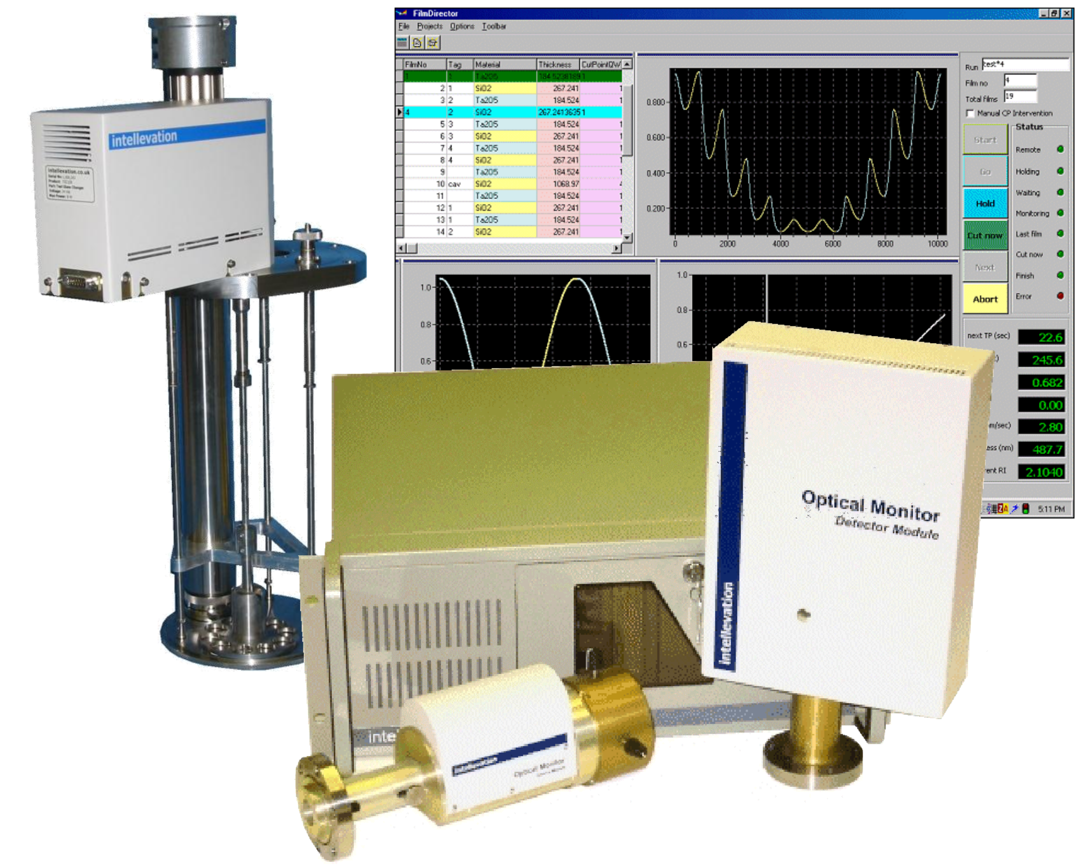
intellemetrics

IL55x Series

Dual Beam Integrated Optical Monitor Systems

for Precision Optical Coating



Integration Manual

For Intellemetrics Models
IL551, IL552, IL553, IL555 and IL563

IL55x SERIES OPTICAL MONITOR SYSTEM
INTEGRATION MANUAL

Integration Manual

This documentation is provided as an instruction manual to Intellemetrics customers and potential customers **only**.

This manual provides integration instructions for Intellemetrics IL55x and IL56x Series of Optical Monitors. These include the IL551, IL552, IL553, IL555 and IL563 systems, collectively abbreviated to IL55x in the remainder of this manual.

Read this manual before you install and use the IL55x Optical Monitor.

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1. Digital I/O Interface

1.1. *Overview*

Intellemetrics provides extensive programmable I/O capability on the Controller Module.

In the following sections we will use a few acronyms, these being;

- OMS: Optical Monitor System, or Optical Monitor.
- CCCS: Coating Chamber Control System. This is the PLC or computer system that is used to control the coating chamber and controls all of the digital I/O to and from the coating system.
- FD: The Intellemetrics FilmDirector software.

1.2. *Physical Pin I/O*

The rear side of the Controller Module is shown in

Figure 1-1. The customer should ONLY use the Customer I/O 37 way d-type socket connector.

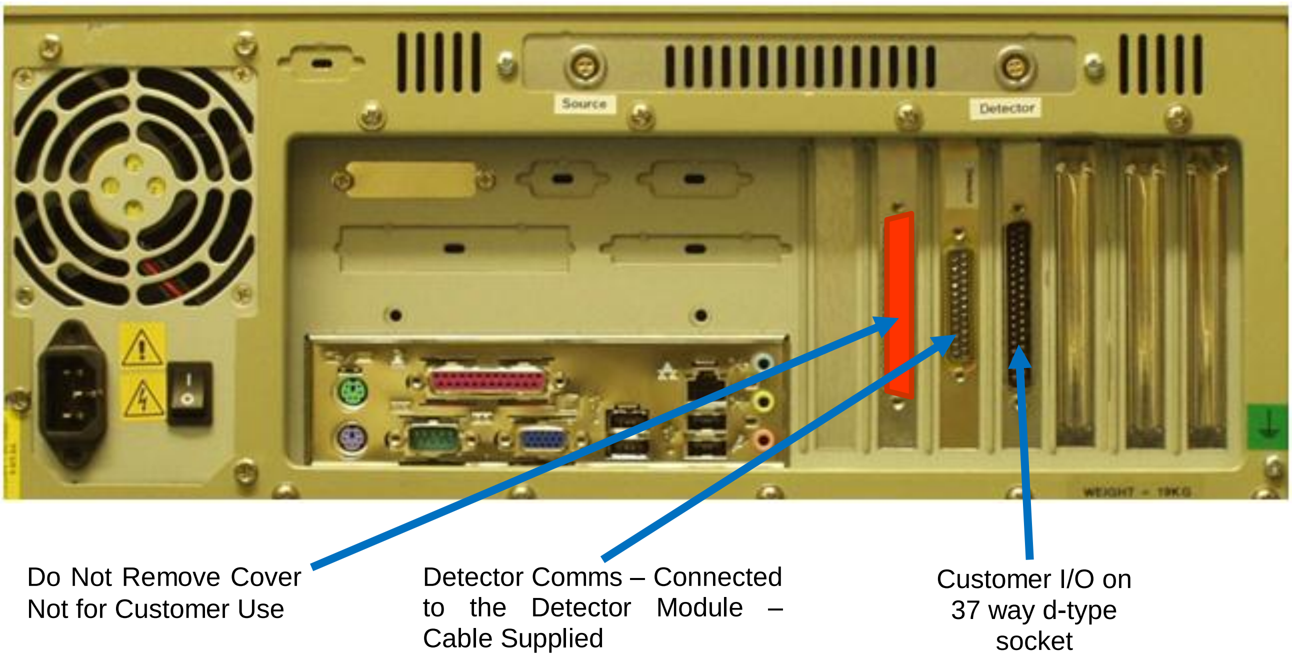
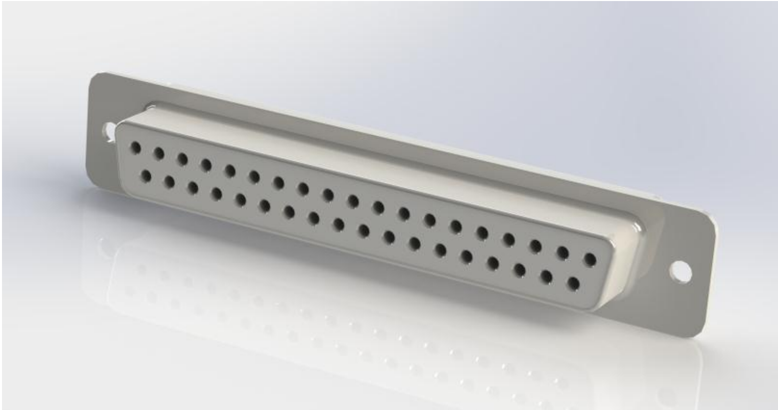


