new project, or to edit an existing one. However, when Film*Director* loads a project, the database is locked to prevent changes occurring during the process run. Thus Film*Maker* cannot open that particular project, but is free to open any other. Conversely, Film*Director* cannot open the project currently open in Film*Maker.*

When Film*Director* opens, it takes care of starting the WLOMDataServer, which, in turn, takes care of starting the OMDigitalIODataserver. These latter two modules will be seen to open and immediately minimize to the system tray. Once the system has been configured, the user should have no need to interact with them.

Monitoring The Deposition Process

It is normal practice that the customer system controller will perform the entire basic pump down functions in readiness for the coating deposition to start, including ramp up of sources.

The system controller sends the IL553 a <*Start*> command via the digital I/O when it is ready to proceed. The optical monitor loads the parameters for the first film, and awaits a <*Go*> command,

At the point where the deposition is to proceed, either by the opening of a shutter over a thermal source or power being applied to an ion beam source, for example, a <*Go*> signal is sent via the digital I/O from the system controller to the IL553 OMS to indicate that deposition is starting, and the IL553 controller is activated to initiate monitoring.

Once into monitoring mode the IL553 OMS will provide the <*Cut*> command necessary to close down the source or close a shutter, and the data collected for that film is saved.

The IL553 then awaits a <*Next*> command before loading the parameters for the next film in the stack.

The IL553 then waits for the <*Go*> command from the system controller to indicate it is to restart monitoring. It then proceeds through to <*Cut*>, awaits <*Next*>, loads the next film parameters and so on until the entire stack has been processed.

Error Indications

Errors in the operation of the Film*Director* software are indicated on screen. Where these are not self-explanatory, contact Intellevation for support.

Switch off the IL553 OMS

The OMS Computer must be switched off by going to the Windows start menu and closing down in the normal way.

⚠	*Caution*	Do not close down using the computer front panel or rear panel switches until the software has been closed.

6. Maintenance

Bulb replacement & Source Re-alignment

Bulb Replacement

Step1). Power down the Intellevation OMS.
Ensure that the Source module end cap is sufficiently cool. Remove the electrical lead at the end cap. The end cap is held in place by a bayonet fitting. Before removing the cap, note the position of the cap relative to the body.

Step 2) To remove the end cap hold the main body of the Source Module in one hand and rotate the end cap anticlockwise (viewed from the end cap) pushing gently at the same time in the direction of the main body to release the cap. See Figure 15.

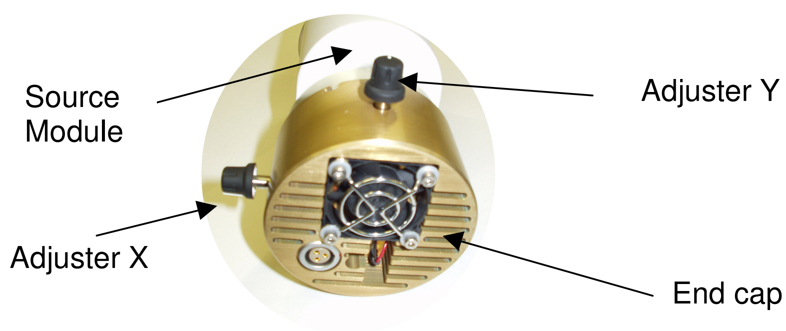


Figure 15. Source Module cap

Caution	Note the orientation of the adjusters viewed from the end cap with the curved cover of the source uppermost. One adjuster is at the 12 o'clock position and the other at the 9 o'clock position. This is the only correct orientation of the end cap

Step 3) The faulty bulb should be removed from the ceramic holder and disposed of, see Figure 16.

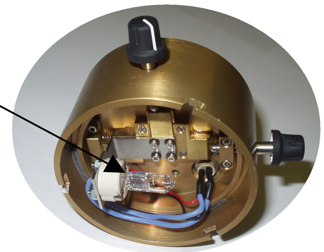


Figure 16. Source Module End Cap detail

Fit a new bulb in the holder avoiding skin contact. The recommended replacement bulb is a quartz halogen filament bulb manufactured by Gilway part number 7404. This bulb is specified as 12V 20watt with an output of 350 lumens and a lifetime of 2000hours. Contamination of the bulb envelope can seriously restrict bulb lifetime. If you are in any doubt gently wipe the surface of the bulb with an alcohol-moistened tissue to remove contamination

⚠	***Caution***	Avoid skin contact with the bulb envelope as this can seriously reduce its working life.

