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PHOTO RESEARCH, INC.

PHOTO RESEARCH®, INC.

PR-650 SpectraScan®
SpectraColorimeter™
Instruction Manual

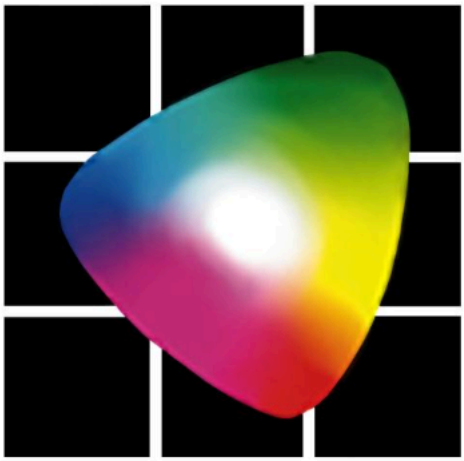


Photo Research®, Inc.
9731 Topanga Canyon Place
Chatsworth, CA 91311-4135
Phone: (818) 725-9750
Fax: (818) 725-9770
Home Page: www.photoresearch.com

PHOTO RESEARCH®

PR-650 SpectraScan®
SpectraColorimeter™

Operating Manual

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Conventions

This manual uses the following typeface, style, and design to present information.

Bold typeface within text highlights important information, and denotes specific keys and steps in procedures.

Italic typeface is used to emphasize certain information and to refer the user to other sections of the document.

NOTES emphasize important information.

CAUTIONS give information concerning possible damage to equipment when using instruments improperly.

Cautions are denoted by the symbol: 

WARNINGS stress the possibility of bodily harm resulting from improper use of the equipment.

Warnings are denoted by the symbol:

Customer Support

Photo Research has support services available to users in case of problems using the PR-650.

Photo Research personnel are available from 8:45 a.m. to 3:45 p.m. (Pacific time), Monday through Friday, except on legal holidays to aid in troubleshooting system problems. The telephone number is **(818) 725-9750**.

Before calling the Photo Research PR-650 Application Engineers, please have the following information ready:

- Instrument serial number
- Software version
- Manuals
- Hardcopy printouts of test data to be faxed to Photo Research to aid in troubleshooting. The fax number is **(818) 725-9770**

Precautions

Although the PR-650 is fairly rugged, it is, nonetheless, a precision optical instrument. Therefore, by taking a few simple precautions, the instrument is designed to give many years of service.

△ Do not drop the instrument or subject it to excessive shock or vibration. Store the instrument and all accessories in the optional carrying case or safely away when not in use.

△ Do not expose the instrument to prolonged periods of high humidity (90% non-condensing) or to temperatures below -4°F (-20°C) or above 149°F (65°C). When the instrument is outdoors in direct sunlight, place a white cloth or other shield over the instrument to prevent overheating. Never leave the instrument on the seat of a car on a sunny day.

△ Operating at temperatures above 104°F (40°C) may result in excessive “dark current” and temporary erratic noisy readings. Excessive dark current should disappear shortly after the instrument is returned to a normal operating environment.

△ Do not allow acetone or other organic solvents to come into contact with the instrument. Do not soak or allow water or other liquids to enter the instrument.

△ Remove the battery pack from the instrument before *extended* storage to prevent damage from battery leakage.

△ Removing the ICM Card with power *ON* or the ICM Card battery with power *OFF* will result in ICM Card memory loss.

△ Make back-up copies of the SAVE/RESTORE software diskettes included with this manual.

△ Charge the battery(ies) upon receipt of the instrument. Removal of the battery from the unit for longer than a few days causes the internal clock to lose power.

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Chapter 1 - System Description

General Description

The PR-650 SpectraColorimeter™ is a portable, spectrally- based telephotometer/colorimeter. It is the latest in the Photo Research family of SpectraScan® *fast scanning* instruments and can perform complete photometry, colorimetric, and radiometric measurements in a fraction of a second. The PR-650 unit includes Pritchard® -style viewing and measuring optics, a holographic grating, diode- array spectrometer, a CMOS microcomputer, a back-lit super-twist Liquid Crystal Display (LCD) read-out, an Integrated Circuit Memory (ICM) Card, and a rechargeable battery — all in a convenient hand-held instrument.

The complete PR-650 system includes the MS-75 Macro-Spectar® Objective Lens, a Nicad Battery Trickle Charger, back-up SAVE/ RESTORE software on a 3-1/2" floppy diskette, an RS-232 cable with adaptors, and the PR-650 SpectraScan Operating Manual.

