# Understanding and Testing the μMAC Box

## What is the μMAC?

The μMAC box is the data logger for the system. **Figure 1** shows a traditional front view of the μMAC.
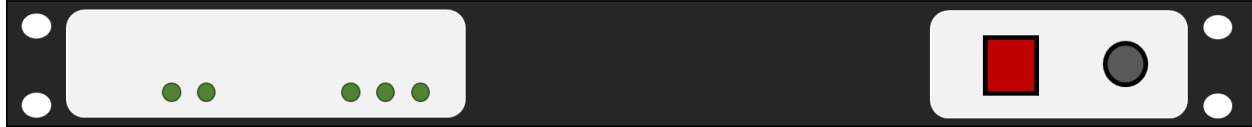


**Figure 1**: Front view of the μMAC box (top). Green circles represent various lights, while grey circles represent the circuit breakers, and red shows a lighted button.

## Walk through of the μMAC box

The front of the μMAC box is quite simple, there is a red light-up reset button and a circuit breaker (**Fig. 1**) The back of the box has many more bells and whistles, which are outlined in **Fig. 2**.
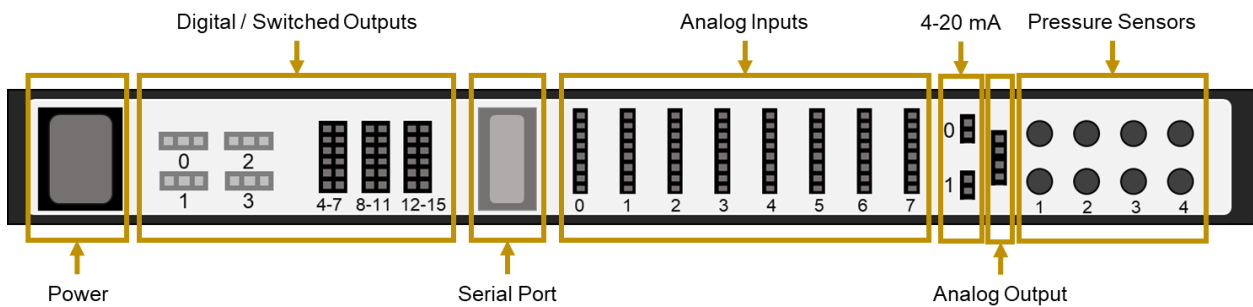


**Figure 2**: Walkthrough of the back of the μMAC box. Numbering of the connections is how it appears on the box.

### Digital/ Switched Outputs

The digital or 'switched' outputs are used to trigger a relay (or switch). There are 16 digital outputs available on the back of the μMAC box, and these are numbered 1-15.

There are two types of digital output connectors on the back of the μMAC. The first are the 3-pin connectors (0-3 in **Fig. 2**), which are for a higher current (12 Amp). The second type of connector are the 12-pin connectors (4 - 15 in **Fig. 2**), which are for a lower current (2.5 – 6 Amp depending on how the outputs are hooked up). All of the outputs put out 120 VAC.
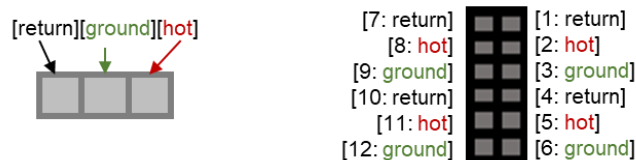


**Figure 3**: Key for the 3-pin and 12-pin digital/ switched output connectors.

For a typical system, digital outputs #0 and #1 are the two used for the solenoids that control the bypass flow and for the electronic ball valve which controls the system size cut (determines the path of the analyzer flow). The configuration file determines which connection goes to which port. To check this look in the µMAC section of the configuration file for these lines:

```
/aerosol/Components/uMAC/DigitalOutputs/DisableBypassValve,0
/aerosol/Components/uMAC/DigitalOutputs/PM1Impactor,1
```

The zero and one indicates that the solenoid cable should be on connection 0 while the impactor switch should be on connection 1.

If the system has a humidifier, the solenoid valve that controls the filling and draining of water from the humidifier is on digital output #4.

### Analog Inputs

There are 8 analog input connections on the back of the µMAC box, numbered 0-7 (**Fig. 2**). These connections are all 8-pin connections. For a typical system the channels in the µMAC menu correspond to the following connection numbers:

| Analog Connector # | 0 | 1 | 2 | 3 | 4 | 5* | 6* | 7* |
|---|---|---|---|---|---|---|---|---|
| Channel #'s | 8 / 9 | 10 / 11 | 12 / 13 | 14 / 15 | 16 / 17 | 18 / - | - / - | - / - |

* The '-' indicates that there is no assigned channel


[1: positive signal / 1st signal]
[2: negative signal / 2nd signal]
[3: ground]
[4: ground]
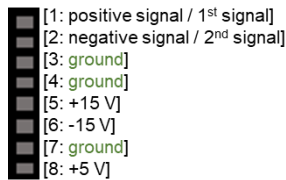[5: +15 V]
[6: -15 V]
[7: ground]
[8: +5 V]

**Figure. 4** Key for the 8-pin connectors.

### 4-20 mA Connectors

There are two 4-20 mA analog input connectors, labeled 0 & 1 (**Fig. 2**). Typically, connection #0 is used and #1 is not. This is used for the pressure transducer connected to the pitot tube in the pump box. The current from the transducer is dropped across a resister and the µMAC gets a voltage representation of the current. Usually, this connector corresponds to channel 19 in the µMAC menu.

