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PSP32

Fluorometer system

PSP32 OPERATIONS MANUAL

This manual covers the setup and operation of the PSP32 multi-probe plant stress monitor. It is capable of performing a multitude of custom programmed test protocols. The PSP32 is a unique tool for plant physiology research.

While the PSP32 has been designed for greatest durability, nothing is indestructible. Here are some cautions on system use:

Warning: Do not turn on the system until assembly is complete.

Warning: The PSP32 system is weather and water resistant, not waterproof. The controller, connecting boxes, connectors and probes were not designed to be submerged in water due to flooding, caused by heavy rains. Components submerged in water are not covered under warranty.

Warning: Probes with dark adaption modules must be stored and shipped with the dark adaption hoods completely closed! If not completely closed, damage may happen. Probes that have been damaged in this way are not covered under warranty.

The default security code to lock out changes by unauthorized people is 1234.

CONTENTS

THE PSP32 SYSTEM

The PSP32 is an advanced chlorophyll fluorescence measuring system. It supports from 1 to 32 measuring probes to be attached to a single controller allowing larger populations of plants to be measured. The system is suitable for field, green house or growth chamber measurement during the day and night, without interruption, for months at a time.

An optional sliding hood (dark adaptor unit) is available for daytime dark adaptation, allowing measurement of photoprotection mechanisms (q_E, pNPQ and qP_d), intense light avoidance (q_M or chloroplast migration), low light survival mechanisms (q_T or state transitions) and photoinhibition (q_I). Furthermore, reliable measurements are possible with the addition of leaf temperature measurement, far red light (for F_o'), an intense 10,000 µmol m^2/s light adapted saturation flash and an FM' correction option according to Loriaux 2013.

Each probe operates as an independent measuring system. A measuring script contains instructions on how to perform the desired measurements. Standard test protocol scripts are provided and can be edited as desired. Probes can be individually programmed, groups can share scripts, or all probes can run the same script.

A central controller saves data from each probe into individual files making later analysis simple and traceable. This also makes it easy to start & stop test runs on some probes without complicating data from probes still running. An Internet gateway is included that can be used to remotely control tests and access data.

PROBES

A probe has a single wavelength light source of either 470nm or 660nm for fluorescence measurement, actinic drive and saturation flash. The wavelength choice is made at time of order. Probes are water resistant but not submersible. A reflective target area on the sample bracket is used to reference ambient PAR levels. Leaf temperature may be measured with a removable thermistor. The standard configuration probe has a 60 degree angled clip to hold a sample stationary while keeping it open to ambient light. The dark adaptor accessory adds the ability to shroud the sample on both the front and back sides to perform dark adaptation. This accessory includes a far red (735nm) light ring for Fo' measurements.

BASE UNIT

The base unit supplies regulated power, manages operation and data collection of connected probes. Four data ports can support up to 8 probes each. Two power ports are available so a redundant power source may be connected. They will accept power from the included mains Voltage power converter or battery & solar power for field work (not included). The unit automatically draws from the source with the greatest Voltage available. Data management can be via an Ethernet port, WiFi, or a

USB memory stick. A web browser interface is included for remote access. Local control is made via a built in 7" touch screen.

INTERCONNECTIONS

Probes are connected to the control unit with cable. A splitter box is required if more than 4 probes are to be used. There are 2 splitter box types available, a 4 probe model and an 8 probe model. The standard cable length included with a probe is approximately 10 meters. Maximum cable lengths are determined by the exact system configuration.

POWER SUPPLY

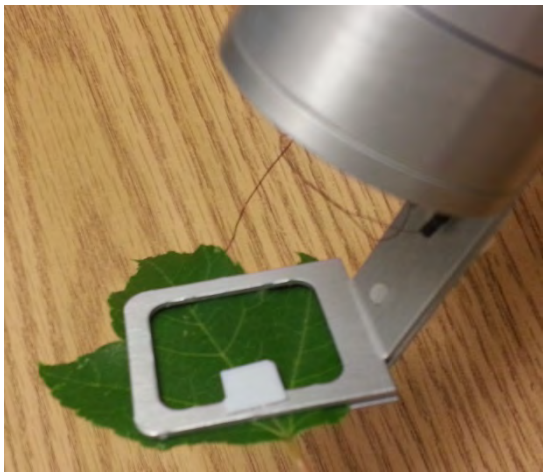
The PSP32 system is shipped with a mains Voltage power converter capable of operating the unit with up to 16 probes. An additional adapter can be added to power additional probes. In the field, it is assumed that solar backed battery power will be used. Appropriate battery and solar size will depend on the number of probes, accessories and the amount of sunlight typically available at the test site. Two battery systems may be connected to the unit for redundancy.

REMOTE COMMUNICATIONS

The PSP32 controller box includes with both WiFi and a hardware Ethernet port. A cellular modem can be fitted to the system. The details of such an item vary greatly with location. Contact your dealer for more information. The WiFi and Ethernet connections can be used with most conventional network systems. Test control and data retrieval can be made from a web browser. Note that there are some limitations to this when the cellular modem is used and are carrier specific. The PSP32 also has a simple point to point (Access Point) mode for data transfer to a smart phone or tablet.

PROBE SETUP

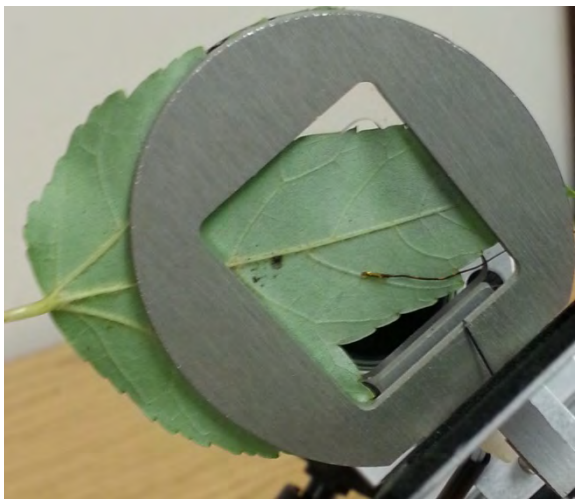
The fluorescence probe is a cylinder with a diameter of 1.5" x 10" long. There are two leaf clip options as shown below:



STANDARD CLIP HOLDER.

DARK ADAPTOR ACCESSORY CLIP.

The leaf is gently held between a front plate (with the white PAR target) and a back plate. The front plate on the dark adaptor unit is transparent because it shadows much more leaf then the standard clip. The dark adaptor unit has a spring that holds the clip closed. The standard clip has a friction fit that is adjustable with the two white bottom screws just barely visible in the photo. There is a small thermistor that can be used for leaf temperature. It should be gently placed on the back of the leaf and held steady with the back of the clip as shown below.



THERMISTOR PLACEMENT ON A STANDARD CLIP (LEFT) AND DARK ADAPTOR UNIT (RIGHT). VIEWS ARE FROM THE REAR OF THE CLIP.

For the dark adaptor unit, note how the thermistor wire is draped close to the front of the clip. This is to make sure the sensor is not disturbed by the hood opening and closing. You can also see where the thermistor plugs into the probe. It is easily changed in case of damage.

Open the clip area by pinching the clip between the back arm guide (where the shutter arm first goes through) and the white screws. Do NOT loosen the white screws.

The leaf does not need to fill the entire sampling area. The active measurement spot is about 3/8" in diameter and to the side of the PAR pad. Even just a few needles can be measured. The unit may need to have the detector gain increased in this case.

The probe is supported by a metal tube clamp with a ¼ - 20 standard tripod thread.

This collar is placed around the probe body and located to balance the probe and cable weight. Note: do not over tighten the clamp on the probe. It is secured with a 3/16" hex driver (included).

There are many ways to mount a probe for field use:

PROBE WITH THE DARK ADAPTOR UNIT SUPPORTED WITH AN 'H' STAND AND ARTICULATED ARM.

A 6" SPIKE AND BACKING PLATE SUPPORT THE ARTICULATED ARM.

The main detail for supporting a probe is that it be secure enough not to stress or tear the sample leaf. Note that the probe will be looking down on the leaf and that the probe should be positioned to the side of the solar track so as to not block natural light to the leaf.

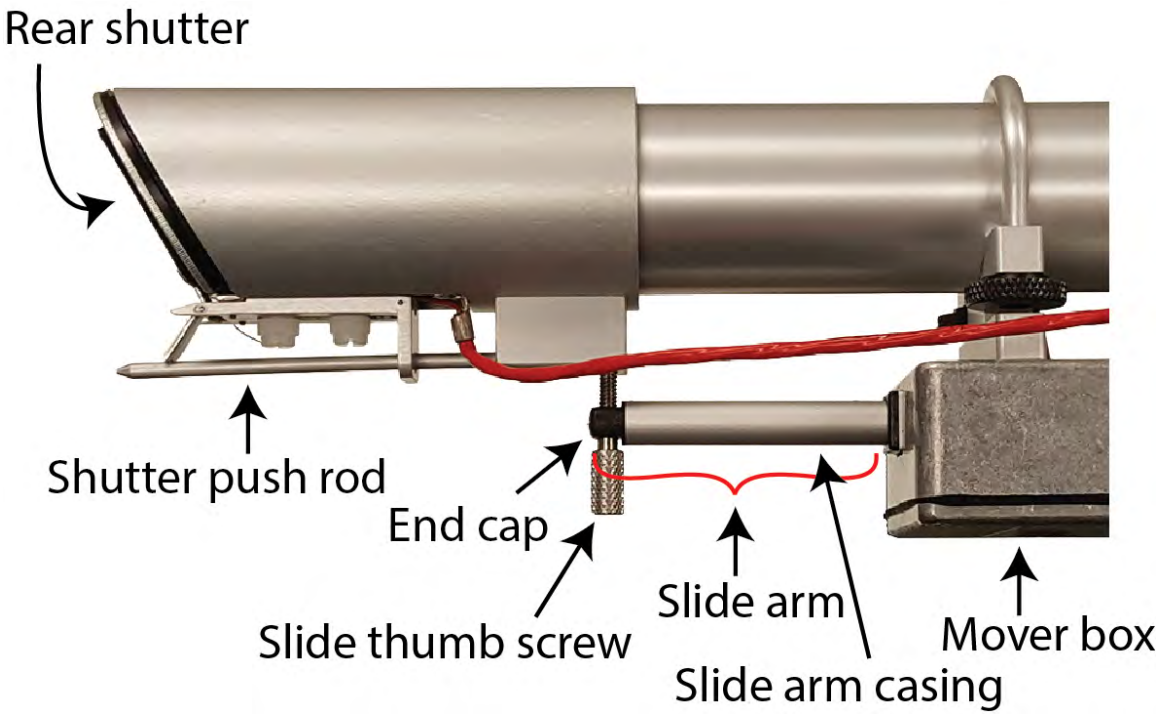
Non leaf samples can also be measured:

The probe is positioned with the bracket placed against the sample. The back clamp can be removed for better positioning. The thermistor is laid on the sample surface.

Contact the factory for this application when using the dark adaptor unit as the back flap is not meant to be removed.

DARK ADAPTOR SETUP:

The above photo shows the bottom view of a probe with the dark adaptor installed. Note that the base unit connects to the mover box and a short link cable goes from that to the probe. The FRED ring (735nm source) is connected to the mover box also. If needed, a button on the side of this box (top in this view) will open & close the hood. There is also a test of the FRED ring that happens when the slide is opened with the button. The FRED source will blink on for a second after finishing the open phase. This only occurs when the manual button is used so as not to interfere with a test using the dark adaptor. Note the location of the slide arm and shutter push rod, it is important to position the probe carefully so that surrounding vegetation won't get snagged in the mechanism when it moves.



This photo shows a close up view of the slide arm with the hood closed. Note the rear shutter is closed by the shutter push rod. Note that the slide arm has a casing and end cap. It is important that

the end cap be tightly secured to the slide arm casing and the slide arm casing is not tightly screwed into the mover box. The arm may bind during movement if the casing is tightened too much. From the factory, this is all accounted for in the setup. If the probe is disassembled for cleaning, make sure the casing is turned until just tight, then back off a turn or so to align the thumb screw hole with the thumb screw. If the mover box is removed from the probe, it should be reassembled in the closed position with its location on the probe body set to provide proper tension for the slide arm. Ensure that the hood completely seals against the sample holder to prevent light leaks.

Please note that the dark adaptor assembly is relatively fragile, especially the rear shutter flap. It should always be stored and transported in the closed state. Mechanical damage to the shutter flap from improper use or storage is NOT covered under warrantee.

BASE UNIT MOUNTING:

The base unit should be mounted with the connector bank facing down. A poll mount bracket set is included with the system. One bracket set screws to the base unit. The other bracket set has a slot for a u-bolt pole mount for a range of 1.5" to 3" poles. Both brackets have matching holes for linking together on the outer sides. This can also be mounted to a board support. A free standing tripod mount is shown in the accessories section.

ITEMS INCLUDED WITH A CONTROLLER

1 - PSP32 Controller box

1 - Set of pole / wall mounting brackets with hardware. (u-bolts not included)

1 - Universal Voltage AC power supply (not weather proof, indoor use only)

1 - Wifi Antenna

1 - 3/16 hex key (for clamp screws)

ITEMS INCLUDED WITH A PROBE

1 - PSP32 probe (specify Blue or Red source at time of order)

1 - 10m probe cable

1 - Probe holding clamp with ¼-20 mounting hole.

ITEMS INCLUDED WITH THE DARK ADAPTOR ACCESSORY:

1 - dark adaptor actuation box

2 - U-bolt securing clamps

1 - hood collar with shutter push rod

1 - hinged door sample holder with FRED ring

1 - probe to dark adaptor link cable

1 - hood securing thumb screw

Probes with the dark adaptor option ordered from the factory will come pre-assembled. Refer to instructions with the dark adaptor unit for customer installation on standard probes.

SYSTEM DEPLOYMENT

Probes should be placed near the selected plant leaves after securing the stands. Using an articulated arm as the final link between the stand and probe greatly eases final placement near the sample. Refer to the previous chapter for information on securing a sample in the clip. Cables are run from the probes to the base unit (or splitter box). Use the Velcro cable bundler strip on each cable to strap the cable to the probe stand and loop the cable to minimize stress and prevent water run down to the probe (if applicable). Note the previous photo of the spike stand mounted probe for an example of cable dressing. Remember that probes and splitter boxes are water resistant but not water proof. Place splitter boxes up off the ground if placed in areas prone to flooding. Note that probes are identified by the probe's serial number located around the rear connector. Use this number when performing an experiment layout and for a sample location guide when referencing sample plot data sets.

When using more than 4 probes, it is best to group them by anticipated experiment sets. This will allow for multiple experiments to be run with the ability to add or subtract probes to non running ports while not disturbing tests in progress on other ports. Note that as probes are managed by serial number, the choice of connecting port is irrelevant to the base unit.

The base unit may be mounted using the included bracket set. It can be clamped to 1-1/2" to 3" pipe or screwed into a board. There is also a convenient optional base unit stand shown in the accessory section. Do not place the base unit on the ground! While it is water resistant it is **not waterproof**. Flash floods and downpours can easily swamp it if left on the ground. Water damage of that nature is not covered under warrantee. Cable entries on the base unit are meant to be at the bottom of the enclosure for proper water resistance.

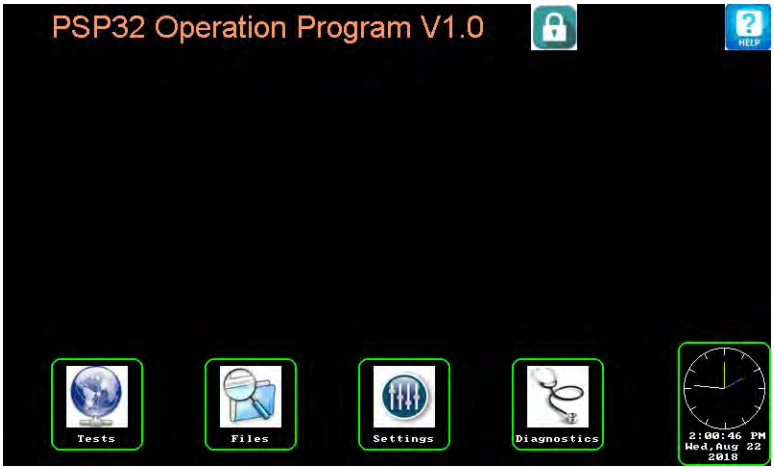
Connect the power source to a battery port. In the case of a solar power source, follow the directions included with that kit. Power for the PSP32 unit would typically come from the charge controller. Refer to "Selecting battery and solar panel size "for information on choosing the correct size of solar panel and battery for your deployment.