Step 4) Place the bulb in the ceramic holder and push gently home ensuring that there is no gap between the bulb base and the ceramic holder. If there is a gap, then the bulb leads must be trimmed accordingly.

Step 5) Replace the bayonet end cap, ensuring that the cap is returned in the same orientation to the main body.

Step 6) Reconnect the source cable.

Signal Optimisation

Open the OMDS screen to monitor the signal and reference levels with an appropriate test glass fitted,
Firstly using adjuster both adjusters on the source module, look into the source module and optimise the viewed brightness. Operating the Y adjuster whilst viewing the screen, get a signal of around 1000 on the reference meter at -20dB in the OMDS screen. Then use the X adjuster to maximise the signal path until it begins to affect the reference. Finally check using a piece of card that the shape of the beam exiting the source module is circular and evenly illuminated.

If these conditions are not satisfied repeat the bulb alignment procedure.

Inspection of Vacuum Windows

Visually inspect the internal surfaces of the vacuum port windows regularly for overspill coating.

Cleaning of outer source/detector test glass

The outer cover glass on both the source and detector modules will collect coating deposits over a period of time, thus obscuring the light path. When this occurs the cover glass should be removed and the coating deposit removed. After several cycles of cleaning the cover glass may become scratched and this will also affect monitoring performance. In this event the monitor glass will need to be repolished or a new cover glass fitted. A silica cover glass is supplied. However as an alternative a borosilicate glass replacement will offer similar optical performance. To help slow down the coating of the cover glass, attach a piece of tubing to the inside of the viewport.

Optical fibre

The optical fibre provided has a long end and a short end and the long end can only be inserted in the source module. The short end is inserted into the detector module. If the optical fibre is disconnected, the ends of the fibre must be protected from dirt ingress. If contaminated the fibre can be cleaned by dragging an alcohol wetted tissue across the face.
In a similar way the fibre entry points in the modules must be protected from dirt ingress when the fibre is disconnected.

Check the Electrical Connections

Inspect all the electrical connections to the IL553 OMS and check that they are secure. Inspect all electrical cables and wires and check that they are not damaged. Replace any cable or wire that is damaged.

Replace the fuse

No replaceable fuse is provided on the OMS Computer.

Replace the computer filter

Every 6 months check the condition of the computer filter. If the filter is dirty then replace the filter.

- Ensure the computer is switched OFF.
- Remove the filter from inside the front panel see Figure 17 below.
- If the filter appears dusty replace it with the spare provided.

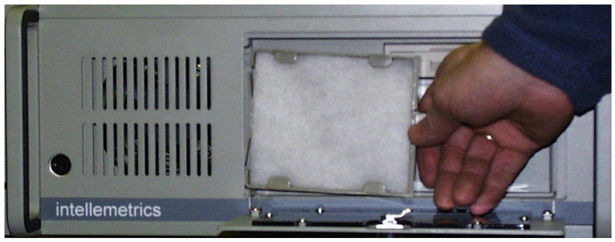


Figure 17. Removing/replacing the OMS Computer filter

Motherboard Battery backup

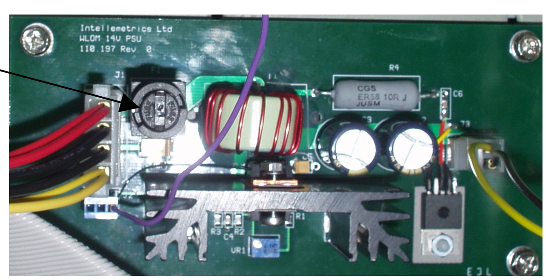
The OMS Computer motherboard is fitted with a ROM battery backup. This is not a user serviceable part and should operate satisfactorily for several years without attention. If you suspect that there is a fault you should contact Intellevation.