Figure 1-1 Rear View of the Controller Module

For the avoidance of doubt, the customer I/O connector on the back panel of the controller module is a 37 way D-type socket, similar to that show here:



The Customer I/O pin configuration is preset at the factory to that shown in *Figure 1-2* below. However, the I/O is fully programmable through the IO data server executable and may be changed to suit the customer's requirements.

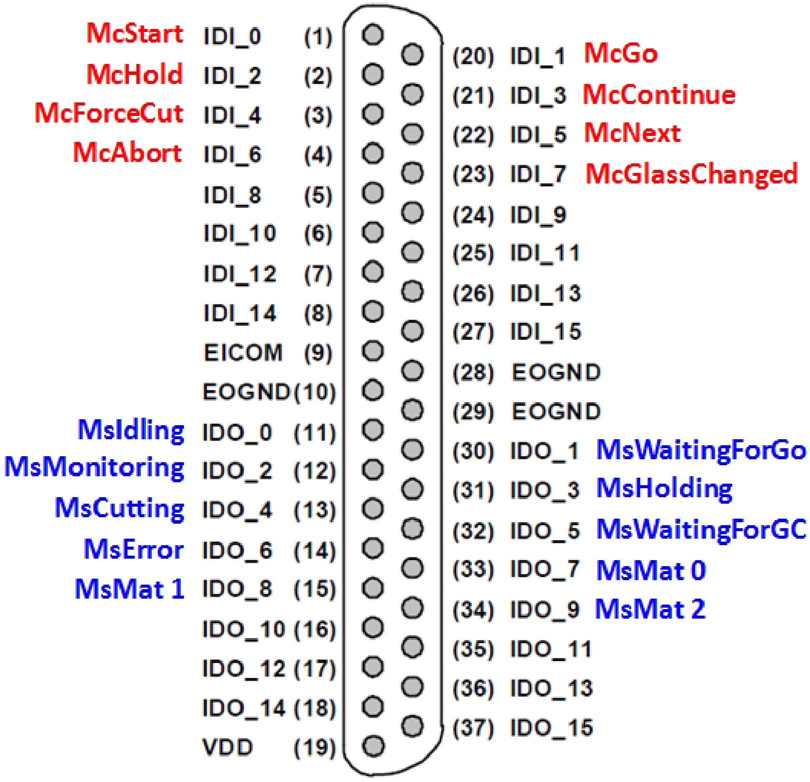


Figure 1-2 Digital I/O interface pin assignments on the 37 way D-type socket connector.

Legend:

- IDI_n = Isolated digital input channel #n.
- IDO_n = Isolated digital output channel #n.
- EICOM = Common ground or common power (5 Vdc to 35 Vdc) of isolated input channels.
- EOGND = Ground return path of isolated output channels.
- VDD = Power supply (5 Vdc to 35 V dc) of isolated output channels.

1.3. Operation

1.3.1. Isolated Digital Input Circuits

The inputs are fully opto isolated with a series input resistor of 1.2 kΩ rated at 0.5 Watts. A logic low is defined as being a voltage of between +1.5 and -1.5 V. Logic high is defined as being a voltage greater than +5 V or less than -5 V and less than or equal to +24 or -24 V. Remember that EICOM is a common connection between all of the inputs. It is not connected to ground and is therefore floating relative to the computer 0 V and chassis. The connection between the outside signal and the 37 way d-type is shown below;

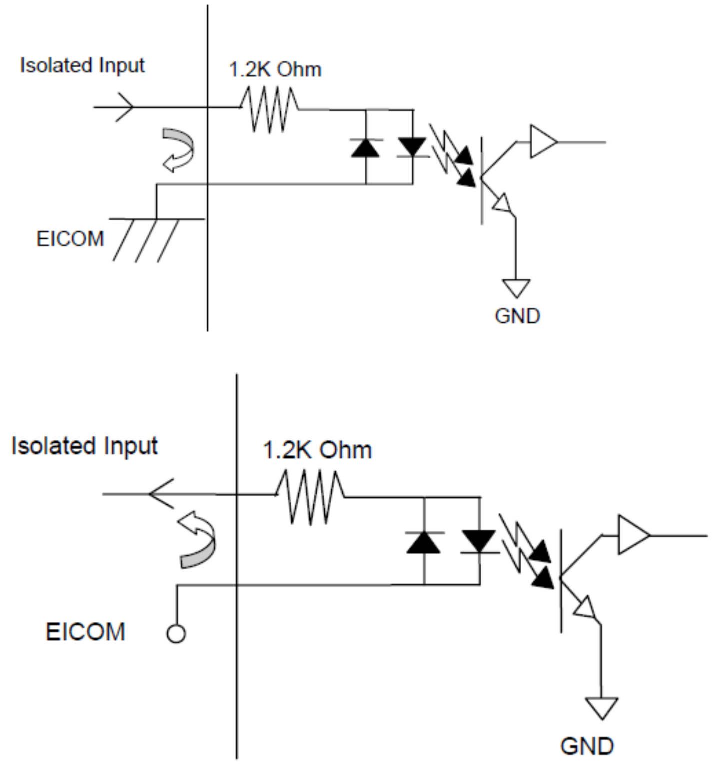


Figure 1-3 Isolated input circuits. EICOM will typically be 0 V (upper diagram), 5 V or 24 V (lower diagram).

