OPTI-SCIENCES
8 Winn Avenue • Hudson, NH 03051 • USA

MPM100
Multi-pigment meter

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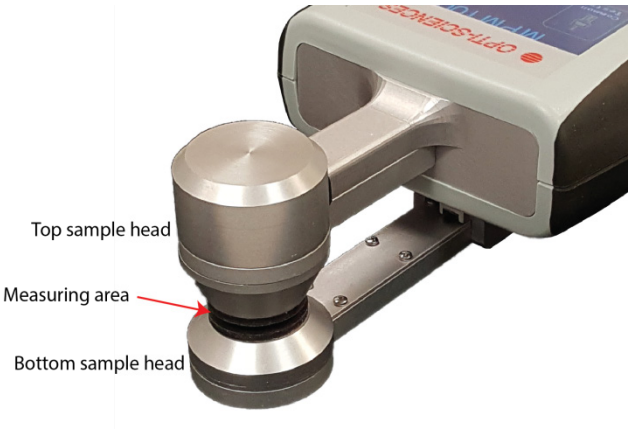
Overview

The MPM100 is a field portable pigment measuring instrument. It can be used on any thin, flat material to measure both optical transmittance and fluorescence characteristics. The sample measuring area is 9.5mm in diameter. The top measuring head contains five light sources and a filtered detector. Three of the sources are dedicated to fluorescence excitation and two are for transmittance. The filtered detector is set for the target fluorophore.



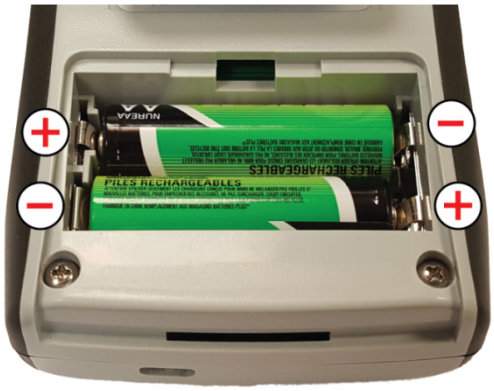
The bottom measuring head contains a broadband detector for transmittance measurements.

User defined formulas calculate final values. This allows for custom tests to be developed and implemented. The instrument includes a high performance data logger, a 3.2" touch sensitive color LCD screen, USB connectivity, a built in GPS receiver, and 2Gb of internal data storage.

Batteries and charger

Four rechargeable AA NiMH batteries and universal voltage battery charger are included. Be sure to install fully charged batteries with the orientation shown.

Battery charger



Battery orientation

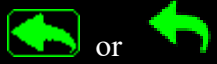
Principle of operation

When a test is started, three source LEDs are flashed and the resulting fluorescence is recorded from the top sample head. Flashes of light are very brief to minimize any effect on the sample. Transmittance measurements are then made by flashing the two remaining LEDs and recording the signal present on the bottom sample head.

Fluorescence LEDs and detector are factory calibrated for a normalized response. Direct optical feedback is used to compensate for drift. Relative changes between fluorescence channels are minimized because the fluorescence is excited and detected on the same side of the sample resulting in no movement between the sources and detector. Fluorescence signal offset is recorded during the calibration phase. This value is used to compensate for possible contamination on the top window. Transmittance is also calibrated and used to compensate for small mechanical variances caused by the sample jaws.

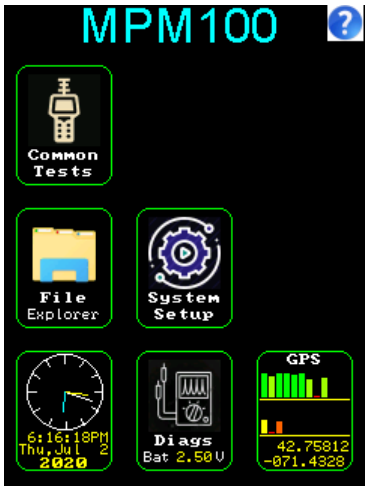
The fluorescence system has a dynamic range of approximately two orders of magnitude. A variable gain amplifier extends the absolute range by 32x. This gain change is applied equally to all three channels. The transmittance system has a dynamic range of approximately three orders of magnitude.

Common icons

	Help. When tapped, a small popup window will appear providing information about the current screen.
	Step back to the previous screen.
	Cancel.
	Create new file.
	Folder / Create new folder.
	Settings.
	View protocol.

Buttons with a green border can be tapped on. Other colors are used for information or warning messages. Where practical, the unit will guide and prompt the user through critical actions.