Network setup will depend on network availability. The wired Ethernet connection is convenient for lab and greenhouse connections. The WiFi modem can be used in most cases like the wired connection. Note that there are some limitations with e-mail functions when using the WiFi vs the wired network connection. In the case of a cellular modem, connect the network cable to the Ethernet port and the power cable to the cell modem power port. The power port is configured for specific cellular modems so check with your dealer for approved models. There may be additional setup steps needed before the modem is brought to the field, refer to the separate documentation included with the modem for additional details. See the setup chapter later in this manual for PSP32 network configuration steps.

Note that network connectivity is not needed for the system to operate, it just provides additional ways to retrieve data and monitor test operations.

GETTING STARTED

Assuming all components are connected correctly, turn one or both battery switches to ON. The unit will display an opening graphic while it starts up. When complete, the main screen will appear and the unit will start a search for any connected probes or sensors. The search may take up to a minute. When finished, a message indicating the total number of probes found will be shown.



THE MAIN SCREEN PROVIDES ACCESS TO ALL OTHER SCREENS

There are four large buttons, a clock, help (upper right corner), and a lock. Most screens will have a help button. It will provide some abbreviated information on the displayed screen functions and buttons. The help screen also has a capture feature that will take a snapshot of the previous screen. This is useful when troubleshooting problems. The lock button is present in only two screens, the main screen and the Probe Summary screen. This button is used to lock or unlock user control of the PSP32 unit. It provides a basic security feature to limit unauthorized changes or access to data on the unit. When locked, a 4 digit PIN number is needed to release the lock. The default PIN is 1234, and can be changed in the Application Setup screen. You will see the message "Rmt" displayed next to the lock button on the main and run screens when a remote connection is logged in.

START A RUN

Let's start a run. Tap **Tests**:

PROBE SUMMARY SCREEN

This screen provides information on all probes present. In this example one probe (serial number 1101) is present. We will load a test script to run.

Tap on **Edit** to bring up the 'Script Editor' screen.

SCRIPT EDITOR SCREEN

We will load one of the examples from internal storage memory. Tap **Load** to bring up the file selection box. Tap the yellow directory entry named SCRIPTS. This will display preloaded script examples. Chose FVM.TXT.

SCRIPT EDITOR SCREEN (SCRIPTS/FVM.TXT)

This is a simple Fv/Fm measurement script. The commands are covered in greater detail later, but you can see it is a simple language. The first command 'Do 0,10' is a loop starting command. Its complimentary command 'Loop' appears on line 3. The line in between (2) is what is repeated. The parameters in the Do statement tell the probe how many cycles to do and how often. In this case, the repeat count is zero, so the loop is continuous. The second parameter is 10 (minutes) this is how often to repeat the loop. This script will take an Fv/Fm measurement every 10 minutes until halted when the user taps the stop test function. Tap the back button (upper left) to proceed. A prompt will appear asking where this script should be sent. In this case, select 'All'.

We are now ready to start the run. Tap **Run** to begin. A prompt will appear asking which probes are to be run. Tap **All** for this example. The probe will begin running the script. If the probe was setup with a sample, you may see something like the following next.

PROBE SUMMARY SCREEN

The summary screen now shows data from the last measurement. Status letters show miscellaneous info of the probe. Note that measurement data taken is buffered in the probe and queried for by the

controller at regular intervals. If there are 10 probes running, they could all take a measurement at the same time, but it may take a small amount of time for the measurement to be seen on the controller. This effect is less obvious with only 1 probe.

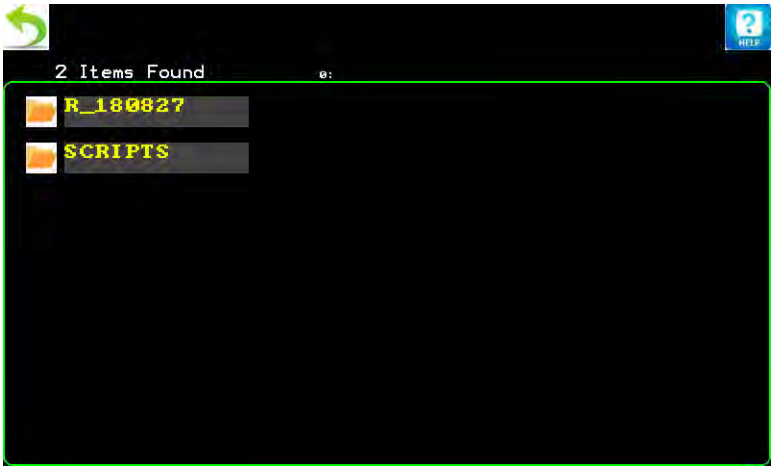
You can see a more detailed view of the probe's activities by tapping its box.

PROBE INFO SCREEN

Here we see the last 30 minutes of activity of probe #1101. Note that the run started @ 14:10:36 and has been taking measurements every 10 minutes. The Saturation flash always shows a plot from the most recent measurement. This plot is not saved. Tap a column of data to graph it in the green box (Fo parameter was selected in the above screen).

You may stop a probe by tapping **Stop** at the top of the screen. The controller will know to only stop this probe because you are in this screen. You can also use the **Stop** button in the previous screen and instruct the unit to stop 'All'. The probe will return to an 'Idle' state awaiting further instructions.

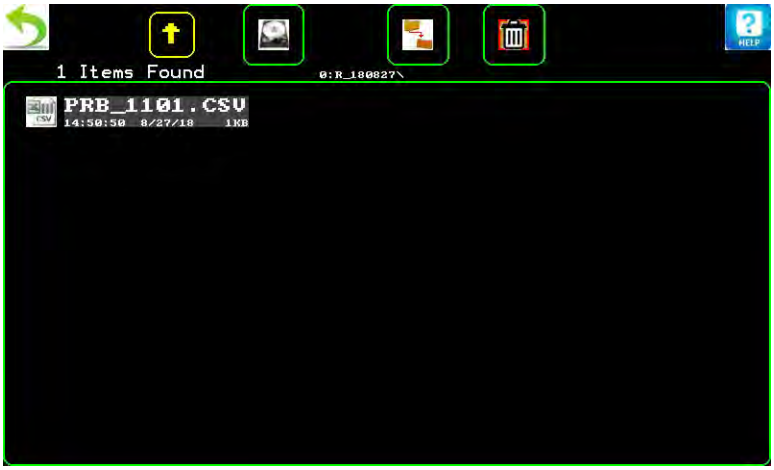
After a few measurements have been made, exit back to the main screen (tap escape twice) and select 'Files'.



DIRECTORY SCREEN

Here you will see two directories now exist. The Scripts directory is where your scripts are stored. The directory R_180827 contains your sample test data. The directory name will be different when you try this because the name is generated at the start of a run based on the date (R_YYMMDD). The directory name is not selectable.

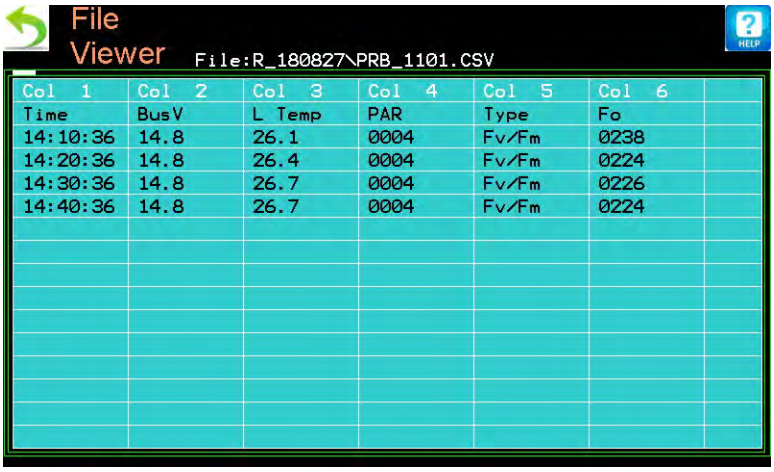
Tapping on this will show the probe's data files.



FILES SCREEN

The data file is named based on the probe serial # as they are unique. This feature is not selectable. Tapping on it will bring up a selection list. Tap **Other**. Next will appear an option to 'View', tap this.

The contents of the test data file will appear.



Col 1	Col 2	Col 3	Col 4	Col 5	Col 6
Time	BusV	L Temp	PAR	Type	Fo
14:10:36	14.8	26.1	0004	Fv/Fm	0238
14:20:36	14.8	26.4	0004	Fv/Fm	0224
14:30:36	14.8	26.7	0004	Fv/Fm	0226
14:40:36	14.8	26.7	0004	Fv/Fm	0224

FILE VIEWER

Here you see the data logged from the sample run. This screen holds several rows/columns of data and can be moved with a finger drag. More details are provided in the File Management section.

Data is stored in a .CSV (comma separated values) file for simple import into most analysis programs.

This data file would look like this:

```
Time, BusV, L Temp ,PAR ,Type ,Fo ,Fm ,Fv/Fm ,Fv/Fo ,Fs ,Fms ,Y(II) ,ETR ,Fo' ,qP
,qN ,NPQ ,hYNO ,hYNPQ ,kqL ,kYNO ,kYNPQ ,FmE ,qE ,FmT ,qT ,FmM ,qM ,qI ,alpha ,Ik
,ETRmax ,Im

14:10:36,14.8,26.1,0004,Fv/Fm,0238,1003,0.762,3.214

14:20:36,14.8,26.4,0004,Fv/Fm,0224,1016,0.779,3.535

14:30:36,14.8,26.7,0004,Fv/Fm,0226,1028,0.780,3.548

14:40:36,14.8,26.7,0004,Fv/Fm,0224,1032,0.782,3.607
```

The first line has a header list for the data columns. Data will be filled in on the basis of the test type. Unused columns will contain no data.

TEST OPERATION

Tap **Test** from the main screen

PROBE SUMMERY SCREEN

This screen provides a summary of all connected probes. Note that they are organized by serial number. In this example there are 3 probes present.

A probe's status is marked by the letters appearing to the side of the plot box. In general, the probes can be in one of two states; idle or running.

'R' indicates that a probe is running a script. You can see that probe serial numbers 1101 and 1113 are running, while probe 1004 is idle.

'S' indicates that the probe has a script loaded. By default, probes come with a basic script loaded, so the only reason for the 'S' to be missing is a fault condition.

'DO' indicates that probe 1101 has a dark adaptor accessory installed and that the hood is open.

'DC' indicates that the hood is closed.

'E' indicates an error occurred while performing a function. Try the function again. If it fails twice the probe may need to be restarted.

'C' indicates an error in background communications between the probe and controller. This may happen from time to time if the probe is busy taking a measurement when the controller attempts a communications. This error is only important if it occurs frequently.

Measurement values and a plot of the most recent measurement flash are displayed. It provides a quick check on functionality. This is handy especially in making sure the samples are still in place. A probe with a dislodged leaf, for example, will display a significantly different plot from normal.

A general information box is located at the top center of the screen. It will display various messages about overall probe operations.

Probes take measurements based on a scripted set of instructions. Tapping **Edit** from the probe summary screen will bring up the script editor.

SCRIPT EDITOR

The last script viewed will display by default. A script may be loaded from memory or created using the built in editor. It then can be sent to connected probes. Note that scripts may only be sent to probes that are idle. More information can be found in the Script Management section.

Tapping **Run** will bring up a selection box with the choices **All**, **Some**, and **Cancel**. Tapping **All** will begin the run cycle on all idle probes. Selecting **Some** will bring up a list box showing all probes ready to run. If there is a mix of probes already running their serial numbers will be replaced by the word 'Busy'. Select the probes to be started and close the selection box by tapping **X** in the upper right corner. Those probes will begin running. A 'R' will appear next to these probes. Note: If all probes are already running, tapping **Run** will have no effect.

Stop will bring up a selection box with the choices **All**, **Some**, and **Cancel**. Tapping **All** will halt all running probes and return them to their idle state. Selecting **Some** will bring up a list box showing all probes that are available to be stopped. The word Idle will replace the serial number of any probes that are currently idle. Select the probes to be stopped and close the selection box by tapping **X** in the upper corner. Those probes will be returned to their idle state. Note: If all probes are already idle, tapping **Stop** will have no effect

Lock icon: This button will disable access to functions until a PIN # is entered. Tests proceed as normal while the controller is locked.

TEST INFORMATION

You may see details of a specific probe by tapping on its summary box. A screen similar to the one below will appear.

PROBE INFO SCREEN

This screen shows the most recent data collected from the selected probe. It also shows the last measurement flash. The specific data available will depend on the test script loaded. There is also a plot box (green border) that can show a plot of a specific data column. Tapping in this plot area will bring up a list of values available to plot. Only part of the data set may be available in this screen. The complete data file can be viewed selecting the files button from the main screen.

Script will bring up the script editor screen. The script currently in the probe will be displayed. Edits will be assumed to be for this probe only unless **Send to** is used. Refer to the section on the script editor for more details. The status box (center top) shows information on the probe. In the above example, 'Script Loaded' indicates a change to the script was successfully loaded.

Stop / **Run**. If this probe is running, the stop button will display. If this probe is idle, the run button will display.

Remember that if any probes are running a script, the program will revert to the 'Probe Summary' screen after 4 minutes of user inactivity.

Note on data logging: Data is not saved to a file with each measurement. It is buffered and written to a file at certain events. Events that cause data to be written are; stopping a run, exiting the run screen, a 24 hour period has elapsed, or a web access event requires the data for transfer.

SCRIPT MANAGEMENT

Probes perform tests by following a set of user programmed instructions. This feature allows for a large variety of possible experiments. The script management screen allows you to create and edit scripts from the controller. The script editor is designed to be a guided editor with all relevant selections being supplied from pull down lists. This makes creating a custom test possible without the need for an exact knowledge of the script syntax.

SCRIPT EDITOR

The script editor lists all commands based on the 4 main classes, with subclasses listed subsequently with each level of selection. Prompts are generated for any required parameters along with some modest information on setting ranges.

SCRIPT EDITOR SCREEN

The script is displayed on the screen 20 steps at a time. Each step is numbered for editing purposes. The line numbers are omitted from the saved copy. Scripts that are longer that 20 steps may be reviewed by dragging the list up or down. A position bar to the left shows relative location in the script file.

The source of the script is displayed at the top of the screen. All scripts are stored in the default subdirectory 'SCRIPTS'. If the script was loaded from a probe, the name entry may be blank.

Send to Sends the displayed script to the probes. A window will appear listing all probes that are available to receive a script.

NewLine Appends a new command step (to the end of the script). List boxes will display to guide you through a selection process.

Insert Inserts a command at the chosen location. A prompt will appear for the line number to place this new command. After entering the location, the regular process for picking a new line follows. The

command previously at that location along with all following are bumped down by 1 to make room for the new command.

Change Changes parameter settings on a line. An example would be a **Pause** command. This command has a time parameter associated with it. This function would bring up the proper box to select a new value. An error message is displayed if the command chosen doesn't have a parameter associated with it.

Delete Deletes the command at a selected line number. All following commands are moved up one line. Some compound commands (such as RLC) encompass multiple commands and should be deleted carefully.

Load Loads a previously saved script. The file selection box will pop up. Note that scripts are usually stored in the SCRIPTS subdirectory.

Save Writes the present script to a file on the internal disk drive. The script should have a 1-8 character name given to it. The program adds the correct path (SCRIPTS) and file extension.

Reset Clears out the displayed script. This is useful for starting a new script. Note that in the case of the previous script belonging to a specific probe, the script saved on the probe remains unchanged. An empty script file cannot be saved to a probe.

A note on the availability of these functions, as previously mentioned the script editor may operate in a global capacity or be linked to a specific probe. This will depend on where the script editor is called from. If called from the Probe Summary screen, then the application is global. If called from the Probe Info screen, then this edit is directed at a specific probe. When in this mode, the probe must be in idle mode for most function buttons to work. The reason being is that a script may not be changed on a probe while it is running. An error message will appear if any of these functions are tried when the probe is running.

