PHOTO RESEARCH®

a JADAK Brand

PR-655/670 SpectraScan®

User Manual

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Notice

The information contained in this document is subject to change without notice. If there are any questions pertaining to the use of this system, contact JADAK.

Jadak and Novanta shall not be liable for errors contained herein or for incidental consequential damages in connection with the furnishing, performance, or use of this system.

Customer Support

PHOTO RESEARCH, Inc. has support services available to users in case of problems using the PR-655/670.

PHOTO RESEARCH, Inc. personnel are available from 8:00 AM to 4:30 PM (Eastern Time) Monday through Friday, except legal holidays, to aid in technical support.

Call (315) 701-0678, FAX: (315) 701-0679 or e-mail: for technical support - *support.pr@photoresearch.com* for instrument repair or calibration *service.pr@photoresearch.com* for technical support. If calling, please have the following information ready:

- Instrument Model
- Instrument Serial Number
- This manual
- Any printed data you feel might aid in resolving the problem - such as test data.

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INTRODUCTION

The PR-655 and PR-670 SpectraScan are the newest additions to the already world renowned SpectraScan colorimeter series of instruments. These unique, portable battery powered instruments utilize fast-scanning photo diode arrays, a 3.5" color touch screen display, and AutoSync® for automatically synchronizing to the source refresh rate insuring the utmost accuracy. Other features include an external trigger port allowing remote measurement activation from a push button or peripheral device, a Secure Digital (SD) card for measurement storage, and a long lasting rechargeable Lithium-ion (Li-Ion) battery for more than 12 hours of operation. The PR-670 adds to the PR-655 with four automated apertures, two measurement sensitivity modes (*Standard and Extended*), and four measurement speed modes (*Normal, Fast, 2X Fast and 4X Fast*).

STANDARD EQUIPMENT

The standard PR-655 includes:

- PR-655 SpectraScan.
- MS-75 Lens.
- 1° measuring aperture
- USB 1.1 Port.
- Secure Digital (SD) Card.
- BP-655 - Rechargeable Lithium-Ion battery pack.
- AC-655-6 – 6' Universal input AC Adapter.
- CD with drivers and Instruction Manual.
- SS-CC-655 Soft-sided Carrying Case.
- NIST Traceable Calibration - (certified for one year).

The standard PR-670 includes:

- PR-670 SpectraScan.
- MS-75 Lens.
- 4 Measuring Apertures – 1°, 1/2°, 1/4°, 1/8°
- USB 1.1 Port
- Secure Digital (SD) Card.
- BP-670 - Rechargeable Lithium-Ion battery pack.
- AC-670-6 – 6' Universal input AC Adapter.
- CD with drivers and Instruction Manual.
- SS-CC-670 Soft-sided Carrying Case.
- NIST Traceable Calibration - (certified for one year).

SYSTEM OVERVIEW

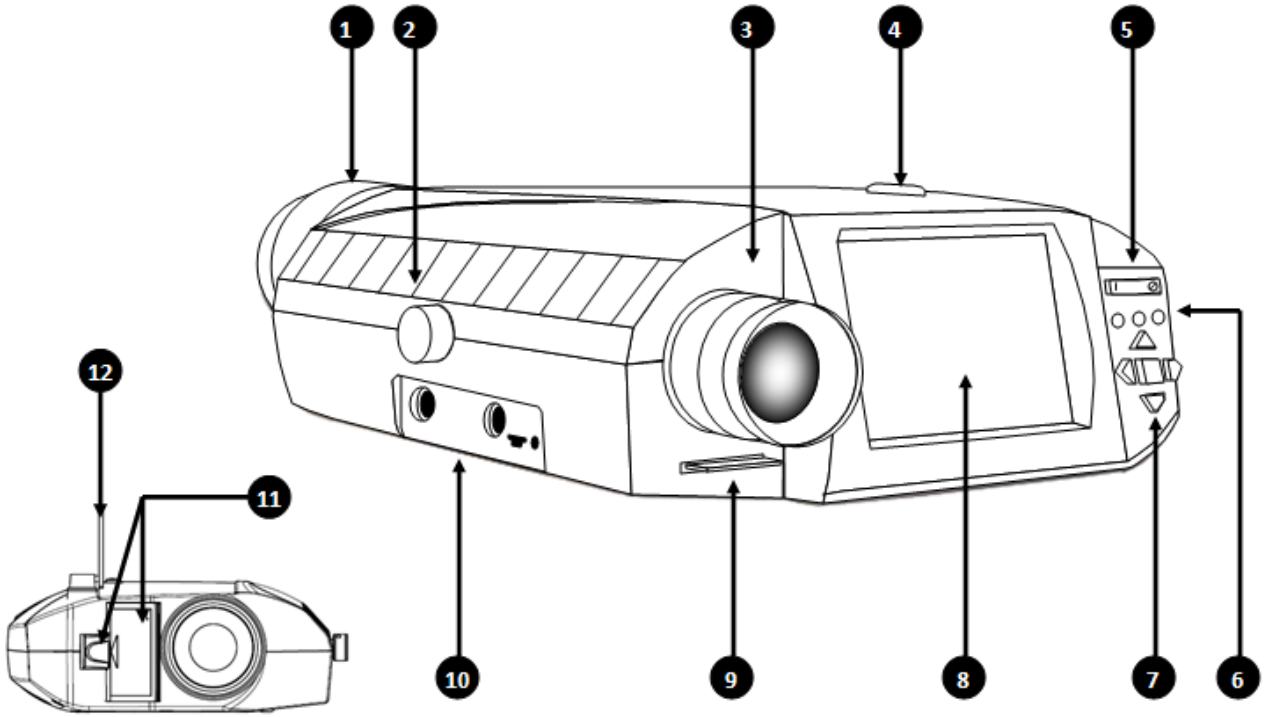


FIGURE 1 - PR-655/670 SPECTRASCAN

Reference	Description	Function	Reference	Description	Function
1	Objective Lens	Focusing on target	7	5-Way Switch	Up, Down, Left, Right, and Enter
2	View Finder Shutter Control	Open/Close view finder	8	3.5" LCD	Data/Navigation
3	View Finder	View target / measuring aperture	9	SD Slot	Data storage
4	Measure Switch	Execute measurement	10	I/O Connector Panel	Instrument connection panel.
5	Power Switch	Turn On (I) / Off (O) unit	11	Battery Door & Latch	Location for Li-Ion battery pack
6	Status Indicators P- Power C - Charge F - Fault	Instrument status indicators	12	Bluetooth Antenna	Optional wireless connectivity.

TABLE 1 - PR-655/670 FUNCTIONAL OVERVIEW

LCD Screen

The PR-655/670 features an on-board, 3.5” high resolution, full color touch screen LCD display. The area visible to the user is called the active area. The active area of the LCD display contains the graphical user interface of the PR-655/670. All setup options and measurements including spectral and CIE graphs can now be controlled and viewed directly on the vivid color display.

System Information

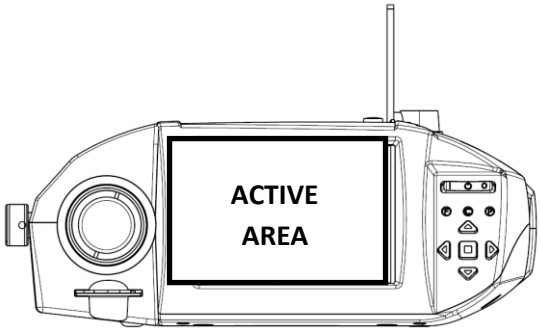
The system status screen, is displayed when the unit is powered on, and shows system information such as serial number, calibration due date, firmware version, and instrument bandwidth. This screen can be viewed at any time by navigating to:

Menu → System Information

FIGURE 2 - PR-670 STARTUP SCREEN

Graphical User Interface (GUI)

The Graphical User Interface, or GUI, is presented on the active are of the display. It allows the user to navigate through the PR-655/670’s menu system.



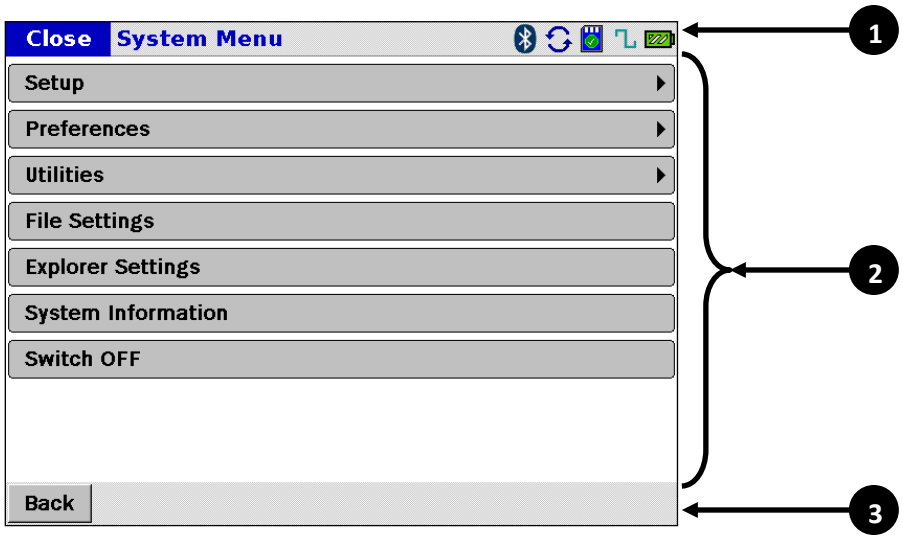


FIGURE 3 - PR-680/680L SYSTEM MENU

The GUI consists of three major panes:

Item	Description
1	Title bar
2	Active pane
3	Command bar

TABLE 2 - GUI PANE DESCRIPTION

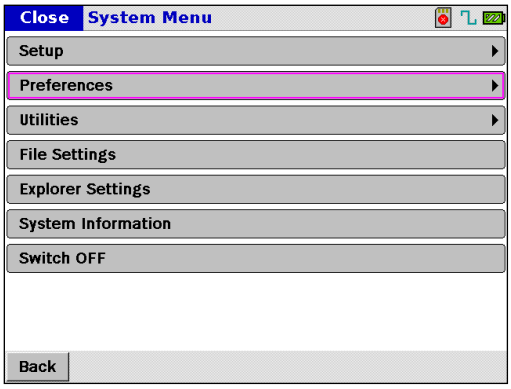
The flow of the menu navigation on the PR-670 is similar to that of a tree structure. In a tree structure there are roots and from the roots exist branches (sub menus), indicated by the following icon (▸) which have more branches or end nodes (leafs). Traversing back to the root is as simple as clicking on the back (Back) icon, located at the bottom right corner of the GUI.

The following example depicts the tree structure mentioned, by navigating to the ***Date & Time*** setup screen from ***System Menu***.

Navigation Steps:

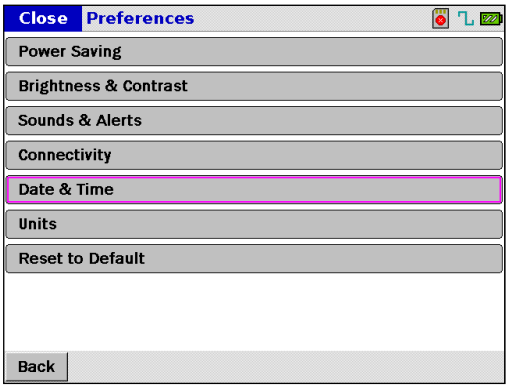
Preferences → Date & Time

Root



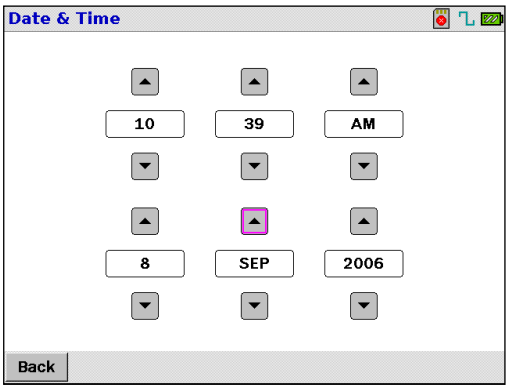
From ***System Menu*** navigate to and select *Preferences.*

Branch



From ***Preferences*** navigate to and select *Date & Time.*

End Node (Leaf)



To traverse back to the ***System Menu*** simply click the **Back** button twice.

TITLE BAR

The title bar displays the current active menu location (1) and critical system information status (2). A detailed list of system status icons can be found in the system status section of this manual.

FIGURE 4 - PR-655/670 TITLE BAR

SYSTEM STATUS ICONS

The system status icons display current instrument state and status. They are triggered either by a selection made in the instrument setup section or by the instrument. Below are all system status icons and their corresponding indication.

	ICON	DESCRIPTION
Battery Charge %	Green w/ 2½ bars	100% Charge
	Green w/ 1½ bars	66% Charge
	Yellow w/½ bar	33% Charge
	Orange w/½ bar blinking	Low Battery
Bluetooth		
		Bluetooth Enabled
	Blinking	Bluetooth Discoverable Mode
	Green	Bluetooth Connection Established
Sync		
	No Icon	Manual Sync Mode (20 – 400 Hz)
		Sync Disabled
		Automatic Sync
Auto Save		
	No Icon	Auto Save to SD card disabled.
		Auto Save On & SD Card Detected.
		Auto Save on & No SD card detected.

TABLE 3 - PR-655/670 STATUS ICON LIST

Detailed information pertaining to the system status icons can be found in their respective sections of the manual.

COMMAND BAR

The command bar is located at the bottom of the GUI, and displays the appropriate navigation and control buttons based on the active pane. There are three main expected command bar views:

BACK BUTTON

Whenever the back button Back is displayed, the user can traverse back to the previous menu or, if desired, back to the root. The Back button also serves **Saves current selections** when in *Instrument Setup and Preferences*.

MAKING MEASUREMENTS

After a measurement is executed or while it is in progress, the *Command Bar* displays the following icons. From the following example, the following functions can be executed:

FIGURE 5 - PR-655/670 MEASUREMENT COMMAND BAR

1) Navigate ***Back*** to the previous menu screen.
2) ***Abort*** a measurement.
3) ***Save*** measurements to the SD card
4) Navigate through measurement results screen < > .
5) Display ***Line*** or ***Hist.*** **(**histogram) plot when in the Spectral measurement results screen.

VIEWING MEASUREMENTS

When at the root *Measurement Screen*, the user can navigate through the measurements in RAM or the SD card using the following command bar. Note that all measurements in RAM will be lost when the unit is powered off.

FIGURE 6 - PR-655/670 MEASUREMENT VIEW COMMAND BAR

From the command bar, the user can execute the following:

1) Navigate to ***Prev*** **(**previous) measurement in RAM or SD card.
2) Navigate to ***Next*** measurement in RAM or SD card.
3) Jump to a particular measurement in RAM or SD card using ***Go To***.
4) Navigate through measurement results screen < > .
5) Display ***Line*** or ***Hist.*** **(**histogram) plot when in the appropriate measurement results screen

I/O PORTS

The I/O port panel is located on the left side of the PR-655/670 instrument when looking from the rear of the instrument. The panel consists of the following I/O connectors:

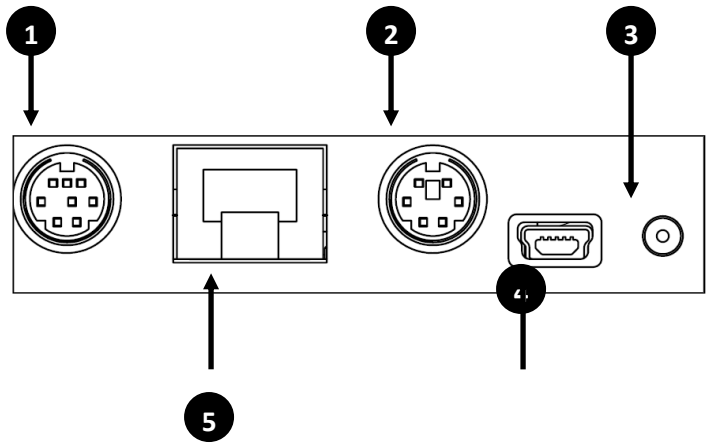


FIGURE 7 - PR-655/670 I/O PORT PANEL

Item	Description
1	Remote Head Connector
2	External Trigger Connector
3	Power Connector
4	USB Connector
5	RS-232 Connector (optional)

1. REMOTE HEAD PORT

The PR-655/670 is equipped with an 8-pin mini din connector for connection to auxiliary PR-514 and PR-515 remote heads.

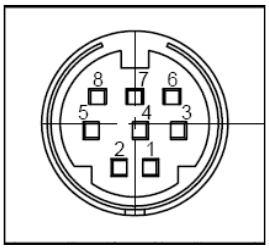


FIGURE 8 - AUXILIARY REMOTE HEAD CONNECTOR

A maximum of 15 auxiliary remote heads in a daisy chain configuration can be connected to the PR-655/670 instrument using this port. Please consult the factory for all available remote head options.

2. External Trigger Connector

The PR-655/670 is equipped with a 6 pin mini-din connector that can be utilized for externally triggering a measurement, and subsequently sending a signal (simple DC signal or pulse) to a source capable of being externally triggered - such as a xenon strobe lamp.

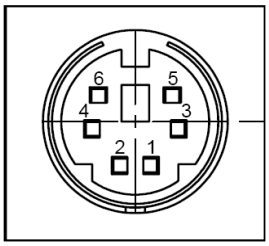


FIGURE 9 - EXTERNAL TRIGGER PIN-OUT

The pin designations for the connector are:

PIN #	NAME	FUNCTION
1	VDD	5V @ 25mA Max.
2	GND	Ground
3	IN	Trigger Input – Contact Closure,
4	SPARE	N/C
5	OUT +	Trigger Output high side
6	OUT -	Trigger Output low side

TABLE 4 - PR-655/670 EXTERNAL TRIGGER PIN OUT

The following examples show sample driving circuits for the external trigger input and output.

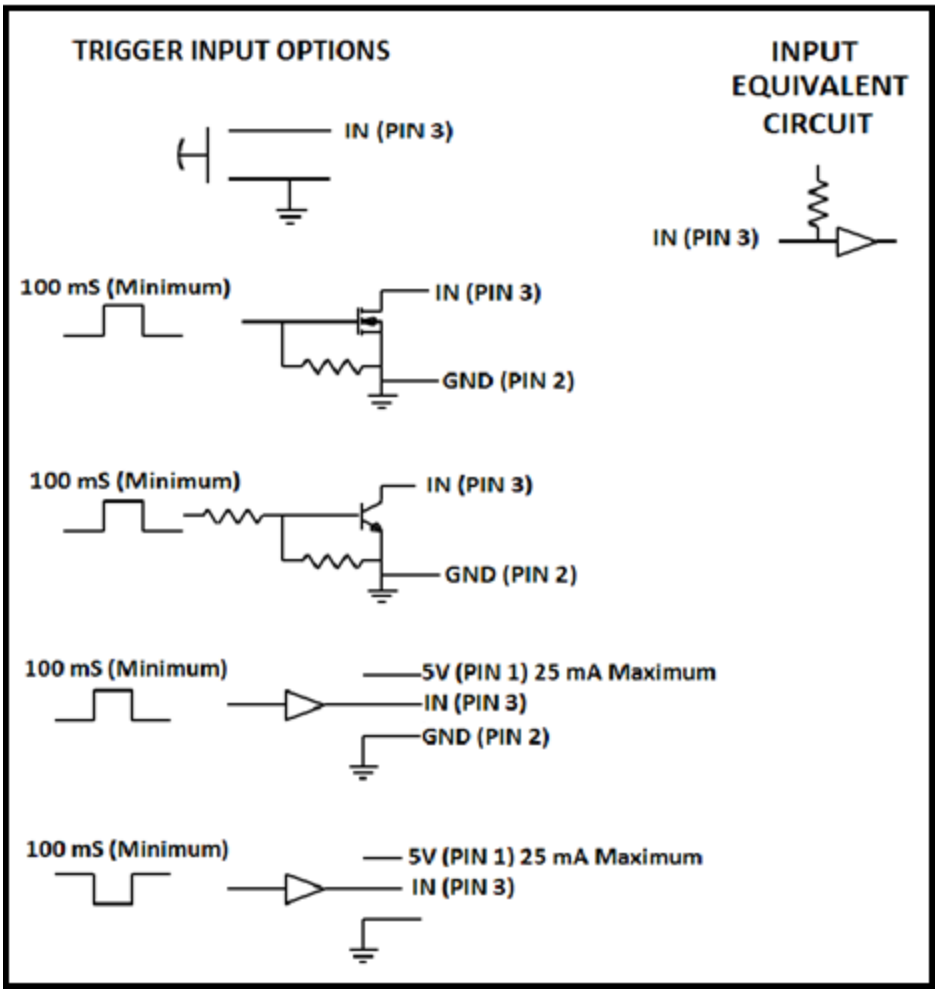


FIGURE 10 - SAMPLE EXTERNAL TRIGGER INPUT CIRCUIT DRIVERS

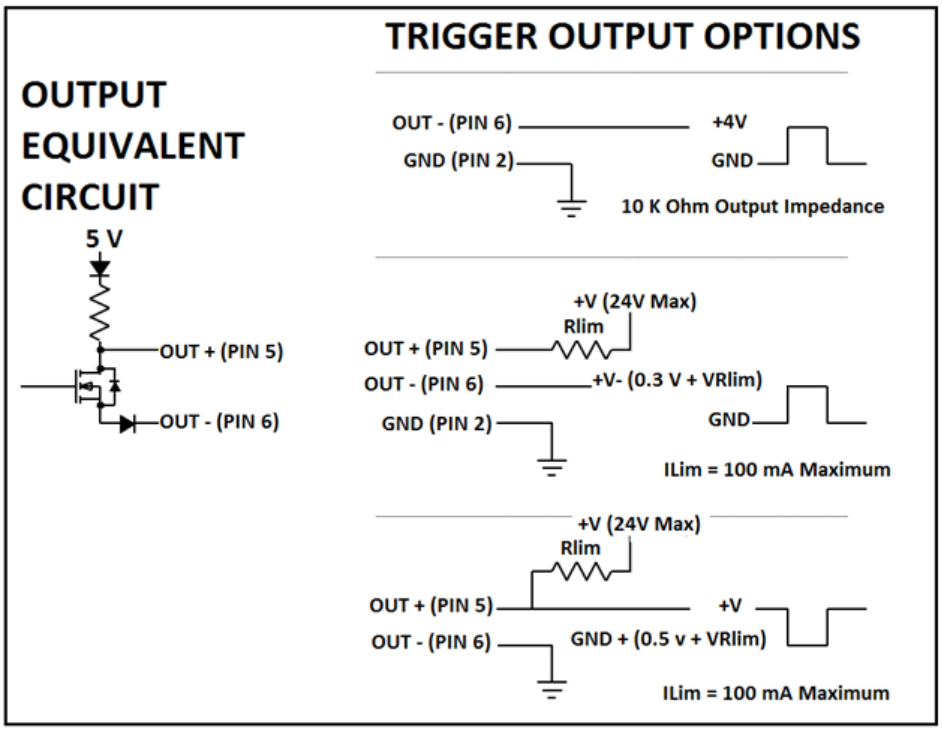


FIGURE 11 - SAMPLE EXTERNAL TRIGGER OUTPUT CIRCUIT

3. Power Connector

The PR-655/670 power (AC Adapter) supply connector. The unit can also be powered using the standard Li-Ion battery pack.

FIGURE 12 - PR-655/670 POWER CONNECTOR

1. Mini USB 1.1 Connector

The PR-655/670 is equipped with a Mini-B USB connector, providing remote communication. The USB interface can also be used to charge the instrument battery when plugged into an active PC.

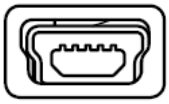


FIGURE 13 - MINI-B USB CONNECTOR

2. RS-232 CONNECTOR - OPTIONAL

For Remote Mode applications requiring traditional RS-232 communications, an optional RS-232 interface can be provided. This option adds an RJ-12 jack to the PR-655/670 system allowing the user to connect the PR-655/670 to a PC's RS-232 port via the included RJ-12 to DB-9 adapter.

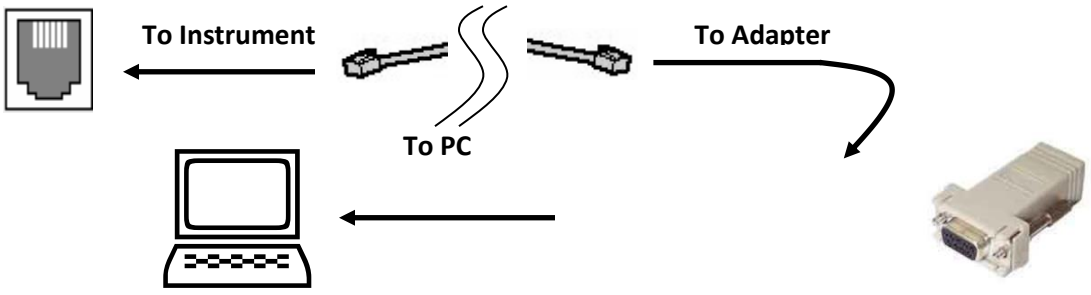


FIGURE 14 - PR-655/670 RS-232 OPTION

Items Included with the RS-232 Option:

1) RJ-12 Jack on PR-655/670
2) RJ-12 to DB-9 adapter
3) 6ft. RJ-12 cable

Please contact factory for custom RJ-12 cable lengths.

BATTERY

The PR-655/670 is powered by a high capacity rechargeable Lithium Ion (Li-Ion) battery pack. The battery compartment of the instrument is located at the front of the instrument to the left of the objective lens. The battery can be charged in the instrument (using the AC Adapter or USB power) or via the optional rapid charger accessory.

Warning: Before using the battery for the first time, charge the battery for at least 12 hours. The instrument can be used with the AC adapter while the battery is simultaneously charging.

Warning: Use only Li-Ion battery packs supplied by Photo Research Inc. to avoid possible damage and voidance of the warranty.

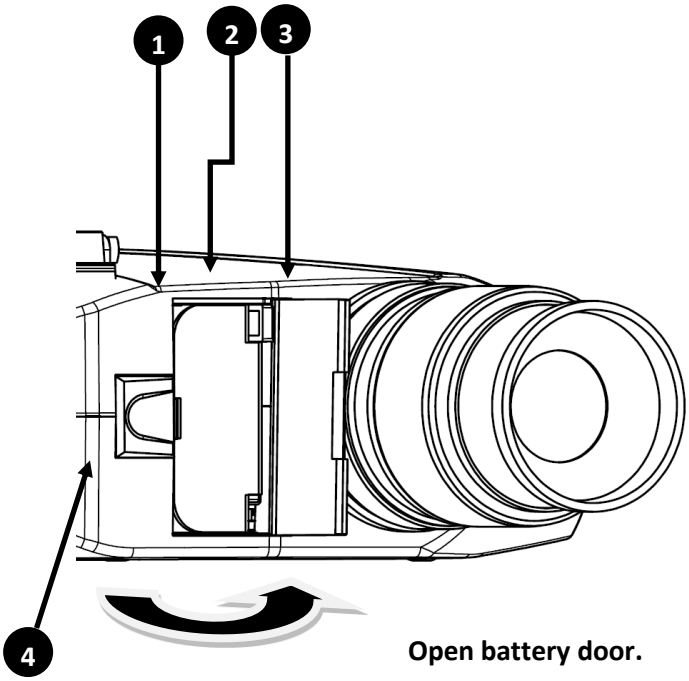
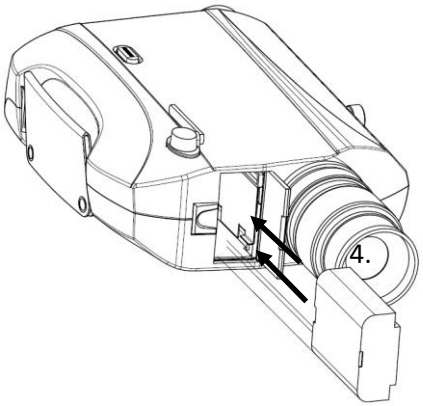


FIGURE 15 - PR-655/670 BATTERY COMPARTMENT CLOSE UP

	Description
1	Lithium Ion (Li-Ion) Battery Pack
2	Battery Eject Button
3	Battery Compartment Door
4	Battery Door Latch

TABLE 5 - PR-655/670 BATTERY COMPARTMENT DESCRIPTION

INSERTING THE BATTERY

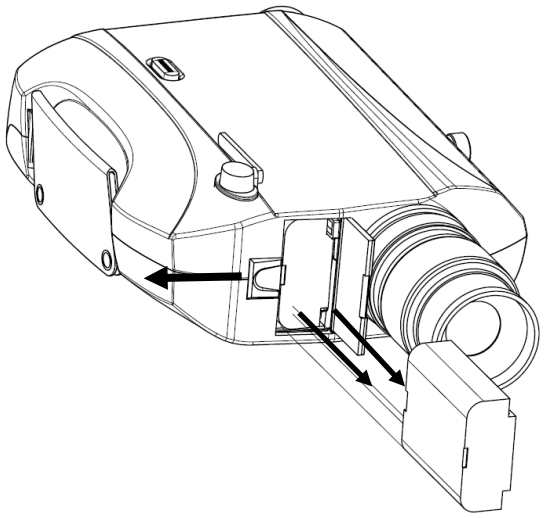


1. Facing the front of the instrument, slide the battery door latch away from the objective lens until the door opens (See **FIGURE 15**).
2. Orient the battery so that the two copper contacts face toward the objective lens, and toward the rear of the instrument.
3. Gently insert the battery until it 'clicks' into place.

   Close the battery door. Make sure the Battery Door Latch has engaged.

FIGURE 16 - INSERTING BATTERY INTO THE PR-655/670

REMOVING THE BATTERY



1. Facing the front of the instrument, slide the battery door latch away from the objective lens until the door opens (See **FIGURE 15**).
2. Press the Battery Eject button located in the upper right hand corner of the battery compartment. The battery will eject. Remove the battery from the compartment.
3. Close the battery door. Make sure the Battery Door Latch has engaged.

FIGURE 17 - REMOVING BATTERY FROM PR-655/670

CHARGING THE BATTERY

Note: Fully charge the battery before the initial use.

1. The PR-655/670 battery will charge whenever the AC Adapter or active USB is connected to the instrument.
2. If you purchased the optional Rapid Charger, the time for a full charge is 3.5 to 4 hrs. To use the charger:
    a. Make sure the charger power supply is properly connected to the charger and an appropriate AC power source. The AC input range is 100 to 240 VAC, 50 – 60 Hz.
    b. The battery and charger are keyed. To insert the battery in the charger, make sure the keys are aligned and push the battery as far forward as possible.
    c. There are three status LED's on the charger, MED, HI and MAX. Depending on the charge state of the battery, the LED's will blink in succession. For example, for a fully discharged battery the MED, HI then the MAX lights will blink one after another. For a partially charged battery, the MED light will be solid, and the HI and MAX lights will blink etc. Once the battery is fully charged, all three LED's will remain steadily lit.
    d. Remove the battery when fully charged.

CONNECTING THE AC ADAPTER

1. Insert the AC power cord into the AC Adapter body.
2. Insert the DC connector located on the opposite end of the adapter into the AC Adapter receptacle.
3. The P (Power) and C (Charging) status indicators should now be illuminated.

Note: The PR-655 / PR-670 can be operated using the AC Adapter while the battery is out of the instrument.

INSTRUMENT STORAGE

When the PR-655/670 will be idle for an extended period of time, remove the battery pack from the instrument. Store the battery pack in a cool dry place. The instrument including all standard accessories should be stored in the provided soft carrying case.

STANDARD OBJECTIVE LENS

The standard objective lens for the PR-655 and PR-670 is the MS-75 - a 75mm f/2.8 MacroSpectar® that focuses from 1:4 magnification to infinity. This objective lens enables the PR-655/670 to perform a variety of measurements including: luminance, radiance, and spectral radiance, chromaticity, correlated color temperature (CCT), Color Rendering Index (CRI), dominant wavelength, etc. For applications other than radiance or luminance the PR-655/670 can be supplied with optical accessories such as a cosine receptor for irradiance / illuminance, LR-127 LED Analyzer for testing LEDs for CIE 127 conformity, fiber probe for remote non-line-of-sight luminance testing, and a series of magnification lens for small spot size analysis. Refer to Optional Accessory section for more information on all available optical accessories.

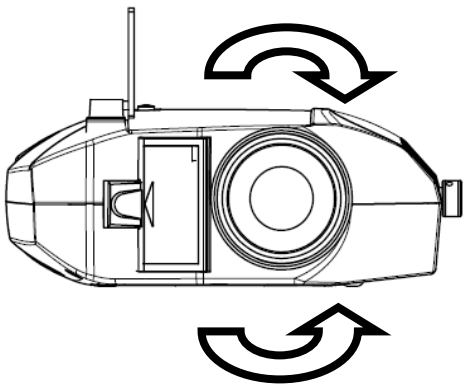
FIGURE 18 - MS-75 OBJECTIVE LENS

INSTALLING AND /REMOVING THE STANDARD LENS

The standard objective lens is installed by aligning the thread from the OBJECTIVE lens with the instrument's lens mount and rotating clockwise while grasping the rubber ring toward the rear of the lens (see

FIGURE 18). The thread should offer minimum resistance during installation.

Install Lens



Uninstall Lens

Removing the Objective Lens

1. Grasping the rear rubber ring (see
2. **FIGURE** 18) turn the lens counter-clock-wise until the lens separates from the lens mount.

Installing the Objective Lens

1. Grasping the rear rubber ring (see
2. **FIGURE** 18) turn the lens clock-wise until the lens seats on the lens mount.

Warning: Hand tighten only! Do not over tighten as permanent damage may occur.

SOFTWARE

Following are all optional software packages that are available for the PR-655/670 systems.

SPECTRAWIN™ 2 SOFTWARE

LITE VERSION

Full featured, menu driven, Windows software that calculates luminance, CIE chromaticity, correlated color temperature, dominant wavelength and excitation purity (saturation) from measured spectral data and provides features such as graphically represented spectral distribution and CIE color space (1931 and 1976), data manipulation (math functions) save/recall binary or ASCII files, print graphics screens or tabular data, reflectance / transmittance, L*a*b*u*v* measurements, ΔE Color Difference and Color Rendering Indices (CRI) of lamp sources.

PRO VERSION

Includes all of the capabilities of SpectraWin Lite and adds support for Macro scripting allowing the end user to create macros that can generate automated test sequences.

Note: For the best performance and compatibility, SpectraWin 2 software should be run under the Microsoft Windows XP system.

All software is serialized to an instrument. One licensed copy is required per instrument.

SPECTRAWIN 2 RGB DISPLAY CAL MODULE

SpectraWin Lite or Pro optional module designed for spectrally based white point calibrations of CRT's, LCD's, PDP's and digital projectors. Calibration is based on "learned" RGB values or user entered Y, xy, values. Calibration is facilitated by on-screen graphical feedback of an RGB bar graph or a moving color point within a CIE diagram - must be purchased with SpectraWin 2.

All software is serialized to an instrument. One licensed copy is required per instrument.

WINDOWS DRIVER DYNAMIC LINK LIBRARY (.DLL)

Fully documented library API that can be used in C++, Visual Basic, and LabView programming that allows for measurement control and data transfer from the PR-655/670 and is designed for development of customer software for integration with the PR-655/670. Includes SpectraWin 2 Lite software.

All software is serialized to an instrument. One licensed copy is required per instrument.

USER SELF CALIBRATION SOFTWARE

Single License

Provides complete recalibration capabilities for the PR-655/670 including wavelength accuracy, spectral intensity, linearity and accessory calibration. This option requires a helium wavelength calibration source (WC-600 or equivalent) and variable spectral radiance/ luminance standard (LRS-455 or equivalent).

5 Unit License

Same capabilities as single unit license but for 5 PR-655/670 instruments. The instrument's serial numbers must be specified at time of purchase.

10 Unit License

Same capabilities as single unit license but for 10 PR-655/670 instruments. The instrument's serial numbers must be specified at time of purchase.

Optical Accessories

The following optical accessories can be added to your existing PR-655 or PR-670. They require calibration with the instrument to provide accurate results. They can be calibrated by the user using the User Self Calibration software.

Neutral Density (ND) Filters

Neutral density filters are used to attenuate the incoming optical radiation (light level). They can be used on applications where the light source may saturate the instrument causing the PR-655/670 to report a "*Light Overload"* condition. ND filters can be mounted on the standard MS-75 lens or the optional SL-1X lens.

The following table lists all available ND filters and their respective characteristics.