Main screen icons



Default home screen

Home screen with custom protocols

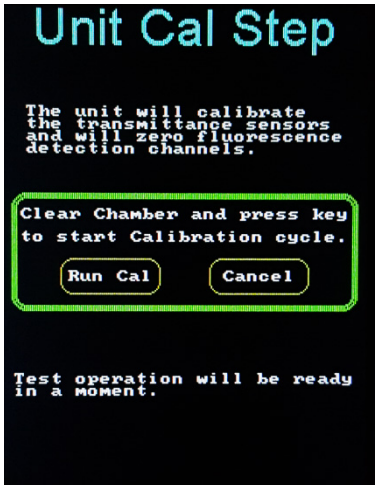
 Protocol	There can be up to three different protocols installed on the MPM100 at a time. Additional protocols may be stored in memory. Installed protocols are shown in the top row of icons. Basic test operation is the same between protocols, differences are in the formulas used for calculated data. When no custom protocols are installed, the common tests icon appears. Tapping a protocol icon starts the test mode.
 File explorer	File management application. When tapped, you may view, transfer via USB and delete stored data.
 System setup	Configure basic parameters such as auto power off and audible feedback. Custom protocols are installed from this screen.
 Clock	Animated icon showing system time. Tap to access the clock setup screen.
 Diagnostics	Animated icon showing battery voltage. Tap to view basic unit troubleshooting values.
 GPS	Animated icon showing current GPS status. Tap to view GPS details.

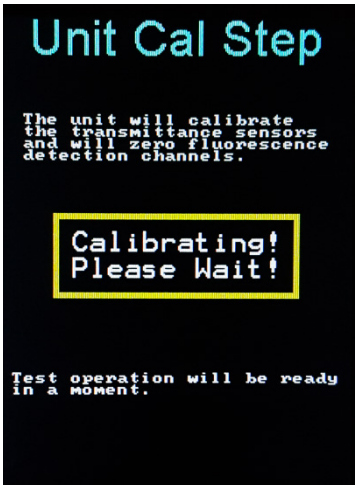
Running a test

Tap on a protocol icon to start taking measurements.

If needed, the instrument will prompt to run a calibration. Make sure the sample area is clear and tap Run Cal to continue. Transmittance path and fluorescence offsets for the sample area will be measured. These values are used to compensate for mechanical variations and debris buildup in the chamber area.

Note: Calibration needs to only be performed once after turning on the instrument. Once calibrated, selecting a different test will skip the calibration screen.





Tap Use Default to use the directory path included in the protocol file and create a file name comprised of the current date. The file name format is RDDMMYY.CSV.

Example: R010720.CSV would be automatically generated for July 1,2020. If this file already exists, data will be appended to it.

Select Alt is used to enter a new file name, or append data to an existing file.

Directories are listed before file names. Select the desired directory and then the file to append data to.

Tap the new directory icon to create a directory

Tap the new file icon to enter a new file name.

Tap the left and right arrows (upper right and left) to scroll through available pages.

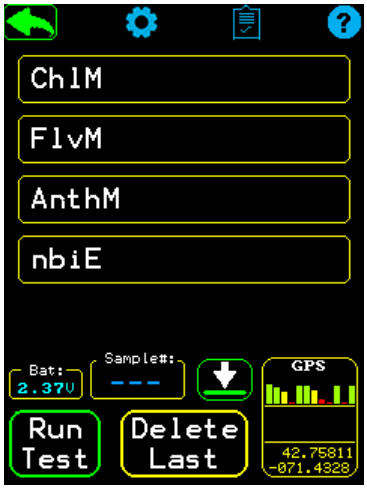
Tap the up arrow to exit a subdirectory.

Select a new folder and filename

Test screen

The instrument is now ready to record measurements. Place a sample between the jaw heads and tap Run Test, or a test will automatically start if configured to do so.

A typical test screen is shown. The number of parameters shown will vary with protocol script.



Bat

Displays the current battery voltage.

Sample

Displays the current sample number

Leaf side indicator

 and  show the side of the sample being measured.  indicates measuring the top of the sample while  indicates measuring the bottom. Tapping on the icon toggles the state. The icon will also change automatically if so selected in the test setup screen.

Run test

Starts a measurement.

Delete Last

When bordered with a green line, deletes the last point measured. The last averaged point will be deleted if averaging mode is selected up to the point where all averaging is done. After this, the delete button will delete the average value.

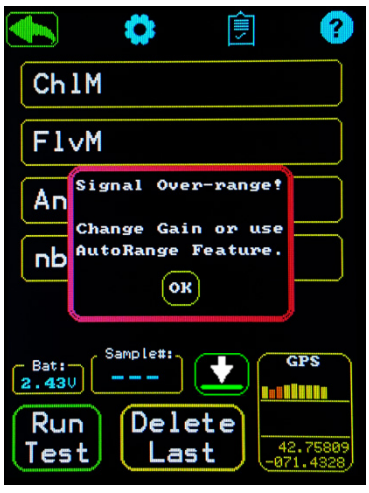
GPS

Live view of GPS status.