The 256K ICM Card includes the PR-650 operating program, correction factors, and memory storage for at least 150 measurements. An optional 512K ICM Card allows storage of over 580 measurements.

The optional light-weight heavy-duty foam-lined carrying case safely stores the system components with space for additional accessories including an RS-2 Reflectance Standard, additional batteries and an AC Adaptor and Rapid Charger.

Figure 1-1: PR-650

The input optics (MS-75 macro objective lens) enable the PR-650 to perform a variety of measurements. These include: luminance, illuminance, integrated and peak radiance, chromaticity, color temperature, color difference, and source refresh frequency.

The optional RS-2 Reflectance Standard (Halon) can be used with the PR-650 to measure illuminance/ irradiance and reflectance. Other optical accessories are also available to further extend the versatility of the PR-650 including cosine- corrected illuminance/irradiance and remote measurement with a fiber probe. To realize the smallest spot size (0.052", 1.38mm) that the PR-650 can measure, the optional SL-1X (supplementary lens) can be used.

Each nicad battery, rechargeable in 15 hours using the Trickle Battery Charger, (or one hour with the optional AC Adaptor/Rapid Charger) provides at least two hours of continuous operation when used without the LCD back lighting.

Back lighting of the LCD screen can turned off, or set to one of three light levels to enable optimum viewing under various ambient light conditions by repeatedly pressing the O/I LITE key (to the far right on the Display Panel).

An alternative "Energy Saving" power option helps extend battery life by providing automatic shut-off of the unit after three minutes when no key is pressed.

To give the user advance notice and minimize possible data loss when the Main Battery or ICM Cad battery begin to lose power, the messages "MAIN BATTERY" and/or "RAM CARD BATTERY" begin to flash in a LOW BATTERY WARNING screen.

The PR-650 has been designed with a standard tripod mount for stability along with a leather covered nylon strap that can be adjusted to fit securely over the hand when making measurements that require portability. An optional AC Adaptor/Rapid Charger is available for use where portability of the unit is not essential.

The RS-232 (CTRL/XFER) cable equipped with a 25-pin sub D connector (and optional 25 to 9-pin converter and gender changers) enables the user to connect the PR-650 to a Host PC serial port for remote control or bi-directional data transfer. Printouts of measurement data are also possible with the PR-650 via direct connection to a serial printer using an optional RS-232 printer cable (Part No. PC-650).

Hardware Set-Up

Although there is minimal setup involved in preparing the PR-650 to make measurements, the next section should be carefully reviewed to verify that all connections are correct, and that all components are correctly installed before turning the unit on.

Objective Lens

The instrument should arrive with the MS-75 objective lens installed. If it is not, attach the threaded end of the lens to the front of the PR-650 (See Figure 1-1). Then, grasping the lens by the small band *(the band embossed with the words Photo Research closest to the threaded end),* turn it clockwise to tighten it securely. Turn the lens counter-clockwise to remove it. The wide knurled band on the lens is used for focusing. Check that the lens cap has been removed prior to using the instrument.

ICM Card

Generally, the unit arrives with the ICM Card in place. The ICM Card should always remain in the unit. The only times when it should be removed are: if it has not been installed correctly and an error message appears when the unit is turned on, or if the present ICM Card is to be stored and a new card installed.

Figure 1-2 on the next page gives an example of an ICM Card showing where the card components are located. In certain cards, however, the positions of the Write Protect and the Battery may be reversed. Therefore, it is important to insert the card with the label “THIS SIDE UP” in the correct position.

Figure 1-2: ICM Card Components

When the 3-volt lithium battery for the ICM Card begins to lose energy, the message "RAM CARD BATTERY" will begin flashing in a LOW BATTERY WARNING screen.

Under normal conditions, the ICM Card battery should last for about two years. However, if the ICM battery should need replacement, it must be removed and replaced *while the ICM Card remains installed in the PR-650 with the power ON.*

If the battery is removed from the ICM Card while the card is out of the instrument, all data on the card is lost necessitating a complete restore of the utility program RESTR650 (included on the SAVE/ RESTORE diskette).

To remove the battery, simply release the battery lock using a pen point (or similar object) while the card remains in the unit, and slide out the battery holder containing the battery. Replace the battery in the holder and slide it back into the card; it automatically locks in when reinstalled.

△ Turn ***OFF*** power to the unit before inserting or removing the ICM Card. Inserting or removing the card at any time when the power is *on* causes memory loss that will require restoring program memory.