1.3.2. Isolated Digital Output Circuits

An external voltage source, minimum 5 Vdc and maximum 35 Vdc, is necessary to power the internal isolated circuits. The positive side is connected to the VDD pin with the negative side connected to EOGND. When the isolated digital output goes to HIGH, the Darlington outputs will sink current through the load from VDD.

The VDD pin has a 'fly-wheel' diode which can protect the driver if the load is inductive such as a relay, motor or solenoid. VDD must connect to the same external power as the load to form a 'fly-wheel' current loop.

The outputs are split between three chips, each chip able to sink up to 500 mA. The sink current for the outputs is therefore calculated by dividing the number of outputs sinking at the same time per chip into 500 mA. You should note that the VDD external power supply must be capable of providing enough current for your chosen configuration. IDO-0 to IDO-5 are on chip one, IDO-6 to IDO-10 are on chip two and IDO-11 to

IDO-15 are on the third chip. The Darlington outputs of the drivers have an output low voltage of typically 1 V with a maximum of 1.6 V at 500 mA. The leakage current when off is less than 0.1 mA.

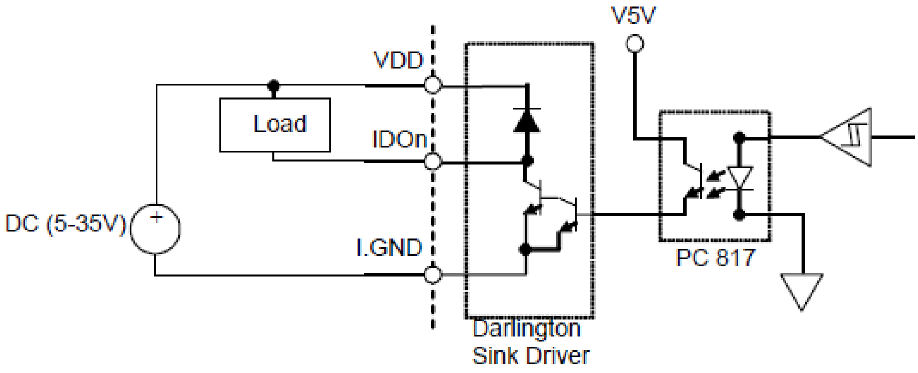


Figure 1-4 Isolated output circuit. The Load is typically a 4.7 kΩ pull up resistor.

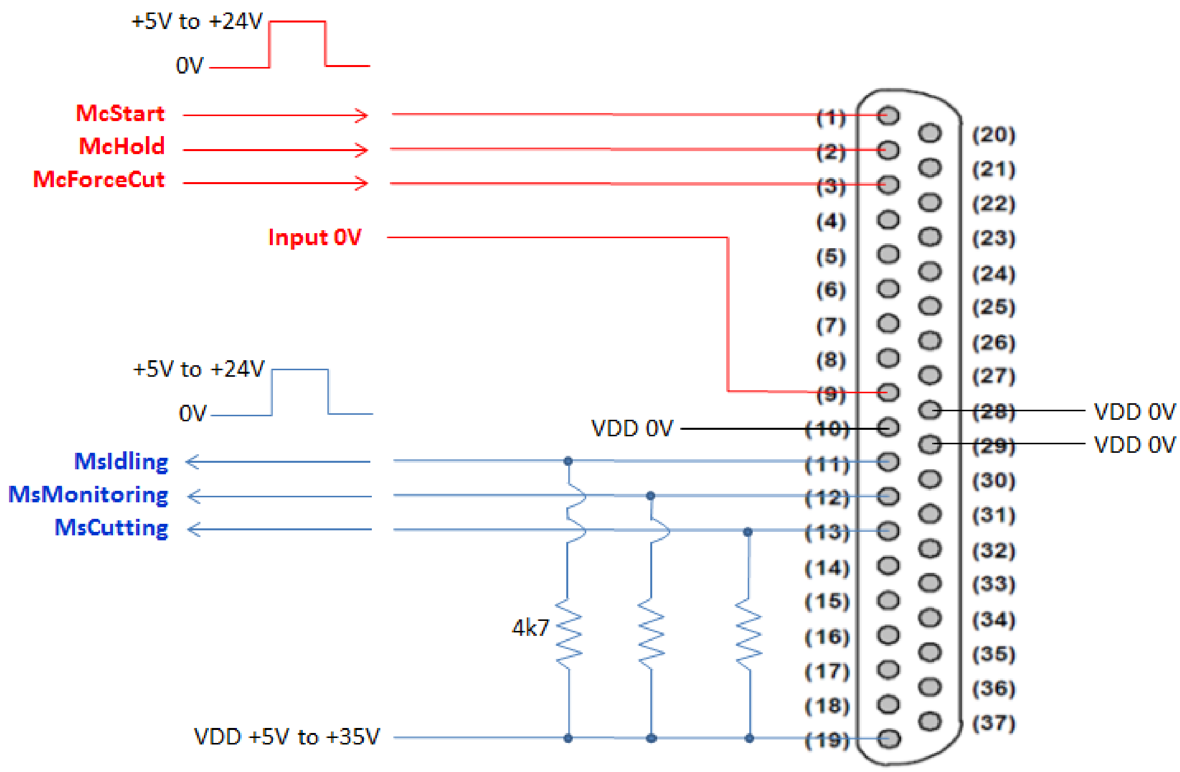


Figure 1-5 Example Wiring Diagram. The above diagram shows just 3 inputs and 3 outputs for clarity. The VDD 0V and the Input 0V pins may be connected together if a common power supply is being used for the inputs and outputs.

2. Digital I/O Data Server (IODS)

The IODS provides a user interface around the digital in/out ports. This 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 (see Figure 2-1) 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.