Error messages

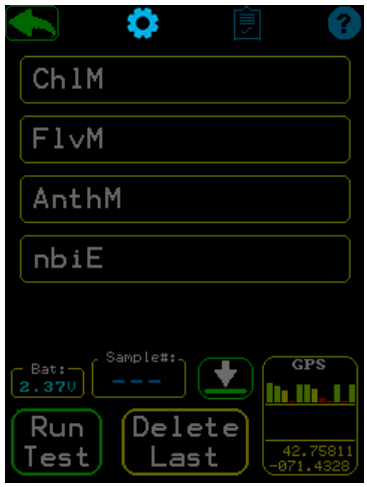
Fluorescence overload and low signal are the only signal integrity checks performed. These errors can usually be avoided by enabling the auto-range feature (test setup).

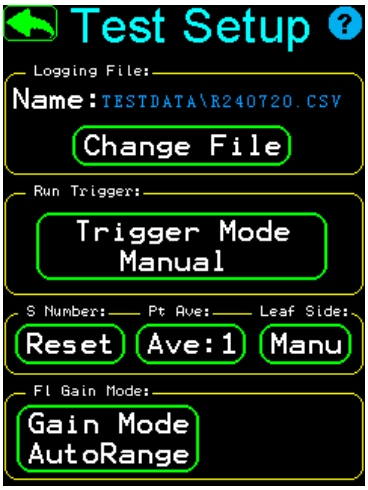
No integrity checks are performed on calculated parameters due to the variable nature of the user defined calculations. In general, math range errors will be recorded as 0. Raw signal data can easily be added to logged data to provide verification of data.



Test setup

Tap the  icon from the test screen to enter test setup.





Logging File

Displays the currently selected file used for data storage. Tap on Change File to select a different file and/or directory.

Run trigger

Measurements may be started via several methods. Tap on Trigger Mode to cycle through the available options.

Manual disables assisted test start mode. You must tap Run Test from the test screen to start a measurement.

Automatic starts a test every time the jaws are closed. A message will appear after the measurement is complete to indicate when the sample may be removed from the chamber.

After Jaw Cycle A test will be started after a complete open-close-open-close sequence. This is particularly useful when there are many samples to measure and they are distant from each other (do not need to hold jaws open between samples).

Sample present starts a test when the instrument detects a fluorescence signal. This mode requires the sample to have sufficient fluorescence for reliable detection. Samples having a low chlorophyll content may not be well suited for this option.

S Number

The current sample number can be reset to 1 at any time by tapping the Reset button.

Pt Ave

Number of calculated data points to average. Averaging may be set from 1 (no averaging) to 8 points per saved measurement. Raw signal values, time, and location are not averaged and are only recoded when the last averaged point is measured. Tap Ave:# to enter the number of averaged measurements.

Leaf side

Auto Automatically toggles the leaf side indicator ( and ) with each measurement.

Manu Leaf side indicator ( and ) is manually set from the test screen

Fl Gain Mode

The fluorescence detection system has an auto ranging feature that adjusts the signal gain for each sample. This feature can be switched off by tapping Gain Mode to lock detection range across different samples. Tap Locked Gain to set the detector gain (1-5) When in locked mode, it is possible to set the gain too high and saturate the detection system. A warning message will appear to alert of this condition.

Protocol view:

Tap  to view the currently running protocol.

Title

Name that appears on the main screen icon.

Log Dir

Default directory where data files are stored. This entry may be overridden by changing the log file name from the test setup screen.

Data Logged

Lists data that is saved to the log file with each measurement. The order listed is the order an item is saved in the log file.

There can be up to 5 named parameters in a test protocol (Val1 - Val5). The details of each appear in a series tabs. Tap on each tab to view details. For each parameter, the following information is presented.

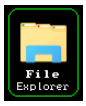
Name

User defined name assigned to the parameter.

Formula

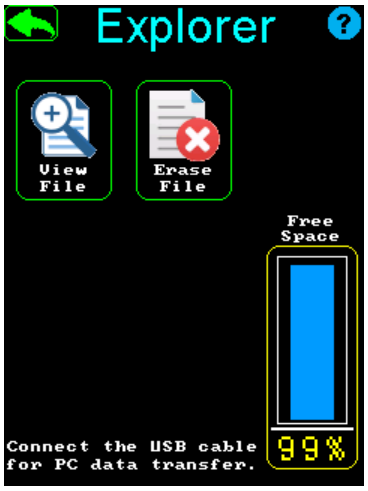
The steps used to calculate the parameter from the raw instrument data. There can be up to 8 steps per calculation.

File explorer

Tap 

to enter the file explorer screen. Data can be erased, viewed, and transferred to a host PC via USB.