Individual script size is fixed and the maximum number of steps possible is a complex question due to the composition of some commands. The maximum length is 122 instruction spaces. Some commands (those with parameters) may use 2 or 3 of these spaces per command. The language reference section has additional information on the amount of space used of each command.

Scripts can be created on a PC using a simple text editor program. Script files are stored in a plain text format that is easy to understand after reviewing the chapter on the language syntax. They can be loaded to the system via a memory stick or by the web interface.

SCRIPT LANGUAGE

A script tells a probe what to do and when to do it. The probe performs all technical details of the measurement and buffers the data for reporting back to the controller. The user only has to tell the probe what kind of measurement is to be made.

Scripts can be composed on the controller console, or with a simple text editor. When composed on the controller, all actions are driven by pick lists and parameter prompts. The user only needs to focus on the desired sequence to be created.

Scripts can be written in most word processor programs. They are plain text with just a few basic rules. Commands are not case sensitive. Remember to save the file as a plain .TXT file with no formatting characters. Most word processor programs have this option under the 'Save As' menu option.

Scripts run indefinitely. Once a probe completes the execution of the last line, it will rerun the entire script.

A command line may use tabs or spaces to separate fields.

Commands should be typed in as shown (case insensitive).

Script commands may be broken down into four groups:

1-Commands that perform a measurement.

These commands will make a standard measurement type such as Fv/Fm or Y(II). Complex measurements such as a stepped RLC or multi-phase quenching test can also be constructed with some additional steps. It is assumed that data will be generated and saved by any of these commands.

2-Commands that control protocol details and settings.

These commands set values relevant to a property of a measurement or one of its calculations. Some examples include choosing a saturation flash processing type or setting a constant for ETR calculations. Any number of these commands may be used in a row.

3-Commands that control hardware features.

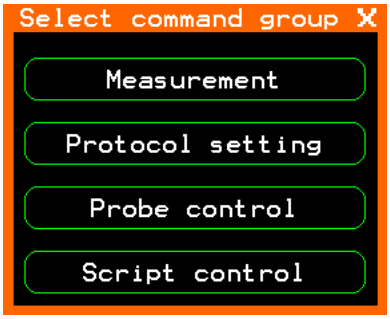
These commands allow for user control of the various light sources and accessories available on a probe. Two examples would be moving the dark adaptor hood and switching the far-red source on. These commands are often used just before or after a measurement to change the sample's environment.

4-Commands that perform script flow control.

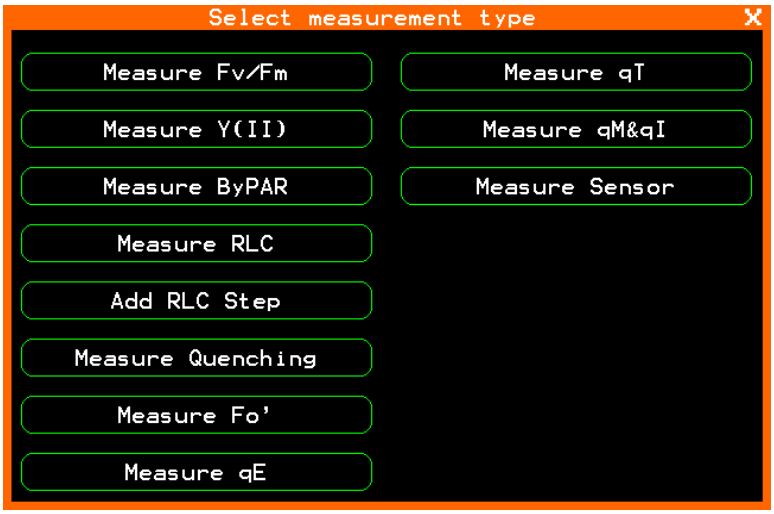
These commands control the timing as well as trigger conditions for test flow, allow for start of a test at a specific time or the interval between measurements just to name a few examples.

Note: There are three parameters that are included with all measurements: PAR, Leaf Temperature and Bus Voltage (the power supply Voltage at the probe).

Tapping **NewLine** or **Insert** from the script editor screen will display the select command group window.



Measurement commands



`Measure Fv/Fm`

Performs a Fv/Fm measurement. The sample is assumed to be in a dark adapted state either by nature or using a dark adaptor unit. This measurement takes about 4 seconds to complete.

Values obtained with this command can be used to set the pre-dawn calculation values needed by quenching test calculations. The pre-dawn value is obtained by tracking the Fv/Fm ratio for a maximum value and storing this as the 'reference' Fv/Fm measurement for later Quenching calculations. There is a command to manage this setting in the protocol settings section.

Parameters measured: Fo, Fm, Fv/Fm, Fv/Fo

`Measure Y(II)`

Measures light adapted parameters. They include Y(II) and ETR. The constants used in the ETR calculation can be modified with commands in the protocol section. This measurement takes about 4 seconds to complete.

Parameters measured: Fs, Fms, Y(II), ETR

`Measure ByPAR ###`

This performs either a dark or light adapted measurement depending on the current PAR level as set by the ### value. If the PAR value is less than the set point a dark adapted test is made. This measurement takes about 4 seconds to complete.

PAR value (0 to 255 µE)

Parameters measured: either Fv/Fm or Y(II).

`Measure RLC`

Start a Rapid Light Curve measurement. A RLC test consists of making a measurement at 4 or more different actinic drive levels. A best fit curve with curve fitting according to Eilers and Peeters (1988). It is calculated using the PAR vs Y(II) values. The equation for this curve provides the needed constants for calculation RLC test values such as alpha or Im. This measurement will take a sum total of each of the dwell times plus 4 seconds per step.

`RLC Step` **`SS,IIII`**

The Rapid Light Curve protocol requires at least 4 steps to perform the test. At least 2 steps should be higher than actinic saturation light level. This command is used to specify each of the steps. It should only appear immediately after the Measure RLC command. The probe uses its internal light source and assumes a dark adaptor unit is present or the test is performed when ambient light levels are low. There is a maximum of 8 steps allowed.

SS amount of time in seconds that the sample is illuminated (5 to 60 seconds).

IIII is the illumination intensity (10 to 2500 µE)

Parameters measured (each step): Fs, Fms, Y(II), ETR

Parameters calculated: Alpha, Ik, ETRmax, Im

`Measure Quench`

Performs a quenching measurement. Calculations are performed based on protocol settings detailed later. Calculations of quenching parameters use predawn Fv/Fm measurement values in their computation. Predawn Fv/Fm measurement is a requirement for parameter calculation. The quenching relaxation parameters require dark adaption for specific periods of time. Commonly 4-7 minutes in the dark to measure q_E in field plants, 15-20 minutes in the dark to measure qT, and 20-30 minutes in the dark to measure qM and qI.

Parameters measured & calculated: Fs, Fms, Y(II), ETR, Fo, qP, qN, NPQ, (Hendrickson or Hendrix) YNO, (Hendrickson or Hendrix) YNPQ, (Kramer equation designations) qL, YNO,

YNPQ It also allows measurement of the **quenching relaxation parameters:** q_E, q_T, q_M, and q_I if one selects these parameters as well. This measurement takes about 4 seconds to complete.

`Measure Fo'`

Performs a direct Fo' measurement with the dark adaptor unit using the far red light. This measurement takes about 4 seconds to complete.

Fo' is used in quenching and relaxation calculations. It may be calculated or measured directly if a dark adaptor *unit is fitted.*

Parameters measured: Fo' (not recorded)

`Measure` q_E

Measures the photoprotective xanthophyll cycle and Δ pH of the thylakoid lumen relaxation parameter q_E. It assumes all needed environmental settings are met. This measurement takes about 4 seconds to complete.

Parameters measured: Fm_E, q_E

`Measure` q_T

Measures the relaxation parameter q_T or state transitions. This measurement takes about 4 seconds to complete. It assumes the needed dark adaption time is met.

Parameters measured: Fm_T, q_T

`Measure` q_M`&`q_I

Measures the relaxation parameters q_M or chloroplast migration & q_I or photoinhibition.. This measurement takes about 4 seconds to complete. It assumes the needed dark adaption is met.

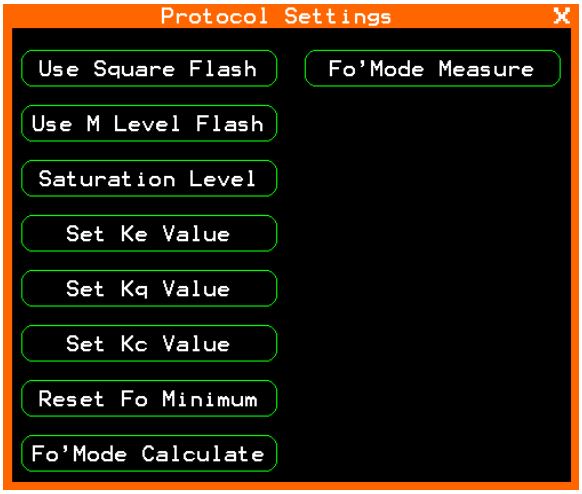
Parameters measured: Fm_M, q_M, q_I

`Measure Sensor`

This command is for logging data from a probe's environmental sensors. No saturation flash measurement is performed. The data acquired by this command varies with choice of probe.

Parameters measured: PAR, Leaf Temperature

PROTOCOL SETTINGS



`Flash Square`

This command sets the saturation flash to square profile mode. This is the default mode.

`Flash M Level`

This command sets the saturation flash to use the Fm' correction method according to Loriaux (2013) calculation method. It will work for all actinic light levels. However, the recommendation is to at least use it at high actinic light levels near leaf saturation.

`Saturation Level ###`

This command sets the saturation flash power in % of maximum (typical maximum is 10000µE) It can be used to limit flash power during night time measurements.

flash power in % (10-100)

Electron Transport Rate equation and meaning of terms

The standard equation for measuring ETR or electron transport is ETR= Y(II) x .5 x .84 x PAR
On the PSP32 we use the following parameter designations:
ETR= Y(II) x Ke (or the ratio of PSII to PSI reaction centers) x Kq (or leaf absorptance) x PAR

`Set Ke #.##`

Ke is the ratio of photosystem II reaction centers to photosystem I reaction centers. This command allows the user to set an alternate Ke value for the ETR calculation.

#.## Typical values range from 0.30 to 0.60. The default average is 0.50 .

`Set Kq #.##`

Kq is the term for leaf absorptance. This command allows the user to set an alternate Kq value for the ETR calculation.

#.## Typical values range from 0.60 to 0.94. The average default is 0.84.

`Set Kc #.##`

This command allows the user to set an Fo' calculation tweak factor percentage.

#.## Typical values range from 0.0 to 0.50 . Default is 0.

`Reset Fo Min`

This command is used to reset the pre-dawn Fv/Fm tracking value. It would be done at the beginning of each dark adapted measurement cycle in a Quenching measurement protocol.

`Fo’ Mode Calc`

This command tells the probe to use a calculated Fo' value for processing quenching data. Calculations for a measurement will be reported just after the measurement. This is the default mode.

`Fo’ Mode Meas`

This command tells the probe that an Fo' measurement sequence will follow a quenching measurement. The probe will wait for the Fo' measurement to do quenching calculations. Quenching calculations from the previous quenching measurement will be reported after the Fo' measurement.

PROBE CONTROL COMMANDS

`Open DA Unit`

(DA=Dark Adaptor) This command opens the dark adaptor unit slide to allow light to hit sample. dark adaptor unit movement takes about 4 seconds to complete. The command is ignored if dark adaptor unit not present.

`Close DA Unit`

This command closes the dark adaptor unit slide to block light from sample. dark adaptor unit movement takes about 4 seconds to complete. The command is ignored if dark adaptor unit not present.

`Far Red On`

This switches on the Far Red (735nm) light source. It is only available when a dark adaptor unit is installed. The command is ignored if the dark adaptor unit is not present.

`Far Red Off`

This switches off the Far Red (735nm) light source. It is only available when a dark adaptor unit is installed. The command is ignored if the dark adaptor is unit not present.

`Actinic Light ####`

This command controls the internal Actinic source. The Actinic intensity setting does not take into account the ambient illumination level and would be additive.

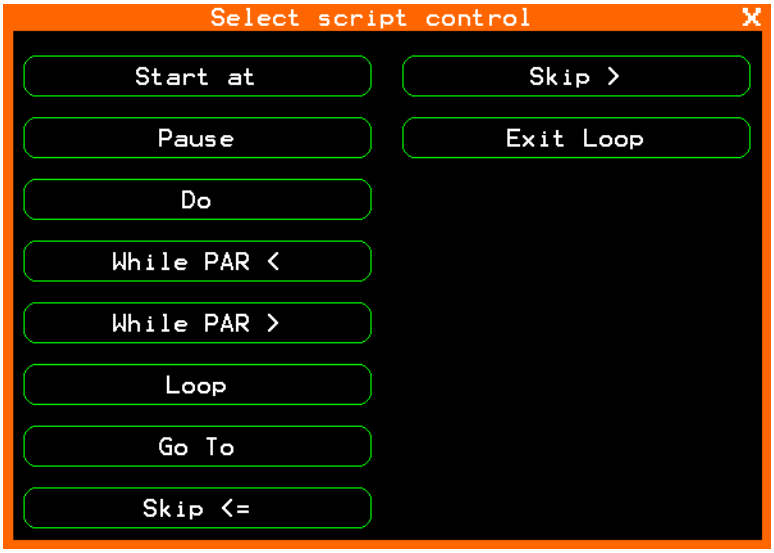
Actinic intensity 0µE(off) to 2500µE.

`Actinic Step ####`

This command will change the internal Actinic source intensity by a set amount. The absolute intensity is still limited to 0-2500µE and will simply hold at either limit if the range is exceeded by executing this command. This command is useful for composing test protocols that study stepped light intensities.

The value can be a positive or negative with a range of +/-0µE to +/-1200µE in 10µE steps.

SCRIPT FLOW CONTROL COMMANDS



`Start at ##:##`

Have a probe pause at this line until the specified time is reached. Then it will continue to the next line. Use this command to synchronize measurements to a specific start time. For example, a value of 13:04 would cause the probe to wait until 1:04 pm is reached. Then the probe would execute the next instruction.

##:## hours:minutes in 24hr format.

`Pause #####`

This is a simple wait command. The probe will wait at this instruction for a number of seconds. Use this instruction to create time delays between script actions.

1 to 65536 seconds

`Do` **`count,pause`**

This is the starting command for building a repeating block of instructions. When the Do command is executed a countdown timer is started. Next, the instructions following the Do will be executed in sequence. When the associated Loop command is reached, the program will

either pause until the countdown timer reaches zero and restart the loop, or if the loop count has been reached, the program will exit the Do-Loop sequence.

Count number of loops to perform 0 to 255 (a value of zero will cause the loop to continue indefinitely)

Pause time in minutes 0 to 255 (a value of zero will cause the loop to execute immediately)

`While PAR <= ####`

This is a conditional Do statement that is based on the current PAR level. It will continue to loop while the PAR reading is less than or equal to the set value. It can be used to bound different night and day test protocols.

0µE to 2500µE.

`While PAR > ####`

This is a conditional Do statement that is based on the current PAR level. It will continue to loop until the PAR reading drops below a set value. It can be used to bound different night and day test protocols.

0µE to 2500µE.

`Loop`

This command is the end marker for a block of commands that are repeated under a do/loop structure. The program will pause on this line until either the countdown timer reaches zero, or the loop count has been met.

Note: About Do-Loop and While-Loop structures

Do and While structures may be nested up to 8 levels. This means you can have a Do-Loop or While-loop inside the bounds of another one up to 8 times. Exceeding this will cause unpredictable results and should be avoided. You should also avoid Go To branching out of a loop, as this will corrupt the Do stack and cause unpredictable results. The ExitLp command can be used (often with a conditional test) to safely exit a Do-Loop structure.

`Go To #`

This command is used to cause the program flow to jump to a specific line label and start executing commands from there.

Note: About line labels

There can be up to 10 line labels in a script. Labels consist of a number (0-9) followed by a colon. The line label should be in the same line as its command.