Figure 2-1 The Digio and Data Server Icons 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 Module'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, e.g. a hardware port which is fixed in direction as an input cannot be mapped to a 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 optical monitor system controller 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 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.

The nomenclature used is as follows.

Mc…………….. is a "machine Command" INPUT to the optical monitor system.

Ms………………is a "machine Status" OUTPUT from the optical monitor system.

We have put machine command inputs in **RED** and machine status outputs in **BLUE** in this manual for clarity.

2.1.1. Machine Command Inputs

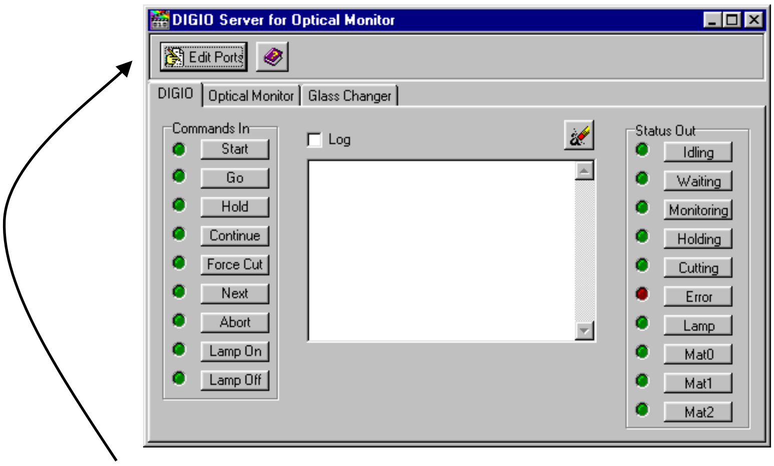
State Input	**FD Button Name**	**DIGIO Tag**
Start	Start	**McStart**
Go	Go	**McGo**
Hold	Hold	**McHold**
Continue	Continue	**McContinue**
Cut	Cut Now	**McForceCut**
Next	Next	**McNext**

Abort	Finish	**McAbort**
Glass-changed	na	**McGlassChanged**

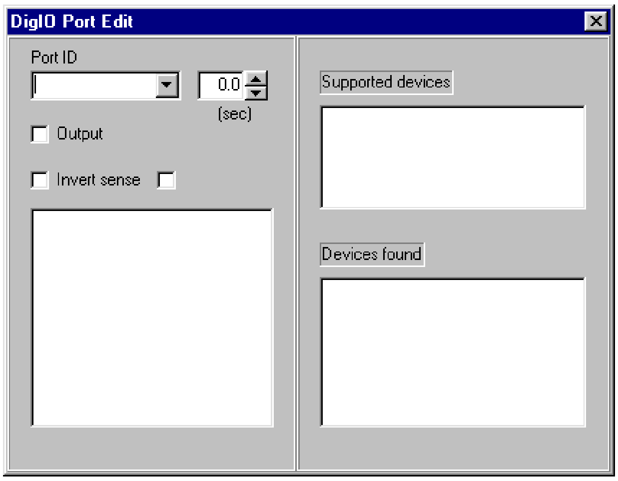
2.1.2. Machine Status Outputs

Machine State	**DIGIO Tag**
Idling	**MsIdling**
Waiting	**MsWaitingForGo**
Monitoring	**MsMonitoring**
Holding	**MsHolding**
Cutting	**MsCutting**
Error	**MsError**
Waiting for GC	**MsWaitingForGC**
Material 0	**MsMat0**
Material 1	**MsMat1**
Material 2	**MsMat2**

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



- Press the *Edit Ports* tab.
- If permission to edit is denied, then go to START: RUN
- Type “regedit” in the field and then press return.
- Choose *HKEY_LOCAL_MACHINE*
- Go to software/Intellemetrics/digioserver.
- In the *PERMISSION to EDIT* field type ”0”=inhibited, “1”=OK to edit.



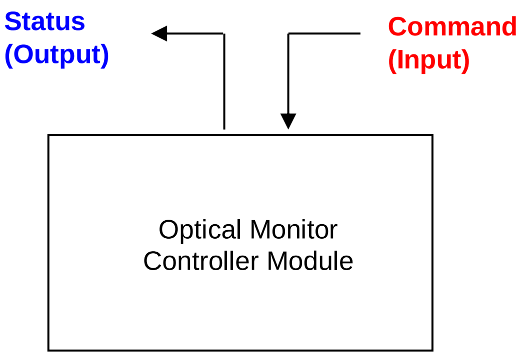
The supported device should read ADLINK 7230. This will enable you to edit the *Ports*.

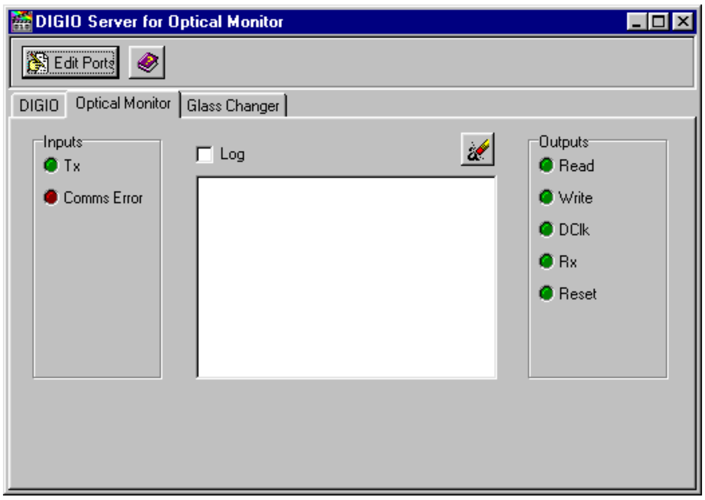
Warning	Please note that when you exit the *Edit Ports* tab the ports will be set to the new programmed values.

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

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.