Fuses

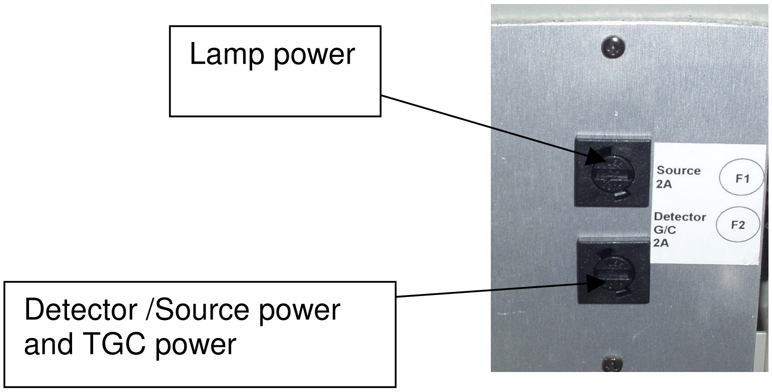
There are three fuses located inside the OMS computer, which protect a) the secondary 14V power supply and b) the circuits supplied.

The fuse (no 0) mounted on the PCB, shown below, protects the 14V board. The rating is 3 amp.

Fuse No 0



Fuses 1 and 2 on the back of the upright behind the case fan protect the source (lamp) and the detector and test glass changer power outputs respectively.



As soon as the OMS computer is powered up, the respective output voltages will appear at the back panel of the OMS computer at the Lemo style power output connectors.
Confirm the voltages are present at these connectors.

If there is no voltage available then power down the computer, remove the cover of the computer and inspect the fuses.

If a fuse is blown then firstly check cabling and connections to make sure that the short is not internal in the cabling and then proceed to replace any faulty fuses with fuses of an identical rating.

7. Storage and Disposal

Storage

If the IL553 OMS is to be stored, return it to its protective packaging and store in clean, dry conditions. When required for use, install the IL553 OMS as described in Section 3.

Disposal

Dispose of the IL553 OMS and any components in accordance with all local and national safety and environmental requirements.

8. Spares

The following spares are available from Intellevation to support the IL553 OMS.

Description	Part Number
Optical feedthrough body	131.331
PTFE anti scratch washer	131.333
Window retaining cap	131.334
Feedthrough nut	131.332
Feedthrough washer	131.306
Spare quartz halogen bulb	M35 12V 20 watt L7404
Spare dust filter for Computer	TBA
5 metre detector signal to computer cable	WLOM25W
5 metre detector power cable	WLOM4W-5W
3 metre synchronisation cable	WLOM9W
5 metre optical fibre assembly	Low OH silica
5 metre source power cable.	WLOM3W
Vacuum window (Infrasil)	TBA
O-ring seal at vacuum window of feedthrough	BG 45 18-0396-24

9. IL553 Optical Monitor Configuration

Customer: Tecport Optics
Customer Order: 2361
Intellevation Job Number: Int06/1242

Item	Details
Model	IL553 OMS
Computer S/N	1000236
Film*Maker* software version	Version 1.0.5 build 116
Film*Director* software version	Version 1.0.1.build 31
Display	SVGA 1280x1024 (not supplied)
Detector	TE cooled Si-/InGas
Detector Module IL553	S/N 1000240
Source Module	S/N 1000241
USB Port Key (DesKey)	S/N 15117
Supply Voltage	115/240VAC
Mains Cable	1
Detector Signal Cable	1
Detector Power Cable	1
Source Power Cable	1
Synchronisation Cable	1
Reference optical fibre assembly	1 Low OH silica
I/O Card	2
Lamp	Gilway L7404
Monochromator	500-1650nm
User Manual	1
Optical feedthroughs	2
Feedthrough nut tool	1
Steering wedges	2
M8x20 socket headed screws	N/A
Windows 2000 User Licence	1
Sacrificial window for feedthroughs	2

Appendix A: Guidance on Intellemetrics Filter Options

A1 Introduction

Intellevation optical monitor systems (OMS) measure the optical signal, either in Transmission through or Reflectance from a test glass in the coating process.

The Intellevation OMS will provide termination of all layers programmed into the OMS. However the highest termination accuracy is achieved on layers which are multiple quarter waves, and as a general rule the OMS should be programmed with this in mind.

In order to provide accurate termination in the presence of system noise, which is always present to a degree on all coaters, Intellevation provide a set of noise filters and associated termination algorithms. These are user selectable and optimisation of these filters will largely determine the degree to which the deposited coating on the test glass will replicate the design programmed into the OMS. This document sets out some guidelines to filter setting from which the user can rapidly “home in” on the best filter options.

The Intellevation OMS provides signal amplification and user selectable filtration to smooth out any noise present in the signal. The main benefit of filtration is in improving the reliability of the termination. On the negative side some filters introduce a phase delay in the monitored signal that results in late (but reliable) termination.