Neutral Density Filter	Signal Attenuation	% Transmission
ND-0.3	2	50
ND-0.7	5	20
ND-1	10	10
ND-2	100	1
ND-3	1000	0.1

TABLE 6 - NEUTRAL DENSITY FILTERS FOR THE PR-655/670.

Reflectance Standard

The 2" diameter (51 mm) PTFE reflectance standard can be used for making ambient light measurements, measurements of point sources (e.g. lamps) or measurements of the illuminating source for reflectance or L*a*b* calculations. The reflectance standard features a Society of Automotive (SAE) ¼ - 20 threads, black anodized, aluminum case for mounting to an optical table.

RS-3

The RS-3 is an un-calibrated reflectance standard - all spectral reflectance correction factors are set to 1.00.

SRS-3

Spectrally Calibrated Reflectance Standard for absolute spectral reflectance - includes reflectance factors and certificate of calibration.

IS-655 / IS-670 Integrating Sphere

An integrating sphere is designed to measure the total luminous and radiant power of small point sources such as miniature lamps, light emitting diodes (LED's) and etc. over 4π steradians. Using this accessory, Radiant and Luminous Flux (lumens), correlated color temperature (CCT) and chromaticity coordinates can be measured. The input of the integrating sphere accepts virtually any discrete LED or small lamp with two leads. This accessory replaces the MS-75 during use.

Please consult factory for other special sizes.

CR-655 / CR-670 Cosine Receptor

The cosine receptor can be used for applications where it's required to know the amount of light incident on a surface or object. For example, irradiance or illuminance measurements of light incident on a projector screen or to design light fixtures for a building or office space. The cosine receptor replaces the standard MS-75 lens and reports irradiance in watts/m² and illuminance measurements in footcandles (fc) or lux depending on the unit type selected.

LA-655 / LA-670 Luminance Adapter

For contact measurements of radiance and luminance. Adapter covers 0.52" (13.2 mm) diameter and replaces the MS-75 during use.

FP-655 / FP-670 Flexible Probe

A 2 foot (60.9 cm) long probe designed for contact measurements of luminance and radiance. Probe tip is 0.125" (3.18 mm) diameter and replaces the MS-75 during use. 4 foot and 10 foot versions are also available.

LR-127 Light Emitting Diode (LED) Analyzer

This patented optical accessory is designed to test discrete LED's for compliance to CIE 127 specification. With this accessory both CIE 127 conditions A (far) and B (near) can be measured. Both conditions can be tested with the flip of a lever from 'A' to 'B'. No need to change tubes or even remove the LED between tests. The accessory is calibrated for radiant and luminous intensity (millicandelas) and accepts T1 (3 mm) packages - replaces the MS-75 during use. *Consult factory for alternate LED sizes.*

VARIABLE FOCUS LENSES

MS-7.5 mm – MacroSpectar® Wide-Field Lens

A C mount MacroSpectar® Wide-Field lens with a 3.94" (10 cm) to infinity working distance. Suitable for large area coverage at short distance for non-contact color quality control (L*a*b*) measurements. See the Specifications section for field coverage and working distance. Replaces the MS-75 during use

SL-0.5X - Supplementary Lens

A 0.5X magnification lens that provides field coverage halfway between the MS-75 and SL-1X lenses. Threads into the MS-75 during use. See the Specifications section for field coverage and working distance.

SL-1X - Supplementary Lens

A 1X magnification, fixed focus lens for luminance/radiance measurements. Threads into the MS-75 lens during use. See the Specifications section for field coverage and working distance.

FIXED FOCUS LENSES

MS-2.5X - MicroSpectar™ Lens

A 2.5X magnification, fixed focus lens for luminance/radiance measurements - replaces the MS-75 lens during use. See the Specifications section for field coverage and working distance.

MS-5X - MicroSpectar™ Lens

A 5X magnification, fixed focus lens for luminance/radiance measurements - replaces the MS-75 lens during use. See Table 1 for focus distance and field coverage (spot size) information.

SETUP

INTRODUCTION

This section provides instructions and procedures for setting up general instrument settings of the PR-655 / PR-670 prior to making measurements. For the location of components referred to in this section, please see the **Introduction** section of this manual.

BEFORE YOU BEGIN USING THE INSTRUMENT

Prior to beginning operations, we suggest a couple of steps to help maximize the functionality and longevity of your new instrument. Namely, calibrating the touch screen display and charging the battery.

CALIBRATING THE TOUCH SCREEN DISPLAY

The touch screen display for the PR-655 / PR-670 should be calibrated prior to general use to ensure that it responds properly to requested commands. To calibrate the screen:

FIGURE 19 - INITIAL SCREEN

1. Turn the instrument on. After initialization, touch Menu in the upper left hand corner of the screen. The following screen appears:

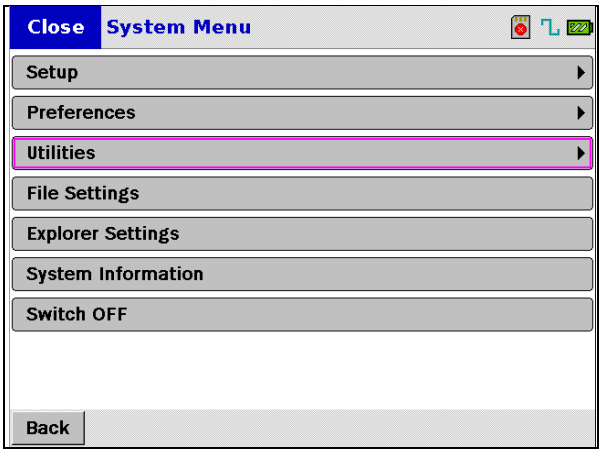


FIGURE 20 - SYSTEM MENU

2. Click on **UTILITIES**.
3. Click on **Calibrate Touch Screen.** The following screen appears:

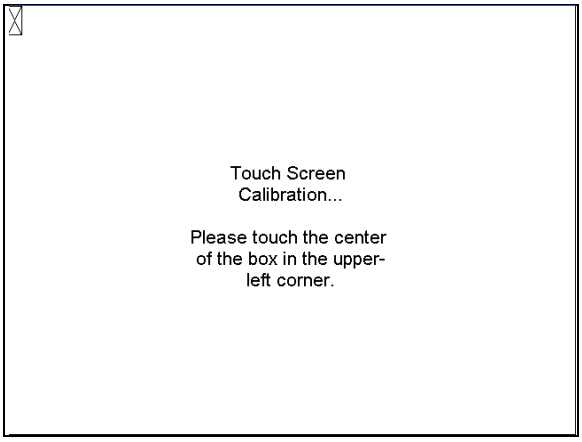


FIGURE 21 - CALIBRATE TOUCH SCREEN

4. Using a pointed object, begin the calibration by touch center of the **X** in the upper-left-hand corner of the screen.
5. You will be prompted to touch 8 additional areas of the screen during the process.
6. Touch Back when finished.

SETTING INSTRUMENT PREFERENCES

Several hardware parameters of the PR-655 / PR-670 can be adjusted to the users liking. They include *Power Saving, Brightness and Contrast, Connectivity* (and optional Bluetooth), *Date and Time, Units* and *650 Remote Mode* (PR-655 only).

1. To access the **Preferences** menu, navigate to the ***System Menu*** *by either* touching **Menu** in the upper left corner of the display, or **Back** in the lower left corner of the display until the menu appears.

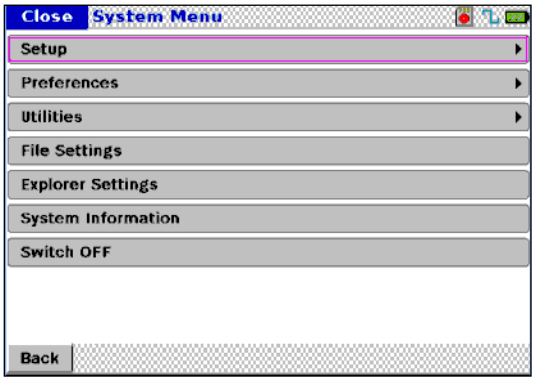


FIGURE 22 - SYSTEM MENU

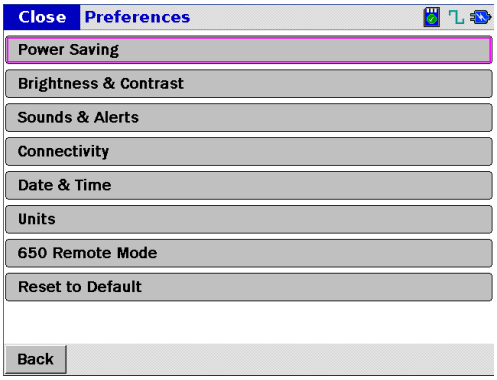


FIGURE 23 - PREFERENCES MENU

ADJUSTING POWER SAVINGS SETTINGS

The *Power Saving* feature can extend the battery life if the instrument is left on and unattended. The user can select to enable or disable this feature.

1. Touch **Power Saving** from the *Preferences* menu.

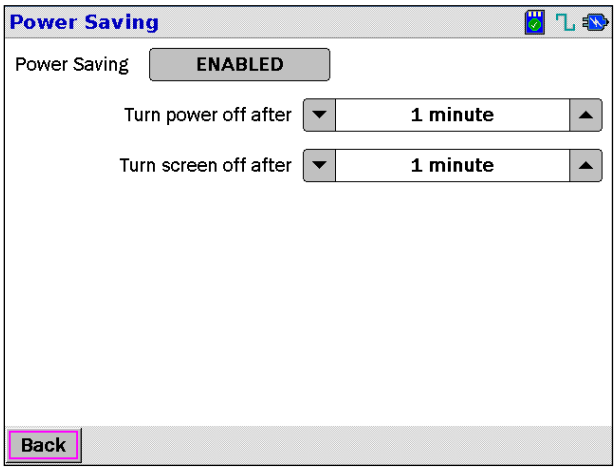


FIGURE 24 - POWER SAVING MENU

2. The current status of the Power Saving feature is displayed in the window adjacent to *Power Saving.* In the preceding example, *Power Saving* is enabled. Touch this field to **Disable** Power Saving. It will then read **Disabled.**
3. To instruct the instrument to shut down after a pre-defined amount of time, touch the ▼ or ▲ icons adjacent to the *Turn power off after* field. Choices are *1 to 30 minutes* or *Never*.
4. If you wish the screen to turn off after a pre-determined time, touch the ▼ or ▲ icons adjacent to the *Turn screen off after* field. Choices are *1 to 10 minutes* or *Never.*
5. Touch **Back** when finished making selections.

ADJUSTING BRIGHTNESS AND CONTRAST

Brightness and **Contrast** control the appearance on the display under various ambient lighting conditions. To access and adjust Brightness and Contrast:

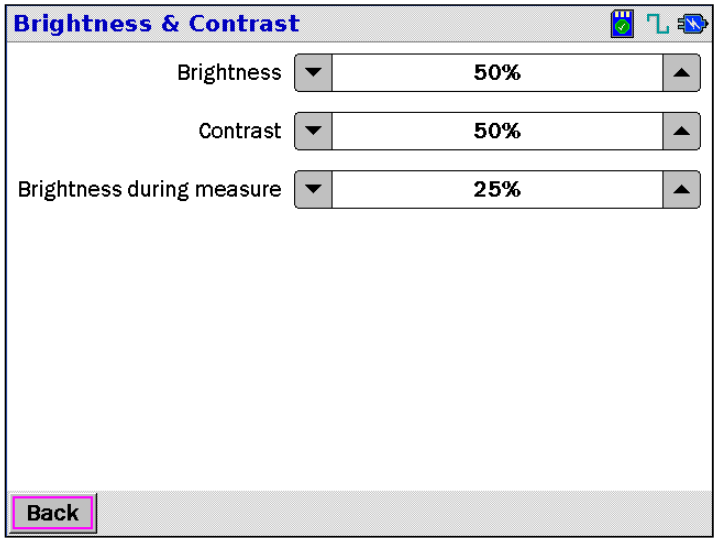


FIGURE 25 - BRIGHTNESS AND CONTRAST SCREEN

1. From the *Preferences* menu, touch **Brightness and Contrast.**
2. To adjust the brightness of the PR-655 / PR-670 display, touch the ▼ or ▲ icons on either side of the *Brightness* field. The brightness level is adjustable from 0% to 100%.
3. To adjust the screen contrast, touch the ▼ or ▲ icons next to the *Contrast* field. The contrast is adjustable from 0% to 100*.
4. The PR-655 / PR-670 screen brightness during a measurement can be set by touching the ▼ or ▲ icons adjacent to the *Brightness during measure* field**.** Settings range from 0% to 100%.
5. Touch **Back** when finished.

Enable and Disable Instrument Sounds

The PR-655 and PR-670 can audibly alert the user to various conditions of the instrument including *audible button click feedback, measure shutter sounds, measurement complete alerts* and *low battery warning.* To enable and disable these features:

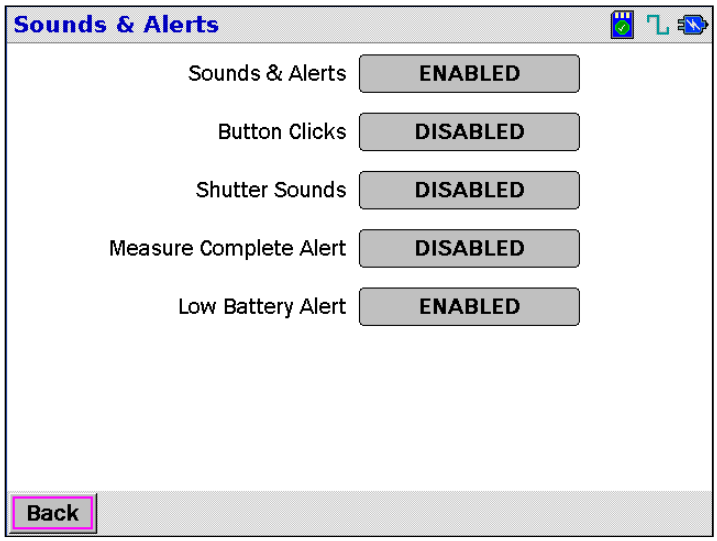


FIGURE 26 - SOUNDS AND ALERTS SCREEN

1. From the *Preferences* menu, touch **Sounds & Alerts.**
2. The field to the right of the field descriptor displays the status of that feature. To enable or disable all sounds, touch the **Sounds & Alerts** field. This field must be set to **Enabled** in order to gain access to the fields below it.
3. If **Sounds & Alerts** is enabled, touch any field next to its descriptor to toggle between enabled and disabled.
4. Touch **Back** when finished.

SETTING THE DATE AND TIME

The PR-655 and PR-670 is set to US Pacific Coast date and time at the factory. If the power is disconnected from the instrument (battery and AC Adapter), the date and time will be maintained for at least 1 year. To reset the date and time:

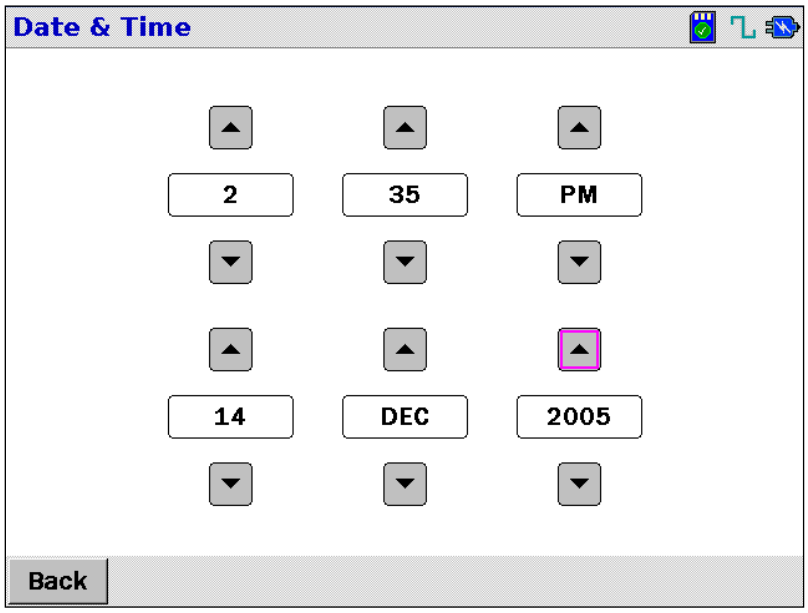


FIGURE 27 - DATE AND TIME SCREEN

1. Touch **Date and Time** from the *Preferences* menu.
2. Touch the ▼ or ▲ icons above or below the field of interest (e.g. Dec. in Figure 27) to scroll to the desired value. The range for the *Year* field is 2005 to 2025.
3. Touch **Back** when finished.

INSTRUMENT SETUP INSTRUCTIONS

Prior to making a measurement, it is necessary to insure that the instrument is aware of the accessory to be used (and aperture for the PR-670), the exposure (integration time), the sensitivity mode (PR-670 only), the number of measurements to average, the SYNC mode and the Dark Current mode (PR-670 only) during the upcoming test to insure that proper calibration factors are applied following a measurement.

FIGURE 28 - MAIN SCREEN

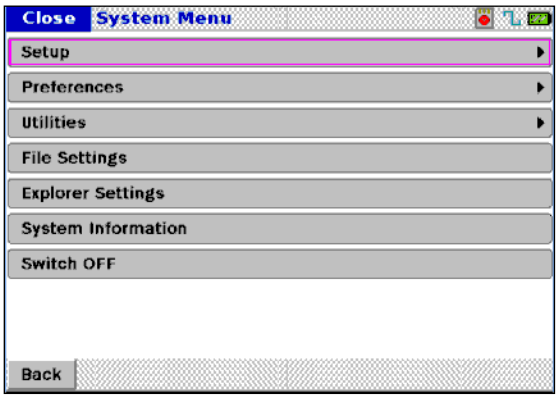


FIGURE 29 - SYSTEM MENU

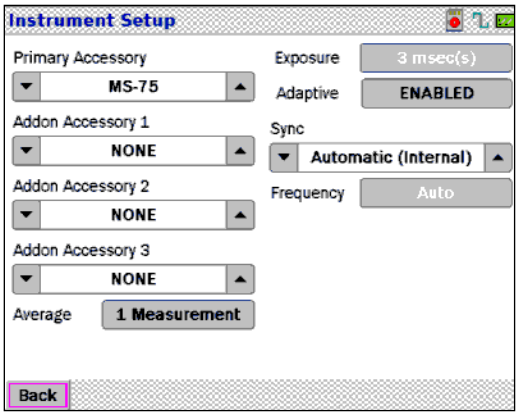


FIGURE 30 - PR-655 INSTRUMENT SETUP

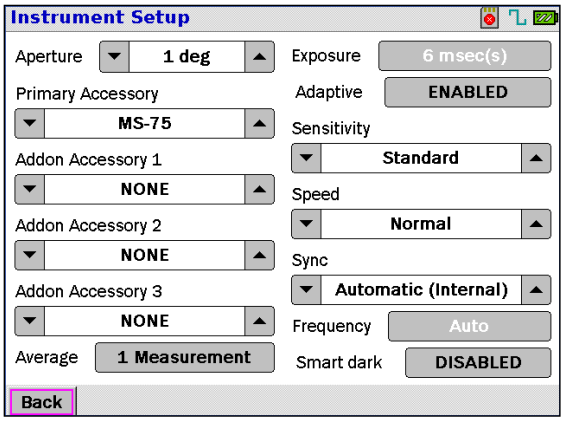


FIGURE 31 - PR-670 INSTRUMENT SETUP

1. From the main screen, touch **Menu (**or use the navigation keys). The **System Menu** appears.
2. Touch **Setup.**
3. The *Instrument Setup* menu appears. The screens differ slightly depending on the model. The PR-670 contains multiple aperture selections and enhanced data acquisition options that are not available for the PR-655.

Selecting an Aperture (PR-670 only)

1. Touch the ▼ or ▲ icon adjacent to the field named **Aperture** to scroll through aperture selections until the aperture of choice is displayed. Standard apertures include the 1°, 0.5°, 0.25° and 0.125°.

Selecting a Primary Accessory

A **Primary Accessory** is one that replaces the standard MS-75 lens during use. Primary accessories include the MS-75, SL-0.5X, SL-1X, MS-2.5X, MS-7.5, CR-655 (CR-670), FP-655 (FP-670), IS-655 (IS-670), ICC-655 (ICC-670), LA-655 (LA-670), CR-655 (CR-670) and LR-127.

1) Touch the ▼ or ▲ icon adjacent to the field named **Primary Accessory** to select the accessory to be used in the upcoming measurement.

Warning: Failure to select the proper accessory in use prior to a measurement will cause the instrument to produce erroneous results.

Selecting an Add-on Accessory

An **Add-on** Accessory is one that is used in conjunction with a Primary Accessory, usually an objective lens. Up to 3 **Add-on Accessories** may be used during a measurement. Examples of Add-on Accessories include all ND filters, the RS-3 and SRS-3.

1. To select an Add-on Accessory, touch the ▼ or ▲ icon next to the Add-on Accessory field to scroll through calibrated selections until the accessory of choice appears. A maximum of 3 Add-on accessories may be used during a measurement.

Setting the Number of Measurements to Average

To help improve measurement results, especially measurements where low light levels are being tested, the PR-655 and PR-670 can be instructed to make consecutive measurements (1 – 99) and average the results. Following a multiple measurement sequence, the spectra are averaged, and resultant photometric and colorimetric values calculated from the averaged spectra.

1. To set the number of measurements to average, touch the field next to **Average**. The following screen appears:

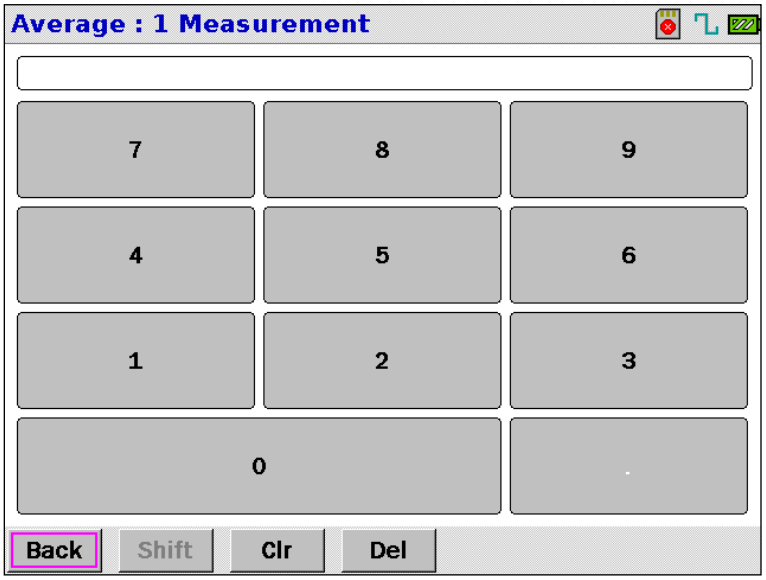


FIGURE 32 – MEASUREMENT AVERAGE ENTRY SCREEN

2. Enter the number of measurements to average. The range is 1 to 99.
3. Touch the **Back** key when done.

SETTING ADAPTIVE EXPOSURE TIME

The exposure time is the amount of time the detector is exposed to light. The PR-655 and PR-670 utilize the patented *Adaptive Sensitivity*™ algorithm that automatically select the proper exposure time for the available signal insuring the most accurate measurement for the available light. Use the following procedure to set Adaptive Sensitivity to ON.

1. To set the instrument to **Adaptive Sensitivity**, make sure the field next to **Adaptive** reads **Enabled.**

SETTING A FIXED EXPOSURE TIME

It may be desirable to set a fixed exposure time for an application. For example, when measuring a display for luminance uniformity, the exposure time will be the virtually identical for each measurement since the luminance levels are very similar for every part of the display. In this example, using Adaptive Sensitivity will make the measurement time longer because of the overhead the algorithm creates in its iterative process to find the ideal exposure time. Use the following procedure to set a fixed exposure time.

1. If the field immediately to the right of **Adaptive** reads *Enabled*, touch the field to set **Adaptive** to *Disabled*.
2. Touch the field adjacent to *Exposure* to display the following data entry menu:

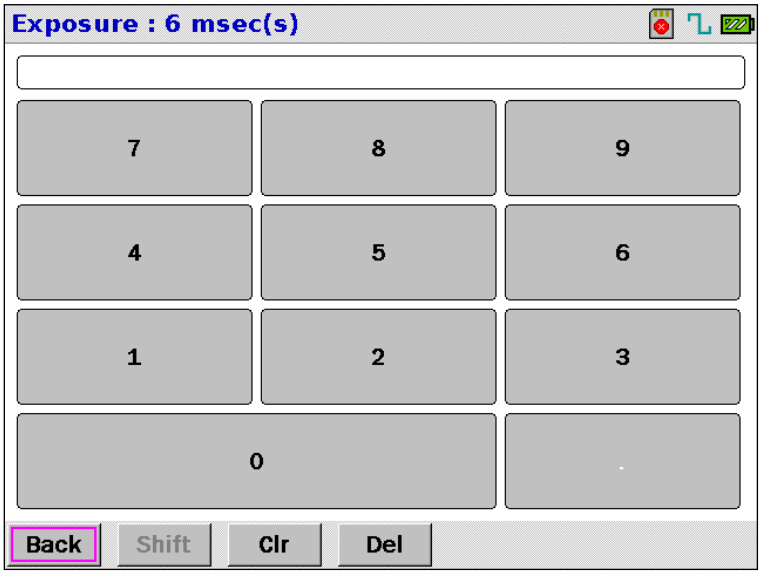


FIGURE 33 – EXPOSURE TIME ENTRY SCREEN

3. Enter the desired exposure time. The range is 3 ms to 6,000 ms for the PR-655 and 6 ms to 30,000 ms for the PR-670.

Note: The sensitivity range must be set to *Extended* to use the maximum value of 30,000 ms (PR-670 only).

4. Touch **Back** when done.

SETTING THE INSTRUMENT SENSITIVITY RANGE (PR-670 ONLY)

The PR-670 has two *Adaptive* sensitivity ranges – *Standard* and *Extended.* For *Standard* sensitivity, the exposure time range is 6 ms to 6,000 ms. For *Extended* sensitivity, the exposure time ranges from 6 ms to 30,000 ms thus *extending* the sensitivity. To set the *Sensitivity* range:

1. Make sure *Adaptive* is set to *Enabled.*
2. Touch the ▼ or ▲ icon in the *Sensitivity* field to toggle between **Standard** and **Extended.**

SETTING THE MEASUREMENT SPEED (PR-670 ONLY)

The total time needed to complete a measurement is certainly an important issue. This feature can help speed up measurements by changing the way the Adaptive Sensitivity determines when a measurement is completed. In the *Fast* mode, the total measurement time will be approximately halved. In *2X Fast,* total measurement time will be reduced approximately 4 times and in *4X Fast* by approximately 8 times.

Caution: To insure measurement quality (accuracy and repeatability) is not adversely affected while using one of the optional measurement speeds (*Fast, 2X Fast or 4X Fast)*, we strongly recommend running tests for accuracy and repeatability prior to using these modes for critical measurements. This is most easily achieved by comparing results with measurements made in the *Normal* mode.

To select a *Speed* mode:

1. Make sure *Adaptive* is set to *Enabled.*
2. Touch the ▼ or ▲ icon in the *Speed* field to toggle between **Normal, Fast, 2X Fast** and **4X Fast**.

SETTING THE SYNC MODE

The PR-655 and PR-670 can be instructed to automatically adjust the exposure time to the frequency of the source. This can significantly improve the accuracy and precision of the measurement of repetitive, intense sources. When measuring these types of sources, the instrument may only be exposed to a very few "pulses" of light. Since the instrument has no way of knowing at what point in the pulse the measurement started (e.g. leading edge or trailing edge) two successive measurements of the same stimuli may yield unacceptably different results. By knowing the frequency of the source, the exposure time can be adjusted to an even multiple of the pulse rate thereby insuring that entire pulses are captured improving the accuracy and repeatability of the measurements. This is not an issue if the repetitive source being measured is relatively low level yielding a long (> 1 second) exposure time.

There are five SYNC modes, *None, Auto, Learn, User and Multi-Sync*

- *None – The instrument does not invoke any of the SYNC functionality*
- *Auto – Automatically measures the frequency and applies correction to the exposure time.*
- *Learn – Uses the SYNC detector of the instrument to measure the primary frequency of the DUT.*
- *User – User entered frequency information*
- *Multi Sync – The instrument tests for primary and secondary frequencies and sets the exposure time accordingly.*

To set the *SYNC* mode:

1. Make sure *Adaptive* is set to *Enabled.*
2. Touch the ▼ or ▲ icon in the *SYNC* field to toggle between **None, Manual,** and **Automatic.**
3. If **Manual** is selected, touch the field adjacent to *Frequency to* access the following data entry screen*:*

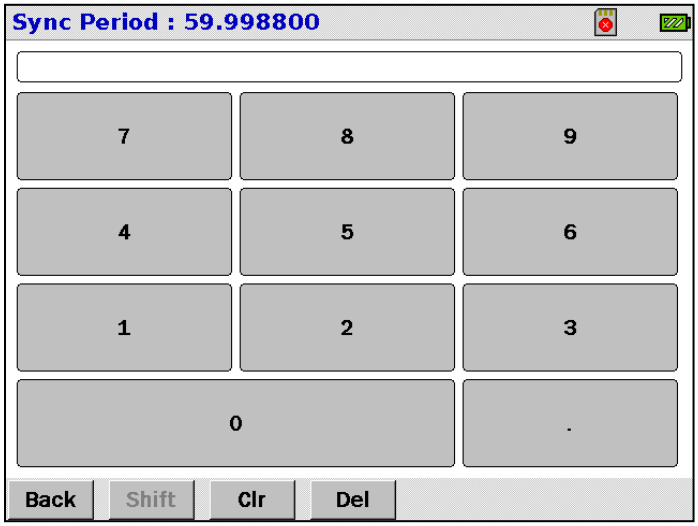


FIGURE 34 - SYNC PERIOD DATA ENTRY SCREEN

4. Touch the numeric keys to enter the SYNC period. The range is 20 to 400 Hz.
5. Touch **Back** when finished.

SETTING SMART DARK MODE (PR-670 ONLY)

During a measurement the PR-655 and PR-670 make two separate measurements – one of the optical signal (**Light**), and a second measurement of the detector dark current (**Dark**). By enabling the **Smart Dark** feature, the PR-670 will attempt to use the same dark current values for more than one measurement thus reducing total measurement time. The *Smart Dark* feature is used when the instrument determines that the (second or successive) measurement in a series is using the same exposure time as the first measurement. If a fixed exposure time is used for a measurement, *Smart Dark* will be used until the exposure time is changed.

Smart Dark is a useful tool for applications such as display uniformity, or other testing where multiple measurements of the same light level are performed.

To enable *Smart Dark:*

1. Touch the field next to **Smart dark** to toggle between *Enabled* and *Disabled.*

FILE SETTINGS

The ***File Settings*** options pertains to accessing the Secure Digital (SD) card installed in the card slot of the PR-655/670. If no card is inserted in the slot, these options are not available for change (grayed out). The ***File Settings*** option allows the user to setup the following features:

1. ***Auto Save*** – Allows files to be automatically saved to an SD card (when available).
2. ***SD File Field*** - Select measurement file to store measurements in.
3. ***Create/Delete/Rename*** measurements files.
4. ***Prompt user for SD card during shutdown*** if measurements exists in RAM.

ACCESSING THE FILE SETTING SCREEN

1. Touch ***Menu***.
2. Touch ***File Settings***.
3. Touch ***Back*** to exit to the ***Main Manu*** after all options have been selected.

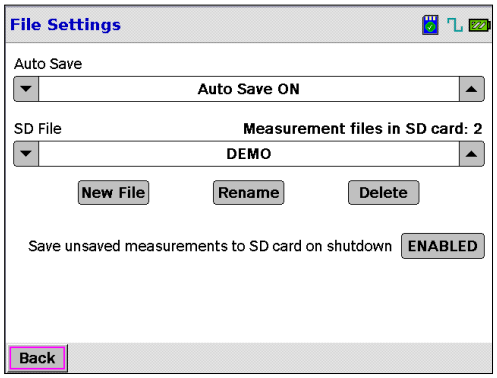


FIGURE 35 - SECURE DIGITAL CARD FILE SETTINGS.

SD FILE FIELD

The ***SD File*** field shows the current measurement file name that measurements are being saved to when ***Auto Save*** is enabled.

1. The ▼or ▲ icons are used to scroll through the available files until the file of choice appears.
2. If you wish to create a new file, it can be created using the **New File** function. Refer to the Creating New Measurement File section for information. If no SD card is present the ***SD File*** field will show the last accessed file (grayed out).
3. If the last accessed measurement file does not exist on the SD card, the following prompt will appear:

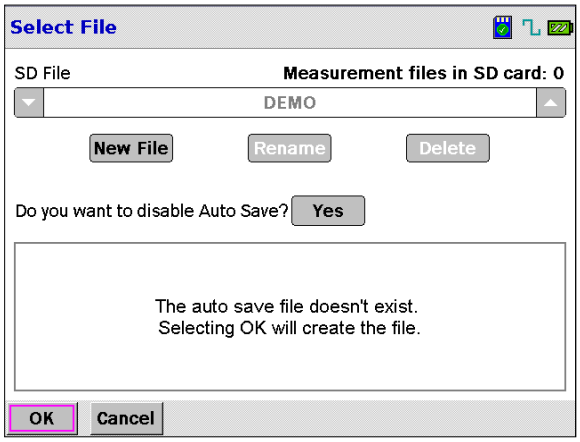


FIGURE 36 - MEASUREMENT FILE DOES NOT EXIST ON SD CARD

4. To create the file Touch ***OK.***

   OR

   To create a new measurement file Touch on **New File**. If **Cancel** is pressed this screen will appear after every successful measurement unless ***Auto Save*** is disabled.

CREATING A NEW MEASUREMENT FILE

Multiple measurements files with up to 200 measurements per file can be saved on the SD card. The file name can be up to 8 characters long with no spaces or extensions.
To Create a new file:

1. Touch **New File**

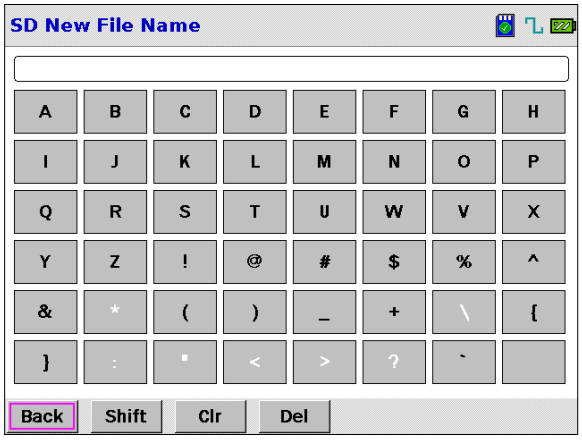


FIGURE 37 - SD CARD NEW MEASUREMENT FILE NAME ENTRY.

2. Enter the desired file name – **8 characters max with no extension**. As the characters are pressed, they appear in the window at the top of the screen. Press ***Shift*** to display a second set of characters as shown in following example.

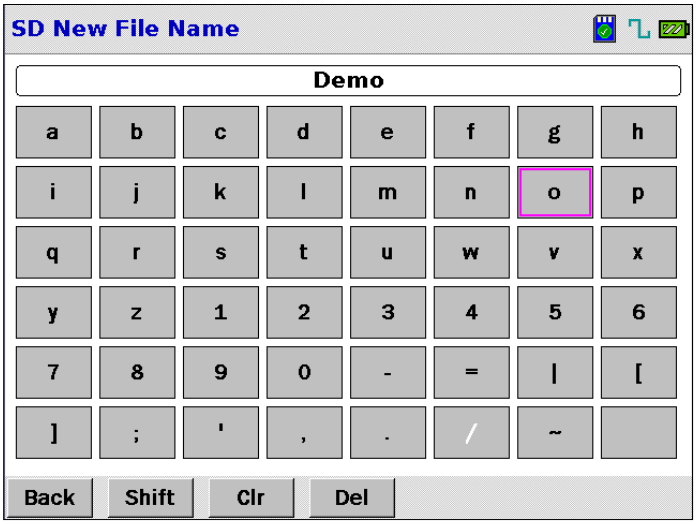


FIGURE 38 - SECOND CHARACTERS SET

3. Touch ***Back to*** finish and save the file.
4. From this point as long as ***Auto Save*** is enabled, all measurements are saved to the selected file.

DELETING A MEASUREMENT FILE

To delete a measurement file:

1. Insert the SD card with the measurement file to be deleted.
2. Select the desired file to be deleted in the ***SD File*** field using the ▼or ▲ icons.
3. Touch Delete.
   Note: All measurements in the file will be lost.