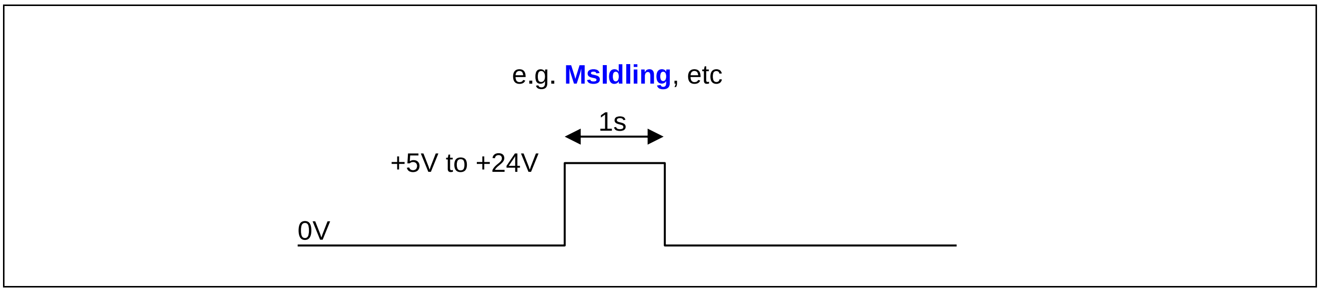
A definition of the STATUS functions can be found in **Film*Maker*** help.





2.2. Digital I/O Server Factory Settings

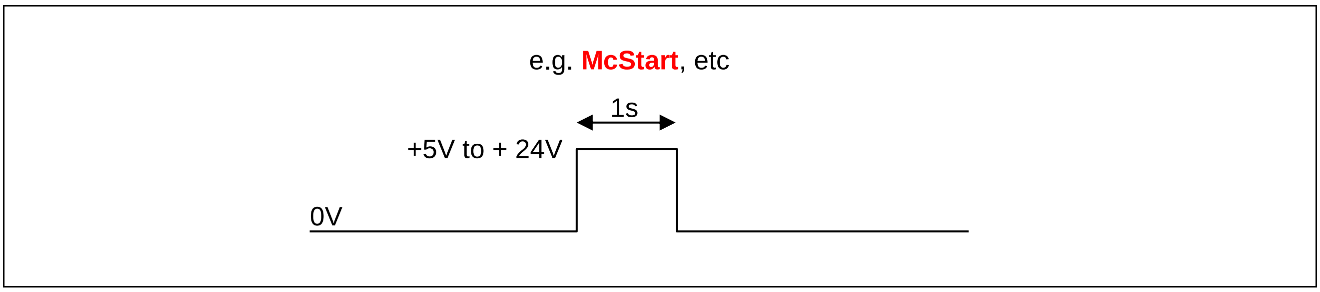
All machine status outputs have been programmed to be +5V to +24V going pulses of 1 second duration, shown schematically below:



The CCCS should be programmed to detect the rising edge of the machine status output pulses coming from the OMS.

The exception to the above rule is the **MsWaitingForGC** status which is set between 0.5s and 2.0s depending upon glass changer type.

With regard to the machine command inputs, the digi IO server in the OMS is programmed to detect the rising edge of the +5V to +24V going pulses of greater than 0.1s duration coming from the CCCS, and therefore it is recommended that the CCCS is programmed to give out 1 second pulses as shown below:



Therefore the **McStart** command will be registered by the OMS 0.1s after the arrival of the rising edge.

2.3. *State Diagrams*

The **Film*Director*** main state control diagram is an aid to understanding how the state machine functions. We show it below in two forms. The first form shows the state diagram from the perspective of the **Machine Command Inputs** and **Machine Status Outputs**. The second form shows the state diagram from the perspective of the **control buttons** and the **status LEDs** shown on the FD screen. It should be noted that both forms are running at the same time. So for instance an **McGo** command can be sent as a digital input or the **Go** button on the FD screen can be pressed with the same effect.