Other filters are more predictive and the phase delay introduced by their use is very small.

As a general rule of thumb, the best results are achieved when the filters are reduced to a point where the filters are just set high enough to prevent system noise from causing unreliable termination of layers.
However on a new process the best way of achieving success is to initially set a high level of filtration, to ensure that the OMS proceeds through the process error and on completion to reprocess and then repeat the coating with the reduced filter set.

The filter/algorithm options available on Intellevation OMS’s are discussed in detail below with guidance as to their use and application.

A2 Normal Filter (linear)

The sinusoidal data stream coming from the detector has a fundamental frequency associated with it, which can be derived, at setup, from the estimated quarterwave time. The filter needs to pass this frequency and reject higher frequencies.
A normalised setting of 1.0 would achieve this perfect filtering, but, unfortunately, the consequential phase delay would be far too large.
To get workable phase delays, we normally have to use settings of 7.5 or higher (ie cutting off frequencies 7.5 times the signal fundamental and higher). The simple algorithms require more filtering (7.5 to 15) than the curve fitting fitter algorithms (25 to 100) discussed in Section A4 and A5.
This is a Simplex algorithm that looks for a number of sample points (as set in the Film*Maker*'s *Filter Threshold* column) to be distributed across an extremum. For example, when *Filter Threshold* equals five, then a maximum will be detected if two points are going up slope, two going down slope, and the remaining point is at the top. Increasing the *Filter Threshold* improves the ability to reject noise spikes, but a phase delay of at least half the *Filter Threshold* setting is inevitable.

The data set must be monotonic, ie that is smoothly increasing to the maximum, then smoothly decreasing to the minimum and so on, with no backward steps. This demands quiet data, which often means high levels of filtering and thus phase delay.

A typical starting set up would be:--

Samples per QW =	100
Normal=	10
Filter Threshold=	5

A3 Filter Crossing (two linear filters)

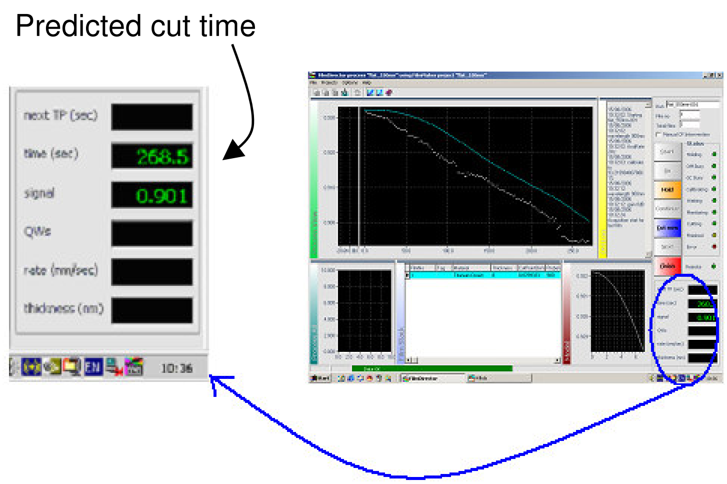
This employs a second Normal filter that runs faster than the main filter by the ratio set in the *Crossing Ratio* column.
The point at which one filtered signal crosses over the other occurs at a reproducible place after each extremum, and this is the CUT point.
The delay here is very consistent so that the error introduced is truly systematic and can be calibrated out.
The positioning of the crossover point is relatively immune to drifts in signal baseline, but does introduce a phase delay.
The higher the *Crossing Ratio*, the better the noise rejection, but also the greater the phase delay.

A4 Fitter 1 (quadratic filter)

Fitter 1 employs a parabolic curve fitter that operates on a queue of the most recent data points. It determines the position of the maximum from the equation of the fitted parabola. A turning point is detected when the time stamp of the most recent sample exceeds the time calculated for the extremum.
The size of the queue is set by the *Filter Buffer Size* column. The greater the buffer size, the better the inherent filtering of the fitter, and thus the better the ability to handle noisy data. However, typical OM curves approximate parabolic for only a limited extent either side of the extrema, so will give erroneous results if the buffer size is too large.
A good rule of thumb is that the buffer should be somewhere between one fifth and one third of the *Samples Per QW* column.

Because this algorithm inherently filters, the *Filter* column should be increased to very much higher values than you would use with *Normal* or *Filter Crossing* modes.
A good rule of thumb is to increase the *Filter* by a factor of at least the square root of the buffer size.