For example:

Correct:

1: Pause 500

Incorrect:

1:

Pause 500

`Skip if <= $$$,####`

This is a conditional statement that is based on the value of a elected parameter. It will skip the next instruction if the parameter is less than or equal to the set value. It is used to change protocol steps based on a parameter value.

$$$ Parameter to test (See the parameter list of range of a setting)

Threshold value

`Skip if > $$$,####`

This is a conditional statement that is based on the value of a elected parameter. It will skip the next instruction if the parameter is greater than to the set value. It is used to change protocol steps based on a parameter value.

$$$ Parameter to test (See the parameter list of range of a setting)

Threshold value

`ExitLp`

This command allows for you to gracefully exit an infinite Do Loop. That is a Do statement with the count set to 0. It is often used with the previous commands to exit a group of statements on a specific condition. Upon execution, the probe will find the instruction just after the next Loop

instruction and start execution there. It will back out of nested loops in an orderly manner. It will roll back one loop level, per occurrence, till none remain.

PARAMETER LIST

Enter this name for your selected parameter (the **$$$** value).

Tlf - leaf temperature, Range 0-50.0

PAR - PAR value (5 Min rolling average value), Range 0-2500

Fvm - Fv/Fm ratio, Range 0-0.999

Fvo - Fv/Fo ratio, Range 0-0.999

YII - Y(II) ratio (note, omit parenthesis), Range 0-0.999

ETR - ETR value, Range 0-399.9

qP - qP ratio, Range 0-0.999

qN - qN ratio, Range 0-0.999

SAMPLE TEST SCRIPTS

Note: text in parenthesis is a comment for manual clarity and should not be included in actual script! To add comments to a script, start the line with a "*" and then enter your comment. Comments must be on a separate line from a command.

This script will perform an Fv/m measurement each 1 hr starting @ 12am while PAR<10µE. Then do a Y(II) measurement every hour while PAR>5µE. Then wait until 12am and start again. It will be shown coded two ways to illustrate the versatility of the script language

```
start at 00:00          (Start run at midnight)


while PAR<10            (run the following code if PAR is below 10µE)
  measure fv/fm         (measure Fv/Fm, takes about 4 seconds)
  pause 3596            (pause for 60 minutes minus 4 seconds)
loop                    (return to PAR < 10 value test)
                        (if PAR is not less than 10, exit while-loop and run next command)
while PAR>5             (run the following code if PAR is above 5µE)
  measure Y(II)         (measure Y(II), takes about 4 seconds)
  pause 1796            (pause for 30 minutes minus 4 seconds)
loop                    (return to PAR > 5 value test)
                        (if PAR is not greater than 5, exit while-loop and run next command)
                        (as there are no additional lines, the program will rerun the first line)
```

This next script will perform an RLC test every hour with a 30 minute dark adaptation period using the dark adaptor unit. As no start time is given, the test will begin once the script is loaded into the probe by the host unit.

```
do 0,60                 (initialize infinite do-loop with 60 minute pause between loops)
  close DA unit
  measure RLC
```

```
  rlc step 10,100          (10 seconds @ 100µE)
  rlc step 10,300          (10 seconds @ 300µE)
  rlc step 10,500          (10 seconds @ 500µE)
  rlc step 10,700          (10 seconds @ 700µE)
  rlc step 10,900          (10 seconds @ 900µE)

  open DA unit
loop                       (pause here for 60 minutes, then restart do-loop)
```

This script will perform a quenching measurement cycle over the day. The test will start at 12AM and collect Fv/Fm measurements every hour until about 6AM. Quenching measurements will be collected every 4 hrs with a qE and qT relaxation measurement. These measurements will be taken, then the system will wait until 12am to start the cycle over again.

```
start at 00:00           (begin test @ 12:00 am)
open da unit             (make sure DA is open)

do 5,60                  (5 measurements, 1 hour apart)
measure fv/fm
loop                     (if less than 5 loops, pause here for 2 hours and then restart do-loop)

reset fo min             (record a new minimum Fo for each day)

do 3,240                 (make 3 quenching measurements with relaxation kinetics every 4hrs)

  measure quench
```

```
    pause 300
    measure quench
    pause 300
    measure quench
    pause 300
    measure quench
    pause 300
    measure quench

    close da unit
    pause 240              (dark adapt for 4 min)
    measure qE

    pause 960              (wait 16 minutes)
    measure qM&qI
    open da unit

loop                       (pause here until 4 hours have elapsed, then restart do-loop)
```

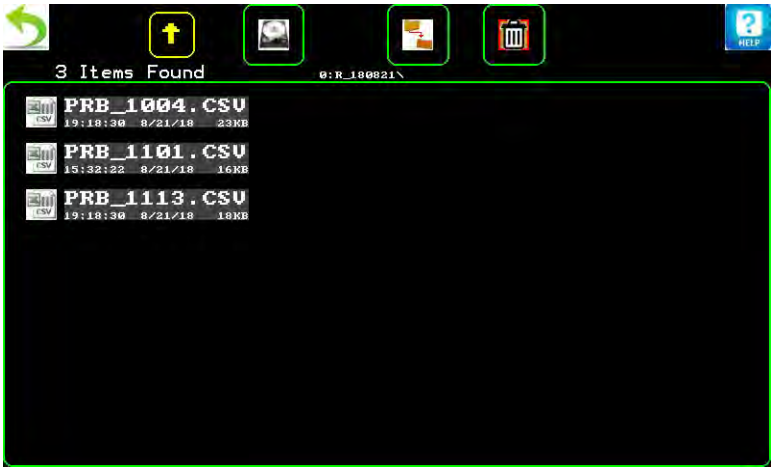
FILE MANAGEMENT

Tap **Files** from the main screen:

FILE DIRECTORY SCREEN

The icon at the top appears when a USB memory stick is present. Tapping on it will switch the view to the USB drive. The example above shows a number of test runs. Folder names are based on the test start date. So a directory named R_180821 is for a test run started on 8-21-18. If more entries than fit on a screen are present, green left and right arrow buttons will appear to allow you to parse through long lists.

Tapping on an entry will cause some action to be performed on that item. For directories, tapping will either change the view to the contents of that directory or, if empty, prompt to erase that directory. For example tapping on the entry 'R_180821' will bring up the next screen.



DATA FILES SCREEN

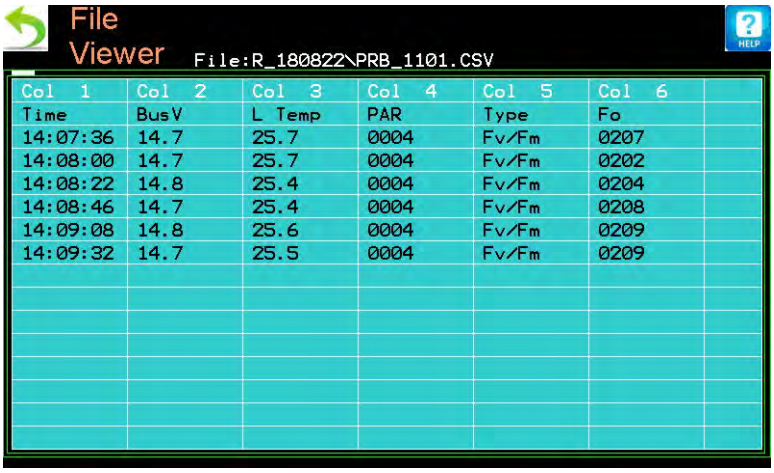
This screen shows the test data files contained in this directory. Note that the directory path is shown above the view box. There are also some additional Icons that appear at the top. The yellow Up arrow

is used to step back to the previous directory level. Green Left & Right arrows will appear if a large number of entries are present. A USB stick was present in this example, so the drive and file copy icons are also shown. Tapping the drive icon will switch the view to the other drive. The directory copy icon will copy the current subdirectory contents to the other drive. Note that it is assumed that any transfers between drives is relative to which drive is currently being viewed. The trash icon will delete all files in this directory. When emptied, the directory is not deleted, this would be done from the file directory screen.

Tapping on a file entry will bring up a selection box. The options include 'Delete', 'Cancel' , 'Other', and (if a USB drive is present) 'Copy'. Most are self explanatory, the 'Other' selection is used to bring up another selection box that has functions based on the file type. For example, selecting 'Other' for the file PRB_1113.CSV will bring up a selection box with 'View' and 'Exit'. Selecting 'View' will launch the file viewing utility for the selected file. If the file cannot be viewed with this utility, an error message will be shown instead.

FILE VIEWER:

The File Viewer can display test data (.CSV files) and scripts (.TXT). Below is shown a sample of both.

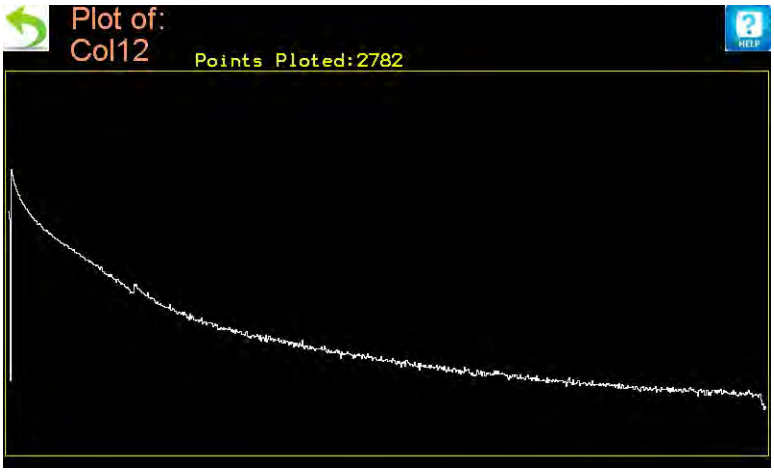


Col 1	Col 2	Col 3	Col 4	Col 5	Col 6
Time	BusV	L Temp	PAR	Type	Fo
14:07:36	14.7	25.7	0004	Fv/Fm	0207
14:08:00	14.7	25.7	0004	Fv/Fm	0202
14:08:22	14.8	25.4	0004	Fv/Fm	0204
14:08:46	14.7	25.4	0004	Fv/Fm	0208
14:09:08	14.8	25.6	0004	Fv/Fm	0209
14:09:32	14.7	25.5	0004	Fv/Fm	0209

DATA FILE VIEW SCREEN

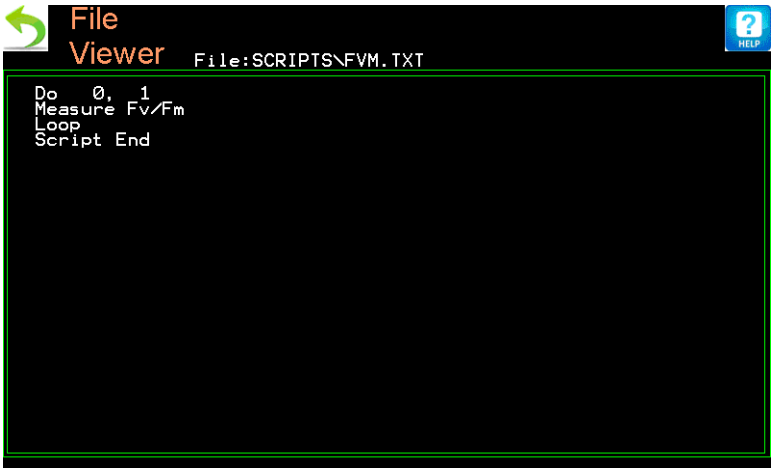
Above is a sample of a test data file. Data is shown in columns, there are 33 columns available in normal test data. Dragging a finger around the screen will move the view window around. In this case, there is a position slider at the top to mark the relative position. There are not enough entries to fill the screen, so no vertical position indicator is shown.

Tapping the top of a column will display a graph of the data if there are at least 10 points available. The plot utility is very basic at this time. Both height and width are scaled to fit the total # of data points. If there are multiple run start and stops in the file these will be graphed contiguously.



VIEW PLOT SCREEN

This is a sample of a data file having 2782 data rows. This is a plot of column 12, which happens to be Y(II) data.

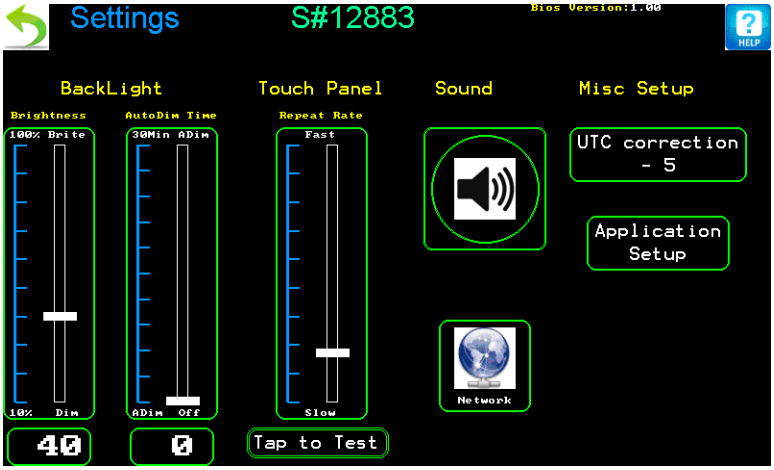


SCRIPT FILE VIEW SCREEN

Script files appear in a similar view. When viewing longer scripts, you can swipe the screen up and down to scroll through the file.

SYSTEM SETTINGS

Tap **Settings** to enter settings.



SYSTEM SETUP SCREEN

The serial number (top center of screen) is important as it will be required for remote login via the web page.

The backlight brightness and auto dimming time are configurable. Brightness has a range of 10-100%. The AutoDim feature shuts off the screen after no button is pressed for the set period of time. The range is 0 to 30 minutes. A setting of 0 switches off this feature.

The repeat rate controls how fast a button press is registered. It should be set based on user preference to allow for rapid typing without having characters unintentionally repeat.

System beeps may be switched on and off with the sound control. Volume is not adjustable.

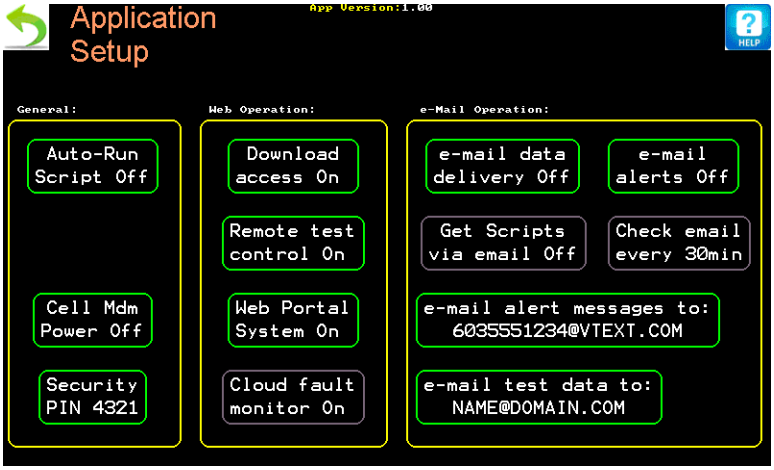
The UTC correction should to be set to your time zone if a network connection is used to set the clock.

Application Setup is used for web access settings.

Tapping **Network** will display the network interface settings screen.

APPLICATION SETUP

Tap **Application setup** from the system setup screen to get to the application screen:



AQPPLICATION SETUP

These settings are specific to some test operations.

GENERAL

Auto-Run Script controls the auto run mode. When set to 'On', this feature will re-start any tests that are interrupted by a system power failure

Cell mdm power controls the power output for an optional external cellular data modem.

Security PIN can be set here. A forgotten PIN may need to be returned to the factory to be unlocked. Note that should this happen, no test data will be lost.

WEB OPERATION

Web settings are only used if a network connection is setup.

Download Access allows remote web access for download of data files. At this time, files may not be remotely deleted as an added security feature.

Remote test control enables web access.

It is reasonable to have any combination of the 2 settings above selected depending on the level of web access and control desired. With both disabled, basic operational status and most recent data from each probe may be viewed, but not altered.

Web portal System controls the web based interface. When set to off, no web portal functions are available. Note that this does not affect the web link feature found in the diagnostics screen.

Cloud fault monitor Reserved for a future cloud storage service.

E-MAIL OPERATION.

e-mail data delivery (On/Off) When on, the PSP32 will send daily test results at midnight each day (11:57pm to be exact). This feature relies on an e-mail account created and setup for the PSP32 unit.

Note that manual operation of the PSP32 while e-mail data delivery is enabled will interrupt automated data transfer. All data will be saved to the PSP32, but only data taken after the manual operation will be emailed.