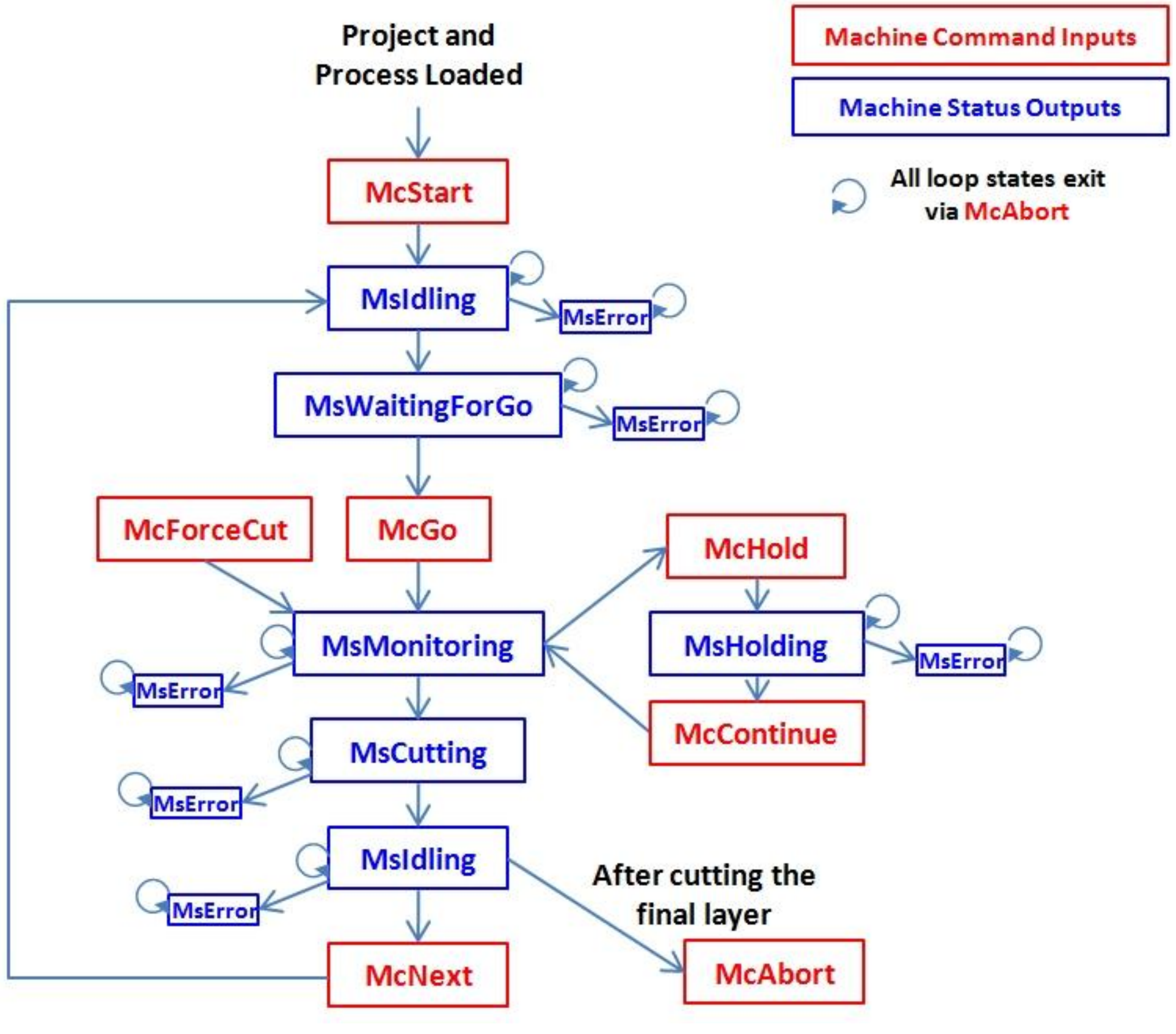


Figure 2-2 OMS state diagram from the perspective of the Machine Command Inputs and the Machine Status Outputs.

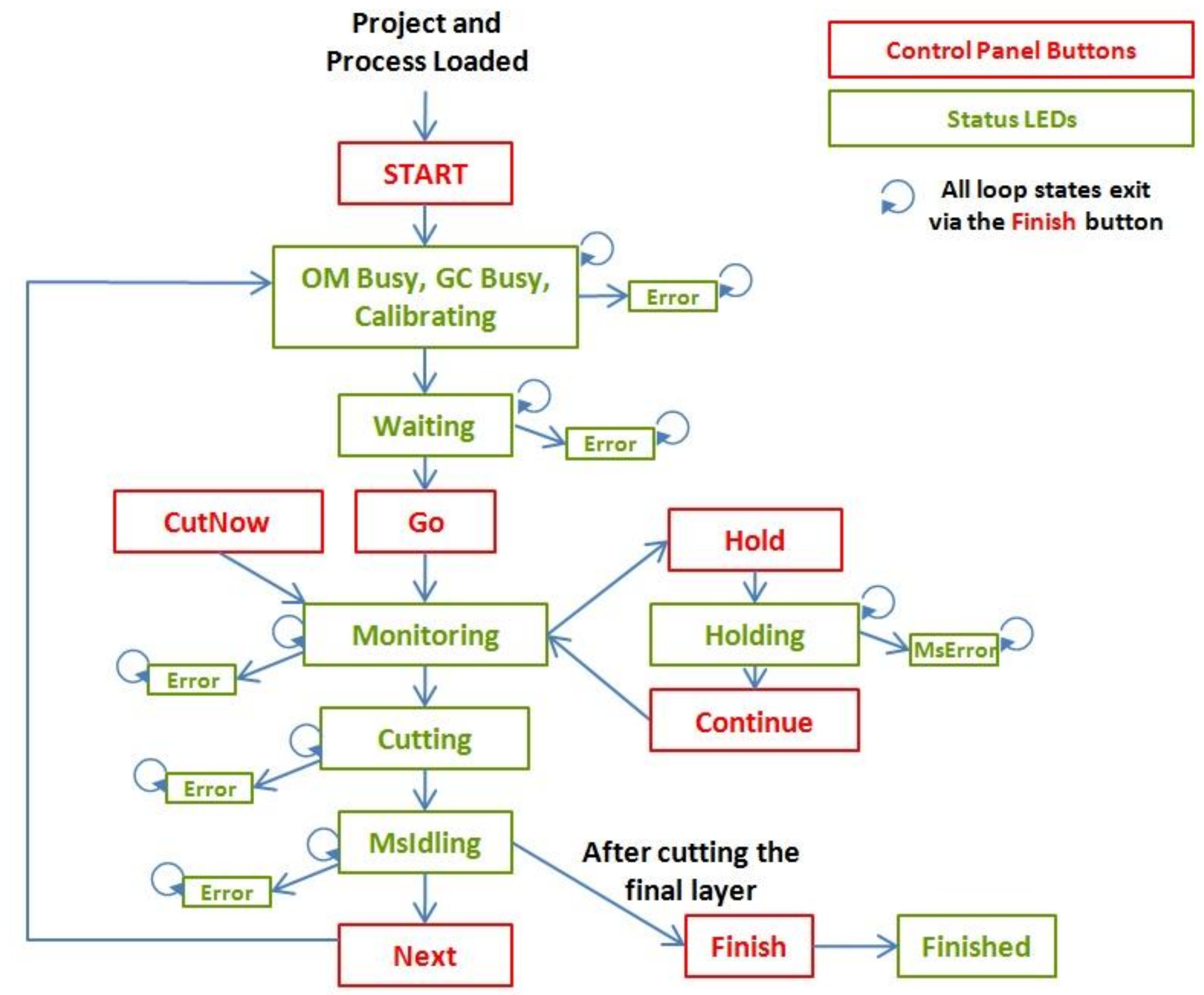


Figure 2-3 OMS state diagram from the perspective of the control panel buttons and the status LEDs on the FD screen.

3. TCP Interface

Selected communication to the Controller Module can also be achieved via TCP, i.e. through the ethernet port. This is designed to be a very simple, yet robust and expandable XML type command structure that is easy to impliment. It is designed to be used alongside the digital I/O communication for the cases where logic state digital I/O commands are not enough.

The following specifies the interface.

Listening Port: 2551 (listens continuously from app. startup)

Multi-client Support: Yes

On-Connection Banner: ‘Hi from Film Director’

Input Format: all inputs are terminated with *crlf* and are XML fragments structured as follows –

<cmd>

<key>*command key word*</key>

<prm>*parameter*</prm>

</cmd>

Output Format: all outputs are terminated with *crlf* and are XML fragments structured as follows –

<msg>message text</msg>

Protocol:

If the input is structurally valid the interface immediately responds with –

<msg>ACK</msg>

If the input is structurally invalid the interface immediately responds with –

<msg>NAK</msg>

Just because the interface returns ACK it doesn’t follow it has done anything with the command that was sent. To understand this you need to query the status.

Command Set:

Command Key Word	**Parameter**	**Action**	**Response**
LoadProject	project name	FD loads the named project and waits for <start> from Digio	ACK
GetStatus	none required	Returns last status/error message from FD	ACK followed by the error/status text

4. System Integration:

The digital IO system, when used correctly, allows automatic monitoring and control of complex coating schemes. However, the digital IO functions are extremely flexible and there are a great many different ways to integrate the optical monitor into the coating chamber control system. These different ways depend upon the level of integration and automation required and on the other equipment within the coating system as well as the preferences of the person doing the integration.