The fitter *Filter Threshold* parameter is applied to the goodness-of-fit, and thus sets the point at which the fitter will consider itself 'locked' to the incoming signal. Only for very noisy data is there any point in increasing this value.
The fitter is predictive, and 'knows' when an extremum is approaching. It writes its prediction of the time of the next turning point to the Film*Director* Process Screen as shown below.



Because the fitter is predictive, it has absolutely no phase delay. However, because it is being fed filtered data, there will still be the phase delay of the filter.

By setting the *Filter* some 10 to 20 fold higher than is usual, and compensating for the noisier data by using a large *Filter Buffer Size*, it is possible to terminate in this mode with almost no delay.

A typical starting setup would be:--

Samples per quarter wave =	400
Filter =	100
Filter Buffer Size =	100
Filter Threshold =	0.01

A5 Fitter 2 (quadratic filter)
Similar to Type 1 fitter with the exception that it works on the reciprocal of the data stream. The reason for this being, that in certain specialised cases, it fits over a wider extent at the extremum than the Fitter 1 algorithm, and thus allows larger buffer sizes to be employed without the size introducing errors discussed above.All four turning point detection algorithms are sensitive to noise spikes to some degree, and erroneously assigning a turning point to a noise spike effectively ruins the run. Because we know in advance the approximate timing of the extrema, it is possible to block out all turning points until one is due.

A6 Curve Follower

This filter option is not currently implemented on this product.

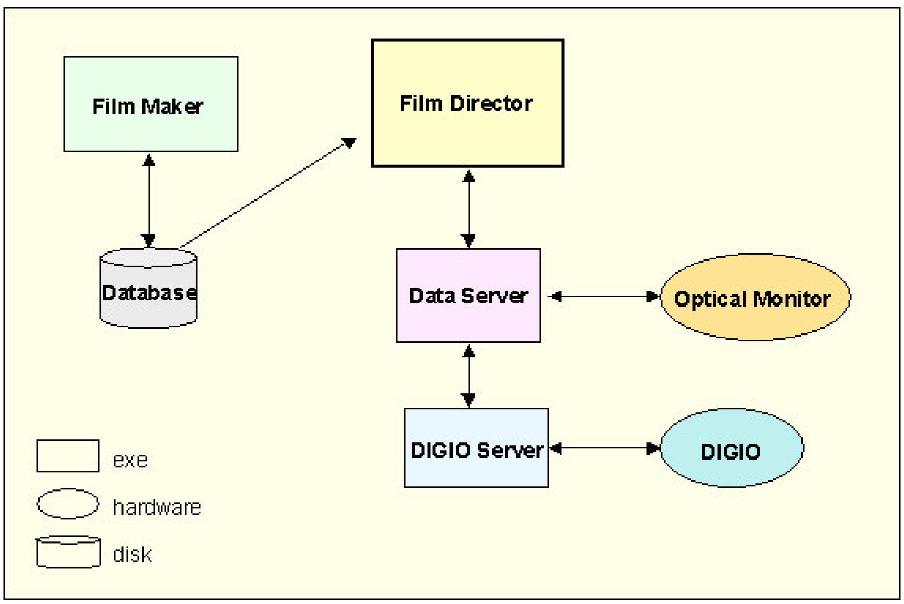
A7 Increasing the Robustness of Turning Point Detection

All four turning point detection algorithms are sensitive to noise spikes to some degree, and erroneously assigning a turning point to a noise spike effectively ruins the run. Because we know in advance the approximate timing of the extrema, it is possible to block out all turning points until one is due.
The *Holdoff* parameter sets the delay after the start of the run before the algorithm accepts a turning point. It is set in units of sample points.
The *Latency* parameter sets the interval after finding an extremum that must expire before another turning point will be accepted. It is set in units of sample points.
Although these parameters suppress the acceptance of turning points, they do not suppress processing, and thus the recovery from the *Holdoff* and *Latency* periods is instantaneous. For example if we have set 100 *Samples per QW*, we can happily set the *Holdoff* at 80 and still be sure of picking up the first extremum.

Appendix B: Introduction to Film*Director*

Film*Director* controls the operation of the optical monitors used by precision optical coating processes. It uses information stored in a database to set-up the instrument parameters of the optical monitor. This it does on a layer by layer basis. It also processes the signal returned by the optical monitor and, guided by parameters loaded from the database, will send a cut signal to the process controller when it determines a given layer has reached target thickness.