Memory space available for saving data is shown as a bar graph.



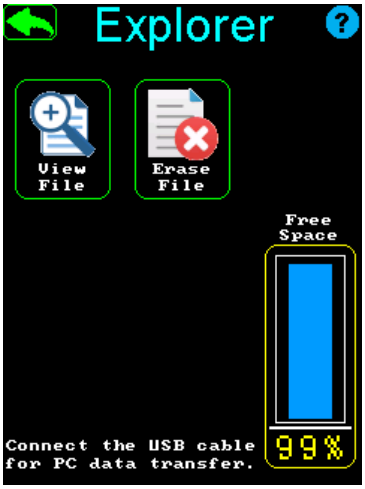
USB access

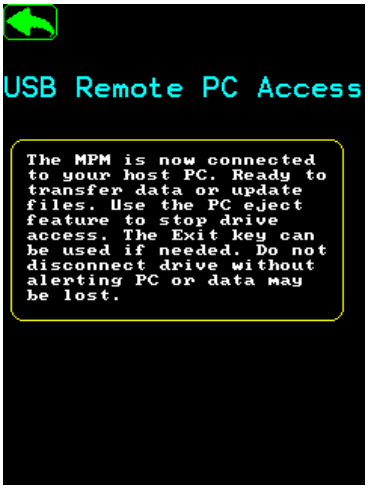
While viewing the file explorer screen, connecting a USB cable between the unit and a PC will automatically activate remote PC access. "MPM100" will appear as a connected drive on the host PC. Test data and protocol files may be transferred using the PC.

Note: Some PCs and operating systems may experience a delay of up 60 seconds before establishing a connection.

Note: Protocol files must be placed in a directory named "PROTOCOL".

Note: Use the eject function on the host PC or the back icon to disconnect the instrument. Failure to do so may result in corrupt data.



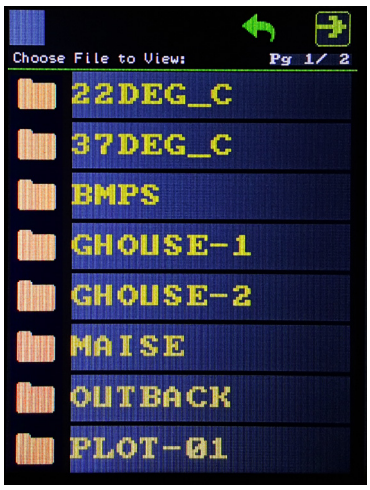


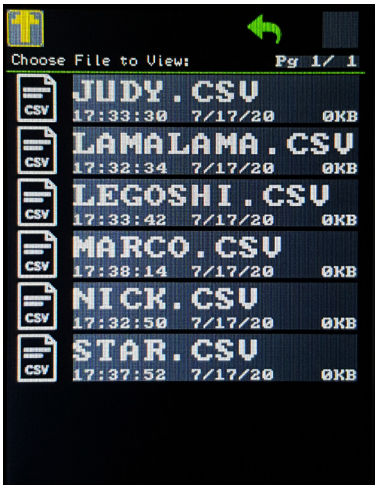
View file

Tap  on the file explorer screen to select a file to view.

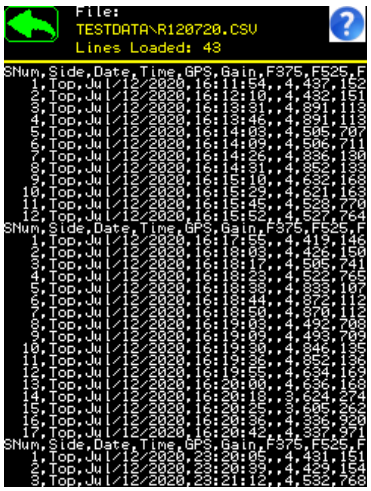
Directories are displayed before file names. Select the desired directory and then the file. To show additional pages of files, tap the arrow keys in the upper left and right of the screen.

Note: The viewer only displays data files with a '.CSV' or '.TXT' extension.

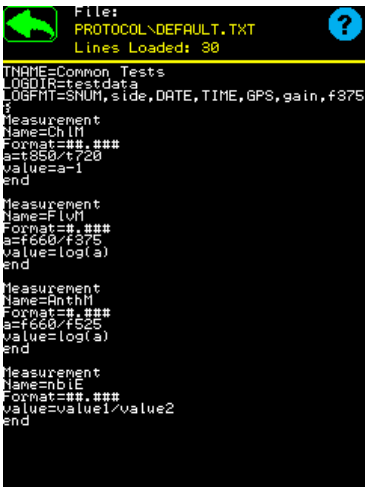




The file name and number of lines are shown at the top of the screen. Often a data file has lines that are wider than the unit's screen and may have more lines that can be displayed on the screen. A scrolling feature is present that allows for the screen to pan around the data set by tapping on the extreme left, right, top, and bottom of the screen.