RENAMING A MEASUREMENT FILE

1. Insert SD card with the measurement file to be renamed.
2. Select the desired file to be renamed in the ***SD File*** field using the ▼or ▲ icons.
3. Touch Rename.
4. Enter the new name for the file.

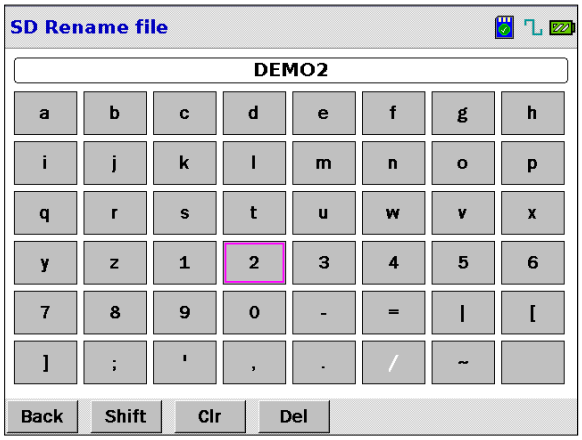


FIGURE 39 - MEASUREMENT FILE RENAME

5. Touch ***Back*** to complete the process.

AUTO SAVE

With Auto Save set to ON, measurements are automatically saved to the file name in the ***SD Field*** in addition to the internal RAM memory area. Use the ▼or ▲ icons to toggle between *Auto Save* ***ON*** and *Auto Save* ***OFF***.

AUTO SAVE ON SHUTDOWN

When ***"Save unsaved measurements to SD card on shutdown"*** is enabled the instrument will prompt the user to save all measurements in RAM before shutting down. The user will have 5 minutes (300 sec.) to select one of the following options.

1. Save measurements on SD card. Touch ***Yes.***
2. Shut down without saving. Touch ***No.***
3. Go back to previous menu and not shut down. Touch ***Cancel.***

This prompt will not appear if ***Auto Save*** is enabled, as the measurements are automatically stored following a measurement.

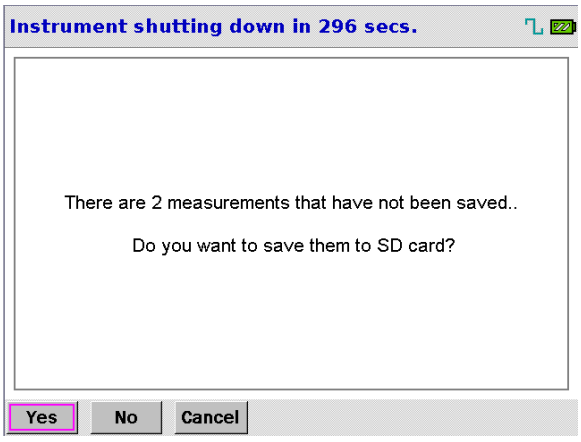


FIGURE 40 - AUTO SAVE ON SHUTDOWN PROMPT

If no decision is made within 300 seconds (5min.) the instrument will power down and all current measurements will be lost.

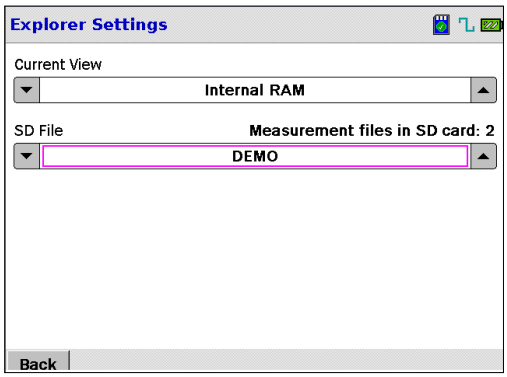
EXPLORER SETTINGS

Explorer Settings determine the memory location (Internal RAM or External SD card) and file name (if SD is selected) for viewing stored measurements.

ACCESSING THE EXPLORER SETTINGS SCREEN

Step 1) Touch ***Menu***.

Step 2) Touch ***Explorer Settings***.



File explorer viewer location.

# of measurement files on SD card.

FIGURE 41 - EXPLORER SETTINGS

CURRENT VIEW

The ***Current View*** option selects the memory location (Internal RAM or External SD). Touch the ▼ or ▲ icon to toggle between *Internal RAM* and *External SD Card*.

SD FILE

If ***External SD Card*** has been selected as the ***Current View,*** the user can select a measurement file to view in the ***File Explorer***. The measurement file can be selected by touching on the ▼ or ▲ icon. Once the desired measurement file has been selected simply navigate back to the ***File Explorer*** to start viewing the measurements contained in the measurement file.

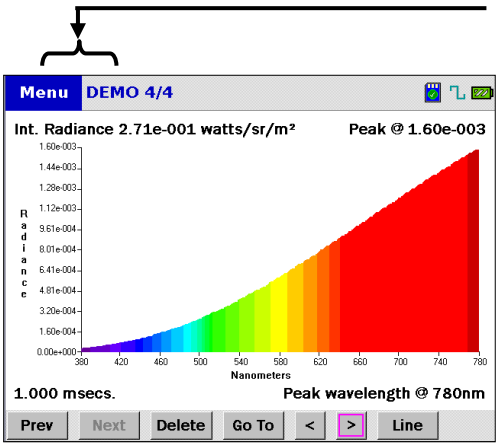


FIGURE 42 - FILE EXPLORER

RECALLING MEASUREMENTS STORED ON SD CARD

Measurements stored on the SD card can be recalled in three ways. **1)** Using the instrument explorer, see Explorer Settings section for more information, **2)** Using SpectraWin 2.0 (optional) ***Import*** feature, refer to SpectraWin 2 manual for more information **3)** Using the in-built ***Remote Control Mode*** capability, see Remote Control Command Detail section for more information.

UTILITIES

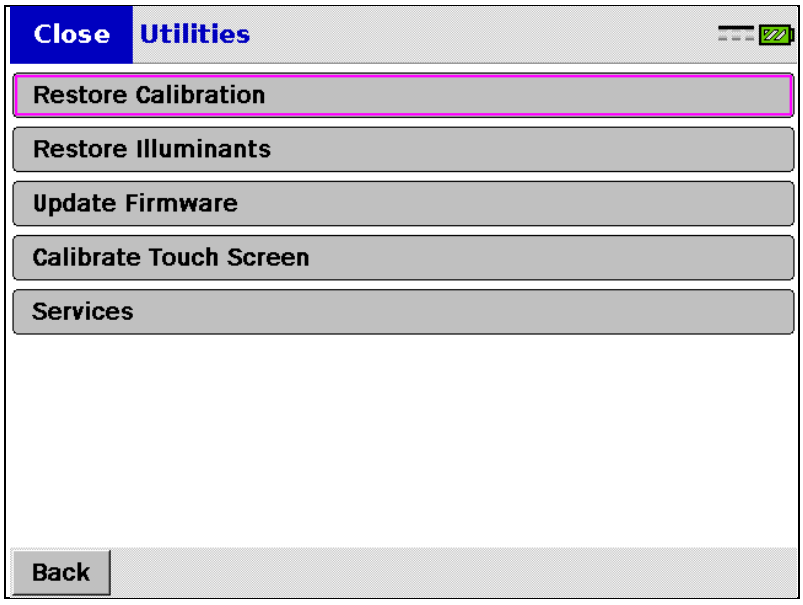


FIGURE 43 - UTILITIES MENU

The Utilities functions include, in addition to calibrating the touch screen described earlier, seldom used features such as Restoring the Calibration files, Restoring Standard Illuminants and Updating Firmware. The Services item is has a factory only accessibility status.

RESTORING CALIBRATION/ILLUMINANTS

This feature should only be used to restore all calibration factors and standard illuminant files to the factory default settings.

Requirements:

1. Secure Digital (SD) card.
2. SD card reader.
3. Zip file with calibration/illuminant information from Photo Research.

RESTORE PROCEDURE

1. Connect the USB card reader to the PC.
2. Copy all calibration and illuminant files (contact Photo Research to obtain these files) to the SD card.
3. Connect AC power to the instrument, or make sure a fully charged battery is used to prevent an interruption in power during the restore process.
4. Insert the SD card into the PR-655/670.
5. Touch ***Menu.***
6. Touch ***Utilities.***

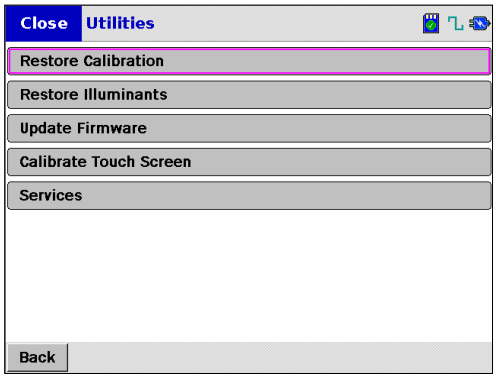


FIGURE 44 - PR-655/670 UTILITIES MENU

7. Touch ***Restore Calibration*** to restore all calibration factors. If restoring standard illuminants, touch ***Restore Illuminants.***
8. Once the restore process is successfully completed the instrument will power down.

Note: If any errors occur during this restore process consult factory immediately.

UPDATING FIRMWARE

The firmware can be easily updated in the field. Simply insert the SD card with the latest firmware revision and instruct the instrument to update.

Note: Calibration and Illuminant factors ***DO NOT*** have to be reloaded after a firmware update.

REQUIREMENTS

SECURE DIGITAL (SD) CARD.

1. SD card reader.
2. Latest firmware PR6XXHW.hex file from Photo Research.

UPDATE PROCEDURE

1. Connect the USB card reader to the PC.
2. Copy the file **PR6XXHW.HEX** supplied by Photo Research on to the SD card.
3. Connect AC power to the PR-655 / PR-670, or make sure a fully charged battery is used to prevent an interruption in power during the restore process.
4. Insert the SD card.
5. Touch ***Menu.***
6. Touch ***Utilities.***
7. Touch ***Update Firmware***.
8. In the confirmation screen that appears, touch ***Yes*** to continue, or ***No*** to return to the ***Utilities*** menu.

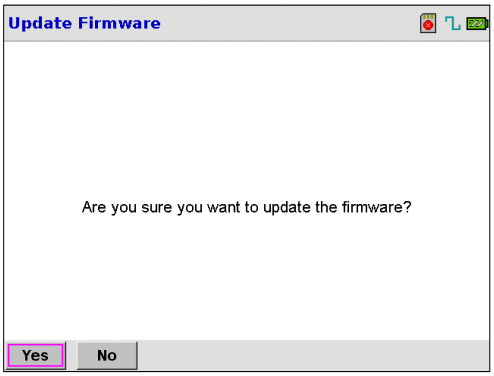


FIGURE 45 - PR-655/670 FIRMWARE UPDATE PROMPT

9. If ***Yes*** was selected, the firmware is automatically updated.
10. At the screen that appears following the completion of the update, press ***OK*** to restart the instrument and initialize the new firmware.

ADVANCED SETUP

CUSTOM SPECTRAL CALIBRATION

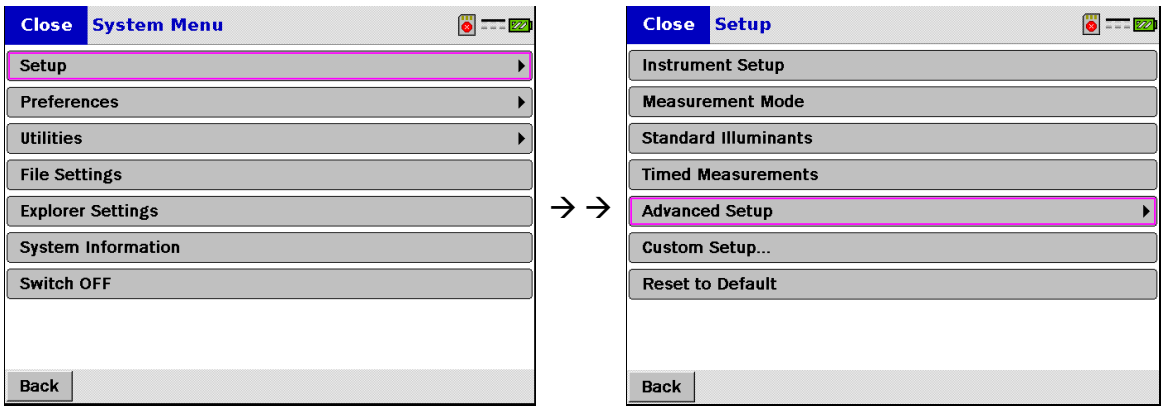
The correlation of two instruments measuring the same sample has always been an issue. This is especially true when comparing results from two different instrument manufacturers, or when the calibration of an instrument is suspect. To help eliminate this problem without requiring full recalibration of the instrument, we have added a Custom Spectral Calibration feature to the suite of features on the PR-655 / PR-670. This feature allows the user to establish a set of unique spectral calibration factors for one instrument based on the measurement of a sample from a second instrument. Then, when both instruments analyze the sample in question, they will correlate with exceptional accuracy.

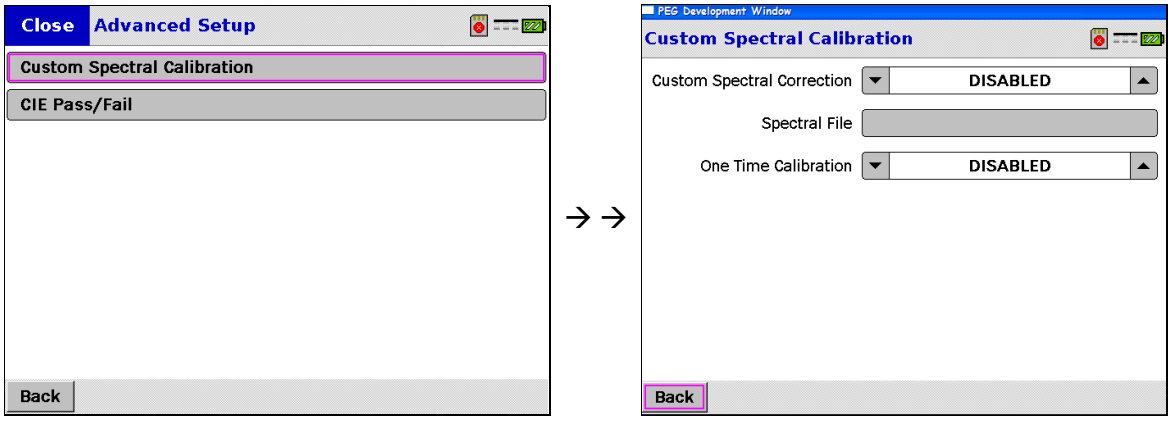
The second (*Source*) instrument can be a Photo Research product, or other spectrally based instrument. The parameters of the spectral data for the second instrument **must** be compatible with that of either the PR-655 or PR-670. The parameters are:

Instrument	Starting WL	Ending WL	WL (Data) Increments in nm
PR-655	380	780	4
PR-670	380	780	2

ACCESSING THE CUSTOM SPECTRAL CALIBRATION MENU

1. Touch **Setup → Advanced Setup → Custom Spectral Calibration.** The **Custom Spectral Calibration** screen appears.



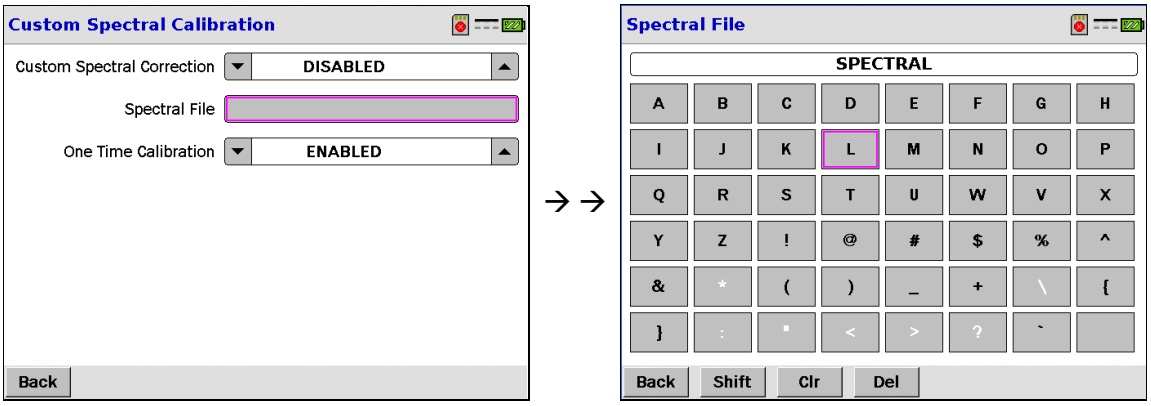


IMPORTING DATA

AS A .MEA FILE

Although it would be unlikely to have to perform this procedure for two PR-655 / PR-670 instruments, it is possible to save a measurement on the SD card of the *Source* instrument, and use that measurement data in the *Target* instrument.

1. Create a new file on the SD card in the *Source* instrument. Make sure this file does not have the same name as another file on the same card with a **.txt** extension. The software will always try to use files with a **.txt** extension first during the spectral calibration sequence.
2. Measure the sample with the *Source* instrument.
3. Save the measurement to the file from Step 1**. Make sure that this measurement is the only measurement in the file**. If multiple measurements are stored in the file, then the most recent measurement (last measurement saved) will be used to generate spectral factors in the *Target* spectroradiometer.
4. Remove the SD card from the *Source* instrument and insert it into the *Target* instrument.
5. Make sure *Custom Spectral Correction* is **Disabled** and that *One Time Calibration* is **Enabled**.
6. Enter the name of the file from Step 1 by touching the Spectral File field to bring up the Spectral File Dialog.



7. Measure the sample with the *Target* instrument.
8. The **Custom Spectral Calibration** is complete.
9. To use these new factors for subsequent measurements, make sure that *Custom Spectral Correction* is ***Enabled*** and that *One Time Calibration* is ***Disabled***.
10. To restore the Target instrument so that it uses only the factory calibration factors, make sure **Custom Spectral Correction** is set to ***Disabled***.

AS A .TXT FILE

Data from other instruments can be used as the baseline or *Source* values for the Custom Spectral Calibration. The following criteria must be met:

A. The *Source* must have the same starting and ending wavelength points, and the same wavelength (data) increment.
B. The file must have a **.TXT** file extension.
C. The file must have the following file format:

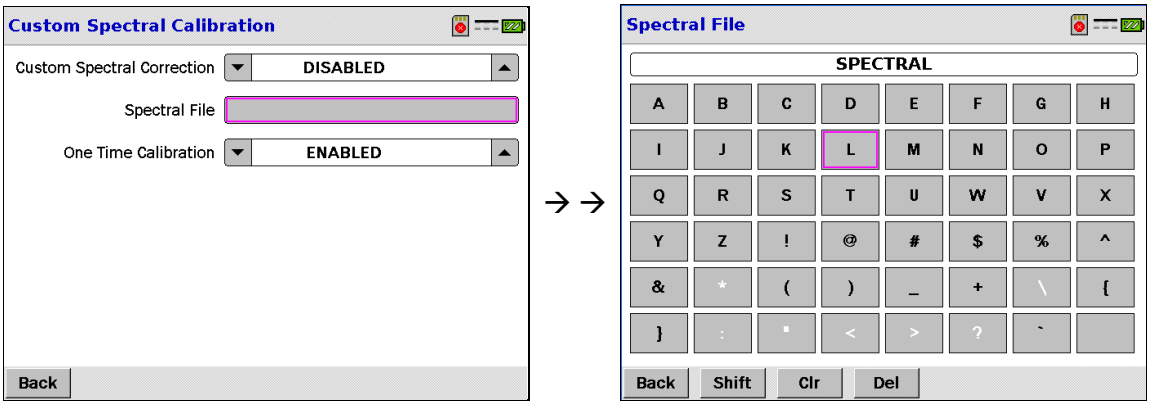
Line 1 – Title (Alpha / Numeric characters only – no spaces)
Line 2 – 380 (Starting Wavelength)
Line 3 – 780 - Ending Wavelength
Line 4 – 4 (for PR-655) or 2 (for PR-670) – Wavelength (Data) Increment (in nanometers)
Line 5 to Line N – Spectral values

Sample **.txt** File:

```
M1
3.800000e+002
7.800000e+002
1.000000e+000
3.722937e-003
3.729762e-003
3.611207e-003
3.971064e-003
4.476557e-003
4.434512e-003
4.972667e-003
4.636224e-003
5.055876e-003
.
.
.
.
.
.
```

1. Create and save the *Source* spectral values on the SD card. Make sure this file does not have the same name as another file on the same card with a **.txt** extension.
2. Insert the SD card in the *Target* instrument.

3. Make sure **Custom Spectral Correction** is *Disabled* and that **One Time Calibration** is *Enabled*.
4. Enter the name of the file from Step 1 by touching the Spectral File field to bring up the Spectral File Dialog.



11. Measure the sample with the *Target* instrument.
12. The **Custom Spectral Calibration** is complete.
13. To use these new factors for subsequent measurements, make sure that *Custom Spectral Correction* is ***Enabled*** and that *One Time Calibration* is ***Disabled***.
14. To restore the Target instrument so that it uses only the factory calibration factors, make sure *Custom Spectral Correction* is set to ***Disabled***.

CIE Pass / Fail (Optional)

The **CIE Pass / Fail** option provides a convenient means of using the PR-655 or PR-670 as a "GO / NO GO" CIE colorimeter. Using CIE Pass / Fail, you can create an acceptance region of various shapes and sizes. After a measurement, chromaticity points that fall with the defined region cause the message "**Pass**" to be displayed on screen, and if the measured point is outside the region, "**Fail**" is displayed.

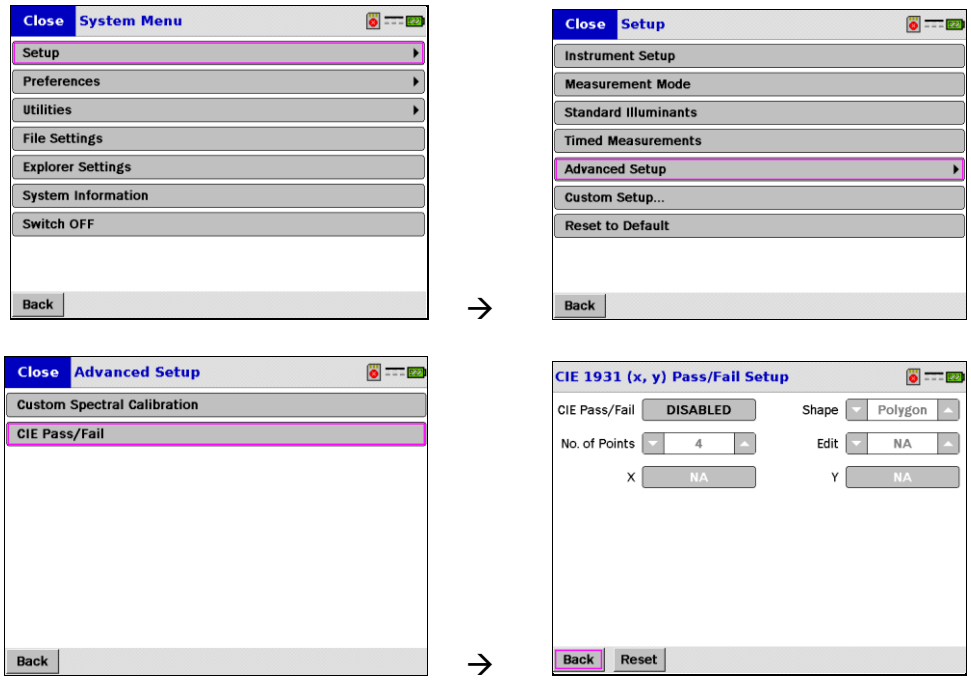
Regions are plotted in the CIE 1931 Chromaticity Diagram x, y coordinates. It is recommended that the user have this diagram handy as a visual aid when plotting regions.

Regions can be defined as Ellipses (or circles), Rectangles (or squares) or polygons (3 - 10 sides).

Using CIE Pass / Fail

Accessing the Pass / Fail Menu:

1. From the main menu, touch **Setup → Advanced Setup → CIE Pass / Fail.**



Defining Pass / Fail Regions

Rectangles (or Squares)

To define a Rectangle or square, two sets of values are entered. The first set is the CIE 1931 x, y coordinate of the upper left hand corner referred to in the Pass / Fail menu as the rectangles are oriented so that the sides are parallel to boundaries (axes) of the CIE diagram.

1. Touch the field adjacent to **CIE Pass / Fail** so that it reads **Enabled.**
2. Touch the ▼▲ icons in the **Shape** field until **Rectangle** appears.
3. Define the Upper Left Corner by:
    a. Touching the ▼▲ icons in the **Edit** field until **Corner** appears.
    b. Touch the gray field next to **Left** to display the data entry field for the **Upper Left CIE 1931 x** coordinate.
    c. Enter the value (including the decimal point) then touch **Back.** This value is the **absolute position** of the x coordinate in the CIE 1931 diagram.
    d. Touch the gray field next to **Top** to display the data entry field for the **Upper Left CIE 1931 y** coordinate.
    e. Enter the value (including the decimal point) then touch **Back.** This value is the **absolute position** of the y coordinate in the CIE 1931 diagram.
4. Define the **Size** by:
    a. Touching the ▼▲ icons in the **Edit** field until **Size** appears.
    b. Touch the gray field next to **Width** to display the data entry field for the **Lower Right CIE 1931 x** coordinate.

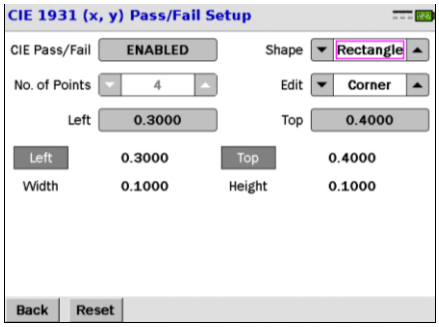
c. Enter the value (including the decimal point) then touch **Back.** This value is the **distance** from the Top Left x coordinate in Step 3c.

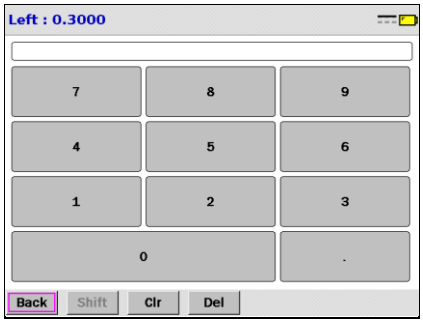
d. Touch the gray field next to **Top** to display the data entry field for the **Lower Right CIE 1931 y** coordinate.

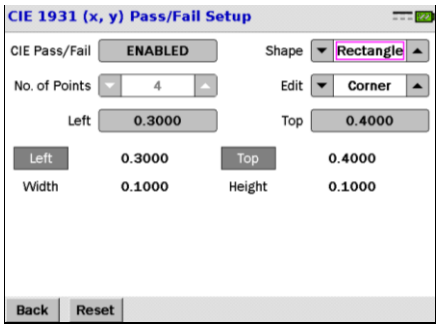
e. Enter the value (including the decimal point) then touch **Back.** This value is the **distance** from the Top Left y coordinate in Step 3e.

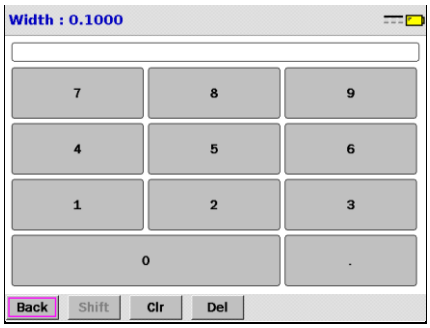
Note: To define a square, the Width and Height values must be identical. For a horizontal rectangle, the Width value must be larger than the Height value, and for a Vertical rectangle, the Height value must be larger than the Width value.

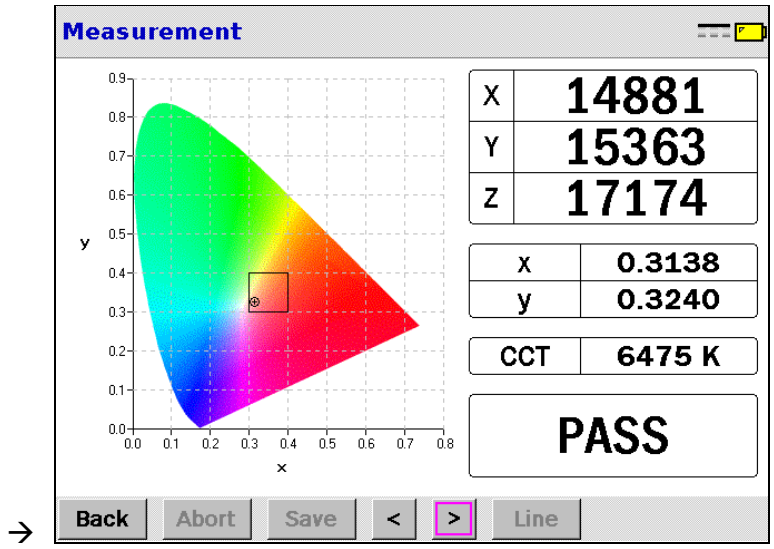
5. Following the measurement, touch the **< >** icons at the bottom of the result screen to scroll to the CIE diagram screen. **Pass** or **Fail** appears in the lower right hand corner of the screen.











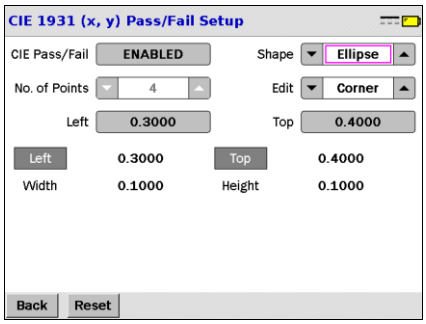
ELLIPSES (OR CIRCLES)

The process for defining an ellipse or square is very similar to defining a rectangle or square. Essentially, a box or rectangle is defined, and the PR-655 / PR-670 creates an ellipse or circle inside the box.

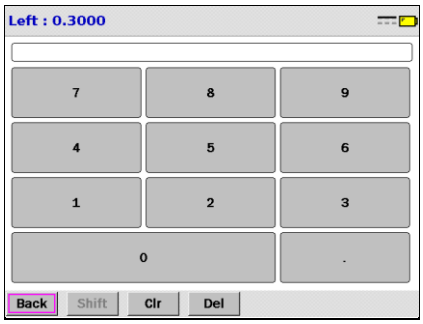
Note: To define a circle, the Width and Height values must be identical. For a horizontal ellipse, the Width value must be larger than the Height value, and for a Vertical ellipse, the Height value must be larger than the Width value.

1. Touch the field adjacent to **CIE Pass / Fail** so that it reads **Enabled.**
2. Touch the ▼▲ icons in the **Shape** field until **Ellipse** appears.
3. Define the Upper Left Corner by:
    a. Touching the ▼▲ icons in the **Edit** field until **Corner** appears.
    b. Touch the gray field next to **Left** to display the data entry field for the **Upper Left CIE 1931 x** coordinate.
    c. Enter the value (including the decimal point) then touch **Back.** This value is the **absolute position** of the x coordinate in the CIE 1931 diagram.
    d. Touch the gray field next to **Top** to display the data entry field for the **Upper Left CIE 1931 y** coordinate.
    e. Enter the value (including the decimal point) then touch **Back.** This value is the **absolute position** of the y coordinate in the CIE 1931 diagram.
4. Define the **Size** by:
    a. Touching the ▼▲ icons in the **Edit** field until **Size** appears.
    b. Touch the gray field next to **Width** to display the data entry field for the **Lower Right CIE 1931 x** coordinate.
    c. Enter the value (including the decimal point) then touch **Back.** This value is the **distance** from the Top Left x coordinate in Step 3c.
    d. Touch the gray field next to **Top** to display the data entry field for the **Lower Right CIE 1931 y** coordinate.

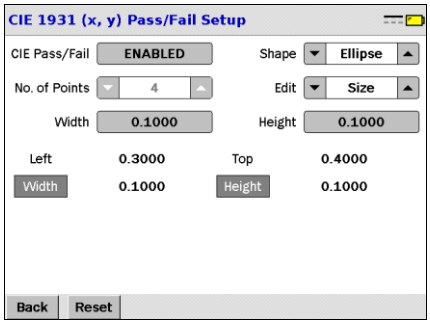
e. Enter the value (including the decimal point) then touch **Back.** This value is the **distance** from the Top Left y coordinate in Step 3e.



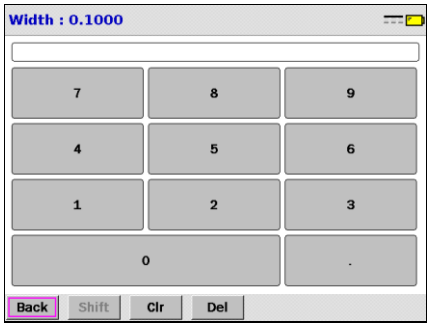
→



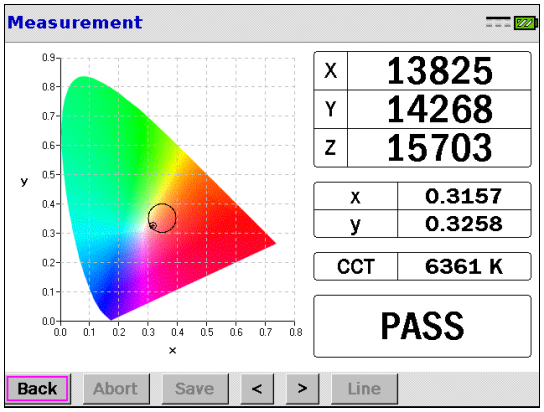
→



→



→



→ Following the measurement, touch the **< >** icons at the bottom of the result screen to scroll to the CIE diagram screen. **Pass** or **Fail** appears in the lower right hand corner of the screen.

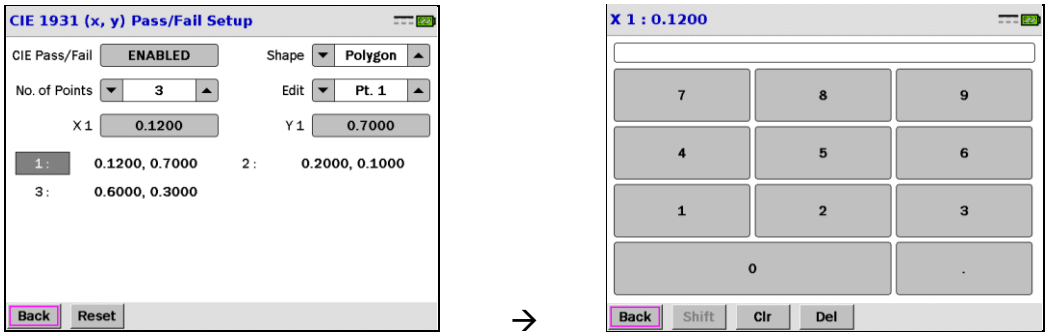
POLYGONS

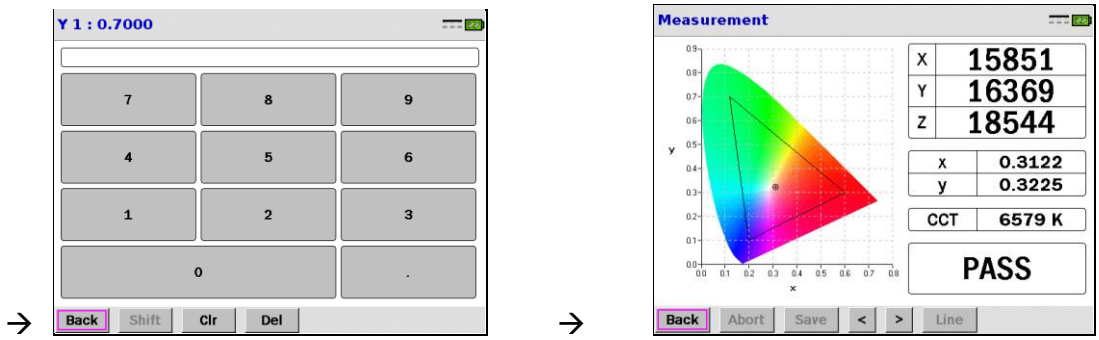
A polygon is generally described as a shape with three or more straight lined sides. The Pass / Fail option provides a method of creating polygonal acceptance regions with up to 10 sides. This can be a useful tool to, for example, define a color gamut and determine whether the sample falls within that gamut.