Film*Director* requires two other elements of software in order to function, namely, a hardware data server and a film-stack database. The first is a program which encapsulates the optical monitor hardware implementation being used, is started automatically by Film*Director*, and normally runs in the background. The second is a database which contains a comprehensive design and build specification for the filter being manufactured. This is normally output by a package like Film*Maker*.



In this example, Film*Maker* is used to load a design, verify its integrity and calculate the instrument parameters that the optical monitor will require. Film*Maker* can then be closed because all that is needed is now in the database.

When Film*Director* starts, it also starts the hardware data server (OMDS), which in turn starts the digitalILserver (IODS) that provides access to the hardware digital input-output lines which, further in turn, provide communication with the main process controller. The hardware data server sets up the optical monitor hardware and verifies that it is functioning correctly. The user connects Film*Director* to the database by loading the project just created by Film*Maker*.

When driven by the process controller, the commands appearing at the digital I/O interface cause Film*Director* to proceed stepwise from one film to the next, fetching the next set of instrument parameters as required, until the entire stack has been built. This orderly sequencing is one of the main roles performed by Film*Director*, and is formally defined in the Sequencer chapter.

The other major role carried out by Film*Director* is detection of a cutpoint condition. To do this, Film*Director* employs an identical analysis engine to that used by Film*Maker.* Projects set up and verified in Film*Maker* are transferred in their entirety when they are loaded into Film*Director*. There is no provision for altering parameters once they have been loaded.

Appendix C. Factory test results for the IL553 Optical Monitor

The IL553 optical monitor was tested for signal response at Intellevation before shipping.
The test optical path was in transmission, with a 5 test glass slides inserted in the path to mimic the Fresnel reflection losses expected in the vacuum windows, sacrificial windows and test glass in the customer chamber. The calibration data was derived for a metal front surface reflector in the test glass position. Intellevation will provide this test sample for confirmation of the results below.

The table of results is given below, and can be used as a check on the performance of the Intellevation OM and test glass changer in the chamber.

IL553 Final Test

Intellevation Ltd. **Bulb -:** gilway 7404

Doc No. 1001.0004 Rev 0

	Detector	Source	Computer
Serial Nos :	1000240	1000241	1000236

Date : **Customer** **Tecport Optics (IRDE)**

Det sw at 1035

Delays *Sig :* 0.01
Ref : 2.01
nCap : 0.95

Calibrate to 96% **Using** **Transmission (Glass X 4)**
Calibrate to 4% **Using**

	Sig 96%	Sig 4%		Ref		noise 96%	noise 4%	
Wavelength(nm)	Atten(-dB)	Atten(-dB)	Target	Atten(-dB)	Target	+/- %T/R	+/- %T/R	Blocked %
550	7.8	N/A	0.5	2.1	0.4	0.09	N/A	0
600	13.8	N/A	0.5	5.8	0.5	0.08	N/A	0
650	18.1	N/A	0.5	6.6	0.5	0.05	N/A	0
700	22.6	N/A	0.5	13.4	0.5	0.06	N/A	0
750	24.3	N/A	0.5	14.9	0.5	0.08	N/A	0
800	24.2	N/A	0.5	15.7	0.5	0.08	N/A	0
850	25.4	N/A	0.5	16.3	0.5	0.05	N/A	0
900	26.9	N/A	0.5	18.4	0.5	0.05	N/A	0
950	27.5	N/A	0.5	19.7	0.5	0.05	N/A	0
1000	26.4	N/A	0.5	18.8	0.5	0.05	N/A	0
1050	22.1	N/A	0.5	19.4	0.5	0.05	N/A	0
1100	24.9	N/A	0.5	22.3	0.5	0.05	N/A	0
1150	24.9	N/A	0.5	23	0.5	0.07	N/A	0
1200	24.5	N/A	0.5	22.8	0.5	0.07	N/A	0
1250	23.3	N/A	0.5	22.1	0.5	0.07	N/A	0
1300	22.1	N/A	0.5	21.7	0.5	0.06	N/A	0
1350	20.6	N/A	0.5	20.4	0.5	0.08	N/A	0
1400	18.3	N/A	0.5	19	0.5	0.07	N/A	0
1450	16.7	N/A	0.5	17.8	0.5	0.07	N/A	0
1500	15	N/A	0.5	16.5	0.5	0.06	N/A	0
1550	12.8	N/A	0.5	15.2	0.5	0.05	N/A	0
1600	10.4	N/A	0.5	12.9	0.5	0.08	N/A	0