### Analog Output

There is a single analog output connector on the back of the µMAC box. This is a 4-pin connector with 2 channels. The top two pins are channel 0 and the bottom two are channel 1. The values for this connector are set in the µMAC menu or in the configuration file. This connector is typically used to control the humidifier gear pump, and the voltage can be varied to change the pump speed.

## Pressure Sensors

There are 8 pressure sensors, 4 pairs of high and low. Typically, these are all wired and assigned to channels #20, 21, 22, and 23. In practice only two of these sensors are typically used, one for the nephelometer impactors and one for the CN box.

## Connector Use and Example Channel to Port Assignment

Here we show the port/ channel assignment at the Bondville Il, USA  (BND) site as of 2023. Figure 5 shows the port use labeled and the channel numbers for the port. Then, text from the configuration file setting the channels is shown. Note that the order of the channel assignment bellow is not how it appears in the original configuration file, but it has been reordered to walk through the ports as they are described in this document.
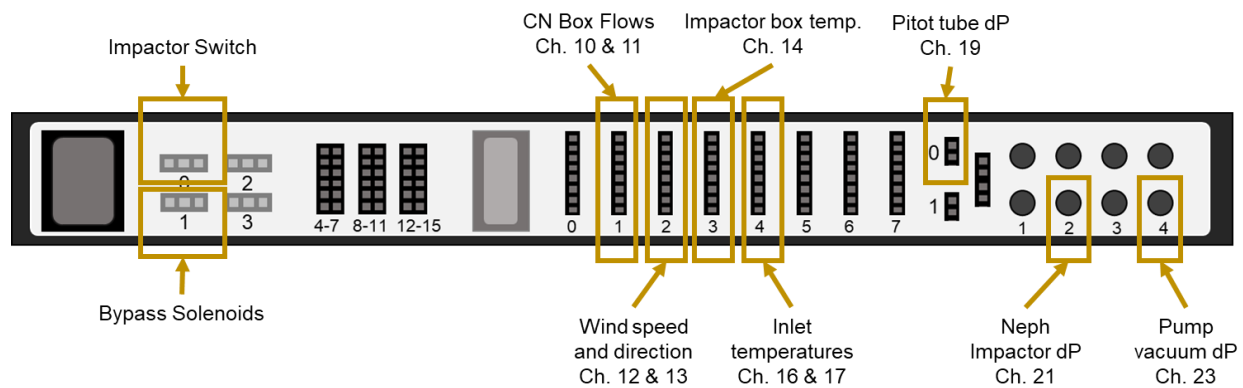


**Figure 5:** Port and channel usage at the BND site as of 2023.

**Lines for assignment of the digital/ switched output ports:**

```
/aerosol/Components/uMAC/DigitalOutputs/DisableBypassValve,0
/aerosol/Components/uMAC/DigitalOutputs/PM1Impactor,1
```

**Lines for assignment of the analog input ports:**

```
/aerosol/Components/uMAC/Variables/Q_Q62/Channel,10
/aerosol/Components/uMAC/Variables/Q_Q62/Metadata/*rDescription,"CPC drier
flow"

/aerosol/Components/uMAC/Variables/Q_Q61/Channel,11
/aerosol/Components/uMAC/Variables/Q_Q61/Metadata/*rDescription,"CPC flow"

/aerosol/Components/uMAC/Variables/WD_X1/Channel,12
/aerosol/Components/uMAC/Variables/WD_X1/Metadata/*rDescription,"Wind
direction from true north"

/aerosol/Components/uMAC/Variables/WS_X1/Channel,13
/aerosol/Components/uMAC/Variables/WS_X1/Metadata/*rDescription,"Wind speed"
```

```
/aerosol/Components/uMAC/Variables/T_V11/Channel,14
/aerosol/Components/uMAC/Variables/T_V11/Metadata/*rDescription,"Impactor box
inlet temperature"
```

```
/aerosol/Components/uMAC/Variables/T_V51/Channel,16
/aerosol/Components/uMAC/Variables/T_V51/Metadata/*rDescription,"Splitter
temperature"
```

```
/aerosol/Components/uMAC/Variables/T_V02/Channel,17
/aerosol/Components/uMAC/Variables/T_V02/Metadata/*rDescription,"Room
temperature"
```