1. Touch the field adjacent to **CIE Pass / Fail** so that it reads **Enabled.**

2. Touch the ▼▲ icons in the **Shape** field until **Polygon** appears.
3. Select the number of points to define by touching the ▼▲ icons adjacent to the **No. of Points** field. The Range is 3 to 10 points.
4. Touch the ▼▲ icons next to the **Edit** field until **Pt. 1** (Point 1) appears.
5. Touch the gray field next to **X1** to access the data entry screen. Enter the CIE 1931 x value for Point 1 (including the decimal point) and then touch **Back**.
6. Touch the gray field next to **Y1** to access the data entry screen. Enter the CIE 1931 y value for Point 1 (including the decimal point) and then touch **Back**.
7. Repeat **Steps 4 – 6** for all remaining points.

Note: The PR-655 / PR-670 automatically connects the first point (Point 1) to the last point (Point 3 in the example),





8. Following the measurement, touch the **< >** icons at the bottom of the result screen to scroll to the CIE diagram screen. **Pass** or **Fail** appears in the lower right hand corner of the screen.

THEORY OF OPERATION

The PR-655 and PR-670 are true Spectroradiometer. They collect the optical radiation (light) through the objective lens or other optical accessory. The signal then passes through the aperture (hole) in the aperture mirror to the diffraction grating (see Figure 48). The grating breaks up the light into its component wavelengths much like a prism turns white light into a rainbow. A broad band light such as sunlight is composed of a large number of different wavelengths of light. When the diffraction grating is exposed to this type of light, it will refract the light at several angles thus creating a dispersed spectrum much like a rainbow. Similarly, if the grating is exposed to a source such as a laser which emits a nearly monochromatic wavelength of light, only the wavelength(s) of the laser will be refracted.

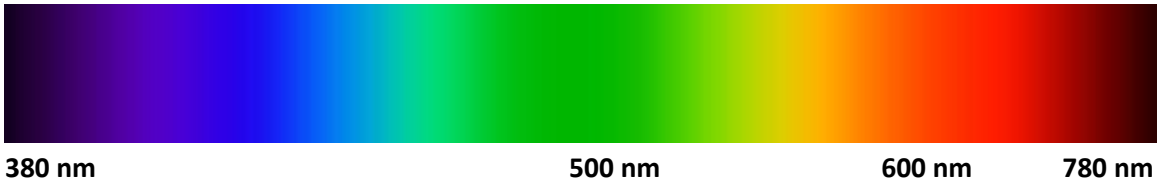


FIGURE 46 – SPECTRUM MEASURED BY THE PR-655 AND PR-670

For the PR-655 and PR-670, the measurement wavelength range is 380 nanometers (nm) (violet) to 780 nm (deep red) – the visible spectrum of the electromagnetic spectrum (see Figure 46).

The diffracted spectrum is then dispersed onto the detector. For the PR-655, the detector is comprised of 128 individual elements. The PR-670 detector utilizes 256 elements. Each of the detector elements in both instruments samples a unique color.

During a measurement, the optical radiation (light) is sampled for a period of time determined by the Adaptive Sensitivity™ algorithm. Adaptive Sensitivity automatically determines the correct integration (exposure) time based on the available signal. Following the light measurement, a measurement of the dark current of the detector is made for the same length of time that was used for the light measurement. The dark measurement is then subtracted from the light measurement yielding the contribution of light for each detector element.

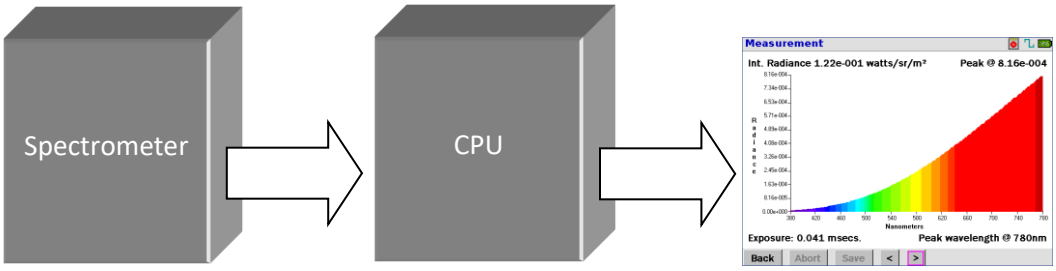


FIGURE 47 - PR-655 / PR-670 SIMPLIFIED BLOCK DIAGRAM

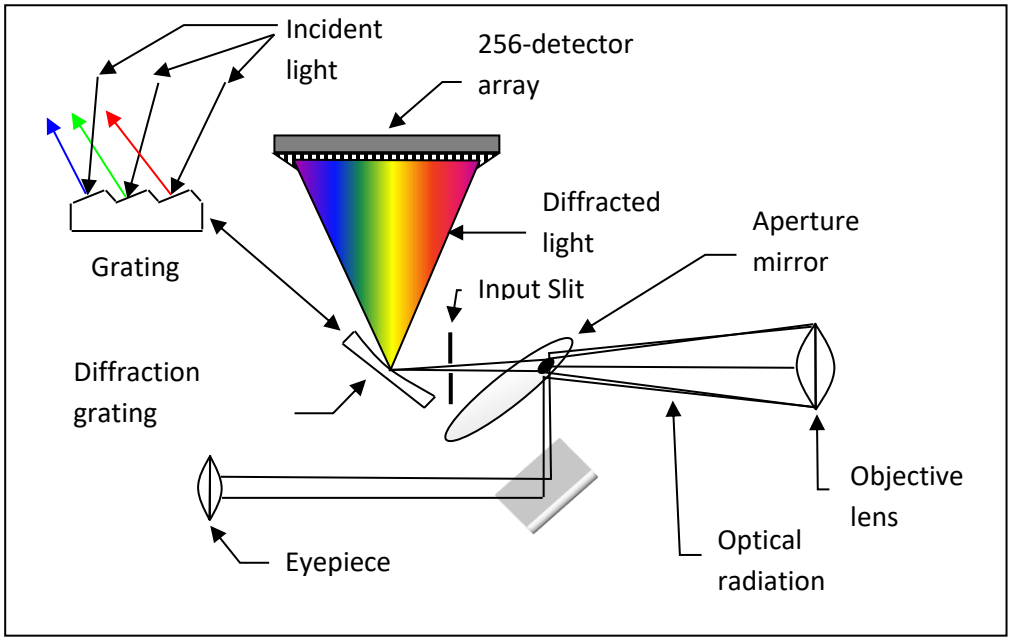


FIGURE 48 – PR-655 / PR-670 SPECTROMETER

The uncorrected or 'raw' spectrum is corrected using factors established during the factory calibration of the instrument. These factors include wavelength accuracy correction, spectral distribution correction and photometric correction. The wavelength calibration is performed using a helium spectral line source. The line source provides known spectral emission lines that the software uses to map the dispersion of the grating to the multi-element detector. The helium lines used during the wavelength calibration are 388.6 nm, 447.1 nm, 471.3 nm, 587.6 nm, 667.8 nm, 706.5 nm and 728.13 nm.

Next, the data is corrected by spectral factors. These factors insure that the spectral power distribution (SPD) of the target is and calculated values such as CIE Chromaticity are accurately reported. Lastly, a scaling factor (photometric factor) is applied ensuring the proper photometric levels such as luminance or illuminance are displayed.

Calculations

The corrected spectral data is then used to calculate photometric and colorimetric values including luminance, CIE 1931 x, y and 1976 u', v' chromaticity coordinates, correlated color temperature and dominant. Following are some of the basic calculations used to generate photometric and colorimetric parameters:

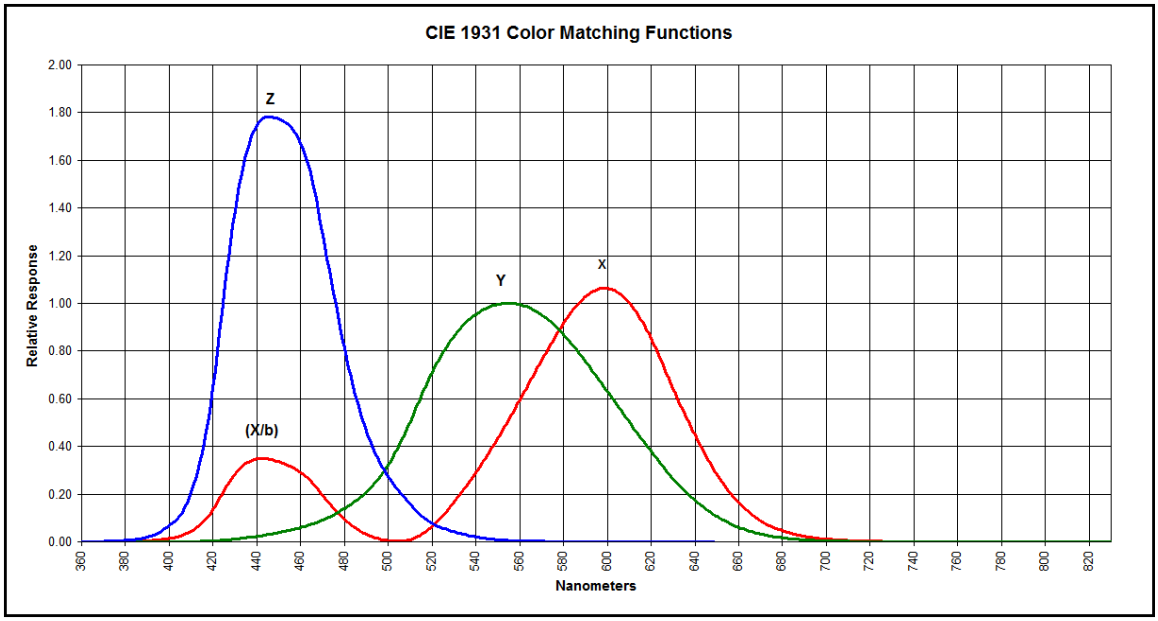


FIGURE 49 - CIE 1931 TRISTIMULUS FUNCTIONS

CIE XYZ Tristimulus and Photometric Values

$$X = 683\int_{380}^{780} S(\lambda)\bar{x}(\lambda)\Delta(\lambda)$$

Where X, Y, and Z are the three CIE Tristimulus values. X represents the red component, Y is the green component and Z is the blue component.

$$Y = 683\int_{380}^{780} S(\lambda)\bar{y}(\lambda)\Delta(\lambda)$$

Y also serves as the photometric value – when using the standard MS-75 lens, Y gives candelas / meter² - the SI unit for luminance. To find footlamberts (English unit of luminance), multiply cd/m² by 0.2919.

683 is a constant used to convert lumens to watts. There are 683 lumens per watt at 555 nm for photopic (daylight) vision.

$$Z = 683\int_{380}^{780} S(\lambda)\bar{z}(\lambda)\Delta(\lambda)$$

S(λ) = the corrected spectral data, $\bar{x}(\lambda), \bar{y}(\lambda), \bar{z}(\lambda)$ are the three CIE Tristimulus functions (curves) and Δ(λ) is the data increment – for the PR-655 the increment is 4(nm) and 2 (nm) for the PR-670.

Once the three Tristimulus values have been derived, useful colorimetric values such as CIE 1931 x, y and 1976 u', v' can be calculated by the following formulae:

CIE 1931 x, y

$$x = \frac{X}{X + Y + Z}$$

$$y = \frac{Y}{X + Y + Z}$$

CIE 1976 u', v'

$$u' = 4X / (X + 15Y + 3Z)$$

$$v' = 9Y / (X + 15Y + 3Z)$$

MEASUREMENTS

MEASUREMENT MODES

Four **Measurement Modes** are available to the user: **Standard**, **L*u*v***, **L*a*b*** and **RGB Display Cal**

STANDARD MODE

In Standard Mode the PR-655 / PR-670 performs a measurement then calculates standard photometric and colorimetric values.

L*U*V* / L*A*B* MODES

L*u*v* and L*a*b* measurements use photometric and colorimetric values for CIE L*u*v* or L*a*b* three dimensional color difference calculations.

L*u*v* tests are usually made of self-luminous samples such as LCD's, PDP's, EL, OLED and CRT displays. Therefore, they are best made in a dark environment, free of ambient lighting that might influence the results.

L*a*b* tests on the other hand are typically performed of reflective or transmissive materials such as paint or optical filters where it is necessary to provide an external light in order to measure the object. Therefore *Illuminated* samples must be selected in the L*u*v* or L*a*b* mode. Following the measurement, the light used to illuminate the object is mathematically removed from the measurement. The resultant spectra are then weighted by the white reference (e.g. CIE D-65) as if the sample were being illuminated by the white stimulus. Finally, before color coordinates and eventually L*a*b* are calculated are calculated on the modified spectrum.

Color coordinates of a white reference are used during the calculation of both L*u*v* and L*a*b*. White references stored in the PR-655 / PR-670 include D65 (daylight at 6500 Kelvins), Illuminant A (Black body radiator at 2856 Kelvins), Illuminant B (daylight at 4875 Kelvins), Illuminant C (daylight at 6772 Kelvins), Illuminant D50 (daylight at 5000 Kelvins), Illuminant D55 (daylight @ 5500 Kelvins) and Illuminant D75 (daylight at 7500 Kelvins).

Following the measurement(s), L*u*v* and L*a*b* values are calculated as follows:

$$L^* = 116\left(Y / Y_O\right)^{1/3} - 16$$
$$u^* = 113L^*\left(u' - u'_O\right)$$
$$v^* = 13L^*\left(v' - v'_O\right)$$

EQUATION 1 - L*U*V*

$$L^* = 116\left(Y / Y_O\right)^{1/3} - 16$$
$$a^* = 500\left[\left(X / X_O\right)^{1/3} - \left(Y / Y_O\right)^{1/3}\right]$$
$$b^* = 200\left[\left(Y / Y_O\right)^{1/3} - \left(Z / Z_O\right)^{1/3}\right]$$

EQUATION 2 - L*A*B*

Where X, Y, Z are the measured Tristimulus values, X_O,Y_O and Z_O are the Tristimulus values of the white illuminant, u'$_O$ and v'$_O$ are the CIE 1976 u'v' values of the white illuminant.

How to Make L*u*v* or L*a*b* Measurements

1. Touch the ▼ or ▲ icons in the **Measurement Mode** field to select **L*u*v*** or **L*a*b***.
2. To make **L*u*v*** or **L*a*b*** measurements, it is necessary to first select a white reference (**Illuminant**). Touch **Select** at the **bottom** of the Illuminant column. A screen similar to the following appears:

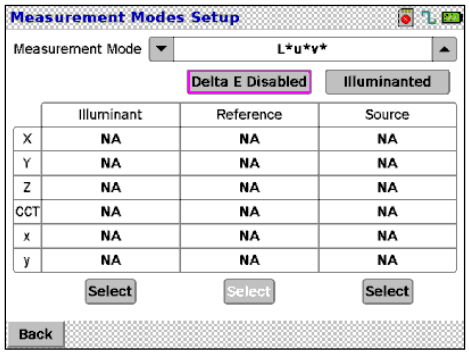


FIGURE 50 - L*U*V* SETUP SCREEN

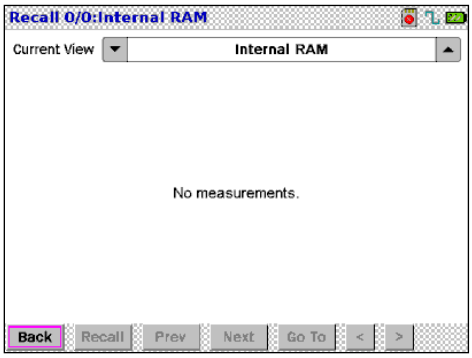


FIGURE 51 - FILE RECALL SCREEN

To access factory stored illuminants, touch the ▼ or ▲ icons in the current view field until standard illuminants appears. An illuminant may also be a previously measured and stored file – for example a florescent lamp. If it is desirable to use a previous measurement then select internal ram or external SD card (if an SD card is inserted).

OR

Press the **MEASURE** button then touch **Back** then **Recall** to accept the measured data.

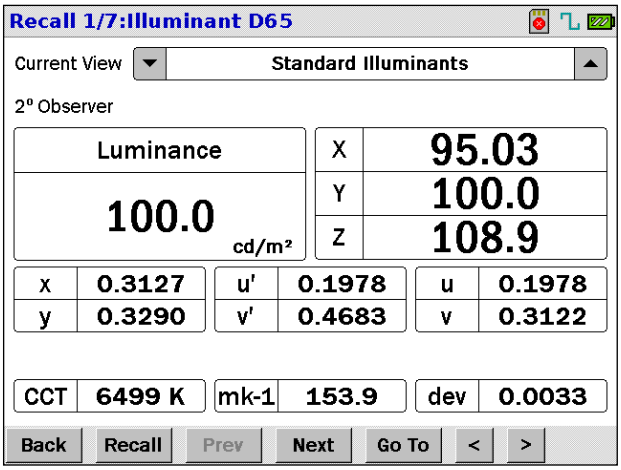


FIGURE 52 - STANDARD ILLUMINANTS SCREEN

3. If using a pre-stored illuminant, at the top of the screen that pops up, the title of the *Illuminant appears.* Touch **Next** (or **Previous**) to scroll through available choices.
4. Touch **Back.**
5. Touch **Recall** to select the illuminant of choice. The *Standard Illuminant* screen updates to show the data of the illuminant selected.

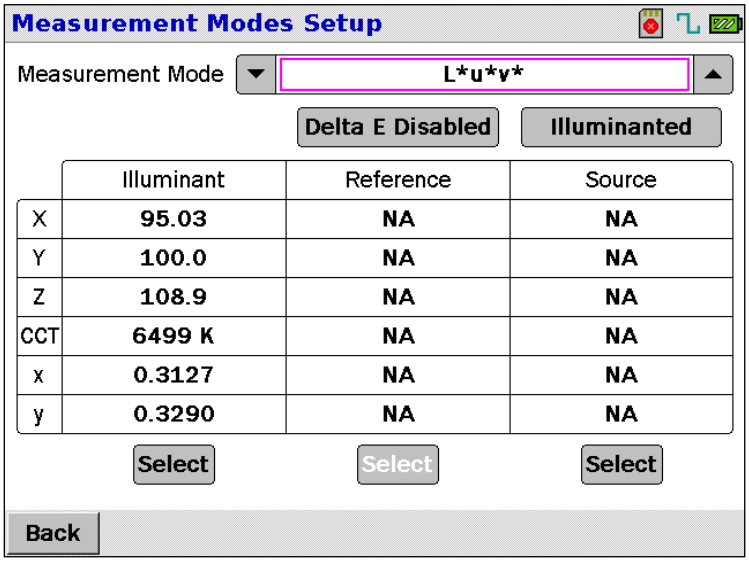


FIGURE 53 - L*U*V* SETUP SCREEN

Touch **Delta E Disabled** to *enable* color difference measurements if desired. If **Delta E** is enabled, **Select** under the *Reference* column becomes activated. The Reference is the "Golden Sample" against which all subsequent samples are compared for color difference calculations. Delta E (CIE ΔE*ab or ΔE*uv) calculates color difference in the respective color systems using the following equations:

$$\Delta E*ab = \sqrt{(\Delta L*)^2 + (\Delta a*)^2 + (\Delta b*)^2}$$

EQUATION 3 - ΔE*ab

$$\Delta E*uv = \sqrt{(\Delta L*)^2 + (\Delta u*)^2 + (\Delta v*)^2}$$

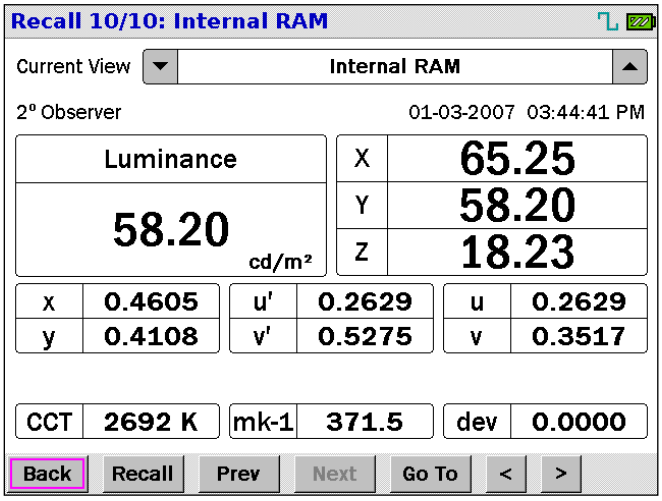
EQUATION 4 - ΔE*uv

6. To make a *Reference* or *Source* measurement:

   In most cases, a *Source* or *Reference* measurement is a *Luminance* measurement. Therefore, the instrument should be set up to perform this type of measurement.

   In the case of a *Source* measurement, a diffuse reflectance standard, such as the Photo Research RS-3 or SRS-3, is placed in the exact location of the measurement area of the device under test – for example the face of a display. For making measurements of test samples, the reflectance standard is replaced by the device under test without disturbing or changing the position of the measurement instrument (PR-655 or PR-670) or the light source.

   a. Touch **Select** under the *Reference* or *Source* column. The following screen appears:



b. Make sure **Internal RAM** is selected in the **Current View** field.

c. Press the **MEASURE button** on the top of the instrument.

d. At the completion of the measurement, touch **Back.**

e. To use this measurement, touch **Recall**. To use a previously stored measurement, touch **Prev** or **Next** until the measurement of choice appears then touch **Recall.**

7. Once the *Illuminant* and *Source* and optional *Reference* have been selected and or measured, the PR-655 / PR-670 is ready to perform L*u*v*, L*a*b* and optional Delta E measurements. To perform these measurements:

a. Press the **MEASURE button** on the top of the instrument. A result screen similar to the following appears:

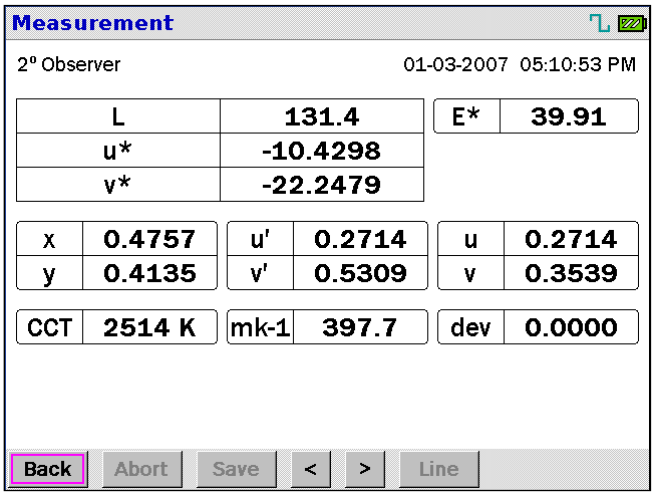


FIGURE 54 - L*U*V* RESULT SCREEN

In this example, **Delta E** has been selected in the *Measurement Mode* setup screen. The displayed values of *x, y, u', v', u, v, CCT, mk-1,* and *dev* are the measured values of the sample.

RGB Display Cal (Standard on PR-670, Optional on PR-655)

The **PR-650** **RGB** measurement mode is designed to provide the user with a convenient, spectrally based interactive method of performing white point calibrations of CRT's, LCD's PDP's and digital projectors or any other display technology that features adjustable RGB channels.

During use, the user is presented with a bar graph and numerical levels indicating the deviation amplitude and direction of the three **RGB** primaries from the target settings. Once the RGB levels of the display are adjusted to the target values set by the **RGB** algorithm, the white point is properly adjusted.

Since the **PR-655** and **PR-670** are spectrally based systems, color matching can be achieved without having a "golden sample" available as a reference. White point calibrations can be based on user entered target values including luminance and CIE chromaticity coordinates (CIE 1931 x, y values). The user can also select pre-stored phosphor sets (NTSC, EBU, CIE, HDTV and SMPTE) or create user phosphor values through measurement or data entry.

Setting up RGB Measurements

Prior to making **RGB** measurements, the proper parameters must be entered into the **RGB** setup menu to insure correct results.

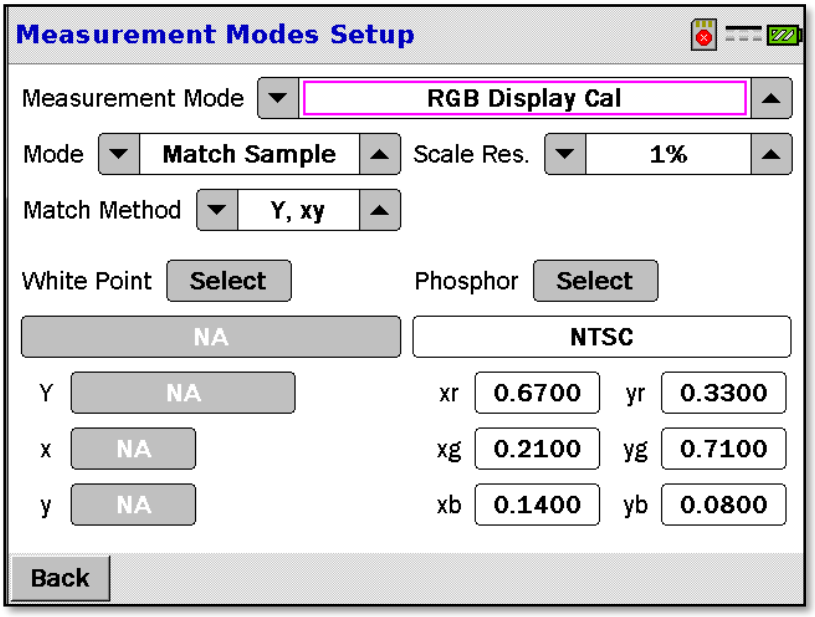


FIGURE 55 - RGB DISPLAY CAL SETUP SCREEN

DISPLAY OPTION

Two options are available in this field: **Match Sample and Match Data.**

In **Match Sample** mode, white point calibrations are based on a measured reference value.

Match Data mode allows the user to enter target values in terms of luminance (Y) and CIE 1931 x, y values.

Whichever method is chosen, all **RGB** measurements require that a phosphor (either stored or custom) be selected and that a reference white point is set.

SELECTING A PHOSPHOR

Proper white point calibration is dependent on the color characteristics of the display primaries. Phosphor is used as a historical reference to CRT's. The data for several types of phosphors are pre-stored in the PR-655 / PR-670. They are CIE, NTSC, EBU (PAL / SECAM), SMPTE and HDTV. The user may also enter display primary chromaticity values, or used measured values.

1. To select a phosphor set touch **Select** located to the right of the **yb** window. The following screen appears:

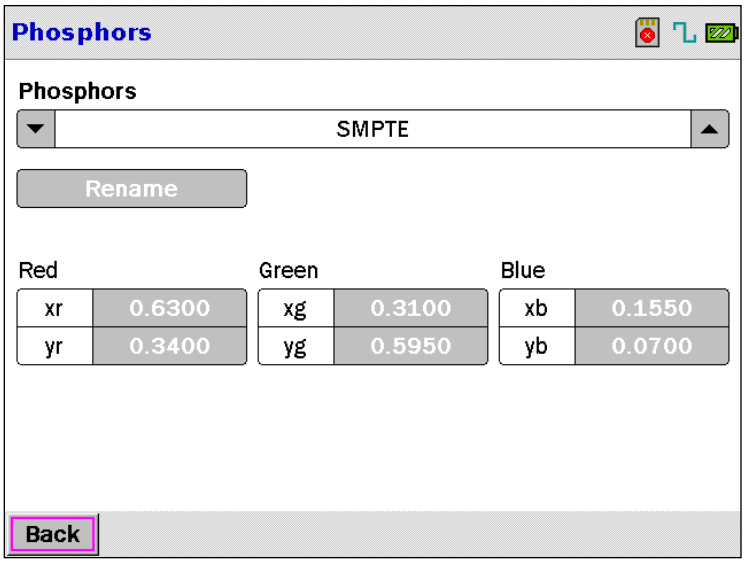
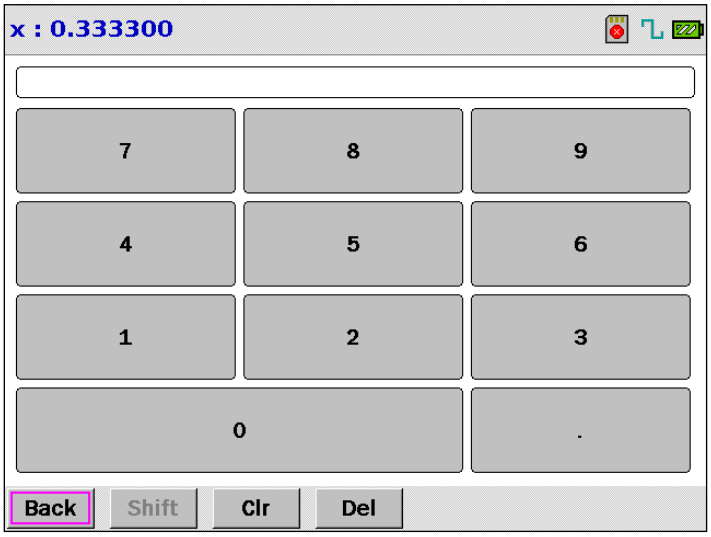


FIGURE 56 - RGB PHOSPHOR SELECT SCREEN

1. Touch the ▲▼ icons in the **Phosphors** field to select pre-stored values or **Custom.** If **Custom** is selected, the user may enter the values in the **Red, Green** and **Blue** fields by touching the field located to the right of the field title. For example, touch the field next to **xr** to display a data entry window as in the following example:



2. Touch the desired values, then touch **Back** when finished.
3. Repeat for both chromaticity (x, y) values for each primary. If the values are not known, they may first be measured by turning on only one primary at a time (3 measurements total) and noting the resultant CIE x, y values for entry into these fields.

Setting the White Point

The White Point (White Pt.) is the background or ambient illumination under which the display is viewed and has an effect on the perceived color of the display. Several pre-stored CIE recommended illuminants and daylight simulators can be selected. They include CIE Illuminants D65, A, B, C, D-50 and D-55.

Alternately, ambient sources (room lighting for example) may be measured and used as the White Pt. values.

1. Touch **Select** next to the **yw** window. The following screen appears:

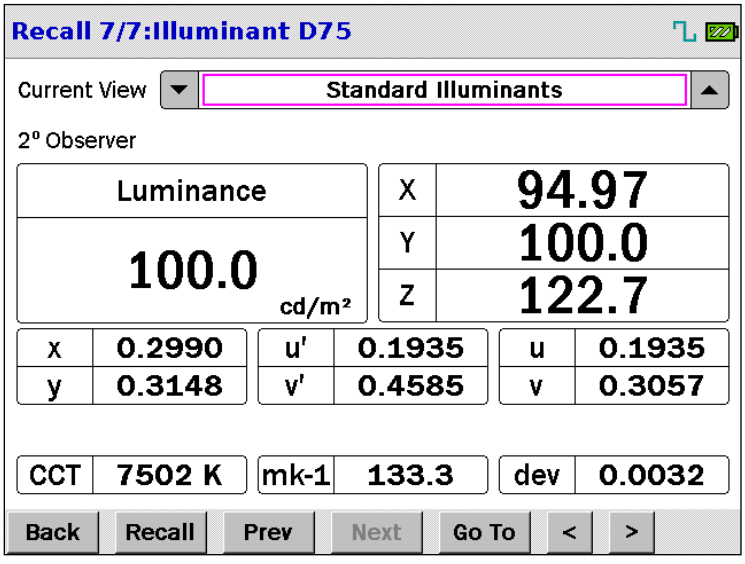


FIGURE 57 - SELECT RGB ILLUMINANT SCREEN

2. Touch the ▲▼ icons adjacent to **Current View** to scroll through available selections. Select **Standard Illuminants**, then touch **Prev** or **Next** to scroll through available choices. The title of the currently displayed data set appears at the top of the screen – in this example, CIE Illuminant D75.
   OR
   Touch the ▲▼ icons adjacent to **Current View** to scroll through available selections. Select **Internal RAM** or **External SD Card**, then touch **Prev** or **Next** to scroll through selections. The title of the currently displayed data set appears at the top of the screen – in this example CIE Illuminant D75.

   OR
   Press the **MEASURE** button to make a measurement of the illuminant.
3. Touch **Recall** to accept the selection.
4. When finished, touch **Back.**

LEARN PROCEDURE

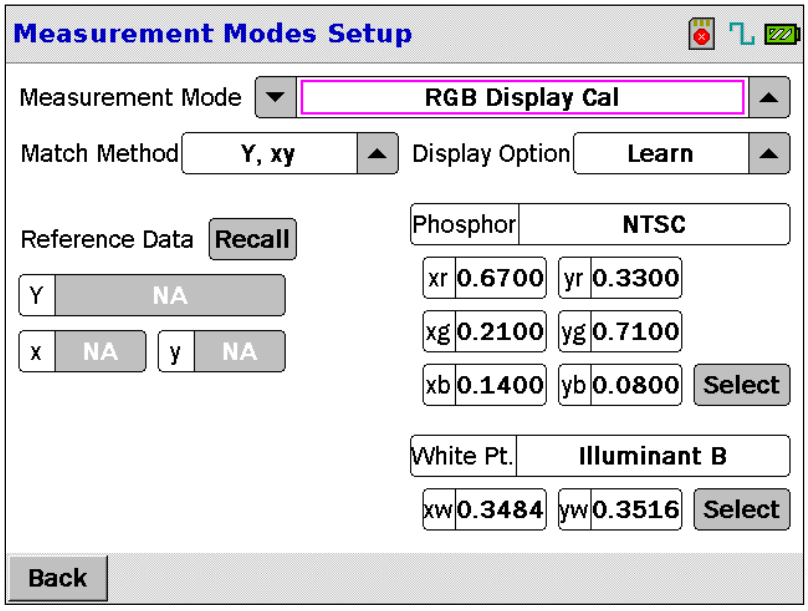


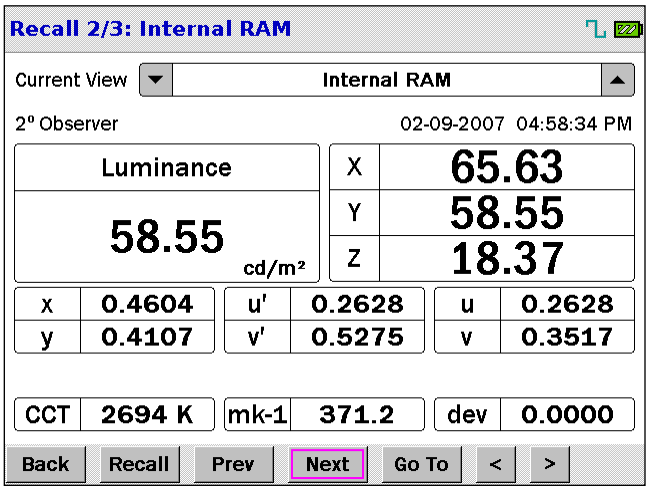
FIGURE 58 - RGB DISPLAY CAL SETUP SCREEN

1. Touch the ▲ ▼ icons adjacent to the **Display Option** field to select **Learn.**
2. Touch **Recall** located next to **Reference Data**. The Measurement screen appears.
3. Set up the display to be measured, then press the **MEASURE** button.
4. Touch **Back.**

5. Touch **Recall** to accept the measured data.

OR

If measurements are stored in RAM or on an SD card, they can be accessed and recalled.



In the preceding example, measurement number 2 of 3 is displayed.

Y x,y (or x,y) Data Entry Procedure

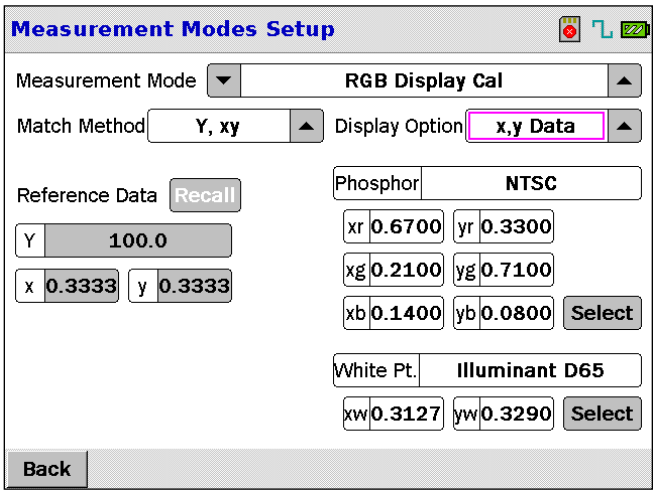


FIGURE 59 - Y XY DATA ENTRY SCREEN

Since the PR-655 / PR-670 measures the spectral content of the sample, it is possible for the instrument to calibrate the display white point based on user entered values for luminance and CIE chromaticity. The user can select to enter **Y x,y** (luminance and CIE 1931 X, y values) or **x,y.** If **Y x,y** is selected, after calibration of the display, the luminance is properly adjusted to the entered value for **Y**. If **x,y** is chosen, the absolute luminance value is ignored and the display is calibrated to chromaticity values only.