Appendix D.
Calibration options available within Intellevation Film*Maker* and Film*Director* Software

Correct setting of the calibration options in the OM is a key to successful operation of the instrument.
Calibration is used to set the instrument signal path level to a known standard (the test glass). **Calibration is required when a test glass change takes place and also when the monitor (*ProbeWavelength*)** is changed, since either of these changes will affect the instrument response in such a way as to require recalibration.

Within Film*Director* there are two calibration possibilities within the Options drop down menu. These options are *Calibrate of Film 1* and *Calibrate on all films*.

D1. Calibrate on Film1

This feature is supported on Film*Director* software version 1.0.1 build 31 forward.

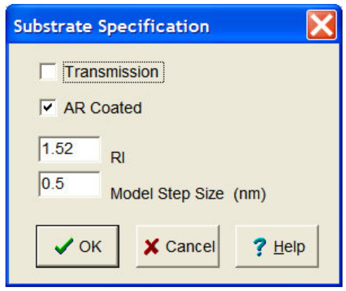
On opening Film*Director* go to *Option* in the top menu bar and tick *Calibrate on Film1.*

1. When the *START* command is given to the Intellevation OM, the detector module will index the test glass changer to a fresh uncoated test glass as programmed in Film*Maker.*
   (eg test *GlassNo* 1 as shown in the Film*Maker* project *teststack 5* below).

Teststack 5.proj

Material	Thickness	CutPointGWs	ProbeWavelength	GlassNo
TiO2	58.5106	1	550	1
SiO2	95.1567	1	550	1
TiO2	58.5106	1	550	1
SiO2	190.311	1	1100	1
TiO2	58.5106	1	550	2
SiO2	95.1567	1	550	2
TiO2	58.5106	1	550	2
SiO2	190.311	2	550	2

2. The monochromator grating will then be indexed automatically to the *ProbeWavelength* (550nm) associated with first film.
3. The OM will calibrate to the Fresnel reflection/transmission associated with the *Substrate Specification*.



4. In this case the refractive index n_s of the witness (substrate) is 1.52; the OMS is in reflection mode and the back surface is A/R coated and therefore does not contribute to the signal.

The calibration reflectance value used by Film*Director* is obtained from the equation.

$$R=((1-n_s)^2/(1+n_s)^2)^{1/2}= 4.26\%$$

5. The process (2) to (5) is repeated for all other *ProbeWavelengths* in the *teststack 5* (in the above case 1100nm).

6. The calibration results are automatically stored in Film*Director* for retrieval later in process.

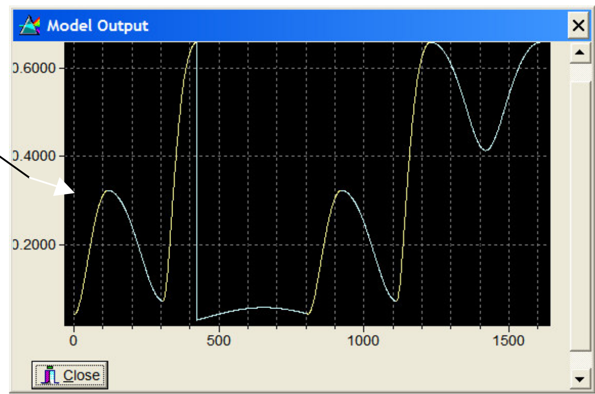
Summary of *Calibrate on Film1*

Calibrate on Film1, performs a calibration on film 1 as described above, after the START command is received by the optical monitor from the deposition system.
It also calibrates the OM at all other *ProbeWavelength*/s called up in the project, on this first test glass (*GlassNo* 1).
It does not repeat the calibration on any other films, even if there is a change of test glass.
If there is a *GlassNo* and/or *ProbeWavelength* change in the course of the process, then the relevant stored value obtained on *GlassNo* 1 is called up for each change of test glass.

D2. *Calibrate on all films*

This feature is supported on Film*Director* software version 1.0.1 build 31 forward. If the *Calibrate on all films* box is checked under *Options* then Film*Director* will calibrate before every film in the stack.
The value which is assigned to the calibration is the value predicted and stored in Film*Maker* from the *Model Output*. See below.