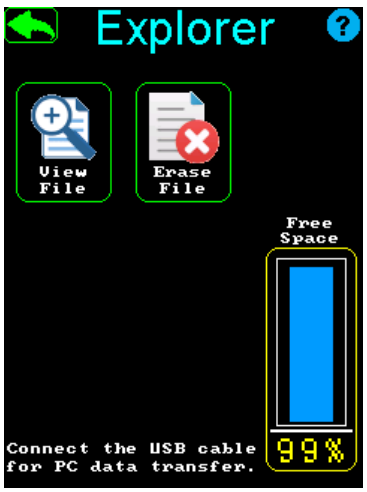
Viewing test data



Viewing a protocol

Delete file

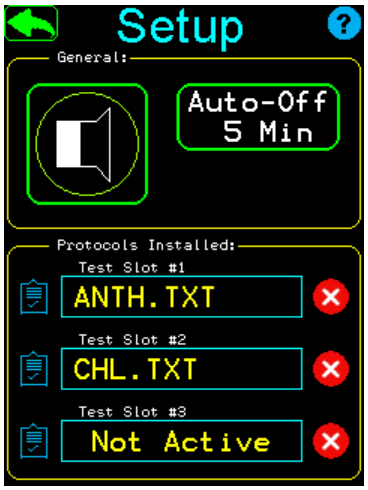
Tap  to pick a file to erase. Any type of file may be erased. There is no recycle bin on this unit, erasing a file is permanent.



System setup

Tap 

to change basic system settings such as audible feedback and auto power off interval.



Install protocol file

Test protocol files are installed from the system setup screen.

Note: Protocol files must be saved in a directory named 'PROTOCOL'. If missing, this directory can be created by a host PC.

Tap the clipboard icon  to install a protocol.

Tap the delete icon  to uninstall a protocol.

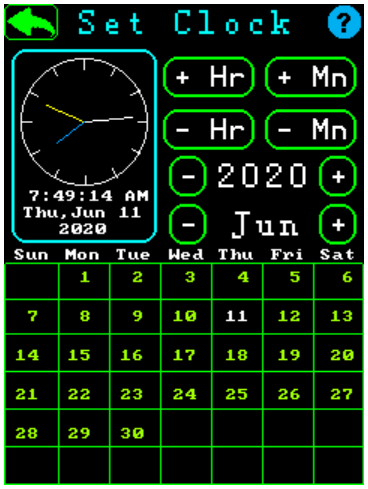
*Note: Protocol files are **not** deleted when uninstalled.*

Note: A default protocol will be used when no other protocols are installed.

Set clock

Tap on 

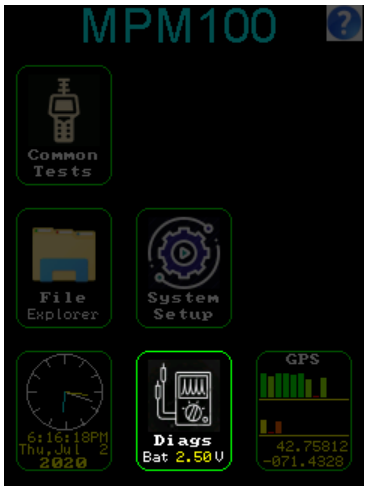
to access the set clock screen.

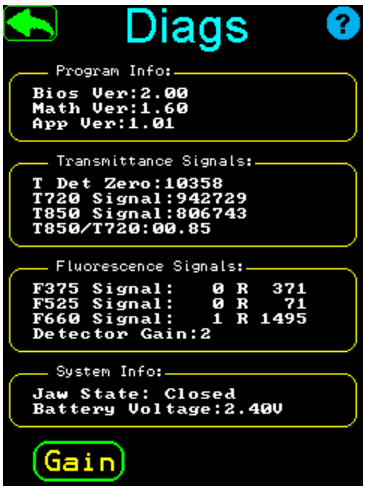


Diagnostics

Tap 

to access some basic system readings. This information can be useful when troubleshooting.





Program Info

This box has information on the version of different parts of the software installed on the unit.

Transmittance Signals

This box has information on the signals used by the transmittance measurement system. The T Det Zero signal shows relative energy in the sample chamber when both sources are off. This value should be below 15000 in most cases. The T720 and T850 signals show the amount of energy detected at these wavelengths. A source fault could be determined by one of these values being the same as the zero value.

Fluorescence Signals

This box shows signal values from the fluorescence detection system. The number is the detected signal, it will rise if a fluorescent material is put in the chamber. The number adjacent to R is reserved for future use. It will normally be near zero.