Y x,y Procedure

1. Touch the ▲▼icons adjacent to **Match Method** to display either **Y x,y** or **x,y.**
2. Enter the desired values for **Y, x** and **y** in the fields directly below **Reference Data** by touching any of the fields. This action brings up a data entry screen like the following example for **Y**:

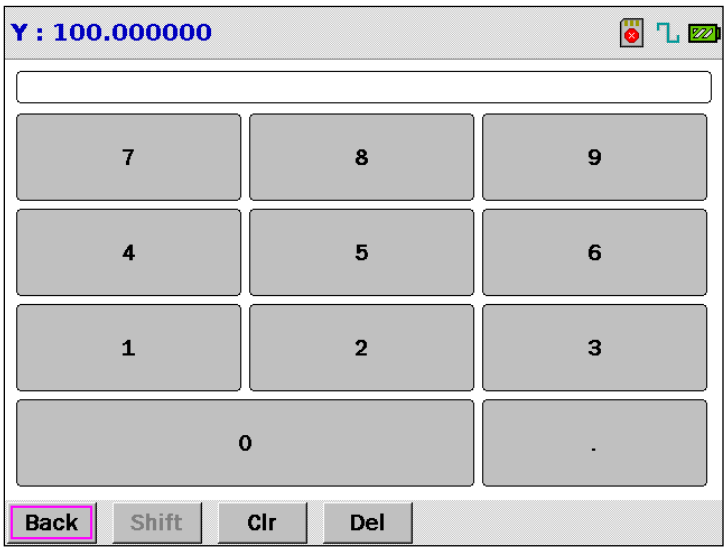


FIGURE 60 - RGB DATA ENTRY

Note: If *xy* is selected, data entry for *Y* is unavailable.

3. Enter the value for **Y,** and then touch **Back.**
4. Repeat for **x** and **y.**

MAKING AN RGB MEASUREMENT

When all parameters have been successfully set, white point calibration can commence.

1. Press the **MEASURE** button to begin the RGB measurement sequence. A screen similar to the following appears:

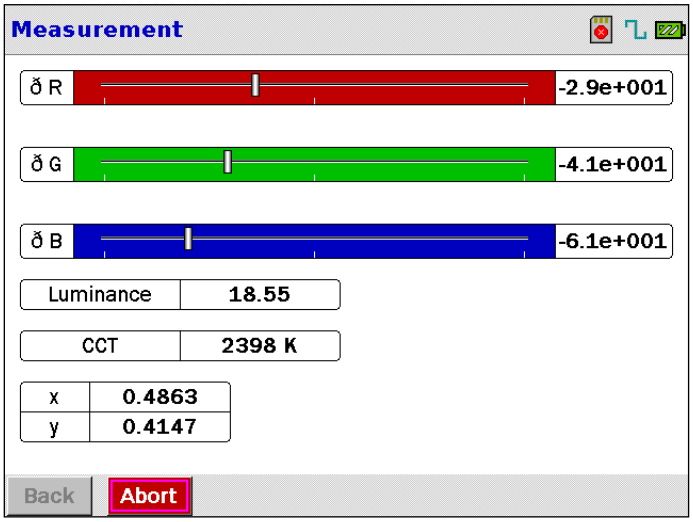


FIGURE 61 - RGB MEASUREMENT SCREEN

2. The instrument will make continuous measurements until the **Abort** key is touched. Adjust the primaries of the display until the vertical indicator bars for **R**, **G** and **B** are all at the center of the respective colored bars and the % deviation (values to the right of the bars) reads 0.00.

   Note that updated *Luminance, CCT* and *chromaticity* values are continuously displayed during the calibration sequence.

3. Touch **Abort to** stop the measurement.

4. Touch **Back** to exit this screen and return to the Measurement Setup Screen at the completion of the calibration.

STANDARD ILLUMINANTS

A Standard Illuminant is a spectral file of a white or near white stimulus that is used for L*a*b*, L*v*v* and RGB. These illuminants were obtained from the CIE (Commission Internationale d'Eclairge) and included Illuminant A (blackbody radiator at 2856 Kelvins), Illuminant B (Daylight simulator at 4850 Kelvins), Illuminant C (Daylight Simulator at 6772 Kelvins), Illuminant D50 (Daylight Simulator at 5,000 Kelvins), Illuminant D55 (Daylight Simulator at 5,500 Kelvins, Illuminant D65 (Daylight Simulator at 6,500 Kelvins), and Illuminant D75 (Daylight Simulator at 7,500 Kelvins).

This feature is informational only. No illuminants can be added or deleted using this function.

1. Touch **Menu** then **Setup** then **Standard Illuminants**. A screen similar to the following appears:

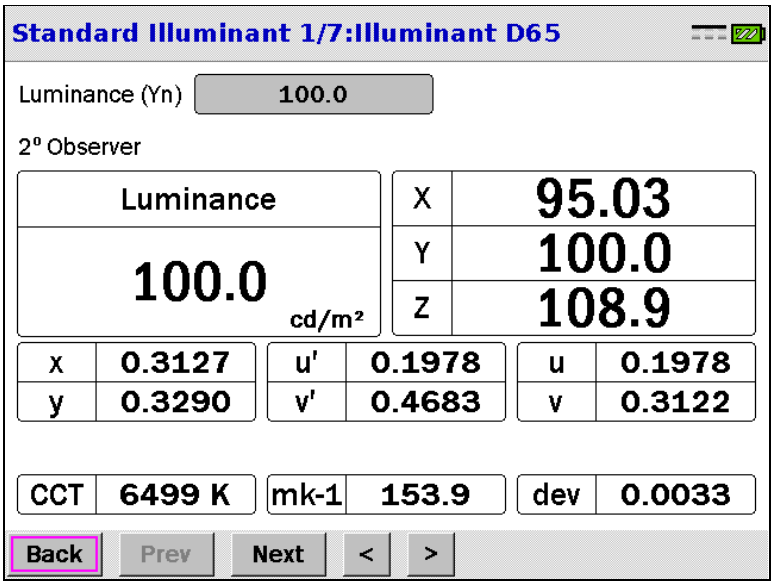


FIGURE 62 - STANDARD ILLUMINANTS SCREEN

1. Touch **Prev** or **Next** to scroll through illuminants.
2. Touch the < > icons to scroll through various data screens for the currently displayed illuminant.

MEASUREMENT TYPES

The PR-655 and PR-670 can make several types of measurements depending on the type of accessory being utilized. They include Lumens (Watts), Luminous Intensity (Radiant Intensity), Luminous Flux (Radiant Flux) Luminance (Radiance) and Illuminance (Irradiance). The most typical measurement is one of luminance in footlamberts or cd/m².

LUMINANCE / RADIANCE

Luminance is defined as luminous flux (lumens) per solid angle (steradians) per unit area being emitted in a given direction and is calculated from *Radiance (watts/steradian/meter²)*.

The SI equation for luminance is *cd/m² (lumens/steradian/meter²)*. The English equivalent is *footlamberts (1/π lumens/steradian/foot²)*. The relationship between cd/m² and footlamberts is: 1 footlambert = 3.426 cd/m². Luminance is measured whenever it is desirable to know the photometric brightness of self-emitting devices, transmissive objects or a surface upon which light is being reflected. Typical applications include display brightness, projector screen brightness etc. Ideally, the object being measured exhibits a uniform emittance pattern over the entire emitting surface.

Luminance measurements with the PR-655 and PR-670 are made with any of the objective lenses, or with the fiber probe (FP-655 / FP-670) or with the luminance adaptor (LA-655 / LA-670) only. The lenses include the MS-75, SL-0.5X, SL-1X, SL 2.5X and SL-5X.

In the following example, let's say a projector screen, the light incident on the surface is illuminance, and the light being reflected from the surface is luminance.

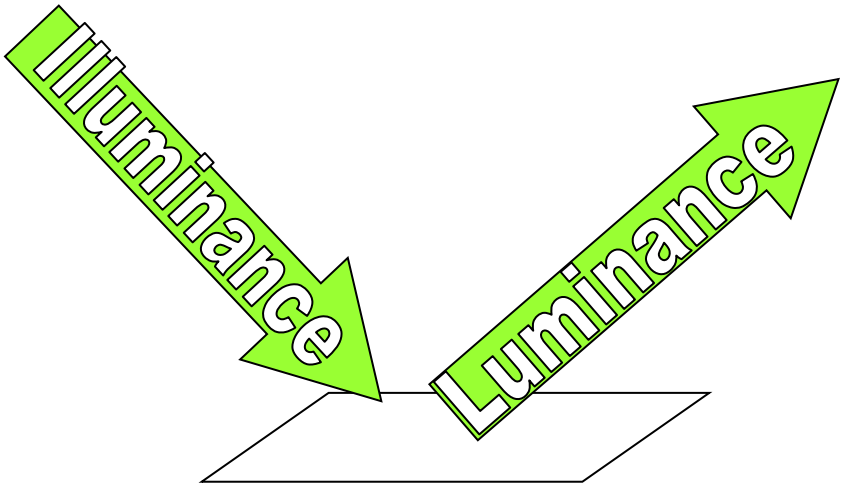


FIGURE 63 - ILLUMINANCE / LUMINANCE CONCEPT

How to Make a Luminance / Radiance Measurement

If using an objective lens, the first step is to align and focus the optical system (lens and eyepiece) on the target.

FIGURE 64 - MS-75 LENS

USING AN OBJECTIVE LENSES

Aligning and focusing the Optical System (Both PR-655 and PR-670)

1. If using the MS-75, make sure the target is out of focus by defocusing the lens. If using a fixed focus lens, such as the MS-2.5X, move either the target or instrument until the target is out of focus.
2. Turn the diopter adjustment on the eyepiece until the measuring aperture (black spot in the center of the field of view) is in sharp focus. If the entire aperture does not focus simultaneously, make sure the **top** and **bottom** of the aperture are in focus.
3. Focus on the target. If using the MS-75 lens, rotate the lens focusing ring until the target is in focus. If using a fixed focus lens, move either the instrument or the target until sharp focus is achieved. **Do not use the eyepiece diopter adjustment to focus on the target.**

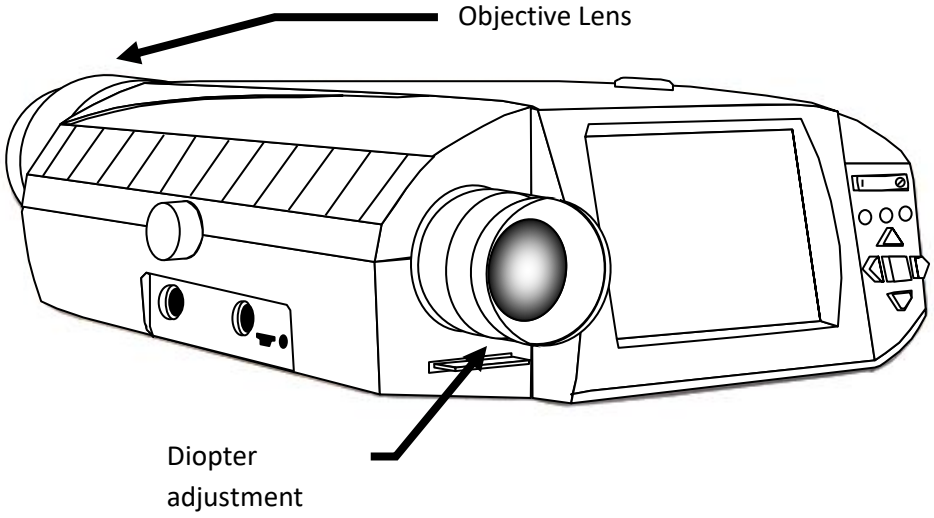


FIGURE 65 - PR-655 / PR-670 FOCUSING

4. Make sure the measuring aperture falls within the lit area of the target. Failure to adhere to this step will result in erroneous readings. If possible, or unless otherwise specified, we recommend that the diameter of the aperture cover 50% to 80% of the smallest dimension of the object (e.g. character '1' in Figure 66).

Correct **Incorrect**

FIGURE 66 - APERTURE ALIGNMENT

5. From the **Instrument Setup** menu, touch the ▲ ▼ icons adjacent to *Primary Accessory* until the installed lens appears.
6. Make any other changes in the *Setup* menu such as *Sensitivity, Speed, Average* etc.
7. Touch the **MEASURE button** to begin a measurement.

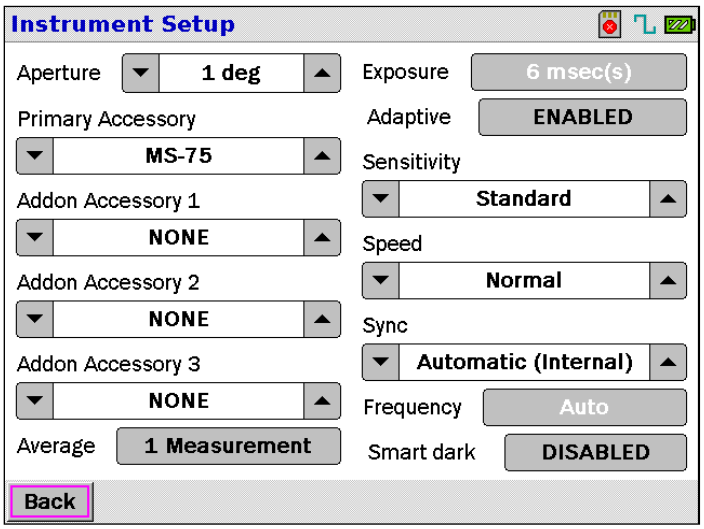


FIGURE 67 - INSTRUMENT SETUP MENU

USING THE FP-655 OR FP-670

FIGURE 68 - FP-655 / FP-670

The FP-655 (FP-670) Flexible Probe enables the PR-655 to measure surface luminance and radiance of backlit sources (e.g. cathode ray tubes, fluorescent lamps and self-luminous displays) that can be placed in contact with the tip of the Probe.

The Flexible Probe is particularly useful for measuring in nearly inaccessible locations. The probe consists of a 24-inch (0.6 meter), flexible fiber bundle and a threaded mounting adaptor. 4 foot and 10 foot versions are available – contact Photo Research for details.

It can also be used to approximate the luminance of more distant sources, averaged over a circular field. (The acceptance angle of the probe is approximately 30° at the half-power points and 50° at the 10% response points. The measuring area is 0.125 inch (3 mm) in diameter when the tip of the probe is placed in contact with a Lambertian source.

Warning: The FP-655 / FP-670 is not recommended for use when measuring LCDs as the act of coming in contact with the device may distort the surface and yield erroneous readings and may cause damage to the display.

1. Remove the MS-75 Objective lens or other accessory by turning it counter-clock-wise.
2. Install the FP-655 / FP-670 by screwing in clock-wise. **Do not over-tighten!**
3. From the **Instrument Setup** menu, touch the ▲ ▼ icons adjacent to *Primary Accessory* until **FP-655** or **FP-670** appears. Note that only the largest aperture can be used for this accessory. The instrument will automatically set the **Aperture** selection to the largest system configured aperture.
4. Make any other changes such as *Sensitivity, Speed, Average* etc.
5. Place the front surface of the probe tip in contact with the target. Make sure it is within the lit area of the device.
6. Touch the **MEASURE button** to begin a measurement.

USING THE LA-655 / LA-670 LUMINANCE ADAPTOR

FIGURE 69 - LA-655 / LA-670 LUMINANCE ADAPTOR

The Luminance Adaptor enables the PR-655 or PR-670 to measure surface luminance and radiance of backlit sources (e.g. cathode ray tubes, fluorescent lamps and self-luminous displays) that can be placed in contact with the rubber cup of the Adaptor. It can also be used to approximate the luminance of more distant sources, averaged over a circular field. (The acceptance angle of the adaptor is approximately 12.5° at the half-power points and 14° at the 10% response points. The measuring area is 0.52 inch (13.2 mm) in diameter when the cup of the accessory is placed in contact with a Lambertian source.

Warning: **The LA-655 / LA-670 is not recommended for use when measuring LCDs as the act of coming in contact with the device may distort the surface and yield erroneous readings and may cause damage to the display.**

1. Remove the MS-75 Objective lens or other accessory by turning it counter-clock-wise.
2. Install the Luminance Adaptor by screwing in clock-wise. **Do not over-tighten!**
3. From the **Instrument Setup** menu, touch the ▲ ▼ icons adjacent to *Primary Accessory* until **LA-655** or **LA-670** appears.
4. Make any other changes such as *Aperture*, *Sensitivity, Speed, Average* etc.
5. Place the front surface of the rubber cup of the Luminance Adaptor in contact with the target. Make sure it is within the lit area or the device.
6. Touch the **MEASURE button** to begin a measurement.

ILLUMINANCE / IRRADIANCE

Illuminance is defined as the density of luminous flux incident on a surface, or light falling on a surface and is calculated from *Irradiance (watts/meter²)*. Three factors help determine illuminance: the luminous flux of the source, the angle of incidence of the light falling on the plane and the distance from the source to the measured plane. Illuminance is given by *lux (lumens per meter²)* and *footcandles (lumens/foot²).* The relationship between footcandles and lux is: *1 footcandle = 10.76 lux.* In the following example, the light falling on the measured plane is the illuminance.

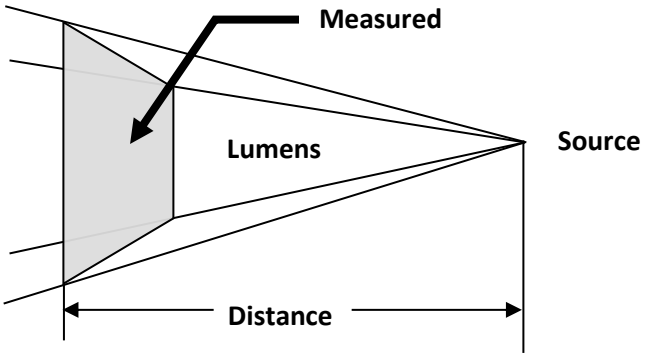


FIGURE 70 - ILLUSTRATION OF ILLUMINANCE

For the PR-655 and PR-670, the (optional) accessories used to measure illuminance are the CR-655 or CR-670, and the RS-3 or SRS-3. The CR-655 (or CR-670) is a diffuser that serves as the surface upon which the incident light falls. During calibration these accessories are photometrically calibrated using a standard lamp whose candela rating has been certified to NIST standards. By knowing the candelas of the lamp, the illuminance can be calculated by:

$$I = \frac{cd}{d^2}$$

EQUATION 5 - ILLUMINANCE FROM CANDELAS

Where: *I* = Illuminance in *lux* or *footcandles.*

d = Distance in feet (*footcandles*) or meters (*lux*).

Following a measurement, candelas can be calculated by:

$$cd = I * d^2$$

EQUATION 6 - CANDELAS FROM ILLUMINANCE

How to Make an Illuminance / Irradiance Measurement

Illuminance measurements are made one of two ways with the PR-655 and PR-670. The first method involves the use of the CR-655 or CR-670 cosine receptor. The second method utilizes the use of a reflectance standard such as the RS-3 or SRS-3.

Using the CR-655 / CR-670

FIGURE 71 - CR-655 / CR-670

1. From the **Instrument Setup** menu, touch the ▲▼icons beneath *Primary Accessory* to scroll to CR-655 or CR-670, depending on the instrument being used. Make any other setup changes (exposure, sensitivity etc.) at this time. Note that only the largest aperture can be used for this accessory. The instrument will automatically set the **Aperture** selection to the largest system configured aperture.
2. Remove the current *Primary Accessory* from the instrument turning the accessory counter-clock-wise.

3. Install the CR-655 / CR-670 by first loosening the knurled set-screw and separating the collar from the main body of the accessory. Screw the collar into the PR-655 / 670 by turning clock-wise. **Hand tighten only. Do not over-tighten!**
4. Replace the main body of the accessory onto the collar and rotate to the desired position. Tighten the knurled set-screw to lock it into position. **Do not over-tighten!**
5. Set the white diffuse surface of the CR-655 / CR-670 at the desired distance from the source.
6. Press the **MEASURE** button to begin a measurement.

USING THE ICC-655 OR ICC-670 INTEGRATING SPHERE

FIGURE 72 - ICC-655 / 670 INTEGRATING SPHERE

The ICC-655 / ICC-670 is a 3" (76.2 mm) integrating sphere with a 1 inch (25.4 mm) measuring port. It is used to make illuminance measurements typically of point sources such as lamps.

MEASURING PROCEDURE

1. From the **Instrument Setup** menu, touch the ▲▼icons beneath *Primary Accessory* to scroll to ICC-655 or ICC-670, depending on the instrument being used. Make any other setup changes (exposure, sensitivity etc.) at this time.
2. Remove the current *Primary Accessory* from the instrument turning the accessory counter-clock-wise.
3. Install the ICC-655 / ICC-670 by turning clock-wise. **Hand tighten only. Do not over-tighten!**
4. Set the front edge of the measuring port at the desired distance from the source. For the best results, the measuring port should be set so that it is perpendicular to the source.
5. Press the **MEASURE** button to begin a measurement.

USING THE RS-3 OR SRS-3 REFLECTANCE STANDARD

The RS-3 Reflectance Standard has an absolute reflectance of 99% (± 1%) from 370 to 780 nanometers. Focusing the PR-655 or PR-670 on the plaque allows the resultant luminance reading, in footlamberts (or candelas, meter²), to be converted directly into illuminance values, in footcandles (or lux). It can also be used to establish the 100% level for relative reflectance of materials or to measure the *Source* part of an L*a*b* test of *Illuminated* samples.

The technique is based on the definition that in the English System, the luminance (in footlamberts) of a perfect Lambertian-diffusing surface is mathematically equal to the illuminance in footcandles which falls on its surface. In metric SI units, illuminance in lux, equals π (3.1416) * luminance (in cd/m²). $lux = \pi * cd / m^2$

This method of measuring illuminance/chrominance is most convenient when physical conditions necessitate *remote* source measurement, such as ambient light falling on a display surface. Since the illuminance measurement is made in the plane of the RS-3 plaque, the measuring instrument does not need to measure the source directly.

△ ***Never*** touch the surface of the plaque. Any surface damage or discoloration will result in erroneous readings. Always keep the plaque cover closed when not in use.

Refer to the Cleaning and Handling Instructions for the RS-3 (and SRS-3) at the end of this section.

MEASURING PROCEDURE

The procedure for making illuminance/chrominance, irradiance and reflectance measurements with the RS-3 plaque are as follows:

Remove the protective cover from the reflectance standard and set it in the plane in which it is desired to measure the illuminance/ chrominance, irradiance or reflectance.

1. For direct single source measurements place the RS-3 in the measurement plane. Arrange the instrument so that it is oriented at approximately 45° to the white surface of the plaque, and is sufficiently close so the measuring aperture is smaller than the image of the light falling on the plaque as seen in the viewfinder.

OR

2b) For display surface ambient light measurements, hold the RS-3 plaque against the display screen in the area to be measured.

2. Arrange the PR-655/670 so it is oriented perpendicular to the white surface of the plaque (or at the required angle for the display under test), and is sufficiently close so that the measuring aperture is smaller than the image of the light falling on the plaque as seen in the viewfinder.

3. Hold the PR-655/670 securely by hand or place it on a sturdy tripod or other suitable support.

4. Align and focus the instrument on the reflectance standard. Make sure the measuring aperture is within the illuminated area on the plaque.

Note: For reflectance measurements, it is not necessary to select RS-3 as an accessory since the measurements are ***relative*** rather than ***absolute.***

5. Select the RS-3 (or SRS-3) as **Add-on Accessory 1** in the *Instrument Setup* menu.

6. Press the **MEASURE** button to make a measurement.

CLEANING AND HANDLING INSTRUCTIONS FOR THE RS-3 (AND SRS-3)

Use the following procedure to maintain the unique optical and reflectance properties of the Reflectance Standard. If the material becomes soiled, use a jet of clean dry air to blow the soil off, or rinse with distilled water. A soft bristle brush may be used.

OR

1a) If the material becomes grossly contaminated or scratched, restore its original optical condition by sanding the surface under a stream of running water using a 220-240 grit waterproof emery cloth.

Sand until the surface is totally hydrophobic (water beads and runs off the material immediately).

Rinse with distilled water.

Note: If the emery cloth grit is too fine the finish will be inadequate as the surface may become too smooth and reflect a high level of specular component (mirror image). Also, if the SRS-3 is refinished, it will be necessary to recalibrate if the standard for optimum accuracy.

LUMINOUS / RADIANT INTENSITY

Luminous Intensity is the luminous flux per unit solid angle in a given direction, and is calculated from *Radiant Intensity (watts/steradian)*. It can be easily thought of as luminous flux (lumens) traveling through a cone (solid angle) in a given direction (for example the forward 180°). Luminous intensity is given in *candelas (lumens / steradian)* or *millicandelas* (1 candela = 1000 millicandelas).

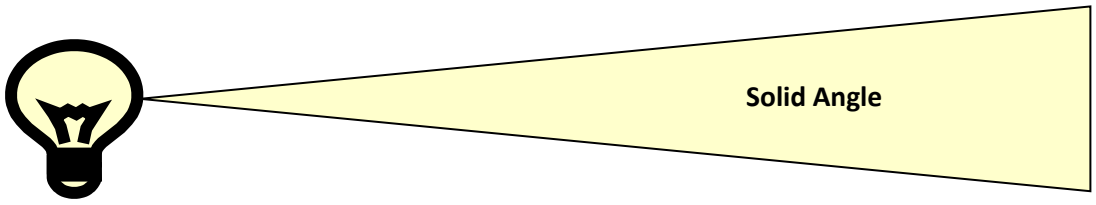


FIGURE 73 - ILLUSTRATION OF LUMINOUS INTENSITY

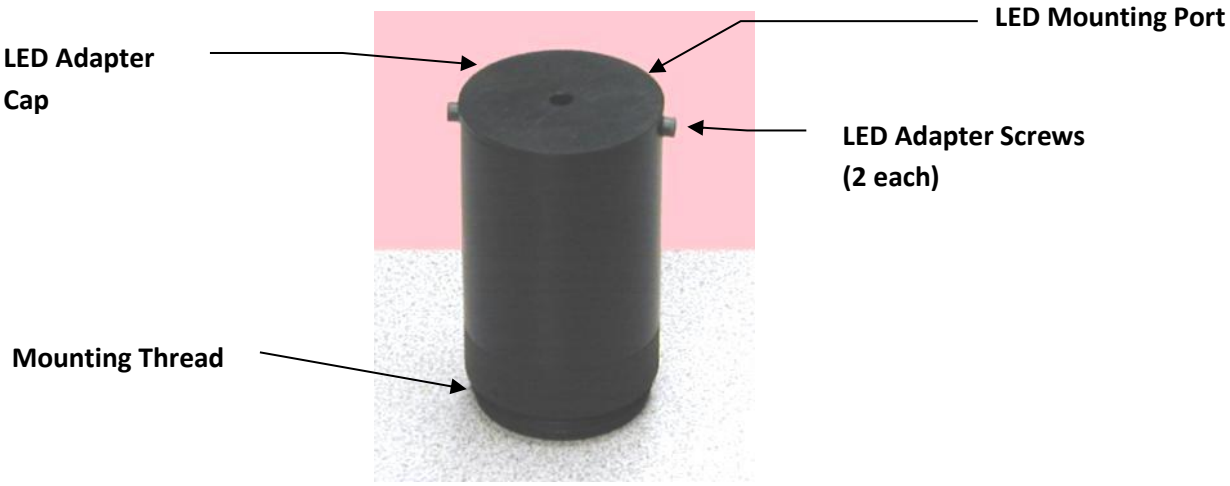


FIGURE 74 - LR-55 LED RECEPTOR

Typical applications for the measurement of luminous intensity include lamps (candelas) and LED's (millicandelas). For the measurement of luminous intensity, the PR-655 or PR-670 can be equipped with the LR-55 LED Receptor and or the LR-127 CIE LED Analyzer. During calibration, these accessories are calibrated using sources where the precise area being sampled is used in calculating candelas as given by $candelas = cd / m^2 * area$ where *area* is the total emitting area of the source.

How to Make Luminous Intensity / Radiant Intensity Measurements

Description

The **LR-55 LED Receptor** enables the PR-655/670 to measure the axial spectral radiant intensity (watts / steradian) and luminous intensity (millicandelas) and color of light emitting diodes (LED's).

The **LR-55** consists of a 2.5 inch (63.5 mm) long tube with an LED port on one end and a mounting thread at the other end. The threaded end is installed into the lens mount of the PR-655 / 670.

During use, the LED's are inserted into the LED port at the open end of the accessory. Two different sized LED ports are supplied with the **LR-55**. One is designed to accept 0.118" (2.99 mm) diameter LED's, and the other accepts 0.205" (5.21 mm) diameter LED's.

Note: Special adapters can be fabricated for LED's that do not exceed 0.275" (7 mm) in diameter. Contact Photo Research for details.

Geometrical Considerations

The **LR-55** is designed to measure the emittance of LED's over an 8.3° acceptance cone.

It is important to note that since the spatial distribution of LED's varies with angle, LEDs measured using acceptance cones other than 8.3° will produce different results. Generally, measurements through smaller cones will yield higher values, while LED's sampled over larger cones will produce measurements with lower radiant and luminous intensity values. Therefore, as part of the measurement report it is important to note the acceptance cone sampled during the test.

Procedure - LED Adapter Cap Replacement

If it becomes desirable to switch LED Adapter caps supplied with the **LR-55**, proceed as follows:

1. Loosen and remove the two SAE 4-40 hex cap screws that secure the LED Adapter cap to the main tube.
2. Remove the LED Adapter cap.
3. Insert the new adapter cap making sure to align the threaded holes in the adapter with the through holes in the tube.
4. Replace and tighten the screws. ***DO NOT OVER TIGHTEN THE SCREWS!!***

Making Measurements

1. Remove the MS-75 lens or other accessory by turning counter clockwise.
2. Install the **LR-55** by threading it clockwise into the PR-655/670 lens mount. **Do not over tighten.**
3. From the *Instrument Setup* menu, select **LR-55** from the Primary Accessory window by touching the ▲ ▼ icons.
4. Insert the LED into the adapter port and allow at least a 5 minute warm-up (unless otherwise specified).
5. Make sure the LED is properly seated in the adapter.
6. Touch the **MEASURE button** to begin a measurement.

Using the LR-127

Overview

The LR-127 is designed to characterize discrete LEDs per the CIE 127 Technical Report – *Measurement of LEDs.* It satisfies the report's requirement of average luminous intensity by providing both Condition A (2°) and Condition B (6.5°) measurement capabilities. This is achieved by actuating a slide from the **A** position to the **B** setting. There is no need to remove the LED from the fixture during the test insuring the accurate determination of average luminous intensity.

FIGURE 75 - LR-127

Installing the LR-127

1. Remove the current optical accessory from the PR-655/670 by turning counter-clockwise.
2. Remove the lens mount (Instrument Side – see Figure 75) by loosening the thumb screw that secures the mount to the main section of the LR-127.
3. Screw the lens mount into the PR-655 lens ring. **DO NOT OVERTIGHTEN** the mount.
4. Slide the main section of the LR-127 onto the lens mount.
5. Rotate the main section until the slide is approximately horizontal and tighten the thumb screw.

Inserting the LED

1. Tighten the small screw in the LED adapter until the ball tip slightly protrudes into the channel. This will insure a snug fit of the LED by pushing it against the opposite wall of the adapter.
2. Insert the LED adapter into the main section of the LR-127 (LED Side – *see Figure 75)* then tighten the thumb screw to secure it.
3. Gently insert the T1.75 (5 mm) LED into the acceptance port of the adapter.
4. Energize the LED to the desired current and allow sufficient warm up.

Making a Measurement

1. Turn on the PR-655 / PR-670. Allow at least 5 minute warm up before making critical measurements.
2. From the *Instrument Setup* menu, touch the ▲ ▼ icons adjacent to the *Primary Accessory* field to select **LR-127A.**
3. Modify other settings (aperture etc.) as necessary.
4. Press the **MEASURE** button to make a measurement and display the results. The photometric values for the LR-127 are given in luminous intensity (millicandelas).
5. Record the reading.
6. Repeat Step 2 and select **LR-127B**.
7. Touch the **MEASURE** button to make a measurement. Record the results.
8. Find the average of the readings from Steps 4 and 7.

LUMINOUS / RADIANT FLUX

Luminous Flux (*given in lumens*) is the basic unit of photometry and is calculated from *Radiant flux* (*given in watts).* It represents the total luminous or radiant output of a source over 360° and is analogous. Typical applications for luminous flux measurements include florescent or incandescent lamps and LEDs where it is required to know the total output of the source.

The correct way to measure luminous (or radiant) flux is by utilizing an integrating sphere. Integrating spheres possess the ability of (as the name implies) integrating or homogenizing the light over the entire 360° emittance pattern of the device under test.

For the PR-655 and PR-670, the IS-655 or IS-670 integrating sphere is available for measuring the luminous and radiant flux of LEDs.

OVERVIEW

Figure 76 - IS-655 / IS-670 Outer View

The IS-655 / IS-670 is a 3 inch sphere designed to measure the total luminous flux (lumens) or radiant flux (watts) of LEDs or other small source such as miniature lamps. This accessory consists of a sphere with baffle and LED Mounting Tube (See Figure 77). During operation, the LED is inserted into the interior end of the Mounting Tube, the Adjustment Screw is set so that the tip of the LED protrudes precisely 0.100 inches into the sphere, and the measurement is conducted. The power cables for the LED (plus and minus current) are connected via mini banana jacks located on the anterior end of the mounting tube.

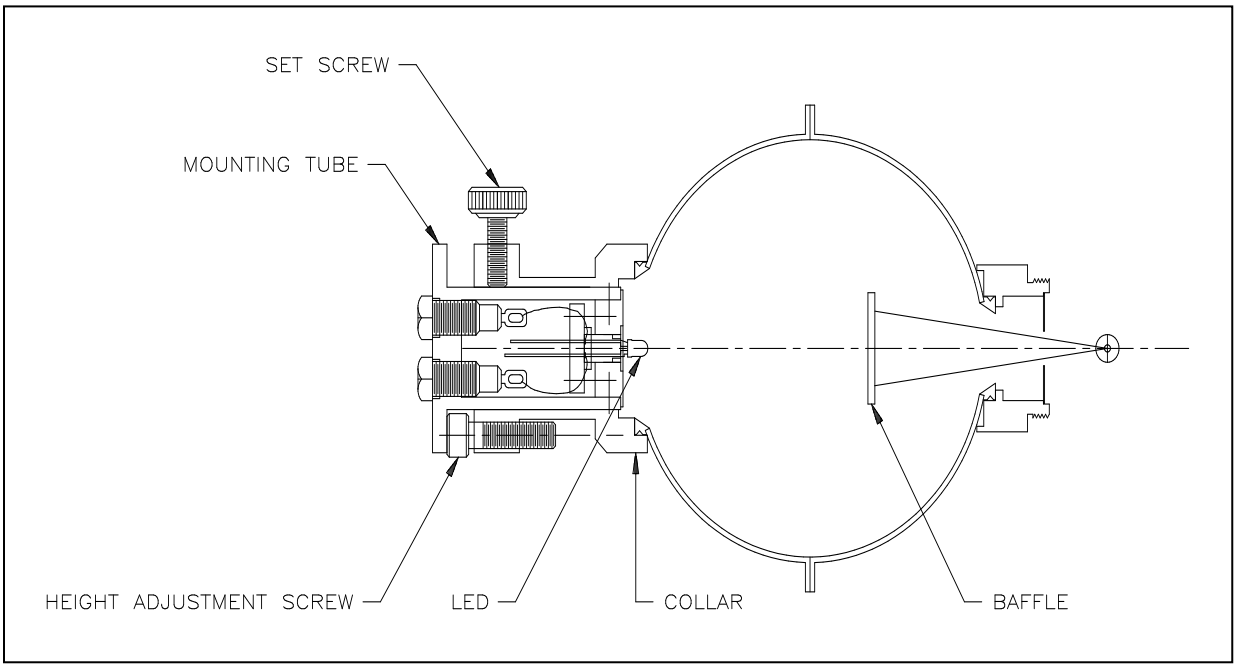


FIGURE 77 – IS-655 / IS-670 INSIDE VIEW

INSTALLING THE IS-600

1. Remove the current optical accessory from the PR-656 / 670 by turning counter-clockwise.
2. Install the IS-655 / 670 by carefully threading clockwise into the C mount ring located in the front of the instrument.