4.1. An Example Using All I/O

The following example shows one such potential integration where all the digital I/O are used. This will probably be the case if a PLC is being used where plenty of I/O channels are available and the coating chamber control system requires a high level of integration and automation.

It should be stressed that this is given only as an example to aid the integration engineer and speed up the integration process. You are free to change parameters or the process flow as required by the particular configuration and processes you are running. And we have chosen a particular coating process scheme, namely an electron beam coating system, with two materials, two shutters, quartz crystal control of the deposition rates and a test glass changer. We have also assumed a case where all layers are cut by the optical monitor. Your set up may be very different but the same principles should apply.

4.1.1. Process Sequence During a Coating Run

4.1.1.1. System Preparation

We will assume that the substrates have been loaded into the chamber, the test glass changer has been loaded with fresh test glasses and indexed to the desired starting position, and the chamber is pumping down.

The first step is to load a Project into a Process in FilmDirector. Once this is done, the START button on the FD screen should now be illuminated. The OMS is now in a ready state waiting for an **McStart** command from the CCCS.

The **McStart** command is used to 'arm' the OMS and give it time to perform all necessary calibrations prior to the first layer being deposited. Typically a minute is a suitable timescale, but this will vary depending upon the complexity of the coating process. It is often best to send the **McStart** command from the CCCS during the final power ramp of the first material, i.e. when the shutter is still closed.

FD now sends out an **MsIdling** status to the CCCS. During this stage none of the FD buttons are illuminated. The **MsIdling** status tells the CCCS that the OMS is performing various calibrations and that the shutter should not be opened until it has finished these calibrations. The OMS will not start monitoring a signal whilst in the **MsIdling** state even if the CCCS sends an instruction to start monitoring.

During this time the OMS will also send out the appropriate binary coded material number on the **MsMat0**, **MsMat1** and **MsMat2** outputs.

Once the calibrations have been completed, the OMS sends out an **MsWaitingForGo** status to the CCCS and the GO button in FD becomes illuminated. This tells the CCCS that the OMS is ready to start monitoring layer 1 as soon as the CCCS is ready to open the shutter. The OMS can remain in this state for as long as it takes the CCCS to prepare itself, i.e. ramp the ebeam guns, get the pressure down to the correct value, stabilise any gas flow rates, etc, etc.

4.1.1.2. The First Layer

Lets assume that the CCCS has now ramped the power to gun 1 and performed the required soak, and that everything in the coating chamber is ready to open shutter 1. The CCCS now sends a command to open shutter 1 (this may be via the crystal controller or via the CCCS's own relay system) and simultaneously sends an **McGo** command to the OMS. The important point here is that the OMS should start monitoring at the same instant as the shutter opens. If there is a significant delay then this means that material will already be deposited on the substrate and therefore FD will calibrate the starting position at the wrong T/R value.

Once the OMS receives the **McGo** command, the HOLD and CUT NOW buttons in FD become illuminated, the OMS starts monitoring the signal from the detector module, and an **MsMonitoring** status is sent from the OMS to the CCCS to indicate that the OMS is now monitoring the live signal.

When the OMS determines that layer 1 has reached the correct optical thickness it will send an **MsCutting** status to the CCCS followed within 100ms by an **MsIdling** status, and the NEXT button in FD becomes illuminated. This signal should be routed so that it closes shutter 1 as quickly as possible. Care should be taken when routing this signal through certain crystal controllers as these may add a significant delay to this actuation and therefore result in thicker films than expected.

Once the cut has been made, the CCCS can send an **McNext** command (analogous to the **McStart** command) to the OMS to instruct the OMS to prepare itself again for the next layer. The timing of the McNext command is somewhat flexible, but a suggested point would be at the beginning of the final ramp of material 2. When the McNext command is received by FD the NEXT button will become unilluminated.

Again the OMS will perform various calibrations relevant to layer 2. If a test glass position change is required, i.e. if layer 2 is on a different test glass to layer 1 then the OMS will send the required commands to the test glass changer to index the required number of steps and perform any calibrations. During this time the OMS enters an idling state and sends an **MsIdling** status to the CCCS as well as resets the **MsMat0**, **MsMat1** and **MsMat2** outputs to those corresponding to the material number of layer 2.

Once the calibrations have been completed, the OMS will send an **MsWaitingForGo** status to the CCCS, and the GO button will illuminate.

4.1.1.3. Subsequent Layers

After the previous **MsCutting** and MsIdling status' were received by the CCCS, and the CCCS actuated immediate closure of shutter 1, then the CCCS will put gun 1 into a low power mode and start to ramp gun 2 to full power and soak for the required time.

When the CCCS is ready to open shutter 2 it will send a command to open shutter 2 (again, this may be via the crystal controller or via the CCCS's own relay system) and simultaneously send an **McGo** command to the OMS.

Once the OMS recieves the **McGo** command, the HOLD and CUT NOW buttons in FD become illuminated, the OMS starts monitoring the signal from the detector module, and an **MsMonitoring** status is sent from the OMS to the CCCS to indicate that the OMS is now monitoring the live signal.

When the OMS determines that layer 2 has reached the correct optical thickness it will send an **MsCutting** status followed by an **MsIdling** status to the CCCS and the NEXT button in FD becomes illuminated.

Once the cut has been made, the CCCS can send the **McNext** command to the OMS to instruct the OMS to prepare itself again for the next layer. Again the timing of this should be similar to layer 1.

The OMS will perform various calibrations relevant to layer 3. If a test glass position change is required, i.e. if layer 3 is on a different test glass to layer 2 then the OMS will send the required commands to the test glass changer to index the required number of steps and perform any calibrations. During this time the OMS enters an idling state and sends an **MsIdling** status to the CCCS.

Once the calibrations have been completed, the OMS will send an **MsWaitingForGo** status to the CCCS, and the GO button will illuminate.

If there are no problems then this process will repeat for all the layers in the stack.

4.1.1.4. The Final Layer

The final layer is controlled in exactly the same way as the previous layers up until the point where the layer cut is made. The **McCutting** status followed by the **MsIdling** status is sent to the CCCS and the NEXT button in FD becomes illuminated.