Calibration value for Film 2 if ***Calibrate on all films*** is checked in Film*Director*

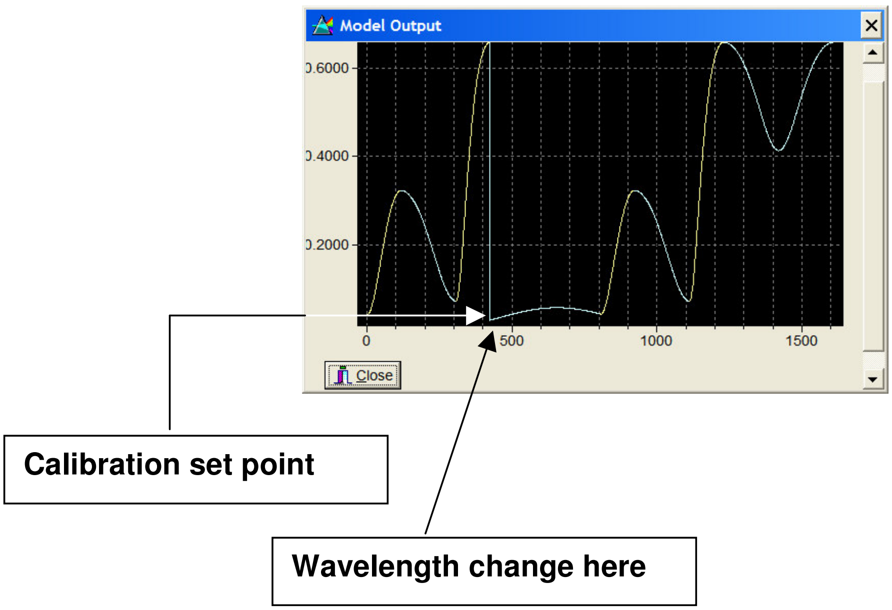


Summary of *Calibrate on all Films*
Film*Director* will recalibrate the OM signal on all films. This option should be used with caution since the recalibration uses the *Model Output* as the set calibration value. This will only be appropriate if the actual signal at the cut point is close to the model. The effect otherwise is to create a scenario where there is potential for bootstrapping of errors, dramatically increasing the build error in the filter.

Also in the case of QW cuts OM scheme, using *Calibrate on all Films* will effectively disable self-correction for CUT error which is a key advantage associated with QW cut. In some special cases of non-QW cut this calibration option has been found valuable.

D3. *ForceCalibrate* (programmable in Film*Maker*)

This function has now been introduced to Film*Maker* from Version-1, Build-5 Release-114 to allow a forced calibration, in response to the scenario where a change of wavelength is associated with multiple films on a single test glass. An example from the *Model Output* of the teststack 5.proj is shown below, where there is a wavelength change in film 4.



This allows the user to be selective and call for a forced calibration on Film 4 as shown in the Film*Mak*er project below.

Material	Thickness	CutPointDWs	ProbeWavelength	GlassNo	ForceCalib	De
TiO2	58.5106	1	550	1	False	
SiO2	95.1557	1	550	1	False	
TiO2	58.5106	1	550	1	False	
SiO2	190.311	1	1100	1	True	
TiO2	58.5106	1	550	2	False	
SiO2	95.1557	1	550	2	False	
TiO2	58.5106	1	550	2	False	
SiO2	190.311	2	550	2	False	

Forced recalibration recommended here

ForceCalibrate is programmed in the Film*Maker* project (not in Film*Director*). The *Calibrate on Film1* option should be ticked in Film*Director* also.

ForceCalibrate will cause Film*Director* to calibrate for all the films selected as *True.*

The forced calibrate will uniquely, among the calibration options, allow the user to calibrate on a test glass which has prior films, and a *ProbeWavelength* change is requested, for example film 4 above.
Following the wavelength change and on the *START* command, the OM will calibrate the signal to the predicted set point level previously obtained from the *Model Output.*

Summary of *ForceCalibrate*
This function is programmed in Film*Maker*, as an alternative to the calibration options available in Film*Director*.
Selecting *ForceCalibrate True* in Film*Maker* will cause the calibration to take place at the start of that film rather than at the beginning of the project.
It allows only those films that require calibration to be calibrated, thus minimising bootstrapping effects.