MOUNTING THE LED

1. Loosen the Set Screw (see Figure 77) by turning it counter-clockwise.
2. Remove the Mounting Tube from the Collar by gently pulling away from the sphere. If there is any resistance, further loosen the Set Screw.
3. Insert the leads of the LED into the two miniature sockets located on the interior end of the Mounting Tube. Push the LED in as far as possible. Take care to note the polarization of the leads. For simplicity, the POSITIVE LEAD should be inserted into the socket corresponding to the RED Banana Jack located on the opposite end of the Mounting Tube.

ADJUSTING THE MOUNTING TUBE HEIGHT

1. Referring to Figure 77, position the tip of the LED so that it is directly adjacent to the Height Adjustment Screw, and resting on the outside surface of the Collar.
2. Adjust the Height Adjustment Screw so that it is just touching the end of the Mounting Tube next to the LED.
3. Attach the LED current source (not supplied) to the Mounting Tube using appropriate miniature banana plugs paying attention to the polarity.
4. Supply the appropriate current to the LED and allow at least 10 minutes warm-up. Make sure the LED is properly lit.

5. Insert the Mounting Tube into the Collar until the Mounting Tube just touches the top of the Height Adjustment Screw.
6. Tighten the Set Screw to hold the Mounting Tube in place. **DO NOT OVER TIGHTEN!**

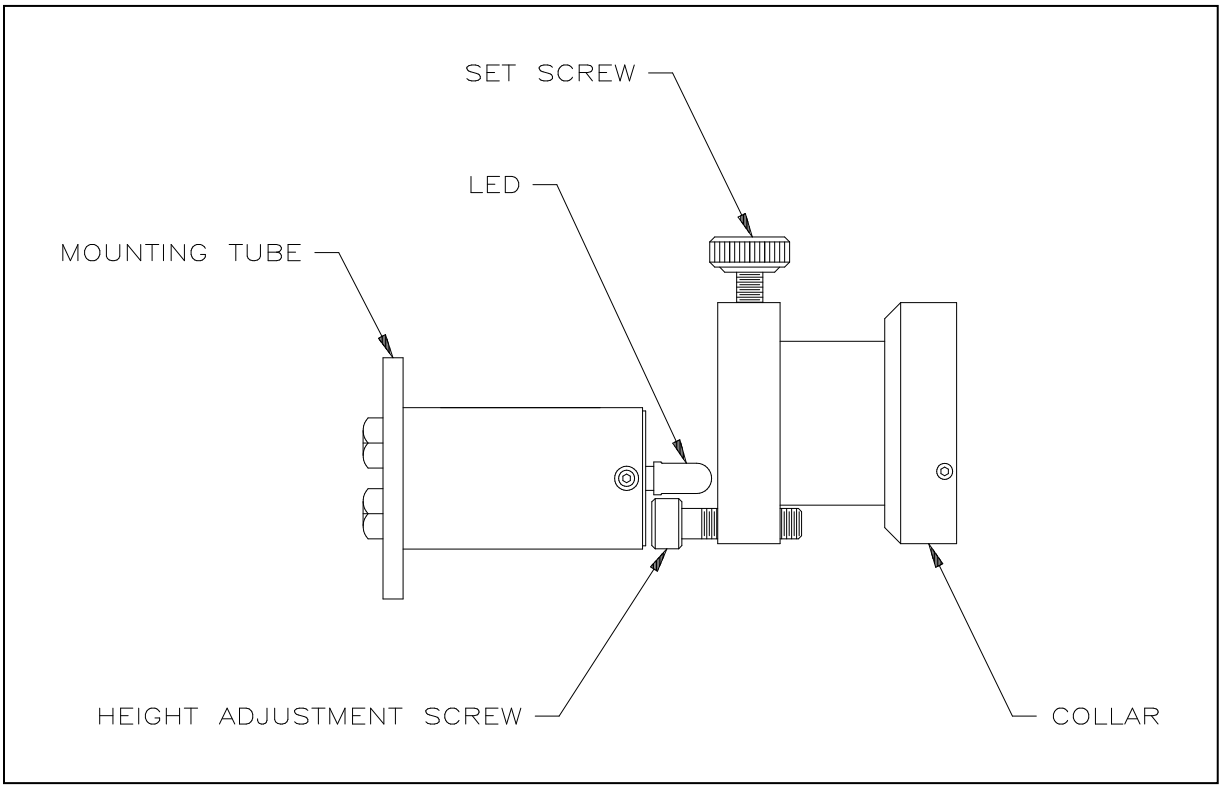


FIGURE 78 - HEIGHT ADJUSTMENT

MAKING A MEASUREMENT

1. Touch MENU then Setup then Instrument Setup.
2. Touch the ▲ ▼ icons in the *Primary Accessory* field to select IS-655 or IS-670.
3. Press the MEASURE button to make a measurement.

TIMED MEASUREMENTS

It may become desirable to make periodic (timed measurements) to, for example, check the drift characteristics at pre-defined intervals for a certain period of time. You may also want to make continuous (repetitive) measurements or a fixed number of measurements. This can be accomplished using the **Timed Measurements** feature.

Note: The *Continuous Measurements* feature should not be confused with the *Measurements to Average* function.

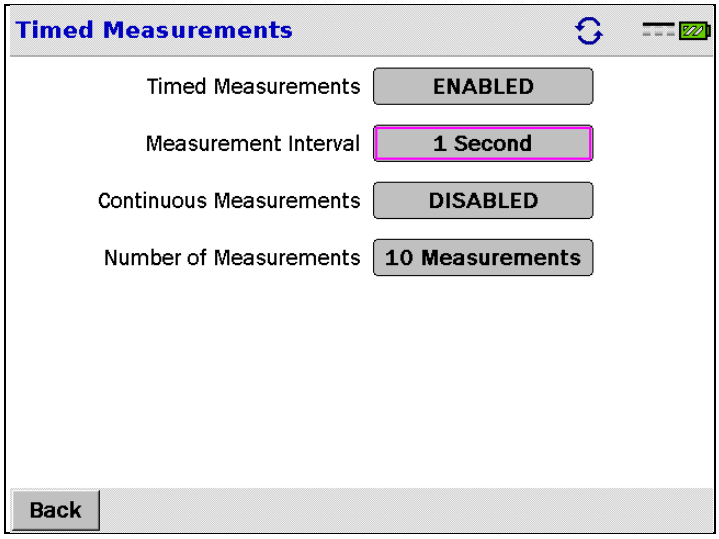


FIGURE 79 - TIMED MEASUREMENTS SCREEN

SETTING TIMED MEASUREMENTS PARAMETERS

TIMED MEASUREMENTS

1. Navigate to the Timed Measurements screen by touching Menu, then Setup then Timed Measurements.
2. If it is desirable to repeat the timed measurement sequence, set **Continuous Measurements** to **Enabled.**
3. Set the time between measurements by touching the **Measurement Interval** filed. The following data entry screen appears:

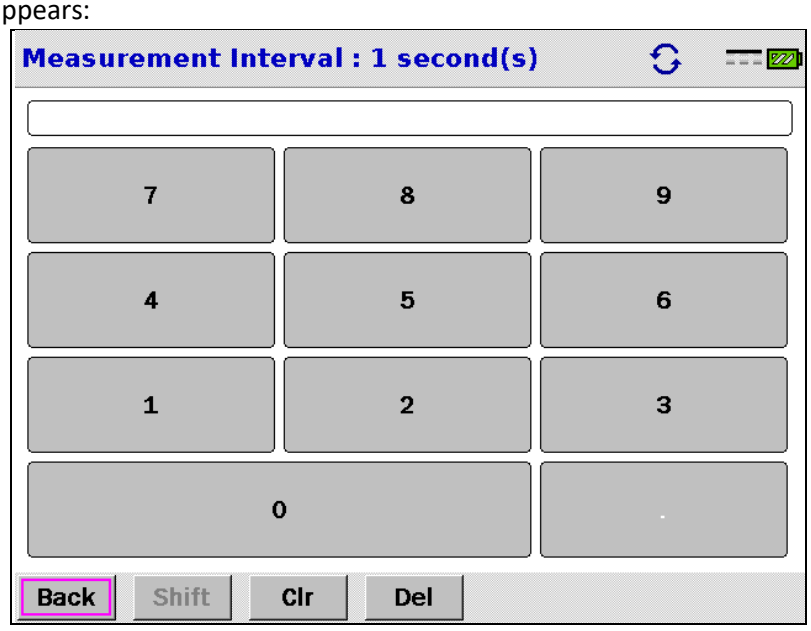


FIGURE 80 - MEASUREMENT INTERVAL ENTRY FIELD

4. Enter the measurement interval (range is 1 to 86400 seconds [24 hours]) then press **Back**.
5. Press the **Measurement Button** to initiate the Timed Measurement Sequence.

CONTINUOUS MEASUREMENTS

1. Navigate to the **Timed Measurements** screen by touching **Menu,** then **Setup** then **Timed Measurements.**
2. Touch the **Timed Measurements** field to that it displays **Enabled.**
3. Touch the **Continuous Measurements** filed until **Enabled** appears.
4. Press the **Measure button** to initiate a continuous measurement.

CONNECTIVITY

USB

The PR-655/670 is equipped with a Mini-B USB connector, allowing for remote communication and USB charging. This port also allows for communication with the optional SpectraWin 2® software, or to control the instrument using Remote Mode commands.

Note: The USB port can only be used to recharge the battery. The PR-655/670 cannot be powered solely off the USB hub.

INSTALLING THE USB DRIVER (WINDOWS XP ONLY)

Prior to using Remote Control commands or SpectraWin 2® software, the PR-6xx, USB driver must be installed on your personal computer.

1. Turn on the PR-655/670.
2. Connect the PR-655/670 to the PC via the USB interface cable.
3. The following screen will appear:

FIGURE 81 - WINDOWS XP NEW HARDWARE WIZARD

4. Choose ***No, not at this time*** and click ***Next.***

5. Choose ***Install from a list or specific location (Advanced)*** and click ***Next.***

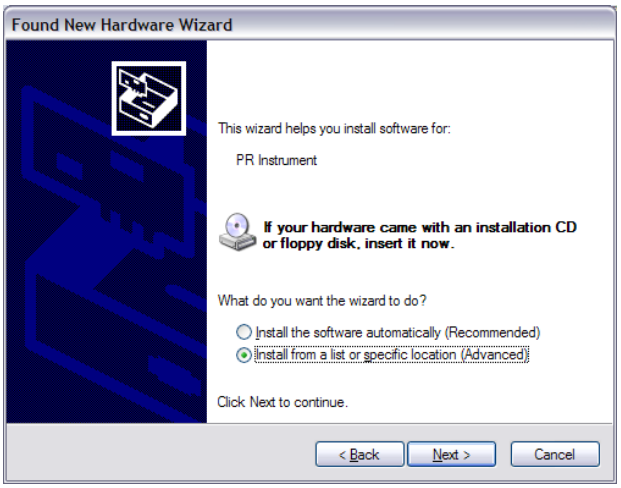


FIGURE 82 - PR-655/670 USB DRIVER INSTALL

6. Insert the CD supplied with PR-655/670 into an appropriate CD drive.
7. Choose **Search for the best driver in these locations** , then browse to ***<CD Drive With PR-6xx_Setup CD>:\usb_driver***

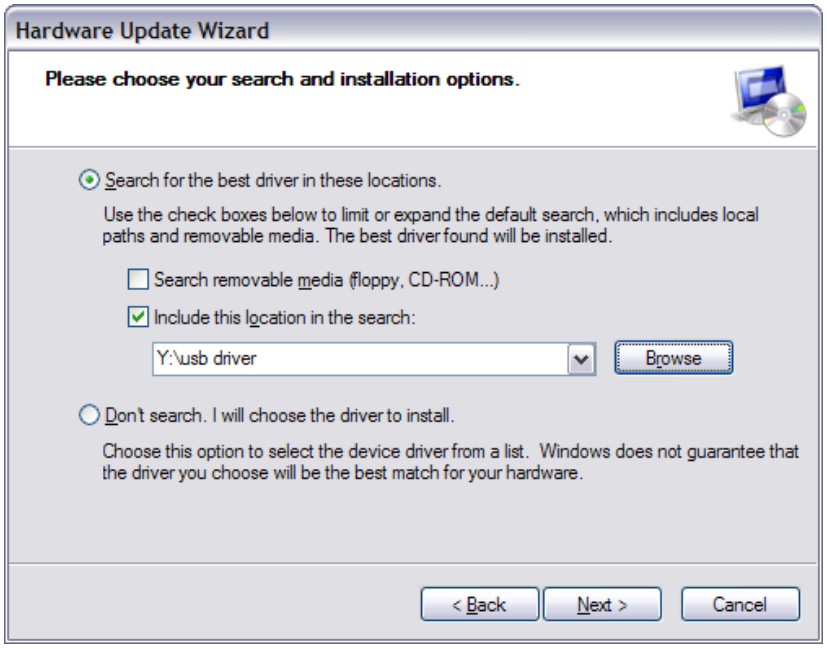


FIGURE 83 - PR-655/670 USB DRIVER LOCATION SELECTION

8. Click ***Next.***

9. Click on ***Continue Anyway***.

FIGURE 84 - WINDOWS XP COMPATIBILITY WARNING FOR PR-655/670 USB DRIVER

10. Click Finish

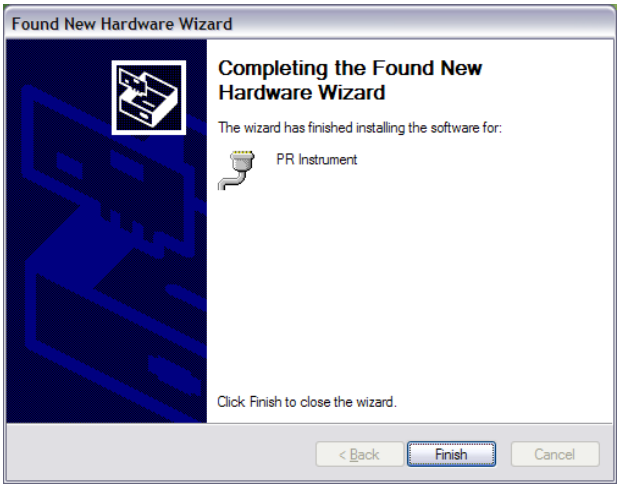


FIGURE 85 - PR-655/670 USB DRIVER INSTALL COMPLETE

USB HUB TYPE

Virtually all modern computers today supply current through the Universal Serial Bus (USB) hub to power external devices when necessary. Typically, the current supplied is 500 mA. Some external USB hubs supply only 100 mA or no current at all. The *USB Hub Type* option provides the means of selecting the power available to the instrument via the PC. If there is insufficient current available for the USB device (PR-655/670), Windows will issue a warning and disable the device.

DETERMINING USB HUB POWER ON WINDOWS XP

1. Click on start.
2. Right click on **My Computer** in the *start* menu.
3. Click on **Properties** to access the *System Properties* screen.
4. Click on **Hardware**.

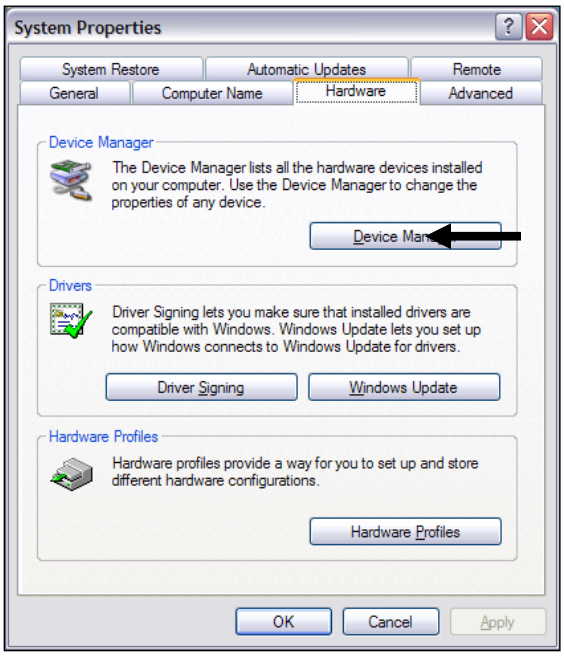


FIGURE 86 - SYSTEM PROPERTIES SCREEN

5. Click on **Device** Manager.
6. Expand the Universal Serial Bus controllers selection by clicking on the +. icon.
7. Right click on USB Root Hub.
8. Click on Propertie**s**.
9. Click on **Power**. The **Total power available** is displayed as illustrated in *Figure* 87.

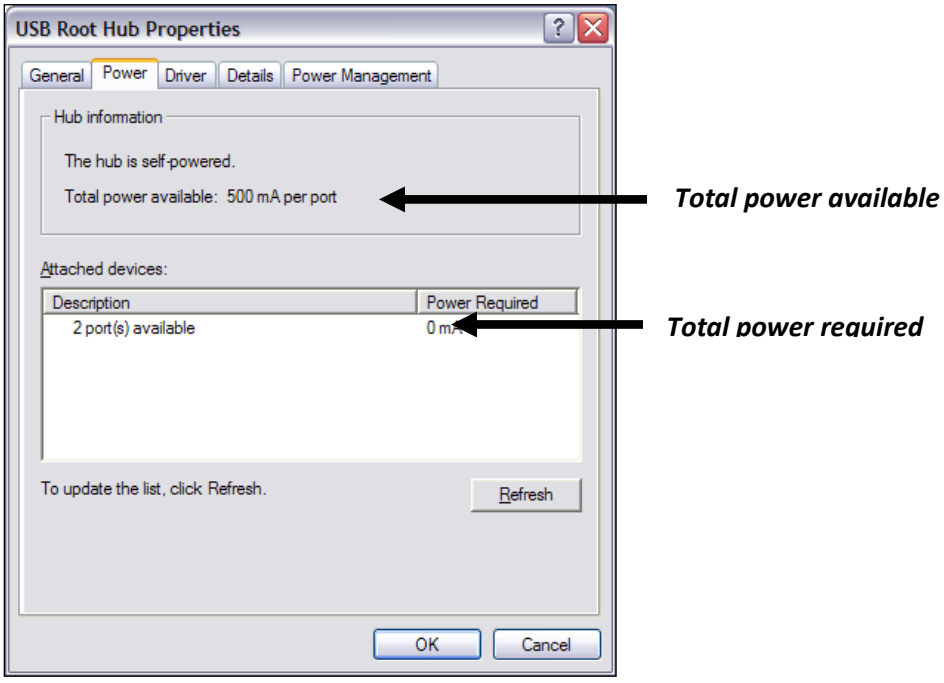


FIGURE 87 - USB POWER SCREEN

SETTING USB HUB TYPE

The USB Hub Type option can be accessed via the Connectivity preference option.

Navigate to ***Menu → Preferences → Connectivity***.

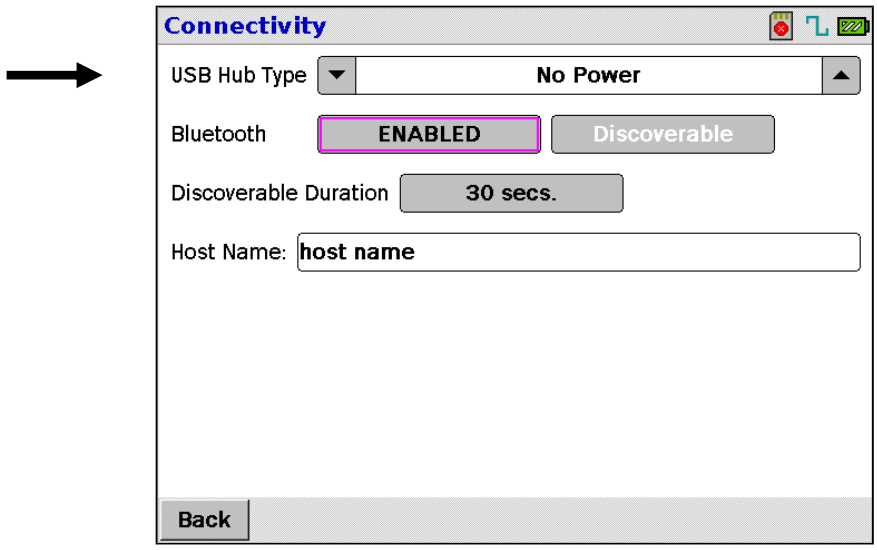


FIGURE 88 - BLUETOOTH/USB CONNECTIVITY MENU

No Power

Press the ▲or ▼ icons adjacent to USB Hub Type until No Power appears. With No

Power selected, the instrument runs entirely on the battery and draws no power from the USB hub.

Low Power (100mA)

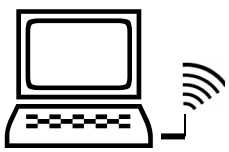
Press the ▲or ▼ icons adjacent to USB Hub Type until Low Power appears. When the

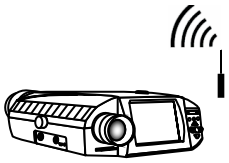
PR-655/670 is powered on the instrument will run partially on the battery and partially on the USB power. This will help preserve the battery charge, as not all power is drawn from it. If the PR-655/670 is turned off and connected to the USB hub, the instrument will trickle charge the battery at a slow rate.

High Power (500mA)

Press the ▲or ▼ icons adjacent to USB Hub Type until High Power appears. In this mode the instrument runs mostly on USB power while charging the battery with remaining power. When the unit is powered off it will charge almost four times faster than USB low power mode.

BLUETOOTH* (OPTIONAL)





HOST (PC) **PR-655/670**

FIGURE 89 - BLUETOOTH TOPOLOGY

The optional Bluetooth feature allows the PR-655/670 to be wirelessly controlled by a remote host using Remote Mode commands from a user developed application or terminal emulator such as HyperTerminal or SpectraWin 2 control software up to 100 meters[1] away. When installed, the supplied driver creates a virtual RS-232 port that operates like a traditional port with respect to programming.

INSTALLING THE (PHOTO RESEARCH SUPPLIED) BLUETOOTH ADAPTER DRIVER ON HOST

The USB Bluetooth adapter enables Bluetooth connectivity on the PC host side. The adapter allows the Host to communicate with the PR-655/670 wirelessly. Before Bluetooth communication can commence between the Host PC and the PR-655/670, adapter drivers need to be installed on the PC. This section will guide in installation of the drivers found on the ***PR-6xx Utilities CD***. This procedure is designed for *Windows XP* only.

1. Insert the CD supplied with the PR-655/670 into an appropriate CD drive.
2. Click on the 

icon**.**
3. Click **Run.**
4. Click **Browse**.
5. Navigate to the drive containing the PR-6xx Installer CD, and double click on **Setup**.

Note: Do not insert the Bluetooth adapter into a USB port until prompted by the Driver Setup Wizard.

[1] 100 meter range is in open space using the Linksys USBBT100 Bluetooth adapter.

6. Click on **Next**.

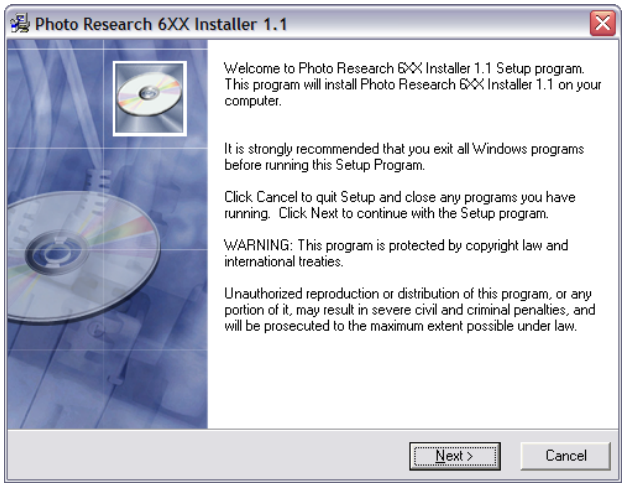


FIGURE 90 - PR-6XX INSTALLER

7. Choose ***I Agree*** *and* click ***Next.***

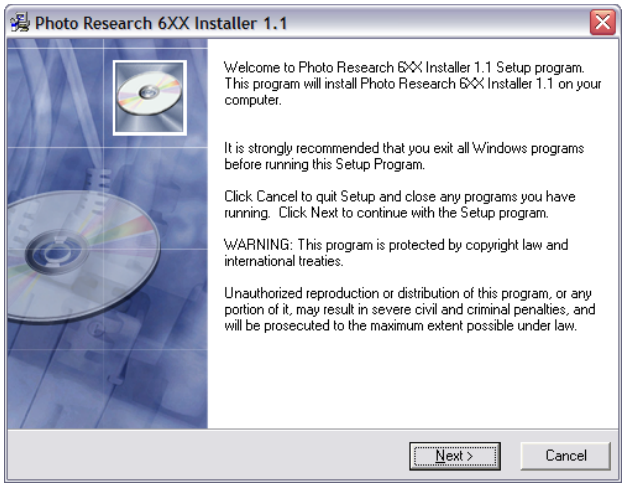


FIGURE 91 - PR-6XX INSTALLER LICENSE AGREEMENT SCREEN

8. The following ReadMe screen appears.

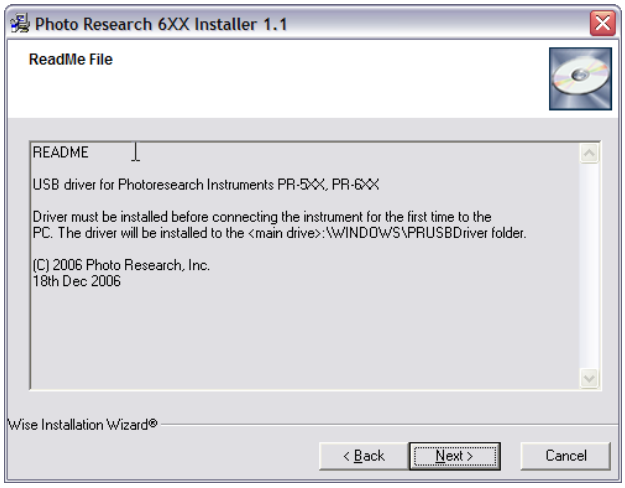


FIGURE 92. PR-6XX USB DRIVER INSTALL LOCATION README

9. Click ***Next***. The following software Destination location screen appears:

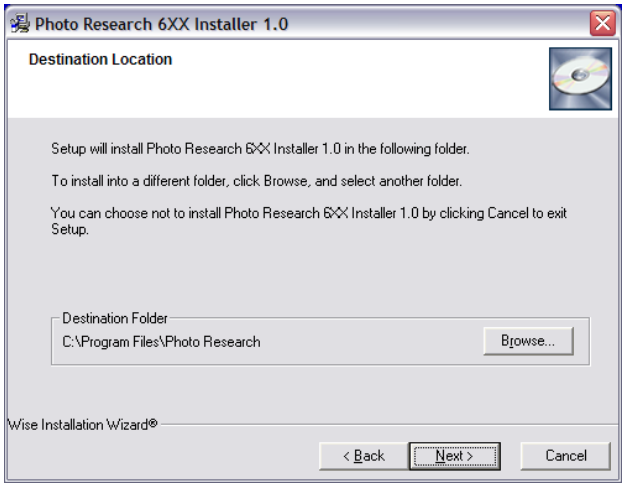


FIGURE 93 - PR-6XX INSTALLER INSTALL DIRECTORY SELECTION

10. Click ***Next*** (then go to Step 11) to install the driver to the default directory (Photo Research) or click ***Browse*** to bring up the following screen and select a different folder.

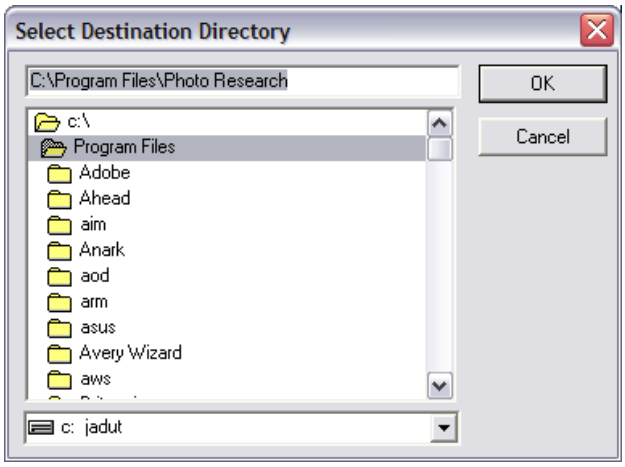


FIGURE 94 - PR-6XX INSTALLER NON DEFAULT DIRECTORY SELECTION

11. Navigate to and select the drive and folder of choice, and then click ***OK.***
12. From the screen that appears, select the **Windows XP Bluetooth Drive.** A demo version of SpectraWin2® can also be installed if desired. .

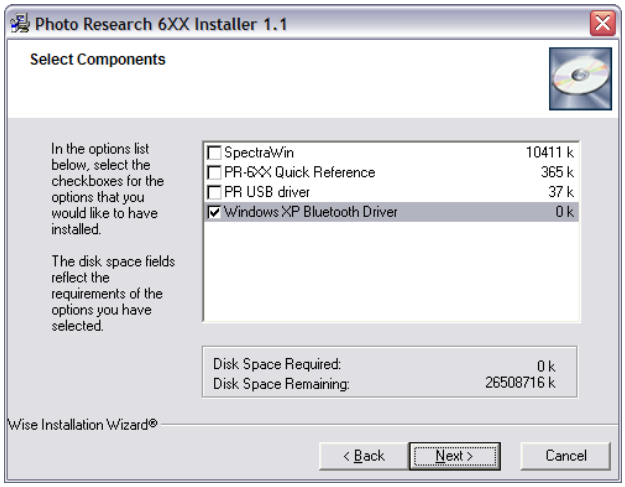


FIGURE 95 - PR-6XX UTILITIES COMPONENT SELECTION

13. Click **Next** to start the installation.

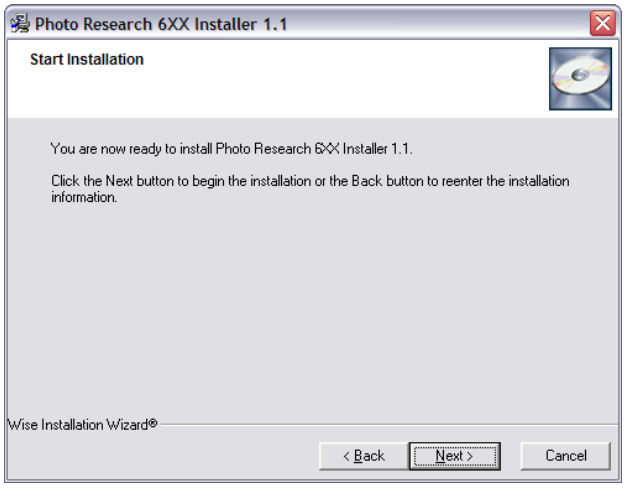


FIGURE 96 - PR-6XX INSTALLER START INSTALLATION

14. The WIDCOMM Bluetooth software installation will start.

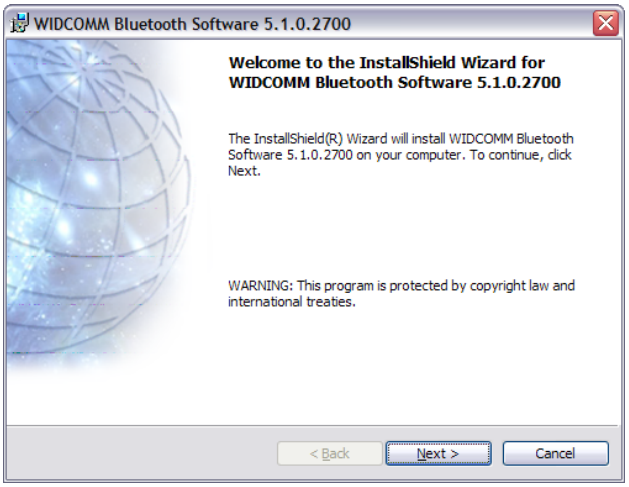


FIGURE 97 - PR-6XX UTILITIES INSTALLATION FINISH

15. Click on I accept the terms in the license agreement and click ***Next.***

16. Click ***Next***

17. Click ***Install.***

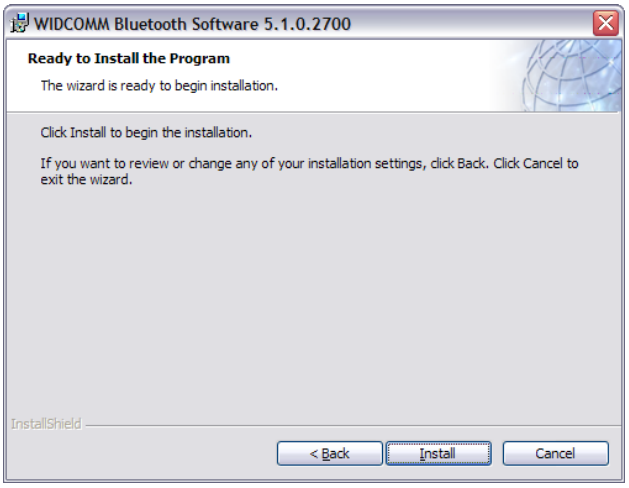


FIGURE 98 - WIDCOMM BLUETOOTH SOFTWARE INSTALLER

18. During the Setup the driver will prompt for the USB dongle.
    DO NOT INSERT DONGLE UNTIL PROMPTED TO DO SO.
19. Click ***Finish.***

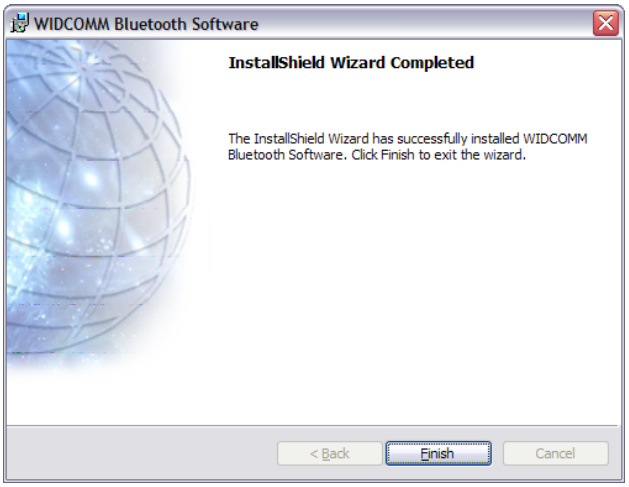


FIGURE 99 - WIDCOMM DRIVER INSTALLATION COMPLETED

20. The ***My Bluetooth Places*** icon appears on the desktop after a successful installation.

FIGURE 100 - MY BLUETOOTH PLACES ICON

21. The ***Initial Bluetooth Configuration Wizard*** will appear.

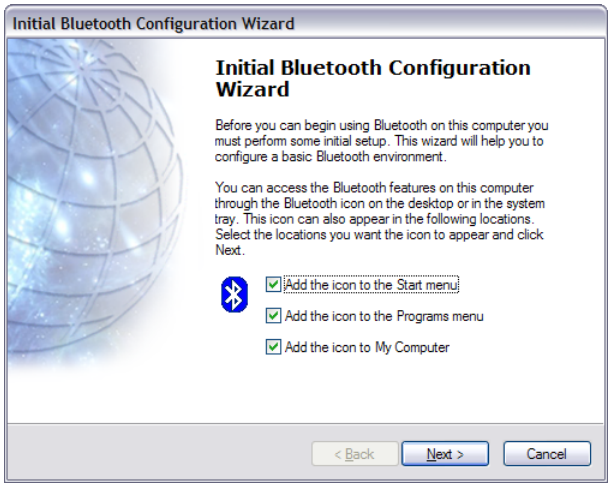


FIGURE 101 - INITIAL BLUETOOTH CONFIGURATION WIZARD

22. Click ***Next.***
23. Click ***Next*** allowing the default settings**.**

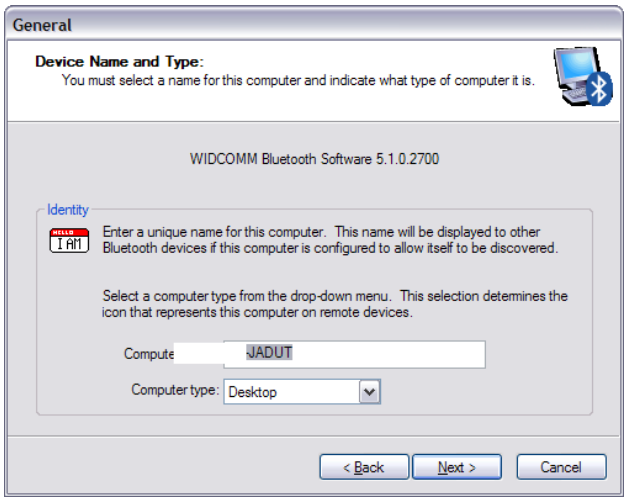


FIGURE 102 - DEVICE NAME AND TYPE SELECTION

24. Make sure that **only** ***Bluetooth Serial Port*** is checked.

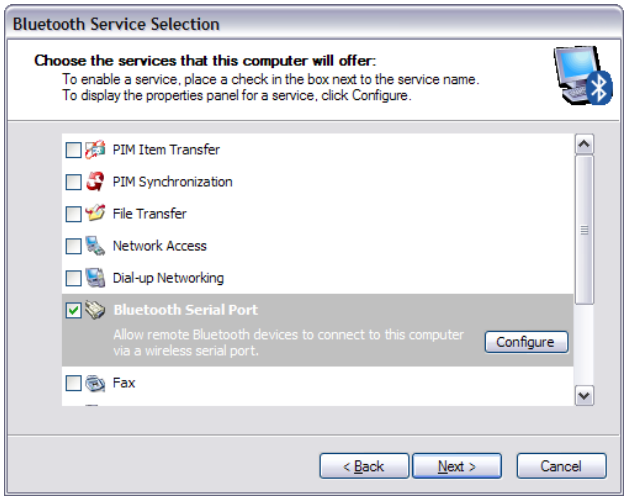


FIGURE 103 - BLUETOOTH SERVICE SELECTION

25. Click ***Skip***.

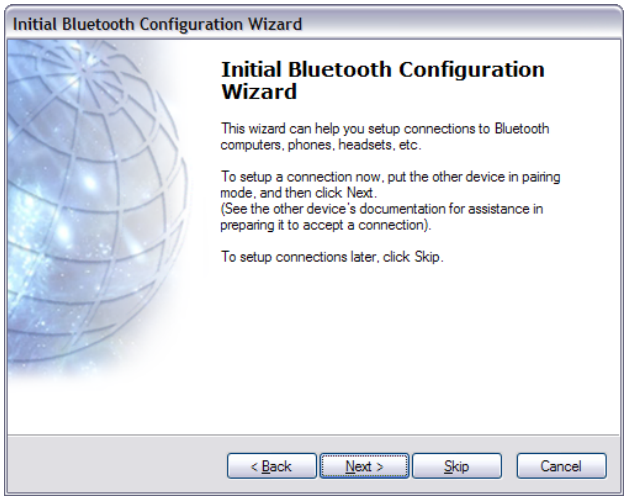


FIGURE 104 - BLUETOOTH FIND DEVICE PROMPT

26. Click ***Finish*** to complete the ***Initial Bluetooth Configuration Wizard*** setup.

FIGURE 105 - INITIAL CONFIGURATION WIZARD COMPLETE

27. The Bluetooth hardware is now ready to use.

ENABLE/DISABLE BLUETOOTH

Bluetooth communications is enabled via the connectivity preferences menu.