The following procedures explain how to remove and reinsert the ICM Card, and how to change the write protect tab.

Removing the ICM Card

Step 1 Turn *off* the power to the PR-650 by pressing and holding down the *red* **0/I** button until the screen goes blank (about a second).

Step 2 Remove the ICM Card by first placing the PR-650 on a flat surface (such as a table or desk) with the ICM Card end of the PR-650 slightly over the edge.

Step 3 While holding onto the PR-650 securely with one hand, firmly pull out the ICM Card with the other hand by grabbing the card between the thumb and index finger and slightly moving it from side-to-side until you pull it out of the unit.

△ *Never* pull out the ICM Card unless holding securely onto the unit.

Changing the Write Protect Tab

Step 4 Change the write protect tab to write protect if storing the card; push the tab to the non-write protect position before installing into the PR-650. The PR-650 is non-functional with the ICM Card tab in the write protect position.

Locate the write protect tab (Figure 1-2) on the ICM Card, and using a pen point (or similar object), push the write protect tab to the appropriate position.

△ Do *not* use a pencil as the pencil point could break off and cause a short circuit inside the ICM Card.

Reinserting the ICM Card

△ **Turn *OFF* power** to the unit before inserting or removing the ICM Card. Inserting or removing the card at any time when the power is *on* causes memory loss that will require restoring program memory.

Step 5 Verify that the power is **OFF** by checking that the screen is blank.

Step 6 Insert the ICM Card with the arrows (connector end) pointing "in" and the label "THIS SIDE UP" visible (Figure 1-2.) The corner with the missing polarity notch should be on the upper right side facing down.

Step 7 Push the card in until it locks (there should be a tactile "click" when the card is properly inserted).

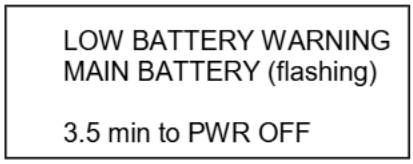
Nicad Battery

Notes: Charge the battery(ies) upon receipt of the instrument, or after non-use of the unit for a week or more.

Removal of the battery from the unit for longer than a few days causes the internal clock to lose power. Therefore, it is recommended that the user keep the battery in the unit during normal use, and remove it *only* when storing the unit for a prolonged period of time.

Since the PR-650 nicad battery lasts for about two hours of continuous use, recharging of the battery will vary depending on individual users.

To give the user advance notice and minimize possible data loss when the Main Battery begins to lose power during normal operation, the message "MAIN BATTERY" begins to flash in the LOW BATTERY WARNING screen as shown below:



After the first warning, the user will get a count down and new warning every 30 seconds for 3 1/2 minutes. At 3 1/2 minutes from the initial warning, the unit automatically powers off, necessitating replacement or recharge of the battery.

The following procedures explain the proper method for removing, recharging (using the Battery Trickle Charger), and replacing the nicad battery.

Appendix H descibes how to recharge the nicad battery using the optional AC Adaptor and Rapid Charger.

Nicad Battery Removal Procedure

Step 1 Turn the PR-650 power *off*.

Step 2 Gently, but firmly, push the battery as far as possible into the battery compartment.

Step 3 While gently pushing the battery in, press the battery release button, located on the right side of the unit, (Figure 1-1), adjacent to the battery door.

This should unlock the battery (or AC Adaptor) from the compartment.

Step 4 Release the pressure on the battery and pull it out of the compartment. Replace with a new or freshly charged battery (or use the following procedure to recharge it).

The following procedure explains how to recharge the battery using the Battery Trickle Charger.

Note: It is recommended that the user charge the battery upon receipt of the instrument or after non-use of the unit for a week or longer.

Charging the Battery Using the Battery Trickle Charger

Step 1 Verify that the Battery Trickle Charger is set to the correct line voltage (110 or 220 volts).

Using incorrect line voltage can cause severe damage to the instrument and possible injury to the user.

Step 2 Plug the battery charger into the proper AC outlet.

Step 3 If installed, remove the battery from the instrument.

Step 4 Insert the female connector of the battery charger into the receptacle of the battery (male pin) (See Figure 1-3.)

Figure 1-3: Nicad Battery Trickle Charger

Step 5 Charge for a minimum of 15 hours for a full recharge with the supplied trickle charger.

Replacing the Battery

The **Battery** is installed with the contacts end inserted first, and the locking notch on the opposite end facing to the right, towards the hand strap (See Figures 1-1 and 1-3).