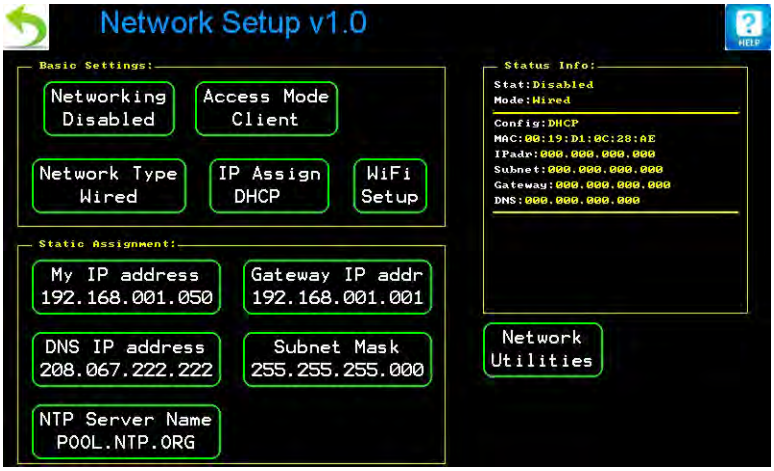
e-mail alerts An e-mail will be sent when an event that may need intervention occurs, such as a probe failure or an issue with the system power. This feature requires an e-mail account created and configured for the PSP32 unit on your network.

Get Scripts via email When enabled, the system looks for an e-mail having script instructions for simple remote test management. This function is not currently available.

Check email every Sets the interval to poll for new email messages. This function is not currently available.

e-mail alert messages to The email address to send alert messages to. The messages are short and in plain text (suitable for SMS messages, and standard emails).

NETWORK SETUP



NETWORK SETUP (WIRED)

Tap **Network** from the application setup screen to get to the network setup screen

Here basic network parameters are configured. In many cases these settings will be dictated by your institutions IT department. Refer to them for more details.

The yellow box to the right shows information on the current network connection and status. It is updated every second.

Configurations on this page should be changed while 'Networking' is 'Disabled'. The new settings will be active after 'Enabling' the network features again.

Networking Switches all network functions on or off.

Network Type selects between wired or wireless (WiFi) operation. Wired operation is standard Ethernet (10/100Mb connections).

Access Mode (only wired) selects the type of connection.

Client network connection (used when connecting to an established network)

Server direct connection (used when connecting to a single device)

Server direct connection is used for a direct connection between the PSP32 and a computer using Ethernet. In this mode, the PSP32 supplies all the needed network support for a device expecting to see standard network services. This includes a DHCP & DNS service.

IP Assign (wired in client mode or wireless in station mode) This button selects the way addresses are assigned. There are 2 settings 'DHCP' (automatic) or 'Static' (manual). When DHCP is selected, the PSP32 gets required network information from a DHCP server running on your network. Static is used to manually enter this information.

When **IP Assign** is set to 'Static',

My IP address The PSP32's IP address.

Gateway IP address The address of the network gateway.

DNS IP address The address of the network name server.

Subnet mask The networks subnet mask.

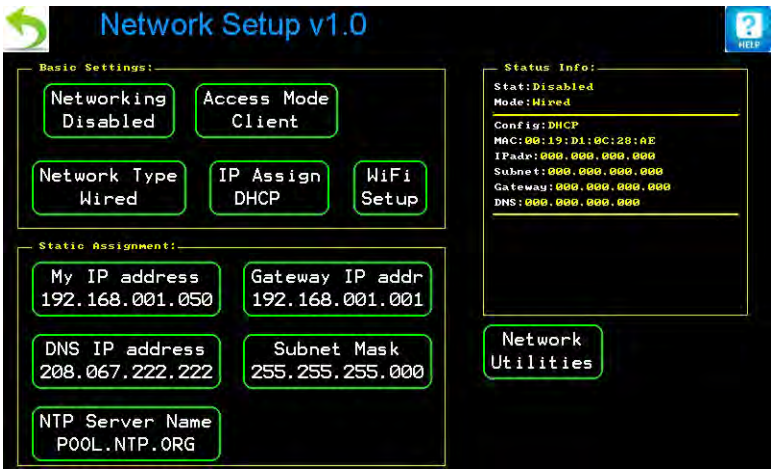
WiFi Setup Opens a screen containing settings used by the WiFi system. It is only available when WiFi mode is selected and networking is enabled.

NTP Server Name The name of the time server used to automatically adjust the clock on the PSP32

WEB ACCESS FOR LAN DEVICES

Wired LAN connection does not support secure login or certificate exchange. Contact your IP department to create an exemption for the PSP32 if your network uses this type of security.

From the Main screen tap **Settings.** Next tap **Network**



NETWORK SETUP SCREEN

The word "Link" will be displayed to the right of "Stat:" when the LAN connector senses a connection.

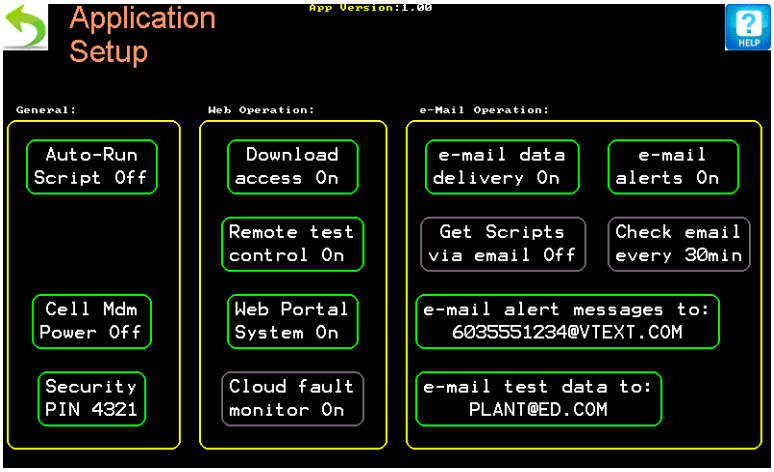
Make sure network is disabled (Tap **Networking** to toggle)

Then tap **Network Type** until Wired is displayed

Tap **Networking** to enable wired connection

If IP Assign is DHCP, the network will assign an address – you will need this number to access remote web services.

Tap **back** then **Application Setup**



APPLICATION SETUP

Tap **Web Portal System** until it displays "On"

For remote control functions, tap **Remote Test control** until it displays "On"

To enable downloading of data, tap **Download access** until it displays "On"

Tab **back**

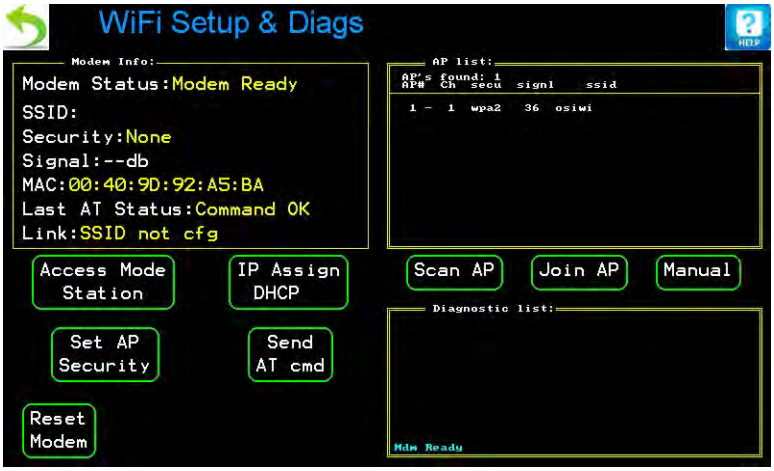
Wired network access is now available.

Using a web browser, navigate to the PSP32's IP address. If you are using DHCP, the address will be displayed in the Network Setup screen, inside the "Status Info" box, next to "IPadr". If you are using a static IP address, then the address will be displayed in the **My IP address** button.

You should now see the PSP System Overview webpage.

WIFI SETTINGS

WiFi settings are accessed by tapping **Settings** from the main screen, then tap **Network.** **Network Type** must be set to WIFI and **Networking** must be enabled. Tap **WiFI Setup**



THE WIFI SETUP SCREEN:

Modem (WiFi) status and settings are shown on the left side of the screen.

Access Mode (*Station/ Access Pt)* Configures the PSP32 to be a network device.

Station: The PSP32 operates as a network device

Access Pt: Allows other wireless devices (tablets/smart phones) to connect directly the to PSP32.

Set AP Security allows you to choose between an open (no password) and secured connection when in *Access Point* mode. Note that only WPA2 encryption is supported. If enabled, the unit will prompt for the pass phrase (8 character minimum).

IP Assign selects between DHCP and Static IP modes.

Send AT cmd a diagnostic feature that should only be used when directed to by service.

Reset Modem initializes an unresponsive modem.

The top right box contains a list of available access points when in Station mode.

Scan AP search for available access points that are broadcasting an SSID.

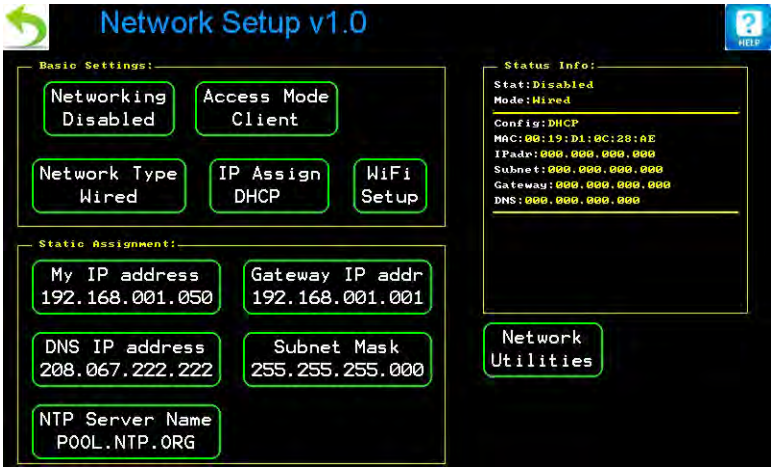
Join AP allows selection of an access point to join from the AP list.

Manual allow for the entry of SSID and password parameters for any access point.

The box in the lower right (diagnostic list) shows status messages sent from the modem.

WEB ACCESS FOR WIRELESS DEVICES

From Main screen tap **Settings**, then tap **Network**



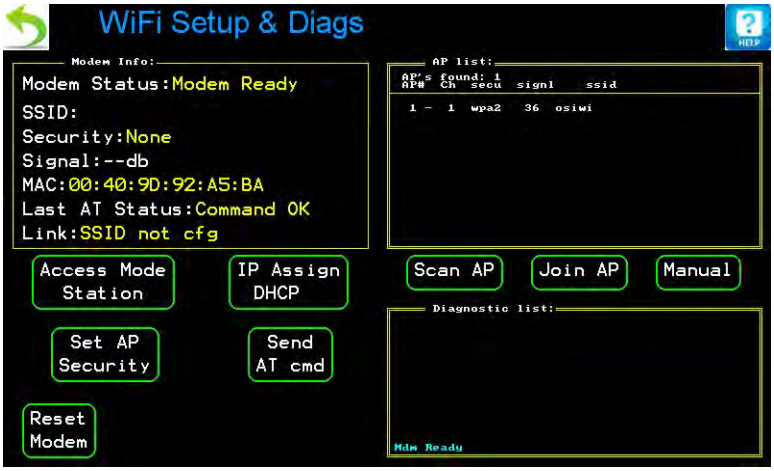
NETWORK SETUP SCREEN

Make sure network is disabled (Tap **Networking** to toggle)

Then tap **Network Type** until WIFI is displayed

Tap **Networking** to enable WIFI

Tap **WIFI Setup**



WIFI SETUP SCREEN

Tap **Access Mode** (Station/Access_PT) until it displays Access PT

Optional security

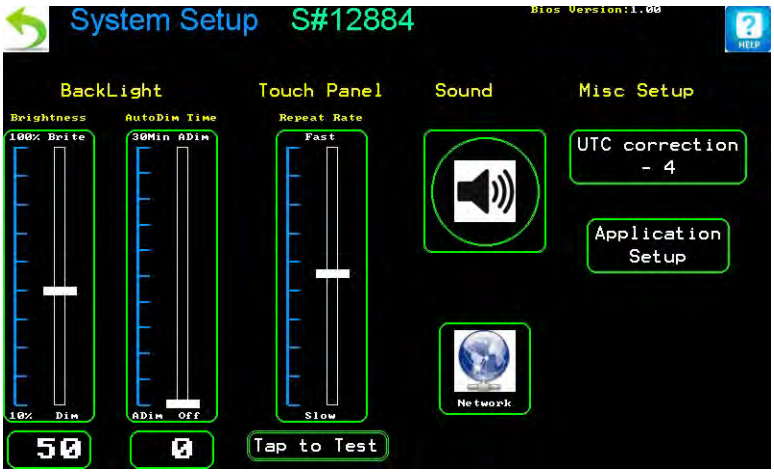
Tap **Set AP Security**

Tap **WPA2**

Type in pass phrase (8-15 characters) when prompted.

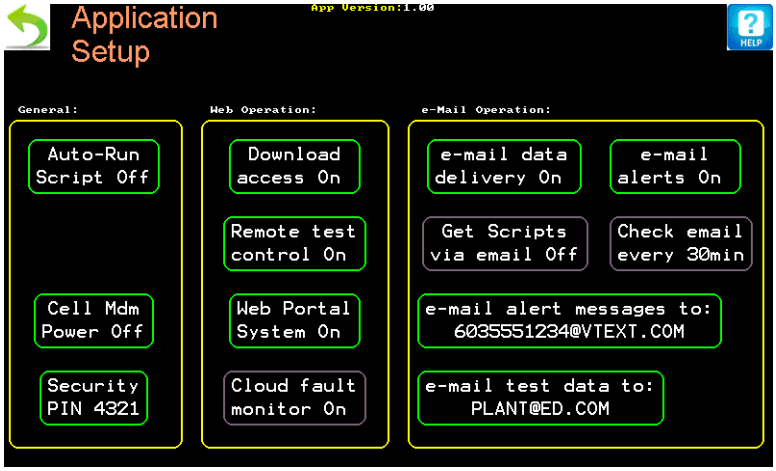
Tap **Apply Settings** – this will reboot the WIFI module

Tap **back**



SYSTEM SETUP SCREEN

Tap **Application Setup**



APPLICATION SETUP SCREEN

Make sure **Web Portal** is On

For remote control functions, tap **Remote Test control** until it displays on

To enable downloading of data, tap **Download access** until it displays on

Tab **back**

Wireless access is now available.

With your wireless device, access the wireless manager, and look for a hotspot called **PSP_mobile**. Log into this network. If secure connections was enabled, use the passphrase entered previously.

Once the device is connected, navigate to site address "192.168.1.10" using a web browser.

You should now see the PSP32 login screen. Enter the serial number and PIN of the PSP32. The serial number can be found at the top of the Settings screen on the PSP32. The PIN is displayed in the lower left corner of the Application Setup screen.

EMAIL SETUP

Note: Email works on LAN and cell modem connections.

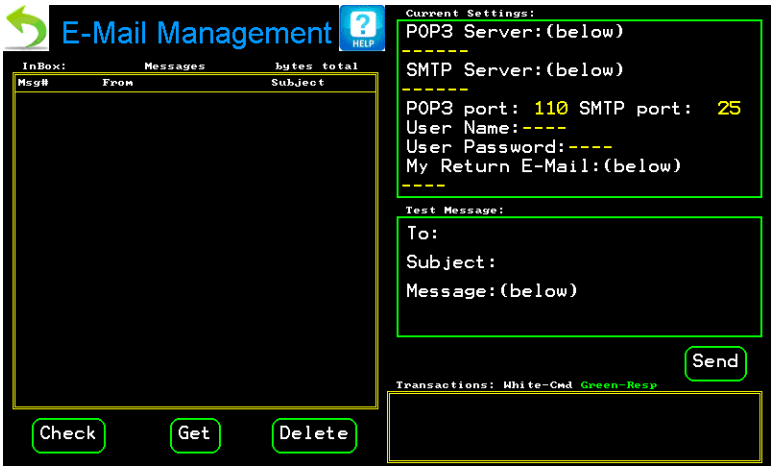
From the main screen, tap **Settings**

Next, tap **Network**

Next, tap **Network Utilities**

A pop up box will display

Tap **email**



EMAIL MANAGEMENT SCREEN

Tap **Current Settings** box to edit email settings. Your IT department should be able to help you with these settings.