System Info

This box shows other miscellaneous info. The jaw switch operation can be verified here. Battery voltage is shown here too. A low battery warning and power off will occur when the battery nears 2.0V.

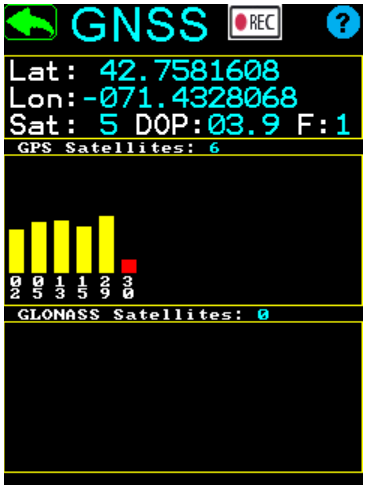
GPS

Tap 

to display GPS location and the number of satellites in view. Satellite number and strength are shown with a colored bar graph. The GPS unit currently monitors two different GNSS (GPS USA and GLONASS Russian) systems to calculate a position fix.

Tap 

to record a track for testing.



Protocol scripts

The MPM100 performs five direct measurements. Three fluorescence intensity, and two transmittance values. How the instrument uses this data is defined by protocol scripts. A script is a plain text file containing simple instructions. This feature allows the creation and editing of custom measurements.

A protocol script consists of two parts.

- Information including the name of the protocol, the default location to save data and what data is saved.
- Mathematical commands defining how to calculate parameters. Each script can have up to 5 calculated parameters and each parameter can have up to 8 calculation steps. A calculation step is a simple 2 argument mathematical expression. Below are some basic rules that must be followed to properly instruct the unit on how to perform the calculation.

Note: Protocol files must be saved in a directory named 'PROTOCOL'. If missing, this directory can be created.

Note: Capitalization is ignored by commands and variables. It is only preserved in variables TNAME and NAME.

Note: The test screen only displays the value(1-5) variable with its corresponding name. To display uncalculated data, a value(1-5) must be set to the desired data point (see example blow).

Note: The value(1-5) variable is calculated in order of appearance in the script file. The first occurrence is assigned to value1, second occurrence is value2, etc..

Comments

Comments may be entered anywhere in a script file. They should be entirely on their own line and start with an apostrophe. Example:

```
'Hello world. This is my first script.
```

Information block

The beginning of a script contains the following information:

`TNAME =`
Test name. This is the name of the test as shown on the main screen icon. 15 character maximum.

`LOGDIR =`
Log directory. This is the default directory used to log data.

Note: A file name will automatically be generated from the current date. Example: A test run on July 1, 2020 will save data to a file called R010720.CSV . New data will be appended to the file if this name already exists.

`LOGFMT =`
Log format. This line contains comma delineated variables that correspond to data that will be logged. A list of available variables is shown below. Data is logged in order of appearance in this line. A calculated variable that is listed but not calculated in the protocols measurement section of the script will be assigned a value of 0.

Reserved variables

Reserved variables are recorded when the last measured point in an average series is measured. These variables are not available for use in a calculation. The addition of any of these variables to the LOGFMT = statement will save the corresponding value to the data file.

SNUM	Sample number of data point
DATE	Date sample taken
TIME	Time sample taken
GPS	Location (when available) where sample was taken. GPS data is represented as 3 variables with intervening spaces: ##.###### ###.###### #.# (latitude longitude and DOP in meters)
SIDE	Sample side (Top / Bottom)
GAIN	Gain of fluorescence system for fluorescence measurement (1-5)

Example:

```
TNAME = Chl-Phy
LOGDIR = Chloro
LOGFMT = SNUM,Side,DATE,TIME,GPS,Gain,T720,T850
```

Note: The above example will store the specified data, but data will not appear on the display. To display data on the instrument screen, at least one value(1-5) variable must be set in a calculation block.

Calculation block

A calculated parameter (measurement) consists of several instructions. There may be up to 5 calculated measurements per protocol.

MEASUREMENT
The first line of a measurement block is "measurement" to mark the start of a group of calculated measurement instructions.

NAME =
The name of the parameter is defined. It can be up to 6 characters maximum. This name is only used in the saved data file header.

FORMAT =
The format of the number to be saved. Defined by a series of "#" characters with a decimal point. For example, "Format= #.##" would save a calculated value of 3.14159 as 3.14.

The final series of lines describe the desired mathematical formula.

Note: There can only be one mathematical calculation per line.

Variables and values

Variables that can be used to create mathematical formulas.

A, B, C, D Temporary variables, typically used in a calculation sequence.

F375 Fluorescence intensity due to the 375nm excitation source (range of 0 to 3500).

F525 Fluorescence intensity due to the 525nm excitation source (range of 0 to 3500).