When properly inserted, there will be a “click” as the locking mechanism, located inside the battery compartment, locks the battery in place.

Operation Keys

All functions of the PR-650 are performed using the eight push-button operation keys. The keys that are effective in any given screen are illustrated on-screen by icons. The most frequently used icons will appear adjacent to their respective keys after the unit has been powered-on and the user is ready to make a measurement.

The **MEAS**ure (**ABORT**) key (not shown below) is located on the top of the PR-650 next to the hand strap and can be seen in Figure 1-1. For the location of the remaining keys, refer to Figure 1-4 below. *White* lettering denotes the primary operation of the keys. *Blue* lettering denotes the alternate operation of the keys which is activated by first pressing the *blue* **ALT** key.

Figure 1-4: PR-650 Display Panel

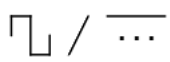
0 / I
LITE

The *red* **LITE** key turns the unit on and off, and is also used to set the back light level. The back light is used for LCD display viewing when in a dark ambient. After the unit has been turned on, the three levels of backlight intensity and backlight off can be selected in sequence by quickly pressing the **0/I** key. To turn the unit off at any time, hold down the **0/I** key until the screen goes blank (about a second).

MEASure
ABORT

The **MEAS**ure key, located on the top of the PR-650 next to the hand strap is used to initiate a measurement (see Figure 1-1). When making a measurement, press the MEAS key firmly, but quickly until the green LEDs begin to flash. Holding down the MEASure key for too long causes the unit to make continuous measurements with a wait of 0.5 seconds between measurements.

Pressing the *blue* **ALT** key and then the **MEAS**ure key will ABORT a measurement in progress and the message "OPERATOR ABORT" will appear on-screen. In screens where a measurement can be performed, a flashing measurement icon appears in the upper right hand corner of the screen indicating whether the unit is in AutoSync™ ( ) or Timed ( ) mode. In addition to this flashing icon, sometimes another letter or number which gives additional information about a measurement to the user flashes alternately with it (e.g. "1", "2", "S"...).

 **(AutoSync and Timed Mode)**

The icons shown above represent “AutoSync mode” (patent pending) or “Timed mode” respectively and their appearance (*flashing*) in the upper right corner of the screen signifies that a measurement can be made. The AutoSync mode first reads the light source refresh rate and then automatically determines the proper sync rate.

Note: When measuring in the AutoSync mode, hold the instrument extremely still. AutoSync mode may not work in high ambient light due to its inability to separate two different source frequencies.

In such a situation, for example, measuring CRTs with fluorescent ambient, shield the light source being measured from the ambient light.)

If the source is below 40 Hz or above 250 Hz, or the source is low level or DC, the AutoSync mode cannot be used. Instead, measurements must be made in the Timed (integration) mode. (See AutoSync Theory of Operation, pages 3-5, 3-6).

Generally, Timed mode is used except for measuring bright, repetitively pulsed sources without a neutral density attenuator. The Timed integration mode works by making measurements from ten milliseconds up to five seconds or more.

For the purposes of this manual, both icons will be represented in the measurement screens as “(M)” (for measurement mode) for both “Timed“ and “AutoSync” modes.

To choose the opposite mode from the one displayed, press the / mode key at any time when the measurement icon is flashing and verify that the proper mode icon has been selected.

⇧ HOST

The screen icon for this key is "⇧ " and appears on-screen after power-on above the up arrow key. The main purpose of the up arrow key is to move the cursor ">" icon up through menu selections within a screen. This key is also used to select numbers in screens requiring data entry, such as data files, or in setting the time and date.

Note: The ALT ⇧HOST key combination is not functional at this time.

⇩ PRNT

The screen icon for this key is "⇩ " and appears above the down arrow key following the initialization screens. The uses of the down arrow key are the same as for the up arrow key, except that this key moves the cursor ">" icon down instead of up.

The **ALT**⇩ **PRNT** key is used to send data to an optional printer. (See Chapter 5, Print Options for information on using a printer with the PR-650). For a printout of the most current data file or a recalled file, the user first presses the *blue* **ALT** key and then the **PRNT** key. A flashing "**P**" indicates printing is in process. The "P" disappears after all data has been sent.

The⇩ **PRNT** key can also be used to send a report to the PC under control of RS-232 communications software (such as Procomm Plus). To initiate this report, press **ALT**, then⇩ **PRNT**.