POP3 Server Name The address of the incoming mail server

SMTP Server Name The address of the outgoing mail server

POP3 Port # Incoming mail server port number. Default is 110

SMTP Port # Outgoing mail server port number. Default is 25

User Name Your user name

User Password Your password

Return email Your full email address

To test email settings, tap on the **test message** box

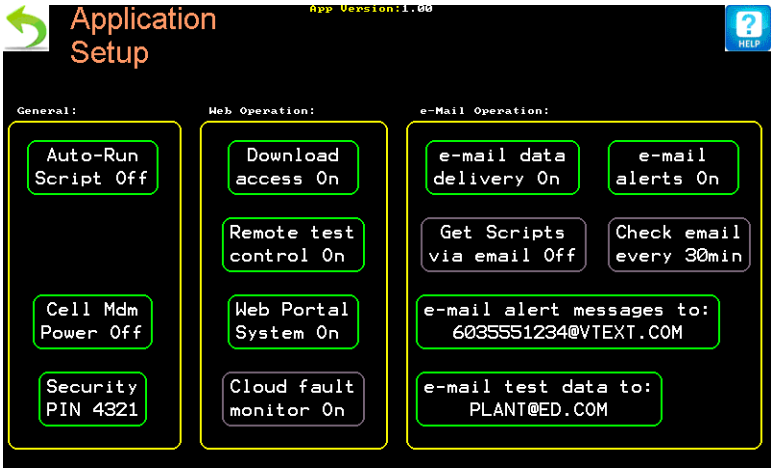
Enter mail to/subject/message

Tap **Send**

WHEN TO SEND A MESSAGE

From the Main Screen, tap **Settings**

Next, tap **Application Setup**



APPLICATION SETUP SCREEN

In the Email operation box:

Email data delivery on/off. When turned on, will send test results via email every day.

Test data will be sent every 11:57PM. There will be one email sent for each running probe with data from the last 24 hours.

Email alerts on/off. When turned on, will send alert messages as they occur.

Alert messages include: low battery, power restored, probe fault, invalid login.

Get scrips via email (function not yet active)

Check email every (function not yet active)

CONFIGURING TEXT MESSAGES:

Text messages (SMS) are sent using email-to-text services provided by most cellular carriers. A list of carriers that support this feature can be found in appendix A. The list contains the email address suffix used by each cellular carrier to relay such messages. They are used by appending the address to the desired cellular number. For example; on Verizon, if your phone number is 603-555-1234, then your texting email address would be: 6035551234@vtext.com. Enter this address in the "e-mail alert messages to:" field (Application Setup screen)

You should not use this address for test data. Text messages are expected to be very short (such as the alert messages).

ALERT MESSAGES

Invalid PIN Entered ! Occurs if the unit is locked and an incorrect PIN is entered.

Probe Start Fault ! One or more of the probes selected to start a script has a fault.

Probe Fault ! One or more probes faults during operation.

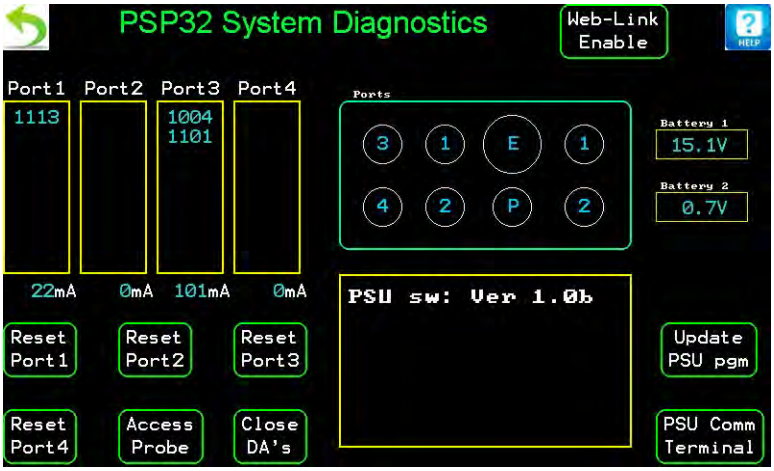
Battery <11.0V Hibernating ! This alert occurs when the system battery(s) voltage falls below 11.0V. The PSP will shut down and await repair/recovery of the power source.

Battery >12.3V Restoring Run ! This alert only occurs when the power source recovers after a hibernating message.

e-mail test data to Sets the email address to which test data is sent. The data is sent in the form of a .CSV attachment. An email message will be created for each active probe having new data within the standard time frame.

DIAGNOSTICS

This screen shows information about system status and probe connections:



DIAGNOSTICS SCREEN

The PSP32 has 4 probe ports that support up to 8 probes each. A list of probes connected to each port and their total power use are shown in the yellow boxes. The probe list should be verified after a system is assembled. Each port should be checked against a list of installed probes. Missing probes may indicate a connection problem. Should a probe need to be reconnected, port reset should be initiated to allow the system to detect the change.

A graphical image identifies port use and numbering. The incoming battery voltage for each battery connection is displayed. Additional software information is shown in the lower yellow box.

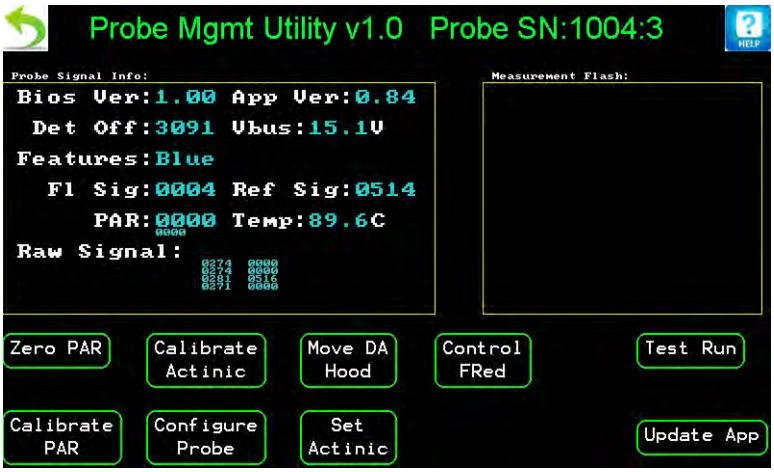
Web-Link enables a WiFi feature that allows a user to have this diagnostics screen view appear on a web page on their portable device. This can be handy when setting up probes in the field. Signal strengths and sensor integrity can be checked without having to go back to the controller box. Screen functions are disabled while this utility is active. This feature also temporarily uses (otherwise disables) network resources in this mode.

The buttons **Reset Port 1**-*4* are used to reset all the ports attached to that port. This action will interrupt all operations on that port.

Close DAs sends out a close dark adaptor command to all probes. Probes with the dark adaptor unit must be closed before packing up for transport. This button provides a quick way to close all dark adaptor units.

Update PSU Program and **PSU Comm Terminal** are used for upgrade and service. Only use these buttons when instructed to by authorized service personnel.

Access Probe opens the probe management utility screen. A selection list of available probes will appear. Probes are identified by their serial number. Note that a probe running a script cannot be accessed with this function. A probe must be in idle mode for this access feature to be available.



PROBE MANAGEMENT UTILITY SCREEN

This is an example of probe serial number 1004 on port 3.

Det Off:#### The capacity to tolerate excess IR light. This is sunlight in the IR spectrum shared with the fluorescence signal. The probe can separate both up to a point, beyond which it may interfere with signal detection. A reading above 200 is OK.

Vbus:##.#V Voltage present at the probe. This information is helpful when evaluating maximum probe cable lengths. The value should be greater than 10.0V for proper operation. A lower value with all other probes being normal may indicate a damaged cable.

Features: The feature list indicates the probe excitation color R-red (660nm) or B-blue (470nm). It also will show DA if a dark adaptation hood is installed.

Fl Sig:#### Signal level from the fluorescence detector. It should have a value greater than 200 and less than 800 for optimal work. This value is useful when positioning the sample and setting probe gain values.

Ref Sig:#### This value is provided for diagnostic purposes.

PAR:#### The current PAR value. The range is 0-3000µE.

Temp:##.#C The current leaf temperature. The range is 0-50.0C Note: a value of 89.6C is used as a connection fault indicator. The external leaf thermistor may be loose or damaged if this value is present.

Raw Signal: Provided for diagnostic purposes.

Zero PAR Sets the Zero level for the PAR sensor.

Calibrate PAR Sets the PAR reading at the sample plate. Changes in sample geometry or the sample clip itself may require a re-calibration.

Calibrate Actinic Used to calibrate the probe's actinic light when changing sample geometry. Non standard samples can be measured by removing the holder clip. When this is done, the actinic level should be re-calibrated to the new geometry.

Configure Probe Opens a list of probe settings available. If a prompt for a service code appears just tap **Return** to continue.

Set Mod Lvl There are 4 steps 1-4 of modulation power. The minimum needed should be used to minimize self excitation. Different sample geometries may require a higher setting.

Set Sat Lvl The % power of the saturation flash (100% is about 10,000µE)

Set Gain Amplifier gain. This setting has a range of 1-6 and should be used if the fluorescence signal level is too low and the auto-gain function can't range properly.

Auto-Range Resets the probe's modulated light intensity and gain settings to optimize it to the sample. It is especially helpful when fitting small samples that don't fill the measurement area.

Set Actinic Switches the actinic light on/off for testing purposes.

Move DA Hood Opens or closes the dark adaptor unit hood.

Control FRED Turns the far-red source on/off. (only present with the dark adaptor accessory)

Test Run Performs a single measurement flash. The results will be graphed on the screen. No data is logged.

Update App This button is used for service work

ACCESS DIAGNOSTICS VIA WIFI

Diagnostics access via web browser is only available using WiFi. It has been optimized to assist with the setup of probes using a smartphone.

First, follow all the instructions in the "Configure web portal for wireless devices" section.

From main screen tap **Diagnostics**

Tap **web-link enable**

With your wireless device, access the wireless manager. If you are currently connected to PSP_mobile, log off (necessary to reset connection to diagnostics mode). Now look for a hotspot called PSP_mobile. Log into this network. If secure connections was enabled, use the passphrase entered previously.

Once the device is connected, navigate to site address "192.168.1.10" using a web browser.

You should now be viewing the PSP-32 Diagnostics page.

When you have finished using the diagnostics mode, tab **web-link enable** to shut this feature off.

To reconnect to the web portal, disconnect from the WIFI network and then reconnect to same network. This will reset the connection properly.

WEB SERVICES

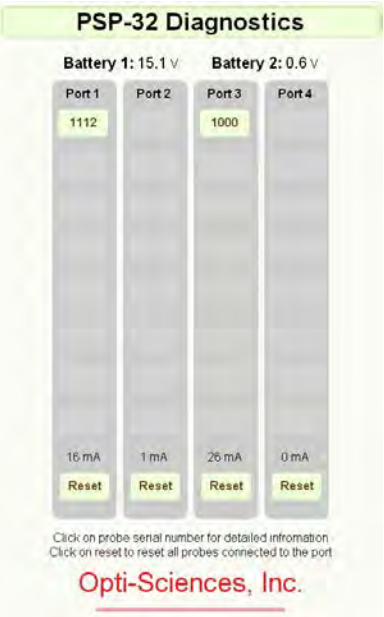
There two types of web enabled services available on the PSP32

A probe setup utility accessed from the Diagnostics screen. This function is only available via the built in WiFi hospot.

A web access portal for managing test operation and retrieving data. This utility works through the default network setting of either wired or wireless.

PROBE DIAGNOSTICS

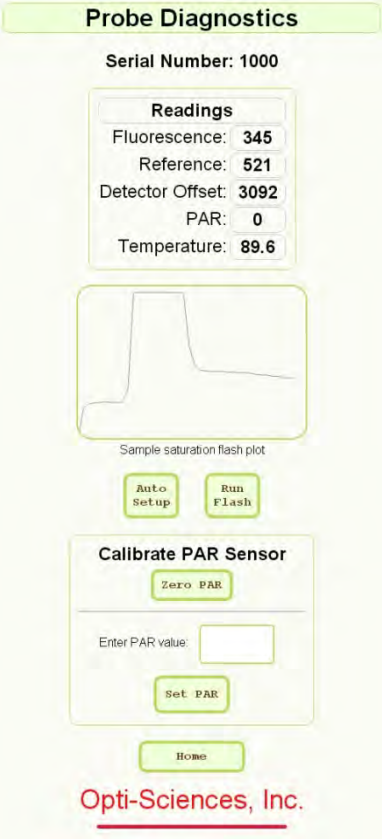
This function is only available when diagnostics via WiFi has been enabled. When active, the mobile device should use the address of '192.168.1.10' to access the page. No login is required for this page. Only one mobile device may connect at a time.



PROBE SETUP UTILITY MAIN SCREEN

Each probe port is shown, with a list of serial numbers of any probes detected. In the above example, serial number 1101 is connected to port 1 and serial number 1113 is connected to port 3. Should a probe be connected, and its number does not appear, check that its connections are tight and then tap **Reset** for the port it is connected to. Voltage present on each battery port is displayed above the port columns and the amount of current being drawn for each port is shown above the reset buttons. These values can be useful when troubleshooting system problems. The readings update at approximately once per second.

Tapping on a probe serial number will open the diagnostics page for that probe.



This page is used to setup and check a probe's operation. Basic signal information appears above a graph of the last flash measurement data.

Zero PAR Used to set the 0 level on the PAR sensor. The PAR sensor may wander up 1 or 2 µE above 0 from time to time and this can be used to correct it. Simply place a black card over the probe lens and press this button.

Auto Gain Adjusts the probe's modulated light fluorescence detection gain based on the current sample. It is useful when measuring needles or moss in different configurations. Simply have the sample loaded in the holder and tap this button. The process takes 5-10 seconds. You will see the readout numbers pause while the probe is busy.

Run Test Performs a single flash measurement and display the curve. This data is not logged and simply provides a check on the probe's operation. There is a 5 second delay from tapping this button to seeing the page update. You should see a saturation flash at the probe about 1 second after the start.

Cal PAR This value box along with the button is used to calibrate the PAR sensor value. This allows for a more accurate PAR reading with a change in holder geometry or differing sample type, like moss. Simply have an external PAR meter near the plane of the measurement area to get a reading, enter it into the box and press the Cal button to perform the calibration.

DATA AND CONTROL ACCESS

See the Network Setup section to configure web access. Using a web browser, navigate to the IP address of the PSP32. Only one user can connect at a time. Other users that attempt to connect while a session is active will receive a warning message. There is a logout feature on the main page used to release the session. After 15 minutes of inactivity, the PSP32 will automatically log off a user. A "Rmt" displayed next to the Lock icon on the main and run screens will indicate when a remote user is logged in.

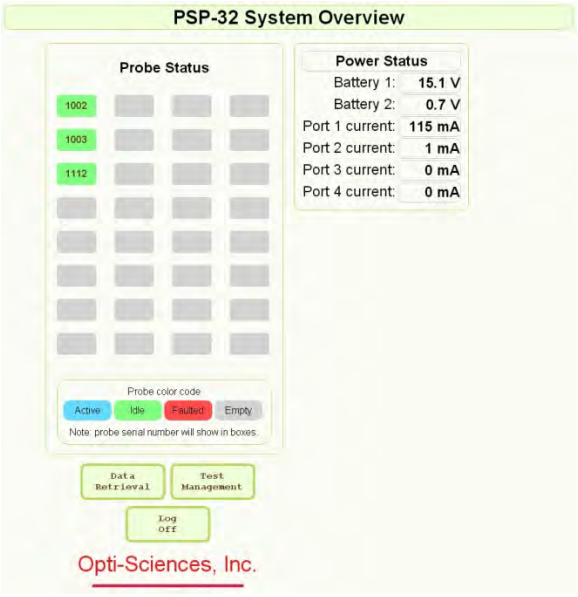
Note that the web portal is not governed by the Lock state. A locked console may still be accessed via the remote interface.

The first step is to login to the PSP server:

LOGIN PAGE

You must know the PSP32 Base Unit serial number and its PIN value to login. The serial number can be found at the top of the Settings screen on the PSP32. The PIN is displayed in the lower left corner of the Application Setup screen.

After a successful login, the main screen will open.