**Lines for assignment of the 4-20mA and pressure sensor ports:**

```
/aerosol/Components/uMAC/Variables/Pd_P01/Channel,19
/aerosol/Components/uMAC/Variables/Pd_P01/Metadata/*rDescription,"Stack pitot
tube"
```

```
/aerosol/Components/uMAC/Variables/Pd_P11/Channel,21
/aerosol/Components/uMAC/Variables/Pd_P01/Metadata/*rDescription,"Impactor
pressure drop"
```

```
/aerosol/Components/uMAC/Variables/Pd_P12/Channel,23
/aerosol/Components/uMAC/Variables/Pd_P01/Metadata/*rDescription,"Pump
vacuum"
```

### How to test a μMAC box

Have an impactor box set up and ready. Make sure the μMAC has power and the breaker on the front is pushed in, is connected to the serial hub and has the necessary connections to the impactor box – this all concerns the first three connections outlined in **Fig. 2**.

#### Testing the 8-pin Connectors

Navigate to the μMAC instrument screen on the cpd laptop and move to the second display by pressing "M", and then "D" Next Display (**Fig. 6**). This will allow you to see all of the channel outputs.

Using an RH to 8-pin adaptor connect the RH probe to each of the 8-pin ports one at a time. Check the readout on the μMAC instrument screen for the connections associated with each 8-pin port. At this point it is helpful to know the calibration on your μMAC for temperature, and to know that the RH should be ~100x the channel readout. To check the calibration look in the configuration file for:

```
/aerosol/Components/uMAC/variables/T_V01/Calibration/#0,-40.0
/aerosol/Components/uMAC/variables/T_V01/Calibration/#1,100.0
```

The #0 is the intercept and the #1 is the slope. Check to make sure the channels are getting reasonable RH and temperature inputs. Its also helpful to test with more than one RH probe as some of the probes could be broken or one very reliable/new probe.

NOTE: *this is the only configuration where the μMAC gets an RH reading, and it should be in the first of the two channels associated with the port. So if you were on the first 8-pin port RH would be in channel 8 and temperature would be in channel 9.*
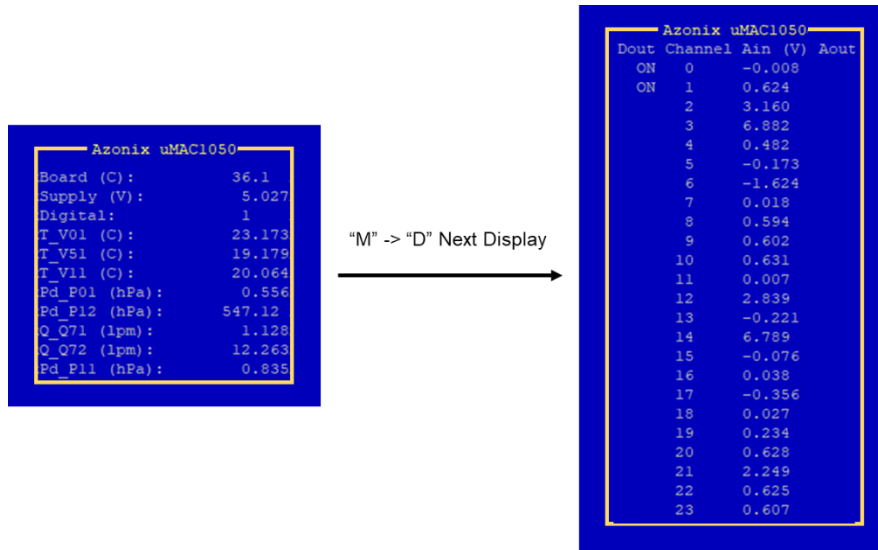


**Fig. 6:** What the μMAC instrument screen will look like and what the next display will look like with all the channel data.

### Testing the Pressure Transducer and Pressure sensors

Navigate back to the main instrument screen (**Fig. 6, left**). Connect a pressure transducer to the 2-pin port on the µMAC (**Fig. 2**). Blow into the transducer and if the pressure variable on the instrument main screen goes up the connection works.

For the pressure sensors attach a handheld pump across two of the sensors. Do one or two pumps and see if the pressure on the instrument main screen goes up, if it does the sensors work.

### Testing Impactor Box Controls

For this test is can be helpful to have a PID box also connected so that the MCF will open and you will have flow that you can measure.

For the solenoids go to the system status menu and put the impactor box into bypass mode. If you hear the solenoids click this control works. Even better if you have flow measure at the "Return Flow From Neph" on the impactor box before and after changing the mode, if flow stops in bypass mode the solenoid control works.

For the impactor switch, go to the impactor schedule on the main cpd menu. Activate the next action and you should hear the switch move in the box. If this does not happen, you could have a problem with the switch or with the configuration file – check both before testing again.