FRWD
BACK

The **FRWD key** is used for scrolling sequentially forward through the program menu screens whenever the "F" icon appears on-screen. To reach a desired screen, the user continues to press this key until the screen is reached. By pressing the **FRWD** key and holding it down, the screens continuously scroll forward.

The **FRWD** key is also used to terminate a data entry sequence, such as setting the time and date, retrieving a file number, or clearing an error message. Pressing the *blue* **ALT** key and then the **BACK** key, causes the screens to scroll in the reverse order. If **ALT** is pressed and the **BACK** key is held down, the screens will scroll in reverse (back) order automatically until the **FRWD BACK** key is released or until the Home (Current Set-Up Screen) is reached.

ENTR
LOCK

The **ENTR** key is used to select a function or individual field within a menu. The *blue* **ALT** key and the **LOCK** key are used to change an unlocked (unprotected) measurement file to a locked (protected) one, and vice versa.

ALT
The *blue* **ALT** key is used as an alternate (or *shift*) key to provide added operations to the other keys.

Pressing the **ALT** and **MEAS**ure keys aborts a measurement in progress.

Pressing the **ALT** and **FRWD BACK** keys causes the screens to scroll backwards.

Pressing the **ALT** and⇩ **PRNT** keys sends measurement data to a printer (refer to section Print and Auto Print for more information).

Pressing the **ALT** and **ENTR LOCK** keys while viewing measurement data, changes a protected file to an unprotected file, and vice versa.

Note: The **ALT**⇧ **HOST** key combination is not functional at this time.

Measurement Status Indicators (Green and Red LEDs)

The measurement status indicators are located in two different places, just above the display screen and in the viewing eyepiece optics. (Refer to Figure 1-4, PR-650 Display Panel on page 1-12.) When the unit is ready to make a measurement and there are no errors, the green LED remains on. Press the MEASure key firmly, but quickly to make a measurement.

Successful initiation of a measurement is indicated when the *green* LED begins to flash. The *green* LED continues to flash for the duration of the measurement. When the measurement is done, the *green* LED stops flashing, but remains on signaling that the unit is ready to make another measurement. If something is wrong with measurement conditions, however, or if a hardware error is detected, the *red* LED begins to flash and an error message appears on-screen. Pressing the FRWD key button will cause the error message to disappear and the *red* LED to stop flashing.

Note: "Low Light" is ***not*** an error, only an indication that signal-to-noise is in the marginal range. Press any key to view the data.

This ends the hardware description and instructions for the general operation of the PR-650. The next chapter discusses the PR-650 software screens and how to use them.

Chapter 2 - PR-650 Software Screens

Description

PR-650 software screens consist of two types: (1) non-interactive informational screens that give users information about the instrument setup and show measurement data, and (2) interactive menu screens that allow the user to tailor the PR-650 software to perform fast, accurate measurements, based on the user's individual system configuration and measurement requirements.

All screens are viewed on a 4-line x 20-character backlit, supertwist Liquid Crystal Display (LCD).

Non-interactive screens include the Initial Screens, Set-Up Screens, and Data View Screens.

Interactive Screens include: Time/Date Screens, Power Options Screens, Data Options Screens, Auto Options Screens and File Options Screens.

Screens are sequentially accessed by pressing the **FRWD** key. Scrolling forward through the menu screens is performed by continuously depressing the **FRWD** key. Scrolling backward is accomplished by pressing the *blue* **ALT** and then the **FRWD/ BACK** key. Backward scrolling stops when the Home (Current Set-Up Screen) is reached.

Initial Screens

When the instrument is first powered up, the Initialization Screen shown below appears indicating that the unit self-test is under way.

Screen 1 - Initialization

PR-650 Colorimeter Self Test In Progress Please Wait

If the self-test is successful, the next screen to appear is the Proprietary Rights Screen shown below.

Screen 2 - Proprietary

S/N: Pat. Pend. Copyright 1991-92 PHOTO RESEARCH

Note: If an instrument self-test fails, the red LED flashes and an error message appears on the display screen (e.g. **RAM Card is missing or Write Protected, etc.**), the error must be corrected before proceeding further. (Refer to *Appendix A, Error Codes* for more information.)

The initialization and proprietary screens appear only once when the instrument is successfully powered on and do not reappear until the unit is powered off and on again.