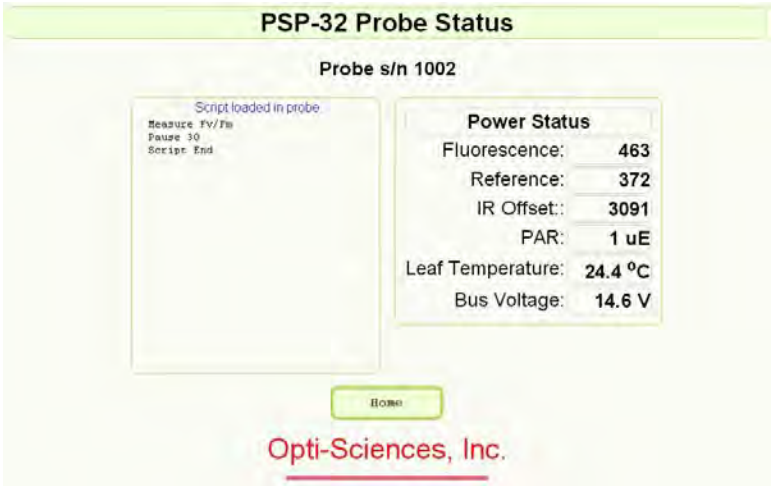


MAIN PAGE

Here you see the status of all probes detected. You may find a mix of running and idle probes depending on your test protocols. Clicking on a probe box will bring you to the probe details page. Faulted probes should be investigated by first viewing the probe detail page.

You may select a probe to see its status in more detail. The data displayed will depend on whether the probe is currently running a script or is idle.

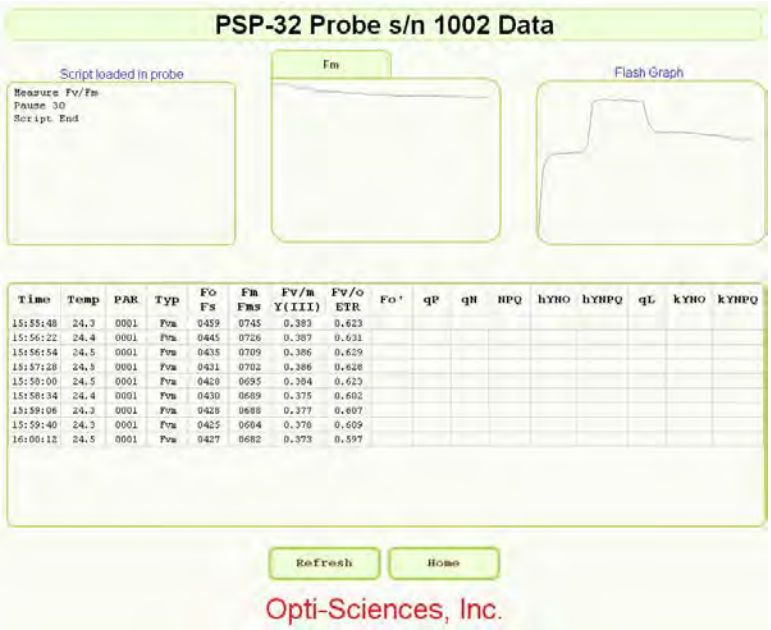
An idle probe will have the following screen:



PROBE (IDLE) STATUS PAGE

Data shown in this screen is updated approximately once every second.

A probe running a test script will have the following screen:

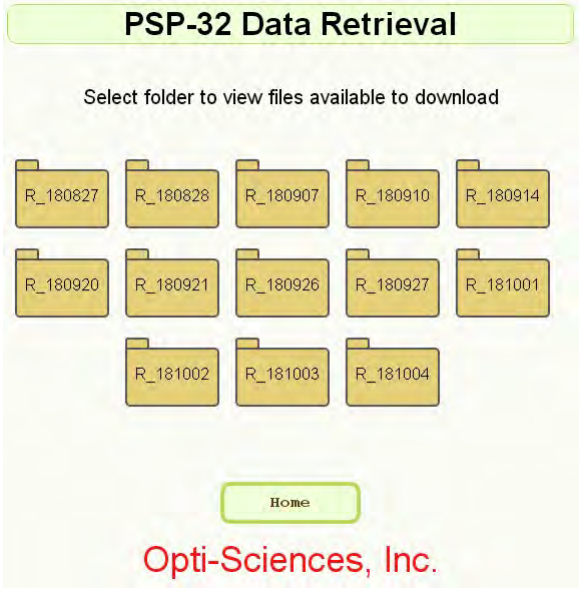


PROBE (IDLE) STATUS PAGE

Data shown on this screen is updated upon the first view of this page and when the **Refresh** button is clicked.

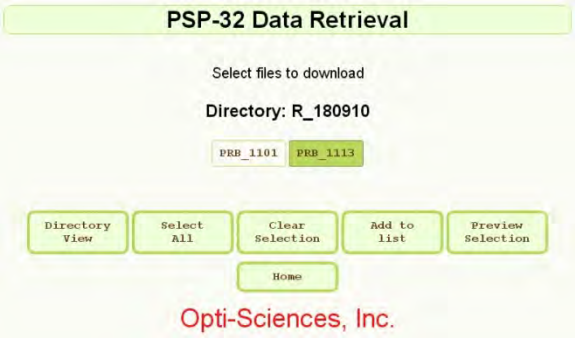
Clicking on the tab above the center graph box will display a list of available parameters that can be graphed.

The **Data Retrieval** button brings you to the directory access page:



DIRECTORY VIEW

Here you will see all the test run folders. All test runs are organized in dated folders. The directory "R_180901" stands for a test run started on Sept 1, 2018. Clicking on a folder will display any files contained within.



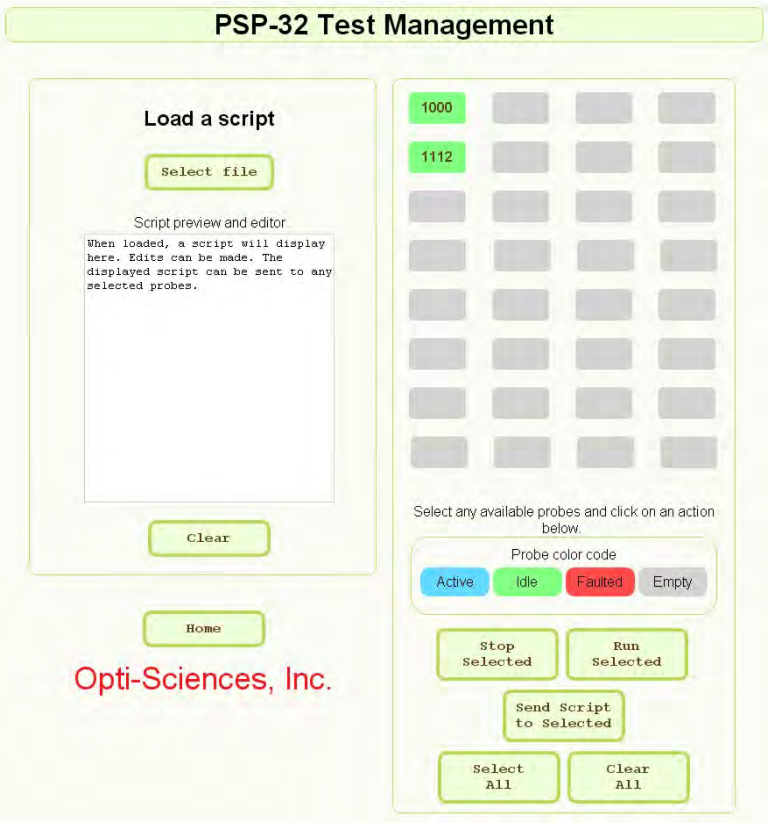
FILE VIEW

In this case, two files are present "PRB_1101" and "PRB_1113". The names identify a probe by its serial number. The files may be selected and added to a list of files to transfer (download).

DOWNLOAD FILES VIEW

The files selected for download appear in the preview selection window. Clicking **Download Now** will begin file transfer.

The **Test Management** button brings you to the probe test management page:



TEST MANAGEMENT PAGE

This page allows you to manage probe scripts. Scripts control the test protocol for each probe. A script may be loaded from a file or directly typed into the Script box. Any combination of Idle probes can be selected to receive this script. Running probes must be stopped before a new script can be loaded.

Probes operation is controlled with the **Stop** and **Run** buttons. This is done by first selecting the desired probes, then clicking the desired function button. Selected probes are identified by a black border.

The **Log Off** button signs out your remote access session

Remember, you must logout to release the Portal. If you do not actively logout, then another user cannot login for the remainder of the access timer period (15 minutes).

SELECTING BATTERY AND SOLAR PANEL SIZE

A safe sizing of the battery will take into account the number of probes in a system along with information on the direct sunlight available at the test site. System power usage can be calculated as two components, first is the idle power use, next is the power usage during a measurement. The system idle power is constant and can be found by adding all the component's operating Wattages. The power used during a measurement is orders of magnitude greater, but is very infrequent, so it must be de-rated accordingly.

As to the battery, a 12V battery with a 55AH rating would have about 660WH of power available. A solar panel having a rating of 100W will generate a total of 600WH per day assuming a 6hr full sunlight period . So a good sunny day will almost fully charge the battery.

Probe: 0.28 Watts idling. Usage jumps to 6.1W for the Saturation flash (duration 1 second)

Dark adaption hood: 0.38 Watts idling. 0.65 Watts when the hood moves. Typical move time 5 seconds.

Base Unit: Idling (backlight off) 1.8 Watts. Operating (backlight on) 7.2 Watts

SPECIFICATIONS

Base Unit:

Probe capacity: 1-32 probes

Probe types: Fluorescence parameters, Chlorophyll content, Spectral characteristics (NDVI, NDRE, PPI)

Optional sensor inputs: (with adapter box) environmental sensors (leaf wetness, soil moisture, gas flux, weather data)

Power source 12-16 VDC 150mA to 6A depending on probe configuration and test phase.

Size: 12" x 10" x 5.5"

Weight 5.6 lbs

Power Usage: Operating Backlight full on 7.2W , with Backlight off 1.8W

Probe:

Source: Blue (450nm), Blue (470nm), or Red (660nm) chosen at time of order.

Actinic Intensity: 0-2,500µE

Saturation Flash: 0-10,000µE

Modulation Adjustability: 4 step level

Gain Setup: Manual (7 step) or Automatic level adjustment

PAR sensor: 0-3000µE reflective sensor reference pad. Field calibratable for alternate sample holder geometries.

Leaf temp: External exchangeable micro thermistor sensor.

Housing: Sealed, water resistant Aluminum body.

Probe clamp: (included) 1.5" diameter tube clamp with ¼-20 thread for mounting

Cable: 4 conductor shielded cord, 30' length included with probe. Custom lengths available.

Power Usage: 0.28W operating, no saturation or actinic light 6.1W Saturation flash (duration 1 second)

Dark adaptor Unit Accessory:

Light Source: 735nm (FRED) ring illuminator. Fixed intensity. Script controlled.

Power Usage: 0.38W idle. 0.65W moving. Typical move time 5 seconds.

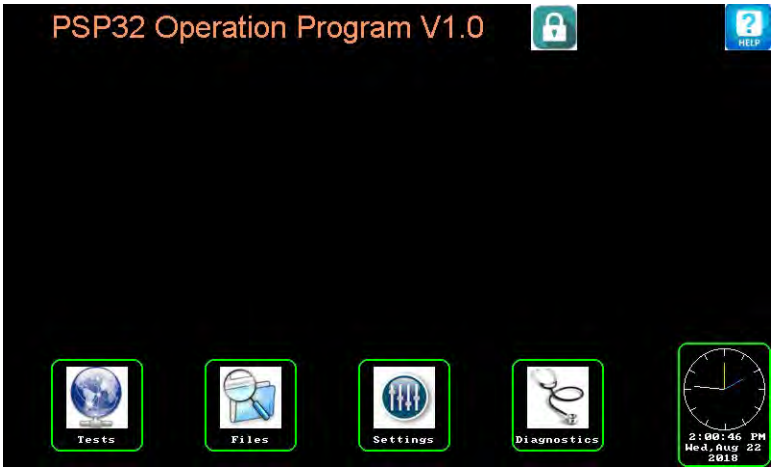
APPENDIX A SOME COMMON SMS (TEXTING) PORTAL ADDRESSES

AT&T Wireless	txt.att.net
Alaska Communication Systems	msg.acsalaska.com
Alltel	text.wireless.alltel.com
Australia T-Mobile/Optus Zoo (Optus)	optusmobile.com.au
Bell Mobility & Solo Mobile	txt.bell.ca
Bluegrass Cellular	sms.bluecell.com
Boost Mobile	myboostmobile.com
Cellcom	cellcom.quiktxt.com
Cellular South (C Spire)	cspire1.com
Centennial Wireless	cwemail.com
Cincinnati Bell	gocbw.com
Cingular	cingular.com
Cingular Prepaid	cingulartext.com
Cricket Wireless	mms.cricketwireless.net
Digicel St. Lucia	digitextlc.com
Fido	fido.ca
GCI Alask Digitel (GCI)	mobile.gci.net
IV Cellular (Illinois Valley Cellular)	ivctext.com
Koodo Mobile	msg.telus.com
Lime	txt2lime.com
Metro PCS	mymetropcs.com
MTS Mobility	text.mtsmobility.com
Nex-Tech	sms.nextechwireless.com
nTelos	pcs.ntelos.com
O2 (M-mail)	mmail.co.uk
O2 UK	o2imail.co.uk
Optus	optusmobile.com.au

Orange	orange.net
PC Telecom	mobiletxt.ca
PTel Mobile	tmomail.net
Pioneer Cellular	zsend.com
Pocket Wireless	sms.pocket.com
Republic Wireless	text.republicwireless.com
Rogers Wireless	pcs.rogers.com
SaskTel	sms.sasktel.com
Sprint	messaging.sprintpcs.com
Syringa Wireless	rinasms.com
T-Mobile	tmomail.net
T-Mobile UK	t-mobile.uk.net
Telstra	onlinesms.telstra.com
Telus Mobility	msg.telus.com
Three	three.co.uk
US Cellular	email.uscc.net
Unicel	utext.com
Verizon	vtext.com
Viaero	viaerosms.com
Virgin Mobile	vmobl.com
Virgin Mobile Canada	vmobile.ca
Virgin Mobile UK	vxtras.com
Wind Mobile	txt.windmobile.ca

APPENDIX B SOFTWARE FLOW

Opening Screen:



There are 5 screens that can be accessed from here.

1 - Test Screen Test operations occurs here.

2 - Files Screen Data management functions are found here

3 - Settings Screen This screen leads to all the settings used by the base unit.

4 - Diagnostics: Here basic system operation can be checked and various problems traced.

5 - Clock: You can set the clock here.

They and their sub-screens are shown next.

1 - Test Screen:

This screen holds an abbreviated view of all test activity. A more detailed view of a specific probe can be seen by tapping its box.

1a-Probe Info Screen:

This screen shows most recent data gathered from a probe and provides control for the probes test operation. One further level exists to define a probes functions.

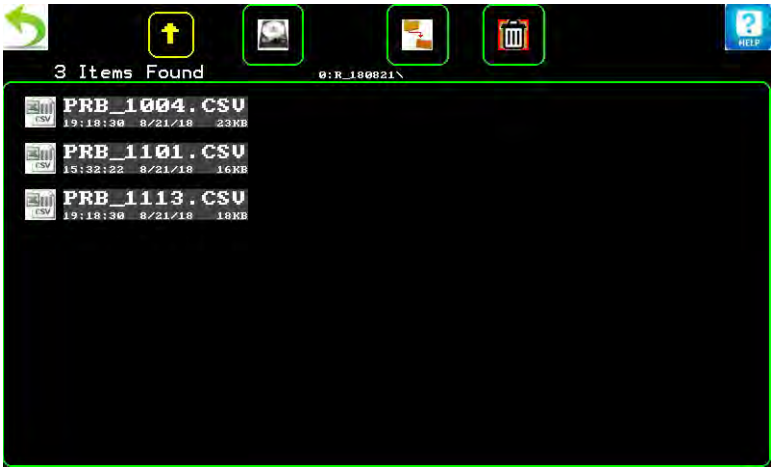
1b-Script Composer/Editor

This screen details the list of commands being executed by the probe. This screen can also be accessed from the first run screen to allow for quick transfer of commands to all probes.