1. Navigate to ***Menu→ Preferences → Connectivity***.

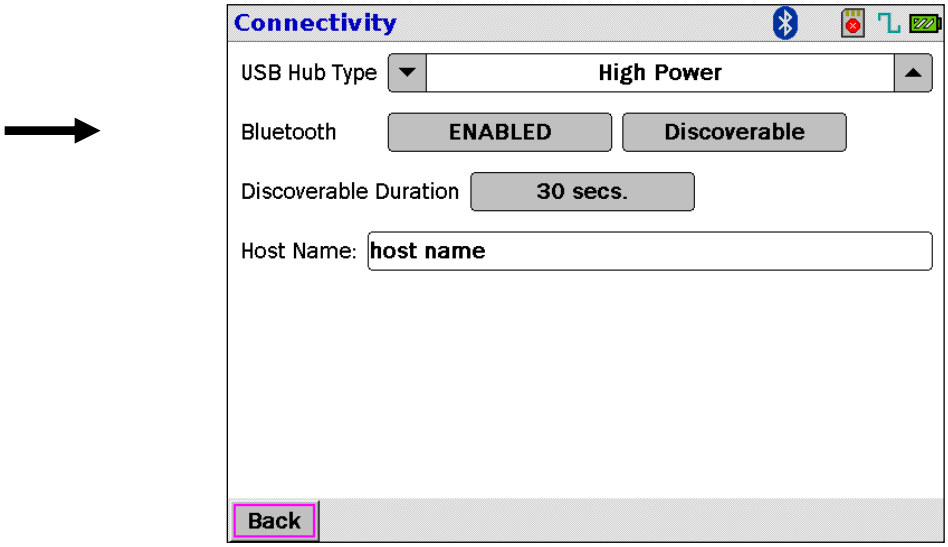


FIGURE 106 - BLUETOOTH/USB CONNECTIVITY MENU

2. The PR-655/670 displays the current Bluetooth status. When the DISABLED icon is viewable, Bluetooth is disabled. Clicking on the DISABLED icon turns **Enables** Bluetooth.
3. The following table describes the four Bluetooth modes of operation.

Bluetooth Status	Bluetooth Icon	Functionality
Disabled	No Icon	Bluetooth Off
Enabled		Bluetooth enabled and connectable by previously paired remote host.
Enabled & Discoverable	(Blinking)	Bluetooth enabled and discoverable by any remote host.
Bluetooth Link Established	(Green)	Successful connection made with a remote host.

TABLE 7 - PR-655/670 BLUETOOTH MODES

BLUETOOTH DISCOVERY MODE

Once Bluetooth has been enabled (refer to Enable/Disable Bluetooth section) the PR-655/670 must be made discoverable in order for a remote host to find and pair to the instrument. The instrument can be made discoverable by clicking on the DISABLED icon to Enable Bluetooth. Once discoverable, the icon will blink (for the specified duration) indicating that the unit is discoverable by a host computer.

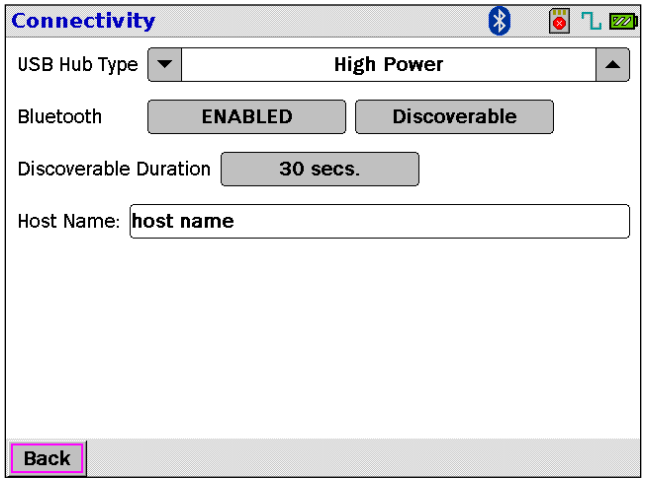


FIGURE 107 - BLUETOOTH/USB CONNECTIVITY MENU

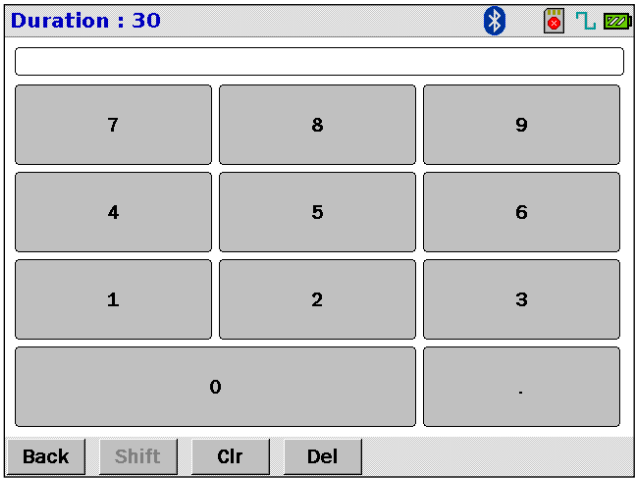


FIGURE 108 - BLUETOOTH DISCOVERABLE DURATION INPUT

By default the instrument will be discoverable for up to 30 seconds by a host computer. If a longer duration is required simply click on the icon next to *Discoverable Duration* and choose the desired duration up to 3 minutes (see Figure 42).

PAIRING PR-655/670 WITH A HOST

This section describes how to successfully pair the PR-655/670 with a remote host using the Bluetooth Adapter provided by Photo Research. The PR-655/670 needs to be paired with a remote host only once. Once pairing has occurred, both the remote host and the PR-655/670 will remember their pairing information. This allows the remote host to automatically (when Bluetooth enabled on the instrument) connect to the PR-655/670 next time around without having the need to re-authenticate it.

Pairing for the first time

1. Enable Bluetooth.
2. Set the PR-655/670 ***Discoverable Duration*** for 120 seconds.
3. Click DISABLED icon to enable Bluetooth.
4. Bluetooth Icon will blink signifying that the PR-655/670 is now discoverable by a new remote host. From this point you have 120 seconds to go to the Remote Host and pair with the PR-655/670. If a longer period is required please set the ***Discoverable Duration*** to a longer period.

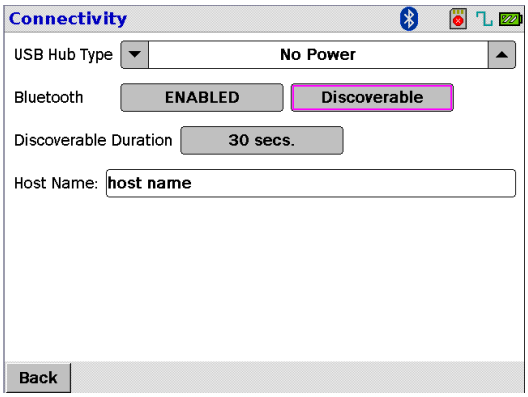


FIGURE 109 - BLUETOOTH CONNECTIVITY SETUP WINDOW

Host

1. Double click on the 

icon located on the desktop.
2. Click on ***Add a Bluetooth Device*** located in the top right corner of the window.

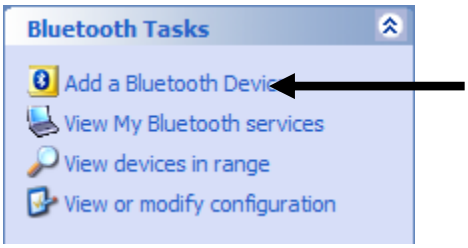


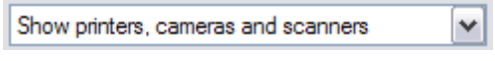
FIGURE 110 - MY BLUETOOTH PLACES

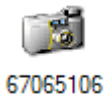
3. The ***Bluetooth Setup Wizard*** will appear.

FIGURE 111 - BLUETOOTH DRIVER SETUP WIZARD

4. Click ***Next***.
5. The wizard will attempt to find the PR-655/670

FIGURE 112 - REMOTE HOST DEVICE SEARCH WIZARD

✓ ***Make sure that***  ***is selected via the drop down menu.***

6. When the PR-655/670 is successfully discovered a camera 

icon will appear with the serial number of the PR-655/670 below the icon.
7. Select the instrument and then click on ***Next***.
8. Give a name for the PR-655/670 instrument. It's recommended that you use the serial number of the instrument.

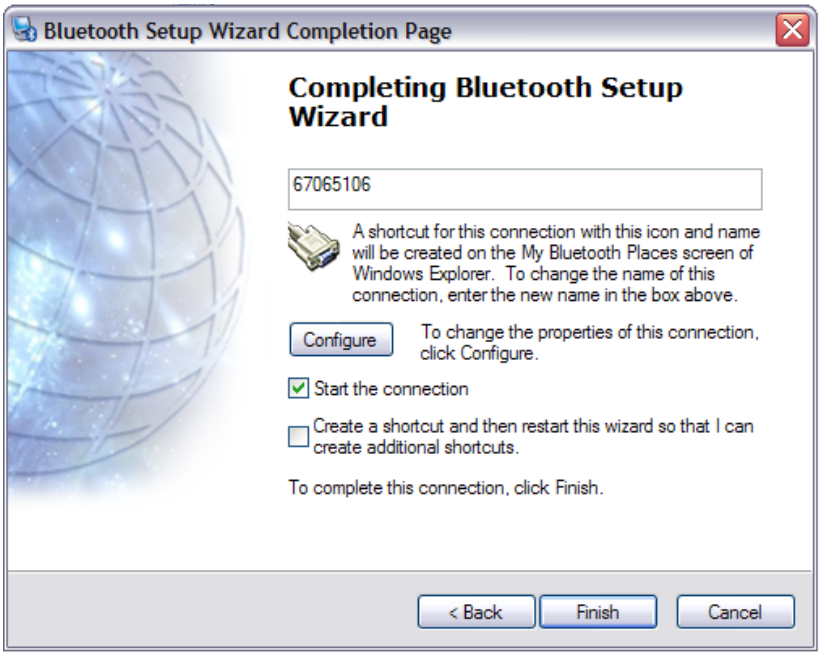
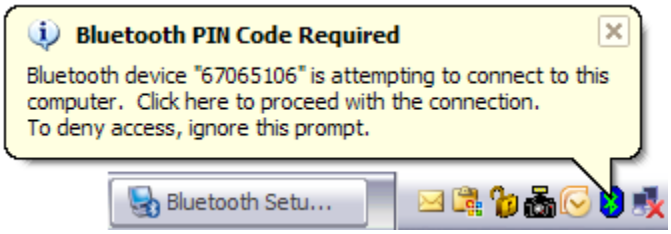


FIGURE 113 - BLUETOOTH SETUP WIZARD DEVICE NAME AND COM SELECTION SCREEN

9. A default virtual COM port will be assigned by the wizard for this communication link. The COM port address can be attained by clicking on *Configure.* This information will also be available later after successfully pairing with the PR-655/670.
10. Click ***Finish.***
11. An informational balloon will appear



12. Click on the Balloon to allow the PR-655/670 to connect to the Remote Host.
13. A window appears prompting for the Bluetooth PIN Code for the PR-655/670. Enter the serial number of the instrument as the PIN code and click ***OK.***

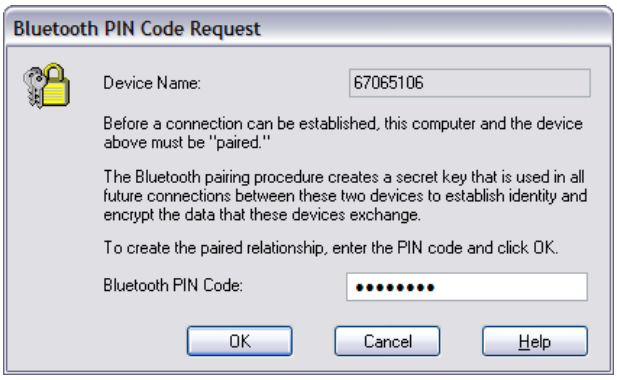
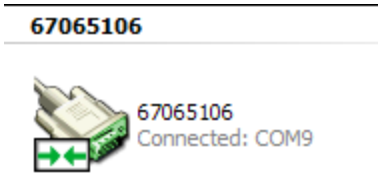


FIGURE 114 - BLUETOOTH PIN CODE REQUEST

14. If successfully paired a serial connector icon will appear in My Bluetooth Places. The PR-655/670 will also indicate a successful pairing and connection by displaying the icon and the name of the Remote Host.

Note: The virtual COM port for this connection is also displayed under the serial number of the PR-655/670.



✓ Wireless communication link has been established between the PR-655/670 and the Remote Host. HyperTerminal or SpectraWin 2 can be launched at this point to communicate with the PR-655/670 wirelessly.

Connecting to PR-655/670 after Pairing

After successfully pairing with the PR-655/670 there is no need to go through the *Bluetooth Setup Wizard* under ***My Bluetooth Place***. Simply open ***My Bluetooth Places*** then right click on the serial connector icon shown below and choose *Connect.*

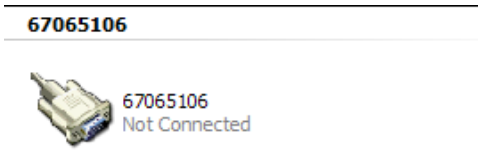


FIGURE 115 - PR-655/670 ICON IN MY BLUETOOTH PLACES (NOT CONNECTED)

The host will attempt to re-connect with the PR-655/670. When connected the above icon will change to green and a Connected indicator will be shown. The instrument will also indicate a successful link by displaying a green Bluetooth icon and the name of the Remote Host (in Hexadecimal).

RS-232 (OPTIONAL)

The traditional RS-232 I/F allows for interfacing to ATE environments and older generation PC systems. The below diagrams depicts the connection between the PR-655/670 and the host computer. To establish a connection between the PR-655/670 simply open the appropriate port (using the specified protocol settings) and enter "**PHOTO**", no other hardware handshakes are necessary.

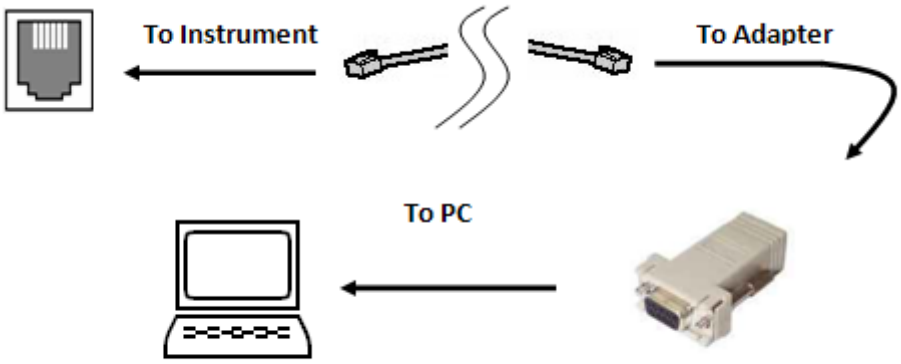


FIGURE 116 - PR-655/670 RS-232 OPTION

HARDWARE PROTOCOL

The RS-232 hardware protocol settings are:

- **Baud Rate**: Selectable (9600, 19.2 Kbps 38.4 Kbps, 57.6 Kbps, 115.2[1] Kbps)
- **Parity**: None
- **Data Bits**: 8
- **Stop Bits**: 1

[1] Default baud rate unless in PR-650 emulation mode.

SELECTING RS-232 BAUD RATE

1. Navigate to **RS-232 Connectivity**, by touching on **Menu**, then **Preferences**.
2. Touch **RS-232 Connectivity.**
3. The following screen will appear.

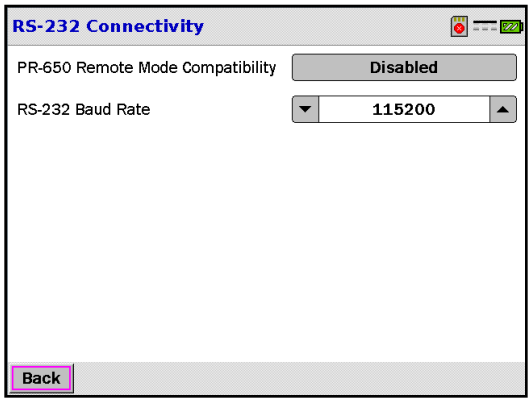


FIGURE 117 – RS-232 CONNECTIVITY, BAUD RATE SETUP

4. Touch the ▲ ▼next to the **RS-232 Baud Rate** text field to select the desired speed.

Selectable Speeds:

- 9600 bps
- 19.2 Kbps
- 38.4 Kbps
- 57.6 Kbps
- 115.2 Kbps (**default**)

REMOTE CONTROL MODE

Remote Control of the PR-655/670 is accomplished using commands sent from the PC in ASCII (text) strings to the instrument. These commands are then executed and the requested information including measured values or instrument setup parameters are returned to the PC.

The PR-655/670 is controlled from a personal computer over the Universal Serial Bus (USB) interface. This is achieved by using a driver that parses appropriate ASCII (text) commands from the PC application then transmits them over the USB I/F to the PR-655/670.

Communication protocol is identical to RS-232 communications. The USB driver emulates an RS-232 interface including opening a COM: port, setting a baud rate, parity, stop bits and flow control. This makes Remote Control operations available for application software written in Microsoft Visual Basic, Microsoft C++ or any other language that is capable of opening a COM: port.

Note: ***While the PR-655/670 is in Remote Mode, the instrument's touch screen is disabled.***

INSTALLING THE USB DRIVER

Prior to commencing *Remote Mode* operations, the **PR-6xx Utilities** software including the USB driver must be installed on your Windows based PC running Windows XP (or later) operating systems. Please refer to the USB portion of the *Connectivity* section for complete installation instructions.

USING REMOTE CONTROL COMMANDS

Note: The following steps are for Windows XP only.

Step 1 - Turn on the PR-655/670.

Step 2 - Set **Power Saving** to **Off.** This will prevent the PR-655/670 from powering off when idle for extended period of time. See **Page 28** of this manual for Power Saving options.

Step 3 - Connect the 655/670 to the PC via the USB interface cable.

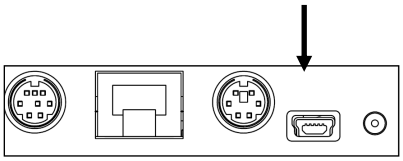


FIGURE 118 - PR-655/670 USB CONNECTOR

Step 4 - Click on 

on your computer desktop.

Step 5 - Click on ***All Programs*** then ***Accessories*** then ***Communications*** then HyperTerminal**.**

Step 6 - In the screen that appears, assign a name (e.g. PR-655 or PR-670).

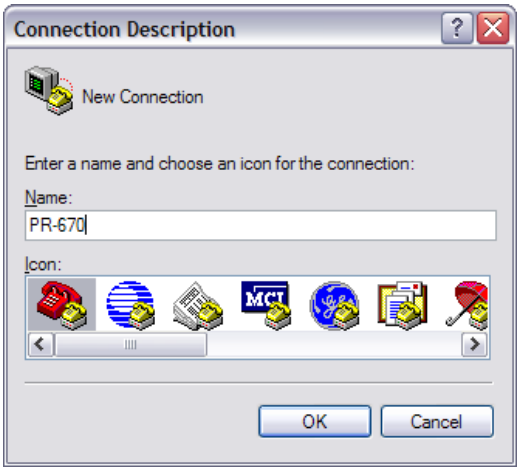


FIGURE 119 - HYPER TERMINAL CONNECTION DESCRIPTION MENU

Step 7 - Click on ***OK.***

Step 8 - In the screen that appears, select the appropriate COM port for communications. The COM port assigned by the USB driver is listed in the drop down window that appears.

FIGURE 120 - COM PORT SELECTION IN HYPER TERMINAL

If in doubt about which COM port is correct, the proper port can be identified in the ***Device Manager*** system screen. To access this screen:

1. From the XP desktop, right mouse click on ***My Computer*.**

FIGURE 121 - MY COMPUTER PROPERTIES RIGHT CLICK DROP DOWN OPTION

2. Click on ***Properties***.
3. Click on ***Hardware***.

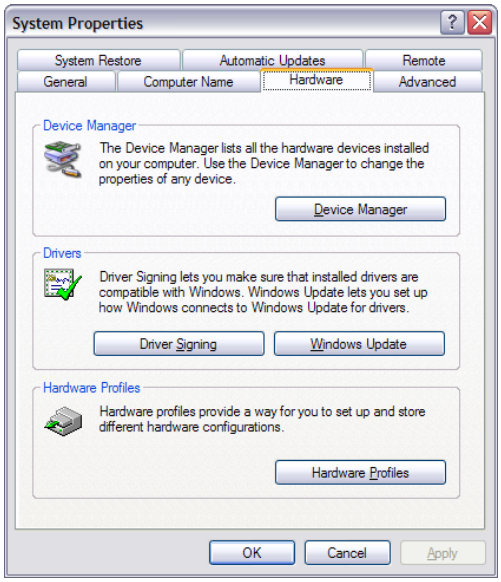


FIGURE 122 - SYSTEM PROPERTIES MENU

4. Click on ***Device Manager***.
5. Note the COM port assigned to the PR-655/670.

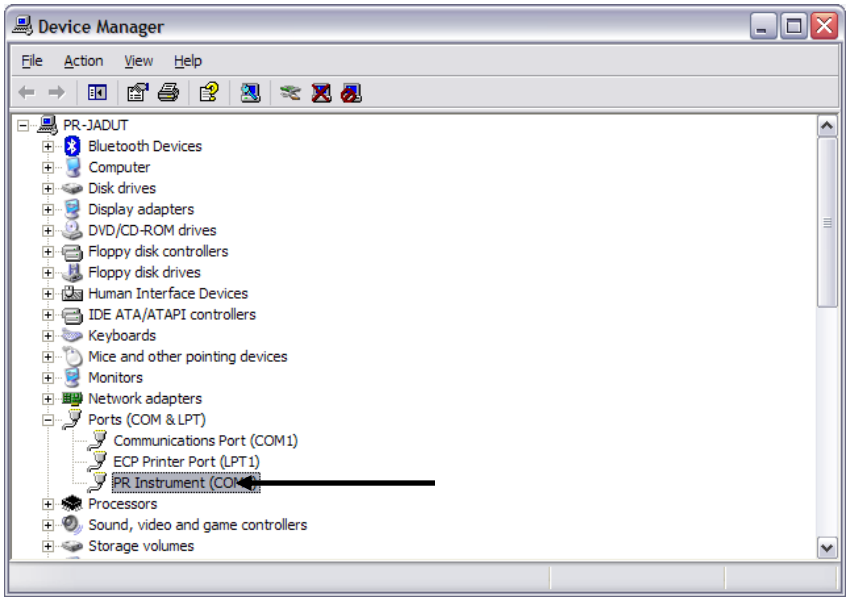


FIGURE 123 - WINDOWS XP DEVICE MANAGER

Step 9 - The next screen is a form used for entering RS232 communications. Since the USB driver sets these parameters, no changes are required. Click on **OK.**

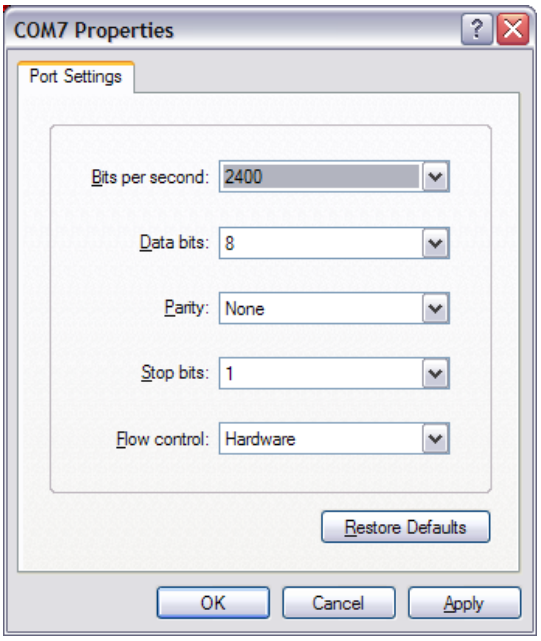


FIGURE 124 - WINDOWS XP COM PROPERTIES WINDOW

Step 10 - The main HyperTerminal appears. Type **PHOTO** (case sensitive).

Step 11 - **REMOTE MODE** is displayed in the HyperTerminal window. The PR-655/670 is now ready to accept Remote Control Commands.

Step 12 - Type **E** then press **Enter** to put the PR-655/670 in *Echo* or *Full Duplex* mode This enables display of characters sent to the instrument on the HyperTerminal window.

ENTERING REMOTE MODE

When communicating with the PR-655/670 using remote mode commands in the following environments, C++, Visual Basic, MatLab, and LabView please note that **single characters and not Strings** must be sent to the instrument. Some examples are given below.

Entering Remote Mode

To enter remote mode “P” “H” “O” “T” “O” must be sent as single characters and not as a single string.

Making a Measurement

For example to have the instrument make a measurement and return spectral data, the following command must be sent “M” “5” ”[CR]” as single characters, not as a single string.

PR-650 Remote Mode Compatibility (PR-655 Only)

For applications where the PR-655 has to be retrofitted into an existing PR-650 software environment, the PR-655 features a “PR-650 Emulation Mode”. In this mode the PR-655 acknowledges all PR-650 Remote Mode commands while continuing to accept all new PR-655 commands. This is ideal for replacing the PR-655 into a pre-existing PR-650 ATE environment where minimal code modification is desired.

Enable/Disable PR-650 Emulation Mode

1. Navigate to **RS-232 Connectivity**, by touching on **Menu**, then **Preferences**.
2. Touch **RS-232 Connectivity.**
3. The following screen will appear.

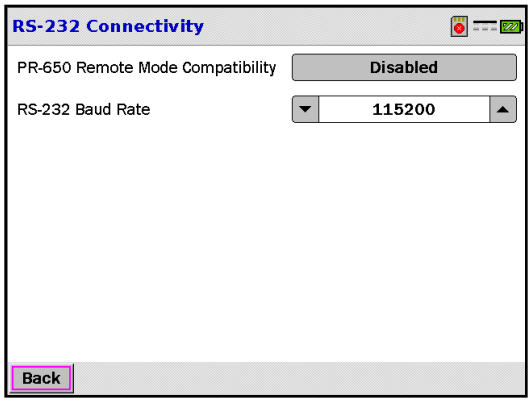


FIGURE 125 - PR-650 REMOTE MODE COMPATIBILITY OPTION

4. The button next to PR-650 Remote Mode Compatibility displays the status of the compatibility mode. Touching the DISABLED button will **Enable** PR-650 emulation mode.

PR-655’s purchased with the optional RS-232 port (Refer to RS-232 section above), can be direct replacements when the PR-655 is set to PR-650 Compatibility Mode. The RS-232 option allows the user to maintain 100% backward compatibility with the PR-650 modes of operation. When in this legacy mode, the PR-655 will operate at 9600 bps only and requires the handshake protocol used in the PR-650 to establish connection with a host PC. Please refer to the **Remote Mode Startup** section of the **PR-650 Operating Manual** for documentation on the legacy hardware handshake required to enter remote mode, and for documentation on the PR-650 Remote Mode commands.

REMOTE CONTROL COMMAND SUMMARY

The following table summarizes all valid Remote Control commands and responses from the PR-655/670. Detailed descriptions including parameters passed with each command are detailed in the **Commands** section.

Command	Description
B	Sets LCD backlight level
C	Clears current session instrument errors
D	Downloads data from the PR-655/670
E	Toggles the Echo (full duplex) mode
F	Measure frequency of light source
I	Requests instrument status or / error report from PR-655/670
L	Defines measurement title – Maximum of 20 characters.
M	Measure command for the PR-655/670. Returned datum depends on the accompanying parameters.
Q	Quit (exit) remote mode.
R	Recall stored measurement
S	Set up measurement parameters
X	Sets LCD contrast level.

TABLE 8 - PR-655/670 REMOTE MODE COMMAND SUMMARY

Usage:

<...> Optional Entry,

[...] Mandatory entry

(...) Comment, NOT PART OF THE COMMAND

Note: ***The default values, e.g. apertures, exposure time etc. are those used for the measurement before the instrument was set to Remote Control Mode or, if in Remote Mode, the value from the previous command.***

REMOTE CONTROL COMMAND DETAIL

Command	Description
B	**Purpose**: Set LCD backlight level **Syntax**: Bnn[CR] Bnn = Backlight / Brightness level in percentage. Range of nn = 0 to 100% **Response**: Backlight set to nn %
C	**Purpose**: Clears the current instrument error **Syntax**: C[CR] **Response**: None
D	**Purpose**: Download data from the PR-6XX **Syntax**: D<data code>[CR] **Response**: 0000,<data>[CR][LF] If all OK, else NNNN[CR][LF] (NNNNN = Error code) *Note: <data> in response code refers to the specific measurement data set returned based on the data code sent to the instrument. Refer to the Data Code section for details..*
E	**Purpose**: Full Duplex (Echo) ON / OFF **Syntax**: E[CR] **Response**: None
F	**Purpose**: Measure frequency of light source **Syntax**: F[CR] **Response**: 0000,ff.ff Hertz (Period = nnnnn milliseconds) If all OK else NNNN[CR][LF] (NNNN = Error code)
I	**Purpose**: Return instrument status / error report **Syntax**: I[CR] **Response**: 0000[CR][LF] If all OK, else NNNN[CR][LF] (NNNN = Error code)
L	**Purpose**: Assign measurement description **Syntax**: L<Character String with max length of 20 characters>[CR] **Response**: 0000[CR][LF] If all OK, else NNNN[CR][LF] (NNNN = Error code) Note: Entry remains valid for the duration of the current Remote Mode session or until a new L command is issued. If L[CR] is issued with an empty string, the current description is returned.
M	**Purpose**: Make a Measurement with the PR-6XX **Syntax**: M<data code>[CR] **Response**: 0000,<data>[CR][LF] If all OK, else NNNN[CR][LF] (NNNN = Error code) *Note: <data> in response code refers to the specific measurement data set returned based on the data code sent to the instrument. Refer to the Data Code section for specific information.*
Q	**Purpose**: Quit (Exit) Remote mode Syntax: Q Response: None

Command	Description
R	**Purpose**: Recall stored measurement data from the PR-6XX **Syntax**: R<data code>,<Measurement #>,<filename.ext>[CR] **Response**: 0000,<data>[CR][LF] If all OK, else NNNN[CR][LF] (NNNN = Error code) **Special Syntax** 1 (Recall from RAM only): **Syntax**: R<data code>,0[CR] Recall last written measurement **Response**: 0000,<data>[CR][LF] If all OK, else NNNN[CR][LF] (NNNN = Error code) **Special Syntax** 2 (Recall from RAM only): **Syntax**: R<data code>,+[CR] Increments the Measurement ID (measurement number) and recalls the data. **Response**: 0000,<data>[CR][LF] If all OK, else NNNN[CR][LF] (NNNN = Error code) *Note: If data code is not specified, code 1 will be sent. If filename.ext is not specified, data returned will be that stored in the internal memory (RAM) of the instrument instead of the SD card.* *<data> in response code refers to the specific measurement data set returned based on the data code sent to the instrument. Refer to the Data Code section for specific information.*
S	**Purpose**: Assign instrument and measurement set up parameters **Syntax**: S[specifier][CR] **Response**: 0000[CR][LF] If all OK, else NNNN[CR][LF] (NNNN = Error code)
X	**Purpose**: Set the display contrast . **Syntax**: Xnnn where nnn is the contrast in % - Range 0 to 100% **Response**: "Contrast set to nnn %" See the Setup Command section for complete details
Z	**Purpose**: Enable Reset Command Mode **Syntax**: ZEnableReset **Response**: 00000,Reset Commands Enabled **Reset Commands:** ZResetPreferences – Reset all Preferences values to factory default. ZResetSetup – Reset all Setup values to factory default. *NOTE: All Reset Commands will shut down the instrument after they are executed.*

SETUP COMMANDS

Setup Commands are used to specify instrument and measurement parameters for the next measurement. To specify more than one parameter, sequential setup commands may be sent to the instrument before the measurement is initiated.

The default parameters are those used during the measurement immediately before Remote Mode operations are initiated. If Remote Mode operations are under way, the default setup values for the upcoming measuring are those defined in the last Setup (S_ command).