F660 Fluorescence intensity due to the 660nm excitation source (range of 0 to 3500).

T720 720nm transmittance channel (range of 0 to ~1.000). Note that the maximum value may exceed 1 due to small mechanical variations that can occur with additional compression of the sensor head.

T850 850nm transmittance channel (range of 0 to ~1.000). Note that the maximum value may exceed 1 due to small mechanical variations that can occur with additional compression of the sensor head.

Value1, Value2, Value3, Value4, Value5 These values store the result of a calculation. **Value numbers are automatically assigned by order of appearance in the script.** The first calculation is assigned to value1, second calculation value2, etc.. Values that have been assigned may be used in subsequent calculations.

Note: When a group of points is averaged, only the final calculated value is averaged. To store the average of a raw signal, assign it to a parameter without any calculations.

Mathematical functions

These functions can be used to create mathematical formulas.

Functions with two arguments (variables or constants).

+	Addition: A + 1
-	Subtraction: A - B
*	Multiplication: A * 2
/	Division: C / A
^	Power: A ^ 3 (cube of A)

Functions having only 1 variable

SQR(A)	A*A
LN(A)	natural log of A
LOG(A)	base 10 log of A
EXP(A)	e^ A
SIN(A)	sine A (in radians)
COS(A)	cosine A (in radians)
TAN(A)	tangent A (in radians)
ABS(A)	absolute value of A

Protocol script outline

A complete script will typically contain the following lines of code:

Information block

`TNAME = Anthocyanin`	name of test (15 characters max)
`LOGDIR = anth`	name of directory (11 characters max)
`LOGFMT = snum,date,time,value1`	list of variables to be saved

Calculation block(s)

`MEASUREMENT`	mark start of calculation block
`NAME = Anth`	name of measurement (6 char. max)
`FORMAT = #.##`	define significant digits
`'Anth = log(F660/F525)`	comment ignored by instrument
`A = F660/F525`	calculate ratio (one calculation per line)
`Value = log(A)`	take log of ratio and store in "value"
`End`	mark end of calculation block

Up to four additional calculation blocks may be added as needed. Each block must begin with "measurement" and end with "end". Each value variable is automatically assigned a number (value1, value2, etc.) corresponding to the order in which they are calculated. The first block is assigned to value1, second block is assigned value2, etc.. These variables may then be used in subsequent calculations.

Note: Do not use the numbered version of value (value1, value2, etc.) on the left side of the equation.

Script examples

Calculation block example

Calculate the ratio of the difference of two values to a third one:

Desired formula is: Parameter = (F660 - F525) / F375. Where F660 is the fluorescence detected with a 660nm excitation. F525 and F375 are similar values excited by their respective wavelengths.

The calculation needs to be broken up into discrete steps, and the complete calculation would be coded as follows.

```
Measurement
Name = DRatio
Format = #.##
A = F660 - F525
Value = A / F375
End
```

"A" is a temporary variable storing the difference between F660 and F525

Value1 is assigned to final value resulting from all the intermediate calculations.

"End" Marks the end of this group of instructions.

Calculation block example

Calculate the ratio of two values:

Desired formula is: Parameter = T720 / T850. Where T720 is the transmittance through the sample at 720nm. T850 is a similar value for 850nm. The complete calculation would be coded as follows:

```
Measurement
Name = Ratio
Format = ##.##
Value = T720 / T850
End
```

Calculation block example

Calculate the sine of a ratio and subtract a constant

Parameter = Sin (T720 / T850) – 1.375 can be coded as

```
Measurement
Name = SinR
Format = #.###
A = T720 / T850
B = sin(A)
Value = B-1.375
End
```

Note: entering "A = sin(T720 / T850)" will not work as it contains two mathematical operations on a single line.

Complete script example

Create a data file storing the sample # , transmittance at 720nm and location information:

```
TNAME = T720
LOGDIR = TRANS
LOGFMT = SNUM,T720,GPS
Measurement
Name = T720
Format = #.##
Value = T720
End
```

Note: To display T720 on the test screen, it must be set to the value variable. Only value variables can be displayed on the test screen.

Complex script example

Note: This is the default script loaded if no custom protocols are installed.

Choose a protocol name to be used on the test icon (up to 15 characters).

```
TNAME=Common Tests
```

Select a default log directory.

```
LOGDIR=testdata
```

Set the list of data items to log per entry.

```
LOGFMT = SNUM, side, DATE, TIME, GPS, gain, f375, f525, f660,
t720, t850, value1, value2, value3, value4
```

Now each calculated parameter is added in sequence.

Calculate a parameter called ChlM and store it in Value1.