2-Files Screen:

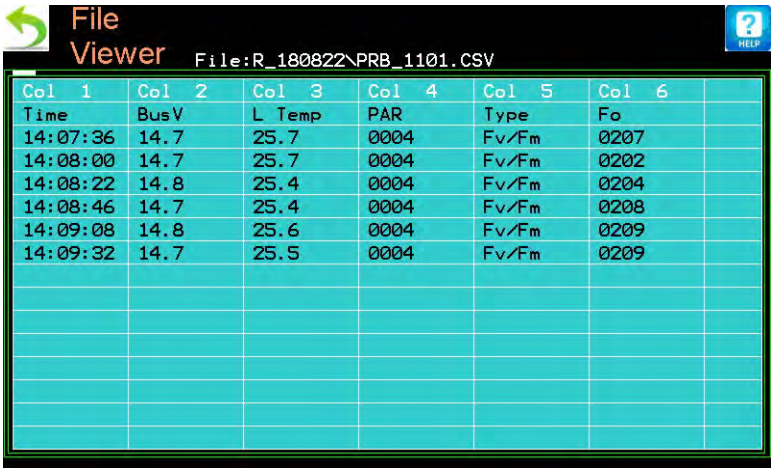
This is a root directory view of the internal drive

2a-Sub-Directory Screen:



This screen is similar to the root level screen, but has some additional utilities available. Selecting to view a file will bring up the next screen.

2b-File Data View Screen:

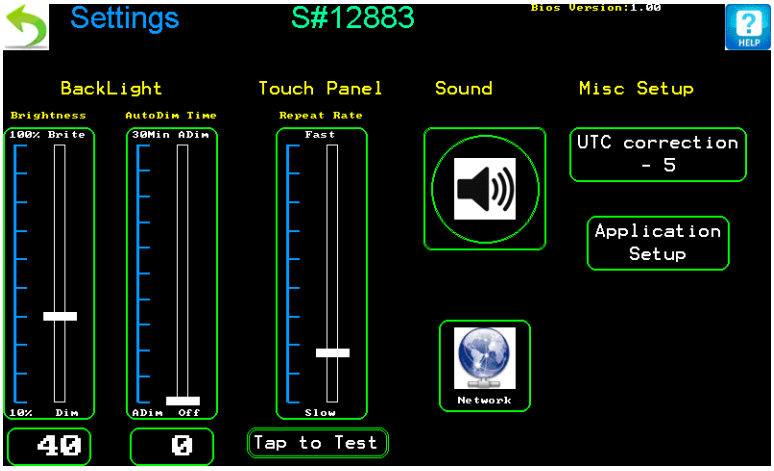


If a data column top is tapped, the column data will be plotted on a following screen.

2c-Data Plot Screen:

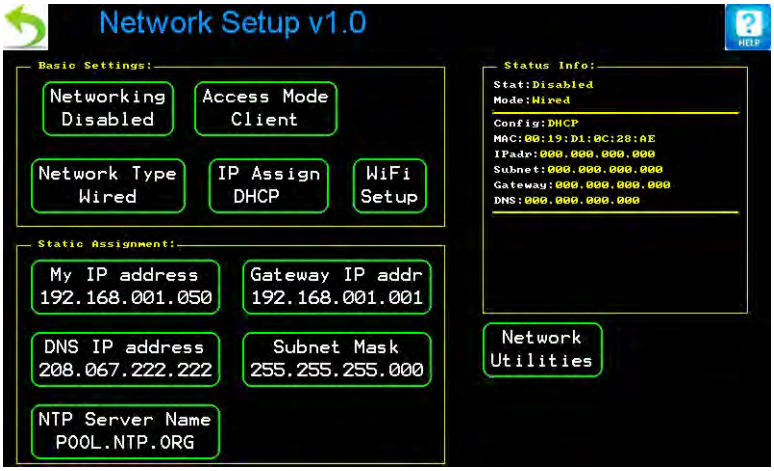
This is a plot of column 12, which in this case is the Y(II) value of a leaf dehydrating over time.

3-Settings Screen:



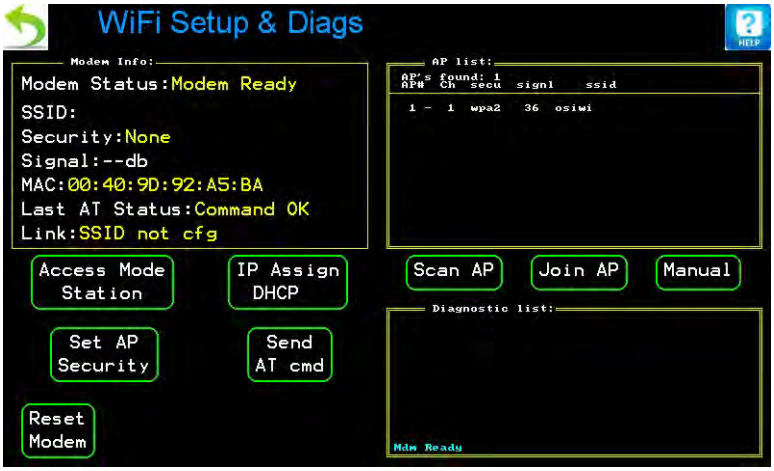
Here various system settings are done. Tapping the network icon will bring you to the next screen.

3a-Network Setup Screen:



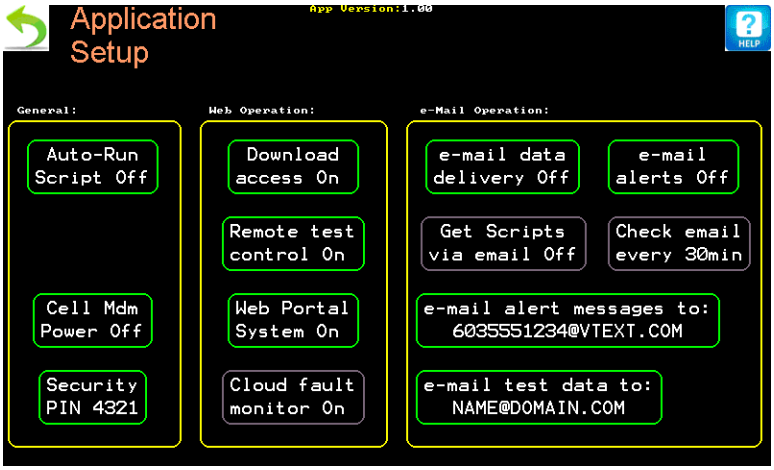
The basic settings for network operation are here. This screen has one additional setup level 'WiFi Setup' if the WiFi type is selected and enabled.

3b-WiFi Settings screen



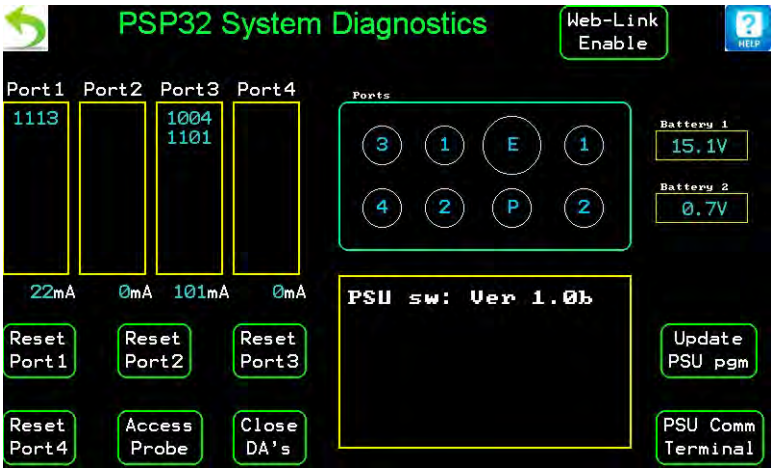
This screen holds settings used for the WiFi module.

3c-Application Screen:



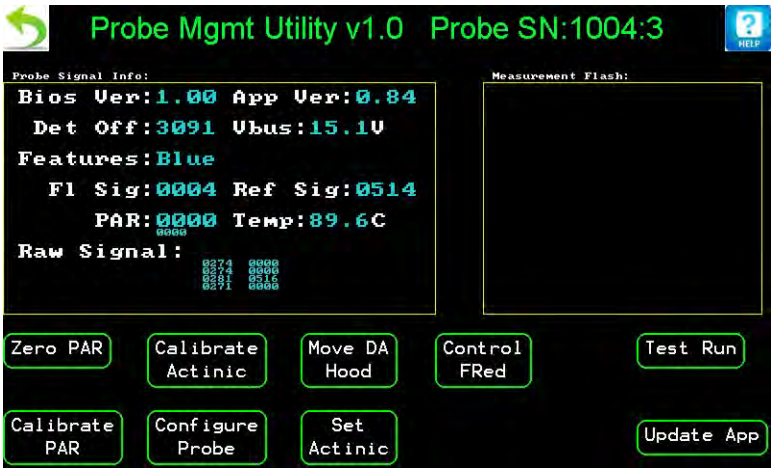
This screen holds settings related to test operations on the PSP32

4-Diagnostics Screen:



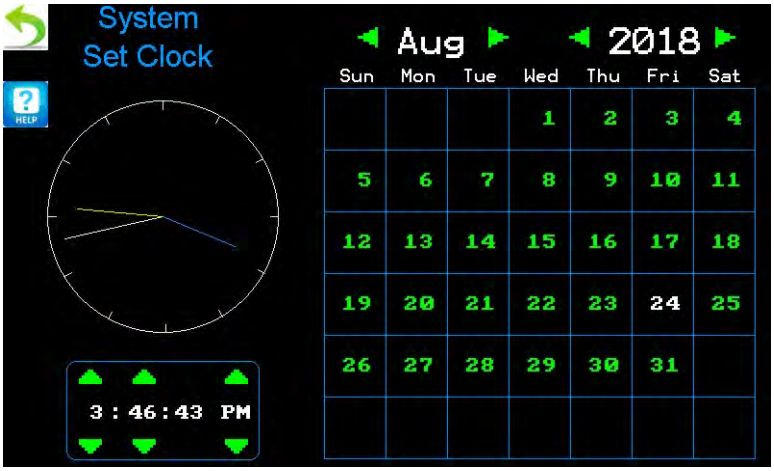
The first screen holds a system overview. Selecting the 'Access Probe' function will bring up the next screen.

4a-Probe Setup & Diagnostics:



This screen holds functions to setup and check the operation of a probe.

5-Clock Screen:



Here you may set the clock.

APPENDIX C ACCESSORIES

Available accessories to make deployment of the PSP32 easier.

BASE UNIT STAND.

This stand provides a simple mounting for the base unit when a poll mount is not available.

Probe cables of standard / custom length:

These will be needed to connect splitter boxes to the control unit.

DC power cable set:

This 16GA cable is used to connect a battery system to the PSP32. The cable is 15 ft standard and terminated w bare leads. A screw terminal lug set will be needed for connection to a solar charger. A 5/16 or 3/8 diameter ring lug will be needed for direct connection to a battery. This choice will depend on the solar kit chosen.

Table stand with articulating arm:

WEIGHTED TABLE STAND AVAILABLE FOR GREENHOUSE USE.

The articulating arm may be attached to many types of tripod, allowing precise adjustment of the probe.

Probe splitter boxes:

4 PROBE BOX. 8 PROBE BOX.

Both boxes have individual indicator lights under each connector. Each of the probe connectors has an internal safety fuse.

Transport case:

The transport case holds most items needed for up the 4 probes to be deployed. There is a custom probe cradle to hold units with the dark adaptor hoods installed. Cable and small stand items are stowed below. The controller and its accessories are placed in the left side cutouts.

There is also a version of this case with two probe cradle slots for a total capacity of 8 probes.

APPENDIX D APPLICATION NOTES

The following list of application notes are available on the USB drive (under "Application notes for PSP32"). Checklists are available for reliable Fv/Fm, Y(II), Rapid Light Curves, quenching and quenching relaxation measurement. Detailed information with citations are available on many topics. Additional application notes on other measuring topics are available at www.optisci.com under Application notes.

app note #0110 Quenching Measurements & the Kinetic Trace Updated 2014

app note #0111 Checklist for Reliable FvFm measurements

app note #0112 Importance of Light History on chlorophyll fluorescence

app note #0211 Checklist for reliable Y(II) (Yield) measurements (updated 2014)

app note #0309 Dark Adaption updated Nov 2014

app note #0312 Chlorophyll Fluorescence Heterogeneity

app note #0411 Checklist for Reliable Quenching (NPQ etc...)

app note #0412 Rapid Light Curves - an overview

app note #0415 Variable Chlorophyll Fluorescence Overview 2015

app note #0510 Heat Stress Measurement Limitations

app note #0610 Measuring Cold Stress in Plants

app note #0618 Wind as a variable in measuring photosynthesis

app note #0712 Plant Stress Measurement Overview

app note #0809 PAR, Y(II) and ETR

app note #0811 Fm' Correction for Y(II) and ETR (Loriaux 2013)

app note #0909 Light Curves

app note #0917 Early drought stress test for C3 plants

app note #1016 Improvements in monitor fluorometers

app note #1213 Chloroplast migration-Game Changing Research highlighted

Desktop Plant Stress Guide 5.1

Plant Stress Guide References list 5.1

APPENDIX E SAMPLE SCRIPTS

The base unit is preloaded with several sample scripts. They perform a range of tests. Each script has a detailed explanation at the beginning of the sample.

SCRIPT 1

```
*This script will make a sensor and Fv/Fm measurement every 60 min until PAR > 5
*then switch to Y(II) measurements every 30 min until PAR < 5 and repeat


while par<=5
  do 1,60
    measure sensor
    measure fv/fm
  loop
loop

while par>5
  do 1,30
    measure y(ii)
  loop
loop
```

SCRIPT 2

```
*This measures fv/fm all day using da hood during day
*night measurements every 60 min, day every 180 min with 30 min dark adapt

while par<=5
  do 1,60
    measure sensor
    measure fv/fm
  loop
loop

while par>5
  do 1,120
    close da unit
    pause 1800
    measure fv/fm
    open da unit
  loop
loop
```

SCRIPT 3

```
*This measures fv/fm every 60 min until par > 5 then
*measures kramer quenching parameters every 30 min

reset fo min

while par<=5
  do 1,60
    measure sensor
    measure fv/fm
  loop
loop

while par>5
  do 1,30
    measure quench
  loop
loop
```

SCRIPT 4

```
*This will measure Fv/Fm in the dark once every 60 min, and Y(II) once
*every 30 min during the day. Report standard Kramer quenching parameters:
*qL, Y(NPQ) and Y(NO) with every Y(II) measurement and use predawn Fv/Fm from
*the previous morning as the quenching reference until about 2:00 PM. Measure
*Y(II), wait for two minutes, close the daylight dark adaption module
*and measure qE after 7 minutes in the dark, qT at 20 minutes
*in the dark, qM and qI at 30 minutes in the dark. Open the dark adaption
*module for 30 minutes and start measuring Y(II) again. When dark, continue
*to measure Fv/Fm every hour reporting qI using the previous predawn Fv/Fm
*repeat at 4 AM

start at 04:00
reset fo min

do 4,60
  measure sensor
  measure fv/fm
loop

do 12,30
  measure quench
loop

measure y(ii)
pause 120
```

```
close da unit
pause 420
measure qe
pause 780
measure qt
pause 600
measure qm&qi
open da unit
pause 1800

while par>5
  do 1,30
    measure y(ii)
  loop
loop

do 12,30
  measure qm&qi
loop
```

SCRIPT 5

```
*This will measure Fv/Fm in the dark once every 60 min. During the day,
*measure RLCs every 120 min. To measure RLCs, have sensors report,
*Close the dark adaption module, dark adapt for 10 seconds and measure.
*There should be 8 steps starting 250 micromoles for 10 seconds,
*500 micromoles for 10 seconds, 750 micromoles for 10 seconds,
*1000 micromoles for 10 seconds, 1,250 micromoles for 10 seconds,
*1,500 micromoles for 10 seconds, 1750 micromoles for 10 seconds
*and 2,000 micromoles for 10 seconds.

while par<=5
  do 1,60
    measure sensor
    measure fv/fm
  loop
loop

while par>5
  do 1,120
    measure sensor
    close da unit
    pause 10
    measure rlc
    rlc step 10,250
    rlc step 10,500
```

```
    rlc step 10,750
    rlc step 10,1000
    rlc step 10,1250
    rlc step 10,1500
    rlc step 10,1750
    rlc step 10,2000
    open da unit
  loop
loop
```