Setup Command	Description
SA	**Select Add-on Accessory 1** An Add-on accessory is one that is used in conjunction with a primary accessory. For example, a neutral density filter (Add-on Accessory) used with the MS-75 (Primary Accessory). Up to 3 Add-on accessories can be specified for a measurement. **Syntax**: SAn[CR] **Where**: n = Accessory code **Response**: 0000[CR][LF] If all OK, else NNNN[CR][LF] (NNNN = Error code) *Note: Accessory Codes can be found by running report 116 (command D116). See the Data Codes section for specific details.*
SB	**Select Add-on Accessory 2** An Add-on accessory is one that is used in conjunction with a primary accessory. For example, a neutral density filter (Add-on Accessory) used with the MS-75 (Primary Accessory). Up to 3 Add-on accessories can be specified for a measurement. **Syntax**: SBn[CR] **Where**: n = Accessory code **Response**: 0000[CR][LF] If all OK, else NNNN[CR][LF] (NNNN = Error code) *Note: Accessory Codes can be found by running report 116 (command D116). See the Data Codes section for specific details.*

Setup Command	Description
SC	**Select Add-on Accessory 3** An Add-on accessory is one that is used in conjunction with a primary accessory. For example, a neutral density filter (Add-on Accessory) used with the MS-75 (Primary Accessory). Up to 3 Add-on accessories can be specified for a measurement. **Syntax**: SCn[CR] **Where**: n = Accessory code **Response**: 0000[CR][LF] If all OK, else NNNN[CR][LF] (NNNN = Error code) *Note: Accessory Codes can be found by running report 116 (command D116). See the Data Codes section for specific details.*
SD	**Select Dark Current Mode (PR-670 only)** Two dark current modes are available – Standard and Smart Dark. In Standard Mode, the instrument measures the detector dark current after each light measurement. If Smart Dark is enabled and two successive measurements yield the same exposure time then the dark current values from the first measurement are used for the second (and possibly successive) measurements. **Syntax**: SDn[CR] **Where**: n=Dark Current Mode 0 = Disable Smart Dark 1 = Enable Smart Dark **Response**: 0000[CR][LF] If all OK, else NNNN[CR][LF] (NNNN = Error code)

Setup Command	Description
SE	**Select Exposure Time** Enter the Exposure (Integration) time for the next measurement in milliseconds. Possible values are 6 – 6,000 (6 sec.) for *Standard Mode, and* 6 - 30,000 (30 sec.) for *Extended Mode.* See the H specifier for more information on setting *Standard* or *Extended* Modes. To set the instrument to **Adaptive Exposure,** send **SE0** (ttttt = 0) **Syntax**: SEttttt[CR] **Where**: ttttt = exposure time in milliseconds **Response**: 0000[CR][LF] If all OK, else NNNN[CR][LF] (NNNN = Error code) *Note: Standard and Extended modes apply only to PR-670. PR-655 exposure range is 3 to 6,000 ms*
SF	**Aperture Select (PR-670 only)** Select the aperture to be used for the next measurement. **Syntax**: SFa[CR] **Where**: a = aperture code **Response**: 0000[CR][LF] If all OK, else NNNN[CR][LF] (NNNN = Error code) *Note: See Data Code 117 for details on aperture codes.*
SG	**Speed Mode (PR-670 only)** Select the Speed Mode for the next measurement. Choices are Normal, 1X Fast, 2X Fast and 4X Fast. **Syntax**: SGg[CR] **Where**: g = Gain 0 = Normal (DEFAULT), 1 = 1X for AC sources, 2 = 10X 3 = 100X **Response**: 0000[CR][LF] If all OK, else NNNN[CR][LF] (NNNN = Error code)

Setup Command	Description
SH	**Sensitivity Mode (PR-670 only)** Select the Sensitivity Mode for the next measurement. The two available modes are Standard and Extended. In *Standard* Mode, the exposure time range is 6 ms to 6,000 ms (6 sec.). In *Extended* Mode, the upper limit is extended to 30,000 ms (30 sec.). **Syntax**: SHm[CR] **Where**: m = Sensitivity Mode 0 = Standard Mode 1 = Extended Mode **Response**: 0000[CR][LF] If all OK, else NNNN[CR][LF] (NNNN = Error code)
SK	**User Sync Frequency** Enter the frequency (in Hertz) of the source being measured. The range is 20 to 400 Hz. This command works in unison with the *SYNC Mode* setting. See the S specifier for complete details on setting the *SYNC Mode.* **Syntax**: SKfff[CR] **Where**: fff = frequency in Hertz. Range is 20 to 400 **Response**: 0000[CR][LF] If all OK, else NNNN[CR][LF] (NNNN = Error code)
SN	**Cycles to Average** Defines the number of measurements (cycles) to average when calculating photometric and colorimetric values. The average of the spectra are used to calculate other values. The range of cycles to average is 1 to 99. The default is 1. **Syntax**: SNaa[CR] **Where**: aa = Cycles to Average Range 1 to 99 **Response**: 0000[CR][LF] If all OK, else NNNN[CR][LF] (NNNN = Error code)

Setup Command	Description
SO	**CIE Observer** Photometric and Colorimetric values can be calculated using either CIE 2° or 10° Standard Observer data sets. Use this specifier to choose the CIE data set for calculations for the next measurement. The default is 2°. **Syntax**: SOn[CR] **Where**: n = CIE Observer 2 = 2° 10 = 10° **Response**: 0000[CR][LF] If all OK, else NNNN[CR][LF] (NNNN = Error code)
SP	**Primary Accessory** A Primary Accessory is one that replaces the standard objective lens (typically the MS-75) during use and can be used in conjunction with an Add-on Accessory. **Syntax**: SPnn[CR] **Where**: nn = Accessory Code **Response**: 0000[CR][LF] If all OK, else NNNN[CR][LF] (NNNN = Error code) *Note: Accessory Codes can be found by running report 116 (command D116). See the Data Codes section for specific details.*

Setup Command	Description
SS	**Sync Mode** Instructs the instrument to adjust the exposure time, when using Adaptive Sensitivity mode, to the nearest even multiple of the refresh rate (frequency) of the source. Choices are *No Sync, Auto Sync, and User Frequency.* In *Auto Sync* mode, the instrument measures the frequency of the source to determine its period. The exposure time is then automatically altered so that it is an even multiple of the source period (1/frequency). *User Frequency* will adjust the exposure time based on a user enter frequency in Hertz as entered using the SK command. See the *User Sync Frequency* section for more details on defining the Sync frequency. **Syntax**: SSf[CR] **Where**: f = Sync mode 0 = No Sync 1 = Auto Sync 3 = User Frequency **Response**: 0000[CR][LF] If all OK, else NNNN[CR][LF] (NNNN = Error code)
SU	**Photometric Units** Select *English* or *Metric (SI)* photometric values to be reported in the applicable Data Codes. **Syntax**: SUn[CR] **Where**: n = Units type 0 = English 1 = Metric (SI) **Response**: 0000[CR][LF] If all OK, else NNNN[CR][LF] (NNNN = Error code)

MEASUREMENT AND DATA SEND CODES

Measurement and Data Send Codes are used to measure (**M** Command) and then specify returned data or acquire values without making a measurement (**D** command).

Either a **D** or an **M** can precede any of the following codes. For example, *M1 or D1 – M602 or D602*. If an M command is sent, a measurement will always be made even if the Data Code does not request measured values. For example, if *M116* is sent to the instrument, a measurement is made then a list of accessories is returned from the instrument.

In the following table, **qqqqq** is the returned error code. If **qqqqq** is all zeros (00000) no error has occurred during the request. All other values for **qqqqq** relate to an error condition. Refer to the Remote Mode Error Code section of the manual for a complete list of error codes and their meanings. **UUUU** in the output format is the photometric unit type of the measurement per the following table:

Type	Code	Units	
Luminance	111	fL	cd/m²
Radiance	11	W/sr/m²	
Illuminance	112	fc	lux
Irradiance	12	W/m²	
Luminous Intensity	113	mcd	
Radiant Intensity	13	W/sr	
Luminous Flux	114	lumens	
Radiant Flux	14	Watts	

TABLE 9 - PHOTOMETRIC UNITS CODES

Note: ***Both qqqqq and UUUU are contained in every output and are not annotated below.***

All data fields are fixed length (except where otherwise noted) and comma delimited. Commas also serve as placeholders for empty fields.

DATA CODE SUMMARY

The following table summarizes Data Codes and their meanings. For full details, please see the Expanded Code table following.

Data Code	Description
0	status (Write to disk most recent, unsaved, measurement)
1	status, units, Photometric brightness, CIE 1931 x,y
2	status, units, CIE 1931 Tristimulus Values
3	status, units, Photometric brightness, CIE 1976 u', v'
4	status, units, Photometric brightness, Correlated Color Temperature, Deviation from Planck's Locus in 1960 u,v units
5	status, units, Peak Wavelength, Integrated Power, Integrated Photon, WL, Spectral Data at each WL
6	status, units, Photometric brightness, CIE 1931 x, y, CIE 1976 u', v'
7	status, units, Photometric brightness, CIE 1960 x, y
8	status, Raw (uncorrected) light per pixel
9	status, Raw (uncorrected) Dark Current per pixel
11	status, units, Scotopic Brightness
12	status, units, Photometric brightness, CIE 1931 x, y, CIE 1960u, v
13	status, Gain description, exposure time in milliseconds
14	status, Sync mode description, sync period in milliseconds
110	status, Instrument Serial Number
111	status, Instrument Name
112	status, Number of Accessories, Number of Apertures
114	status, Software Version
116	status, Accessory List
117	status, Aperture List
120	status, Hardware configuration
401	status, Number of stored measurements in RAM
402	status, Directory of stored measurements in RAM
411	status, List of files in SD Card and number of stored measurements per file.
412	filename ,status, Directory of stored measurements in file "filename" in SD card.
502	status, Current System Timing & Environment Info.
503	status, Stored System Timing & Environment Info.
601	status, Current Setup Report – comma delimited
602	status, Current Setup Report, Verbose

TABLE 10 - DATA CODE SUMMARY

Data Code Details

The following table details available Data Codes including data examples. Each field is comma delimited. Most fields are fixed length, however some are variable length and are indicated as such.

As mentioned earlier in this section, these commands may be attached to a **D** or **M** command - for example, **M5** or **D5.** Commands may not be combined.

To make a measurement and return more than one data type, first send the **M** command with the first response code, the send successive codes using the **D** command until all required data types have been returned.

Data Code	Description
1	**Output Format**: qqqqq,UUUU,Y.YYYe+ee,x.xxxx,y.yyyy[CRLF] **where**: Y = Photometric brightness (e.g. Luminance or Illuminance etc.) e = exponent x = CIE 1931 x y = 1931 y --- **Output Example**: 00000,0,1.865e+01,0.4035,0.4202
2	**Output Format:** qqqqq,UUUU,X.XXXe+ee, Y.YYYe+ee, Z.ZZZe+ee CRLF **where:** U=Units, X = CIE 1931 Tristimulus X (Red) Y = CIE 1931 Tristimulus Y (Green) Z = CIE 1931 Z (Blue) --- **Output Example**: 00000,0,6.136e+01,1.865e+01,2.681e+01
3	**Output Format**: qqqqq,U,Y.YYYe+ee,u'.u'u'u',v'.v'v'v' CRLF **where**: Y = Photometric brightness (e.g. Luminance or Illuminance etc.) e = exponent u'=CIE 1976 u' v'=CIE 1976 v' --- **Output Example**: 00000,0,1.865e+01,0.2231,0.5227

Data Code	Description
4	**Output Format**: qqqqq,U,Y.YYYe+ee,CCCCC,d.dddd CRLF **where**: Y = Photometric brightness (e.g. Luminance or Illuminance etc.) e = exponent CCCCC = Correlated Color Temperature in Kelvins d.dddd = CIE 1960 deviation from Planck's Black Body Radiator locus --- **Output Example** 00000,0,1.865e+01, 3757,0.0129
5	**Output Format**: qqqqq,UUUU,w.wwwe+eee,i.iiie-ee,p.pppe+eeCRLF **where**: w.www = peak wavelength e = exponent i.iii = integrated radiometric value (sum of all spectral data times WL increment) p.ppp = integrated photon radiometric value wl,spectral dataCRLF wl,spectral dataCRLF wl,spectral dataCRLF --- **Output Example**: 00000,0,0.000e+000,1.827e-01,5.147e+01 380,1.627e- 382,9.910e-07 384,5.356e-06 386,5.725e-06 388,8.989e-06 390,1.127e-05
6	**Output Format**: qqqqq,UUUU,Y.YYYe+ee,x.xxxx,y.yyyy,u'.u'u'u'u', v'.v'v'v'v'CRLF **where**: Y.YYY = Photometric brightness (e.g. Luminance or Illuminance etc.) e.ee = exponent x,xxxx = CIE 1931 x y.yyyy = CIE 1931 y u'.u'u'u'u' = CIE 1976 u' v'.v'v'v'v' = CIE 1976 v' --- **Output Example**: 00000,0,2.041e+01,0.4089,0.4151,0.2283,0.5215

Data Code	Description
7	**Output Format**: qqqqq,UUUU,Y.YYYe+ee,u.uuuu,v.vvvv CRLF **where**: Y.YYY = Photometric brightness (e.g. Luminance or Illuminance etc.) e.ee = exponent u.uuuu = CIE 1976 u v.vvvv = CIE 1976 v --- **Output Example**: 00000,0,2.646e+03,0.2081,0.3519
8	**Output Format**: qqqqq, CRLF, lllll CRLF, lllll CRLF, lllll CRLF …… **where**: lllll = Raw signal (light) data (variable length from 1 to 5 digits) for all detector pixels from 0 to 255. --- **Output Example**: 00000, 3475 3426 3477 3451 3483 3459
9	**Output Format**: qqqqq, CRLF, ddddd CRLF, ddddd CRLF, ddddd CRLF **where**: ddddd = Raw signal (dark current) data (variable length from 1 to 5 digits) for all detector pixels from 0 to 255. --- **Output Example**: 00000, 120 135 122 130 131 123
11	**Output Format**: qqqqq,UUUU,S.SSSe+eeCRLF **where**: S.SSS = scotopic luminance, e+ee = exponent --- **Output Example**: 00000,0,3.668e+01

Data Code	Description
12	**Output Format**: qqqqq,UUUU,Y.YYYe+ee,x.xxxx,y.yyyy,u'.u'u'u', v'.v'v'v'v'CRLF **where**: Y.YYY = Photometric brightness (e.g. Luminance or Illuminance etc.) e.ee = exponent x.xxxx = CIE 1931 x, y.yyyy = CIE 1931 y u.uuuu = CIE 1960 u v.vvvv = CIE 1960 v --- **Output Example**: 00000,0,2.041e+01,0.4089,0.4151,0.2283,0.3477
13	**Output Format**: qqqqq,Gain description,nnnnnn msec CRLF **where**: Gain Description is a text description of the Gain Used **Possibilities are**: Normal, Fast, 2X Fast and 4X Fast nnnnnn = Last exposure time in milliseconds --- **Output Example**: 00000,Fast,16500 msec
14	**Output Format**: qqqqq,Sync mode description,nnnnnn Hertz CRLF **where**: Sync mode description = Sync mode in use. Possibilities are: Auto Sync, User Sync, None nnnnnn = Sync Frequency in Hertz --- **Output Example**: 00000,User Sync,120.00 Hertz
110	**Output Format**: qqqqq,ssssssss CRLF **where**: ssssssss = Instrument Serial Number --- **Output Example**: 00000,67065106
111	**Output Format**: qqqqq,mmmmmmCRLF **where**: mmmmmm = Instrument Model --- **Output Example**: 00000,PR-670

Data Code	Description
112	**Output Format**: qqqqq,ac,ap CRLF **where**: ac = number of calibrated accessories ap = number of calibrated apertures **Output Example**: 00000,1,4
114	**Output Format**: qqqqq,vvvvv CRLF **where**: vvvvv = Software version **Output Example**: 00000,2.22D
116	**Output Format**: qqqqq,nn,ss,tt,pp,rr CRLF **where**: nn = ID number of accessory ss = Accessory name (variable length) tt = Accessory type – Possibilities are: Primary or Addon pp = Photometry Mode – Possibilities are: Luminance, Illuminance, Luminous Intensity, or Luminous Flux rr = Radiometry Mode – Possibilities are: Radiance Irradiance Radiant Intensity or Radiant Flux **Output Example**: 00000,0,MS-75,Primary,Luminance,Radiance
117	**Output Format**: qqqqq,nn,ss,bw CRLF **where**: nn = ID number of aperture ss = Aperture Name bw = Effective Bandwidth **Output Example**: 00000,0,1 deg,0.00 00000,1,1/2 deg,0.00 00000,2,1/4 deg,0.00 00000,3,1/8 deg,0.00

Data Code	Description
120	**Output Format**: qqqqq,pp,bw,bb,ee,ii,nrp,frp,lrp CRLF **where**: pp = Number of spectral data points. bw = Bandwidth of instrument bb = Starting WL ee = Ending WL ii = WL Increment nrp = Number of detector elements pixels frp = First useable raw pixel number lrp = Last useable raw pixel number **Output Example**: 00000,201,0.00,380,780,2,256,7,247
401	**Output Format**: qqqqq CRLF **where**: qq - Number of stored measurements in RAM **Output Example**: 6
402	**Output Format**: qqqqq,dt,tm CRLF Directory of stored Measurements in RAM **where**: qq - ID of measurement dt = Date tm = Time **Output Example**: 1,01-30-2007 13:48:26 2,01-30-2007 13:49:09 3,01-30-2007 13:51:03
411	**Output Format**: filename.ext,qqqqq CRLF (List of files in SD Card). **where**: filename.ext = Filename with extension. qq = Number of stored measurements in file. **Output Example**: MK.mea, 1 TSTSAMP.mea, 2

412	**Syntax:** D412, ffffffff.eee **where: ffffffff** = filename of stored measurement file. DOS file naming convention. **eee =** filename extension **Output Format**: qqqqq,dt,tm CRLF (Directory of stored Measurements in file). **where**: **qqqqqq** = ID of measurement **dt** = Date **tm** = Time **Output Example**:
601	**Output Format**: qqqqq,<Primary Lens>, <Addon1>, <Addon2>, <Addon3>, <Aperture>, <Units>, <Exposure Mode>,<Exposure Time (see note) > ,<Gain>, <Cycles>, <CIE Observer>, DarkMode>, <SyncMode>, <CaptureMode>, <SyncPeriod>CRLF **Note**: **The exposure time reported in 601 and 602 (following) reports 0 if the instrument is set in Adaptive Exposure mode. To view the exposure time for the last measurement when the instrument is in Adaptive Exposure mode, send the D13 command.** **Output Example**: 00000,0,-1,-1,-1,0,0,0,0,0,1,2,0,0,0,60.00
602	**Output Format**: Current set report with text labels. Dark mode values: for reports [601] and [602] 0 Disable Smart Dark 1 Enable Smart Dark **Output Example**: 00000,MS-75,None,None,None,1 deg,English,Adaptive,0 msec,Normal,1 cycles,2 deg,No Smart Dark,No Sync,Standard Sensitivity,60.00 Hertz

Remote Control Error Codes

Remote Control Measurement Errors

Error	Meaning
-1	Light source not constant.
-2	Light overload – signal too intense.
-3	Cannot Sync to light source. Light source frequency below 20Hz, above 400 Hz or signal too low to Sync.
-4	Adaptive mode error.
-8	Weak light – insufficient signal.
-9	Sync Error.
-10	Cannot Auto Sync to light source.
-12	Adaptive mode time out. Light source not constant.

Remote Control Parsing Errors

Error	Meaning	Valid Values
-1000	Illegal command	
-1001	Too many fields in setup command	
-1002	Invalid primary accessory code	
-1003	Invalid Addon 1 accessory code	
-1004	Invalid Addon 2 accessory code	
-1005	Accessory is not a primary accessory	
-1006	Accessory is not an Addon accessory	
-1007	Accessory already selected	
-1008	Invalid Aperture index (PR-670 only)	
-1009	Invalid units code	0 = English 1 = Metric (SI)
-1010	Invalid Exposure value	PR-655 3 to 6000 ms PR-670 6 to 30,000 ms
-1011	Invalid Gain code	0 = Normal 1 = 1X for AC sources 2 = 10X 3 = 100X
-1012	Invalid average cycles	1 to 99

Error	Meaning	Valid Values
-1015	Invalid CIE observer	2 or 10
-1017	Invalid Dark measurement mode	0 = Disable Smart Dark 1 = Enable Smart Dark
-1019	Invalid Sync mode	0 = No Sync 1 = Auto Sync 3 = User Frequency
-1021	Measurement title too long	> 20 characters
-1022	Measurement title field empty after sending L command	
-1023	Invalid user Sync period	20 to 400 Hz
-1024	Invalid R command	
-1025	Invalid Addon 3 accessory code	
-1026	Invalid sensitivity mode	0 = Standard Mode 1 = Extended Mode
-1035	Parameter not applicable to this instrument	
-2000	This error code is returned whenever a response code is requested that does not exist, or when no other D command has been sent previously.	

ROUTINE MAINTENANCE

The PR-655 and PR-670 have been designed to give long, trouble-free service requiring minimal routine maintenance. This section gives guidelines for insuring optimum service from your instrument.

CLEANING LENSES / OPTICAL ACCESSORIES

1. Keep the PR-655 / PR-670 clean and dust-free. Store the instrument in a clean, dry environment, preferably in a storage case when not in use. Dust optical surfaces with a soft camel's-hair brush or blow them off with clean, dry air.

△ **Note: Avoid touching optical surfaces**.

2. If the exterior optical surfaces become dirty, clean them as you would any high-quality coated lens. Use lens cleaning fluid or anhydrous alcohol on a piece of lens cleaning tissue or cotton. Do not soak.

△ **Do not use acetone or other organic solvents or excessive pressure! Do not soak or allow water to enter the instrument!**

CLEANING EXTERIOR SURFACES

If the exterior plastic surfaces, such as the display face plate or instrument case becomes dirty or full of fingerprints, use a mild dish washing liquid and a slightly damp, non-abrasive cloth to gently remove fingerprints and dirt. **Do not use acetone or other organic solvents or excessive pressure!** Do not soak or allow water to enter instrument!

RECALIBRATION

The PR-655 is designed to maintain stable calibration for long periods of time and is certified for one year from the factory. However, changes in calibration are inevitable, due to the effects of aging, temperature and dirt accumulation. Therefore, for best results, periodic recalibration is recommended.

To maintain the instrument's accuracy, recalibration checks or recalibration is recommended at one year intervals. Please consult factory for availability of optional user self-calibration.

Please contact the Customer Service Department for a Return Material Authorization (RMA) number, before returning the instrument.

FACTORY REPAIR

IN-WARRANTY REPAIR

If the instrument malfunctions within the one-year warranty period, it will be repaired at no charge to the customer (provided the warranty has not been voided by tampering, physical damage or other abuse).

Note: **Any *unauthorized* tampering with the instrument, including opening of the case, automatically voids the warranty. Batteries are not covered under the warranty.**

Visit our web site, www.photoresearch.com to assign a Returned Material Authorization (RMA) number to your instrument before returning it to Photo Research for service. The entire instrument including all accessories, should be brought or shipped prepaid to the Photo Research Service Department in Chatsworth, CA, USA (or contact Photo Research for information concerning authorized repair facilities in your area).

Pack the instrument and all attachments and accessories in suitable protective packaging, along with a note describing the nature of the malfunction.

The instrument will be returned by a commercial surface transportation method of Photo Research's choice.

If Air Freight or other rapid delivery is desired, the user should include a check or money order to cover the cost of return shipping, or contact Photo Research and supply a shipper account number (e.g. FedEx, UPS etc.) to expedite collect delivery.

OUT-OF-WARRANTY REPAIR

If the instrument is out of warranty, Visit our web site, www.photoresearch.com to assign a Returned Material Authorization (RMA) number to your instrument before returning it to Photo Research for service. The instrument should be brought or shipped prepaid to the Photo Research Service Department (or call Photo Research for locations of authorized repair facilities in your area).

Pack the PR-655 and *all* attachments and accessories in suitable protective packaging along with a note describing the nature of the malfunction.

Photo Research will evaluate the damage and advise the user of the estimated repair and recalibration costs before proceeding.

SPECIFICATIONS

GENERAL SPECIFICATIONS

PR-655

Parameter	Specification
Detector	128 detector array
Aperture	1° (1/2° optional)
Wavelength Range	380 to 780 nm
Optics	Pritchard viewing and measuring system.
Digital Resolution	16 bits
Spectral Resolution	3.12 nm / pixel
Spectral bandwidth	8 nm (5 nm optional)
Spectral Accuracy	± 1 nm
Luminance accuracy (Against NIST luminance standard)	± 2%
Luminance repeatability	± 1% at 3 cd/m2

Color Accuracy (for Illuminant A)	±0.0015 in CIE 1931 x,y
Measurement Capabilities	Luminance, Illuminance, luminous intensity, chromaticity, correlated color temperature, dominant wavelength.
Measurement Time	3 ms to 6 secs.
Battery	Rechargeable Lithium-Ion. (12 hours continuous operation)
Secure Digital (SD) Card	Supports cards up to 1GB
Weight	3.75 lbs (1.7 kg)
Operating Temperature	34° to 95° F (1° to 35° C)

PR-670

Parameter	Specification
Detector	256 detector array
Aperture	1°,1/2°, 1/4°, 1/8°
Wavelength Range	380 to 780 nm
Optics	Pritchard viewing and measuring system.
Digital Resolution	16 bits
Spectral Resolution	1.56 nm / pixel
Spectral bandwidth	8 nm (5 nm optional)
Spectral Accuracy	± 1 nm
Luminance accuracy (Against NIST luminance standard)	± 2%
Luminance repeatability	± 1% at 3 cd/m^2
Color Accuracy (for Illuminant A)	±0.0015 in CIE 1931 x,y
Measurement Capabilities	Luminance, Illuminance, luminous intensity,

	chromaticity, correlated color temperature, dominant wavelength.
Measurement Time	6 ms to 30 secs.
Battery	Rechargeable Lithium-Ion. (>12 hours continuous operation)
Secure Digital (SD) Card	Supports cards up to 1GB
Weight	3.75 lbs (1.7 kg)
Operating Temperature	34° to 95° F (1° to 35° C)

PR-655 / PR-670 Lens Chart

		Aperture			
Accessory	**Working Distance**	**1°**	**1/2° (Optional for PR-655)**	**1/4°(PR-670 Only)**	**1/8° (PR-670 Only)**
MS-75 (355mm to ∞)	355 mm to 305 m	5.25 mm 5.32 m	2.63 mm 2.66 m	1.315 mm 1.33 m	0.658 mm 665 mm
SL-0.5X	91.4 mm to 137 mm	1.5 mm to 2.54 mm	0.75 mm to 1.27 mm	0.375 mm to 0.635 mm	0.188 mm to 0.318 mm
SL-1X	46 mm to 66 mm	0.890 mm to 1.32 mm	0.445 mm to 0.660 mm	0.226 mm to 0.330 mm	0.111 mm to 0.165 mm
MS-2.5X	46 mm	0.51 mm	0.225 mm	0.128 mm	0.064 mm
MS-5X	28 mm	0.289 mm	0.145 mm	0.072 mm	0.036 mm
MS-7.5 (100mm to ∞)	100 mm 3.05 m	17.5 mm 530 mm	4.38 mm 133 mm	1.09 mm 33.1 mm	0.273 mm 0.828 mm
LA-600	Contact	13.2 mm	13.2 mm	13.2 mm	13.2 mm
FP-600	Contact	3.17 mm	3.17 mm	3.17 mm	3.17 mm

TABLE 11. PR-655/670 MEASUREMENT SPOT SIZES

PR-655 Sensitivity Chart (cd/m²)

	Aperture	
Accessory	**1°**	**1/2° (optional)**
MS-75	3.4 to 102,800	13.6 to 411,100
SL-0.5X	3.4 to 102,800	13.6 to 411,100
SL-1X	3.4 to 102,800	13.6 to 411,100
MS-2.5X	10.3 to 310,700	41.2 to 1,243,000
MS-5X	13.7 to 310,700	54,800 to 1,243,000
MS-7.5	3.4 to 102,800	13.6 to 411,100
LA-600	3.4 to 102,800	13.6 to 411,100
FP-600	8.6 to 260,000	34.4 to 1,040,000
CR-600	21.5 to 651,000 lux	86 to 2,604,500 lux

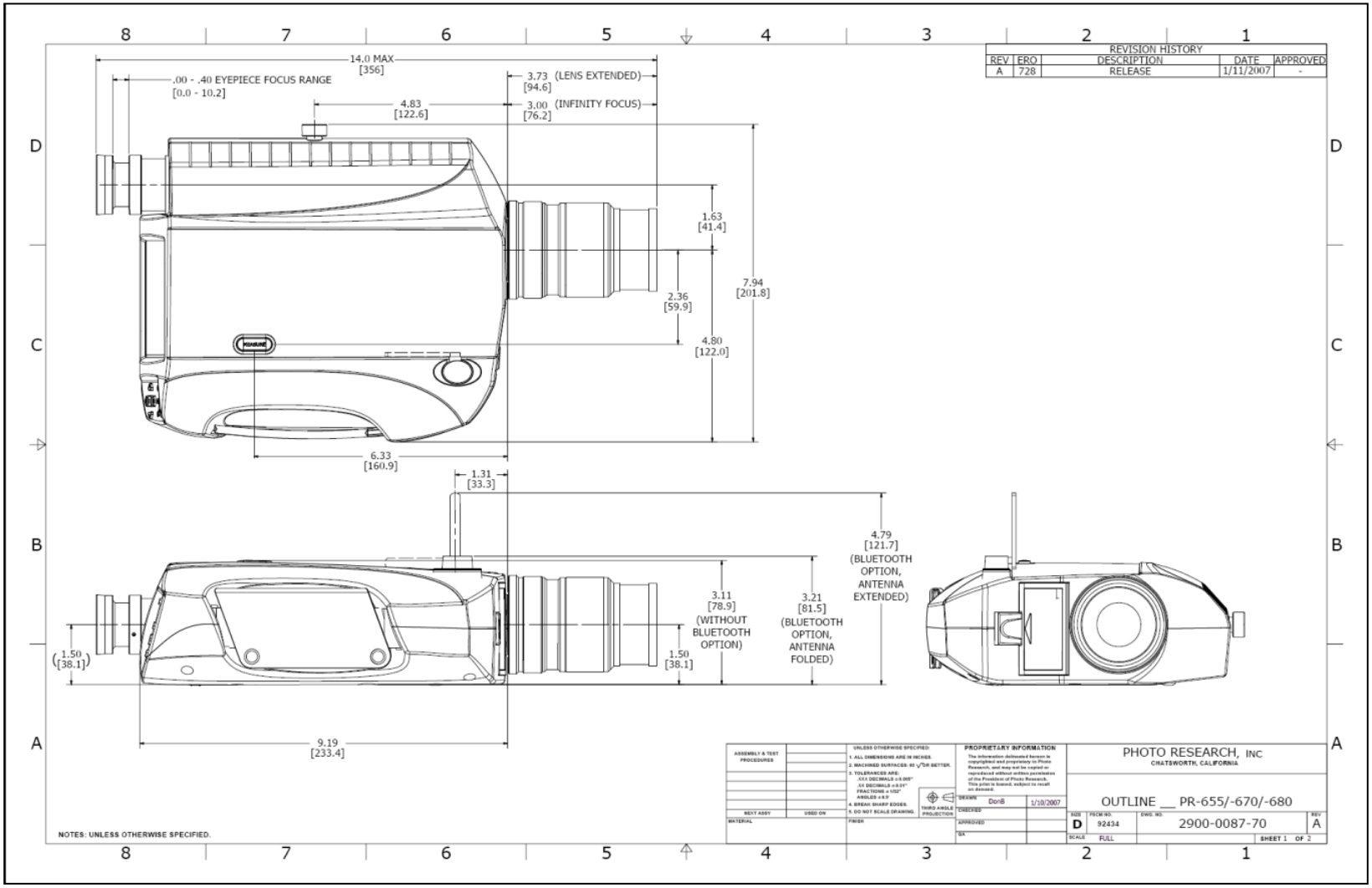
TABLE 12 - PR-655 SENSITIVITY

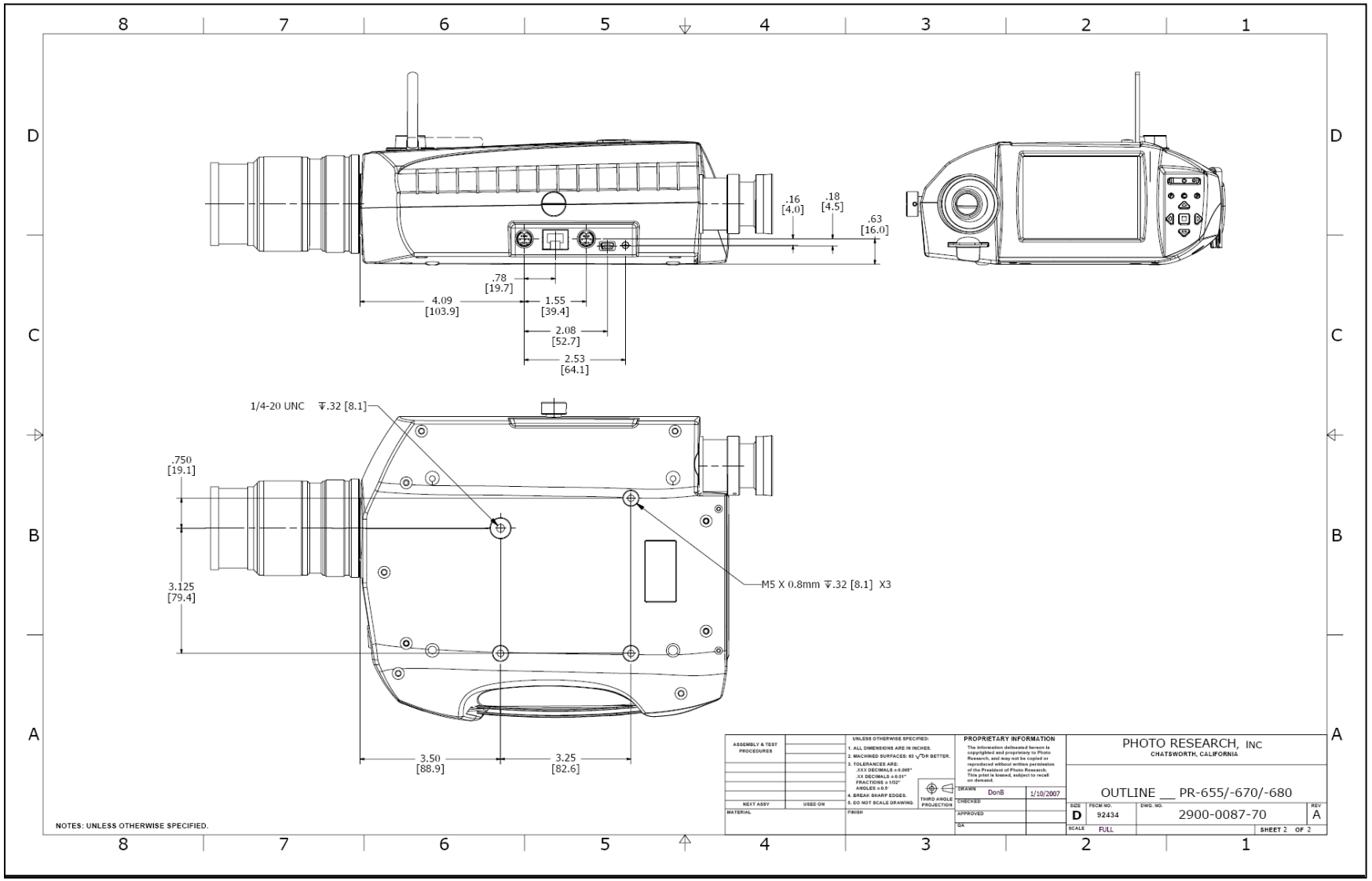
PR-670 Sensitivity Chart

	Aperture			
Accessory	**1°**	**1/2°**	**1/4°**	**1/8°**
MS-75	0.2 to 17,190 cd/m²	0.80 to 68,750 cd/m²	3.20 to 275,000 cd/m²	12.8 to 1,100,000 cd/m²
SL-0.5X	0.2 to 17,190 cd/m²	0.80 to 68,750 cd/m²	3.20 to 275,000 cd/m²	12.8 to 1,100,000 cd/m²
SL-1X	0.2 to 17,190 cd/m²	0.80 to 68,750 cd/m²	3.20 to 275,000 cd/m²	12.8 to 1,100,000 cd/m²
MS-2.5X	1.25 to 50,000 cd/m²	5.00 to 200,000 cd/m²	20.0 to 800,000 cd/m²	80.0 to 3,200,000 cd/m²
MS-5X	1.75 to 70,000 cd/m²	7.00 to 280,000 cd/m²	28.0 to 1,120,000 cd/m²	112 to 4,480,000 cd/m²
MS-7.5	0.2 to 17,190 cd/m²	0.80 to 68,750 cd/m²	3.20 to 275,000 cd/m²	12.8 to 1,100,000 cd/m²
LA-600	0.2 to 17,190 cd/m²	0.80 to 68,750 cd/m²	3.20 to 275,000 cd/m²	12.8 to 1,100,000 cd/m²
FP-600	1.00 to 40,000	N/A		
CR-600	2.5 to 107,500 lux	N/A		

TABLE 13 - PR-670 SENSITIVITY TABLE

PR-655 / PR-670 Outline Drawings




.16
[4.0]
.18
[4.5]
.63
[16.0]
.78
[19.7]
4.09
[103.9]
1.55
[39.4]
2.08
[52.7]
2.53
[64.1]
1/4-20 UNC ↧.32 [8.1]
.750
[19.1]
3.125
[79.4]
M5 X 0.8mm ↧.32 [8.1] X3
3.50
[88.9]
3.25
[82.6]
NOTES: UNLESS OTHERWISE SPECIFIED.
PROPRIETARY INFORMATION
PHOTO RESEARCH, INC
CHATSWORTH, CALIFORNIA
OUTLINE __ PR-655/-670/-680
DRAWN DonB 1/10/2007
SIZE D
FSCM NO. 92434
DWG. NO. 2900-0087-70
REV A
SCALE FULL
SHEET 2 OF 2