Mark the start of a calculated parameter.

```
Measurement
```

Add a comment containing the name and formula (must begin with a "'" character)

```
'ChlM=(T850/T720)-1
```

Declare the name of the parameter here. It can have up to 6 characters.

```
Name=ChlM
```

Set the number of significant digits stored.

```
Format=##.###
```

Break up the formula into single operations. There can be up to up to 8 lines to calculate the value.

```
a=t850/t720
value=a-1
```

Declare the end of this parameter calculation.

```
end
```

The next parameter is called FlvM. It will be stored in Value2.

```
Measurement
'FlvM=log(F660/F375)
Name=FlvM
Format=#.###
a=f660/f375
value=log(a)
end
```

The next parameter is called AnthM. It will be stored in Value3

```
Measurement
```

```
'AnthM=log(F660/F525)
Name=AnthM
Format=#.###
a=f660/f525
value=log(a)
end
```

The next parameter is called nbiE. It will be stored in Value4

```
Measurement
'nbiE=ChlM/FlvM
Name=nbiE
Format=##.###
'ChlM is value1 from above
'FlvM is Value2 from above
value=value1/value2
end
```

Maintenance

There are no user serviceable parts in the MPM100. Do not disassemble the unit. The unit's batteries may be changed via a door on the back. A glasses type cloth is recommended to clean the touch screen surface. Compressed air or a cotton swab with a little isopropyl alcohol may be used to clean out the sample area. Keep this area free of dirt and debris for best results.

Specifications

Fluorescence Sources:	LED 3 channels available. Default values are 375nm, 525nm, 660nm. Other wavelengths from 260nm to 950nm available.
Fluorescence Detection:	Single channel Si Photodiode. Default filter installed for 720 to 900nm range. Custom filters available for 400nm to 900nm.
Transmittance Sources:	LED 2 channels available. Default values are 720nm and 850nm. Other wavelengths from 405nm to 950nm available.
Transmittance Detection:	Single channel Si Photodiode. Default broadband diffuser installed usable for 405nm to 950nm. Custom window options available.
Data collected:	3 fluorescence signals and 2 transmittance signals. Data can be processed by user defined programming formulas.
User Interface:	3.2" TF LCD 240x320 pixel with touch panel. Jaw position sensing switch.
GPS:	Built in 12 channel multi system capable GNSS receiver with internal antenna.
Memory:	2GB of internal storage. USB port for data transfer to host PC.
Power:	2AA NiMH batteries (two sets included) One set provides about 4 hours of runtime.
Instrument Size:	78mm x 50mm x 180mm
Instrument Weight:	270g with batteries
Included items:	MPM100, stylus, 4AA NiMH batteries, universal voltage battery charger, USB cable, manual on USB stick, transport case.

Test data file format

Note: A header is added to the beginning of each test run. The names of the calculated parameters will be substituted for the 'Value#' entry on the header.

The sample data shown below was collected using the default protocol script.

```
SNum, Side, Date, Time, GPS, Gain, F375, F525, F660, T720, T850,C hlM, FlvM, AnthM, nbiE
1, Top, Jul/06/2020, 11:03:59, 42.7580985 -071.4328245 1.1, 3, 609, 2978, 1495, 0.783, 0.927, 0.184, 0.390, -0.299, 0.472
2, Top, Jul/06/2020, 11:04:32, 42.7580858 -071.4328148 0.9, 3, 646, 3091, 1589, 0.778, 0.923, 0.187, 0.391, -0.289, 0.477
3, Top, Jul/06/2020, 11:05:05, 42.7581155 -071.4328356 0.8, 3, 650, 3104, 1590, 0.775, 0.918, 0.185, 0.388, -0.291, 0.475
4, Top, Jul/06/2020, 11:05:15, 42.7581185 -071.4328283 0.8, 3, 437, 1923, 1074, 0.877, 0.909, 0.037, 0.391, -0.253, 0.095
5, Top, Jul/06/2020, 11:05:27, 42.7580998 -071.4328130 1.0, 3, 467, 2058, 1156, 0.877, 0.910, 0.037, 0.394, -0.250, 0.094
6, Top, Jul/06/2020, 11:05:32, 42.7580940 -071.4328158 0.8, 3, 442, 1950, 1085, 0.877, 0.910, 0.037, 0.390, -0.255, 0.095
7, Top, Jul/06/2020, 11:05:38, 42.7580890 -071.4328165 0.8, 3, 470, 2077, 1168, 0.877, 0.910, 0.037, 0.395, -0.250, 0.094
8, Top, Jul/06/2020, 11:05:50, 42.7580843 -071.4328118 0.8, 3, 457, 2022, 1135, 0.879, 0.910, 0.035, 0.395, -0.251, 0.089
9, Top, Jul/06/2020, 11:05:56, 42.7580835 -071.4328075 0.8, 3, 445, 1970, 1098, 0.879, 0.910, 0.035, 0.392, -0.254, 0.089
```