At this point the CCCS has two choices;

- The CCCS can send an **McAbort** command to the OMS. This will result in the whole process finishing and the screen will be cleared.
- The CCCS does not send any command. This is the recommended route because the FD screen will remain with all graphical data on the screen (useful if the coating engineer wants a visual

feedback before proceeding). The FINISH button will be illuminated indicating that the system is waiting for;

a. The coating engineer to press the FINISH button on the screen OR
b. The CCCS sending an **McAbort** command to the OMS to activate the FINISH button.

Whichever route is taken, all run data will be automatically logged and can be reviewed in FilmReviewer which is accessed via FilmMaker.

4.1.1.5. Problem Layers

Example 1

Lets assume that during the deposition of layer 2 (though it could be any of the layers) a problem occurs with the deposition process. Maybe the deposition rate drifts out of bounds or a gas flow rate becomes too low. Lets assume that the CCCS decides to temporarilly halt the process until the problem is fixed. The CCCS will immediately close shutter 2 and simultaneously send an **McHold** command to the OMS, the OMS will stop monitoring layer 2, it will send an **MsHolding** status back to the CCCS and the CONTINUE button in FD will illuminate.

The OMS can stay in this state indefinitely whilst the problem is being fixed. However, once the problem has been fixed, then the CCCS will send a signal to open shutter 2 again and simultaneously send an **McContinue** command to the OMS. This will instruct the OMS to seamlessly continue the monitoring of layer 2 and send an **MsMonitoring** status to the CCCS.

From there on, the layer can be cut in the normal way and iterated to the next layer in the normal way.

Example 2

Lets assume that during the deposition of layer 2 a more fatal problem occurs with the run. Maybe we run out of material 2. The CCCS will note a fatal error and will send an **McAbort** command to the OMS. This will force the OMS to finish the sequence and abort the monitoring. The FINISH button will temporarilly illuminate.

Note that the **McAbort** command can also be sent after the **McHold** command if you wish to abort the process from within the Hold state.

Example 3

Lets assume that the at some point during the deposition of a particular layer the CCCS makes a decision to cut a particular layer before the OMS decides to do so, thereby overriding the OMS. In this case the CCCS sends an **McForceCut** command to the OMS. In this case the monitoring immediately stops and the NEXT button in FD becomes illuminated.

4.1.1.6. Additional Input Commands and Output Status Possibilities

At any stage, an **McAbort** command from the CCCS will force FD to finish the entire process.

During any monitoring stage, i.e following an **MsMonitoring** status, an **McForceCut** command from the CCCS will finish monitoring of the current layer. The system can then be interated to the next layer as normal. This can be used in cases where the OMS is not required to make the layer cut, i.e. the cut signal will come from the CCCS based on a crystal controller reading.

During any of the above stages the OMS may output an **MsError** status. This indicates that a fatal error has occurred within the monitoring system. It is advisable that the **MsError** status output is routed so that it closes the shutter and alerts the operator. The only way to come out of the error state is to send an **McAbort** command from the CCCS or to press the FINISH button on the FD screen.

The **MsWaitingForGC** status and the **McGlassChanged** command are only used in cases where there is a test glass changer present in the system. If the test glass changer is supplied by Intellemetrics then these signals will be internally routed between the Controller Module and the Test Glass Changer and the customer does not need to be concerned with them. They may want to accept the **MsWaitingForGC** status output to their CCCS maybe to indicate on their screen that the next test glass position has been selected, but this is purely optional.

However, if the customer is driving their own test glass changer from their own CCCS then the **MsWaitingForGC** status and the **McGlassChanged** command will need to be used.

After an **McStart** or an **McNext** command has been received by the OMS, the OMS will perform various calibrations and adjustments to prepare itself for the upcoming layer. If a test glass change is required then the OMS will send an **MsWaitingForGC** status to the test glass changer and/or the CCCS. If an Intellemetrics test glass changer is installed then the test glass changer will index to the next position and then send back an **McGlassChanged** command.

If the customer has their own test glass changer then receipt of the **MsWaitingForGC** status from the OMS tells the CCCS to change the glass, and the OMS waits for the **McGlassChanged** command before it will continue.

4.1.1.7. Material Number Outputs

The material number that is going to be used for each layer can be output to the CCCS using the **MsMat** status outputs. These outputs allow upto 7 binary encoded materials to be specified as defined in the table below;

Material Number	Mat 0 Logical State	Mat 1 Logical State	Mat 2 Logical State
Before McStart	0	0	0
1	1	0	0
2	0	1	0
3	1	1	0
4	0	0	1
5	1	0	1
6	0	1	1
7	1	1	1

NOTE: The Logical States above can be high or low depending upon how you setup the Digital I/O Server.

The material numbers are set in the Materials Database in FilmMaker. Simply select the material in the database and then select a material number, thereby assinging thsat number to that material.

Warning: The vast majority of customers choose not to use the Material Number Outputs. If you do use them, then care must be taken when defining the corresponding Material Numbers in FilmMaker. Please feel free to discuss this with Intellemetrics if you are considering using these outputs in your integration scheme.

4.2. An Example Using Reduced I/O

There are occassions when there are many less I/O channels available for the integration purpose. An example of this may be a system that does not have a PLC where the process controller is effectively the crystal controller module. There may be a number of I/O channels available on the crystal controller, but many of these may be already in use for controlling other systems on the chamber. In this case a much reduced I/O set may be available.

In this case it is still possible to perform complex coating runs with an acceptable level of automation using just two input and one output channels.

FilmDirector will then perform its calibration steps and go into the Waiting state with the Go button illuminated. This can all occur during the initial ramp of the ebeam guns.

When the crystal controller is ready to open the shutter to start depositing the first layer, it sends an **McGo** command to the optical monitor which then starts monitoring layer 1.

When the optical monitor determines that an endpoint has been reached it will stop monitoring and send an **McCutting** status to the crystal controller which should be programmed to close the shutter. The crystal controller should be programmed to send an **McNext** command to the optical monitor at the end of the layer, which will tell the optical monitor to move the monochromator, change test glass and perform any calibrations that are required before the next layer. The optical monitor will then wait for the next **McGo** command and the sequence is repeated through all the layers.

The above sequence relies on the optical monitor being given enough time between commands to perform the required calibrations etc. Typically a two stage ramp and soak process with a crystal controller will take a few minutes and this is plenty of time. However, if the crystal controller is ready before the optical monitor then sequencing problems may occur and extra delays may need to be programmed into the crystal controller sequence.