After the instrument successfully powers up, the *green* LED lights up signaling to the user that the unit is ready to make a measurement and the following screen appears:

Screen 3 - Ready to Measure

```
Press MEASURE        (M/A)
or Press F for
next screen
↑  ↓      F       E
```

The "(M/A)" shown in the example screen above and in other example screens used throughout the manual denotes the flashing screen icons of either "_" for Timed measurements or " " for AutoSync measurements. In some screens there is also another flashing symbol which alternates with the measurement mode. This is represented in the manual by the letter "**A**" for **Alt** key functions and in other measurement screens by the appropriate letter or number. These symbols are explained more fully later in this chapter.

If the measurement parameters are set to the user's specifications, a measurement can be made immediately from the "Press MEASURE" screen by firmly, but quickly pressing the **MEAS** button, located on the top right hand side of the instrument.

If, however, the user wishes to check the setup parameters before making a measurement, he advances sequentially to the next screen by pressing the **FRWD** (F) key.

The next sequential screen, the Status Screen, shows the current software version and serial number of the instrument:

Screen 4 - Status Screen Example

```
Software Ver.      2.00
Serial Num 1111

READY      ↓ FE
```

△ The software is calibrated according to the individual serial number of the instrument, and its options. ICM Cards initialized with the serial number of a particular unit will not operate the software on any other unit.

The user presses the **FRWD** key again to access the next sequential screen showing the current setup parameters. This screen and additional setup screens are explained in the following section.

Setup Screens

The current (default) setup screens for the PR-650 reflect the current configuration of the unit and are not interactive. These screens can only be updated when changes are made to other interactive screens, such as the Data Options and Accessory Screens.

Pressing the **FRWD** key from the Screen 4-Status Screen takes the user sequentially to the Current Set-up Screen shown below:

Screen 5 - Current Set-up Example

```
   CURRENT SET-UP
CYCLS:  XX     UNITS : fL
DSP: Y xy    u' v'
PRI ACC: MS-75      ↓ FE
```

Current Set-up Parameters include:

CYCLS: Current number of measurement cycles to be averaged.

UNITS: Current measurement units (fL or cd*m-² for luminance, or fc or lux for illuminance).

DSP: Type of data to be displayed after a measurement.

PRI ACC: Primary accessory in use.

Depending on whether an Add-On or secondary accessory has been ordered with the instrument and will be used in making measurements, another setup screen is accessed by pressing the **FRWD** key again.

An example accessory setup screen is shown below:

Screen 5a. (Optional Set-up Screen)

```
   CURRENT SET-UP 2
ADD ON:   RS-2
ADD ON:
ADD ON:      ↓ FE
```

Note: All three Add-On rows will appear even if there is only one accessory listed.

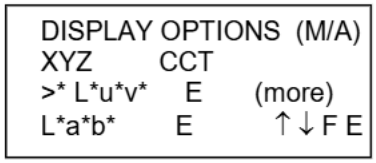
Following the non-interactive setup screens are interactive setup screens that can be changed to new settings which replace the original factory "default" settings. The last settings saved become the new "defaults" and are restored after power off and power on. The original factory default settings are restored using the RESTR650 program explained in Chapter 7.

Interactive setup screens include: Time and Date, Power Options, Primary and Add-On Accessories, Units Options, Display Options, Auto Options, and File Options screens.

All of the interactive menu screens use the same format to activate certain selections. The next section gives a brief overview of how the operator sets parameters in these screens.

Using Interactive Screens

Active menu items in interactive screens are denoted by the "*" (active selection) icon. The user moves the ">" (cursor) icon among the various menu items by pressing the up ⇑ or ⇓ down arrow keys. It is possible for a menu item to have the ">" (cursor) icon appear next to it but not the "*" (active selection) icon, and vice versa. See the example below:



Pressing the **ENTR** key causes the menu item marked by the ">" (cursor) icon to become the active selection designated by the "*" icon. This selection becomes the new default parameter. All selections remain the new "defaults" until changed by the user including source and sample data files which are retained until overwritten.

The "*" (active selection) icon may not appear in screens with the word **("more")** because the currently selected parameter may appear in another related screen. By pressing the **FRWD** key from a screen with the word **("more")**, the user can scroll forward sequentially to view related screens.

The first screen the user comes to without the word **("more")** is the last related screen in a particular sequence.

The upper right hand corner of the menu screen contains a flashing icon which indicates to the user the current mode of operation, i.e. Timed mode, represented by the " " icon, or the AutoSync mode represented by the " " icon.

Flashing alternately with the measurement symbol is a number or letter which acts as an informational prompt to the user explaining what action is being initiated, or what type of measurement is to be made, e.g. "S", for Source.

The "(M/A)" shown in the upper right hand corner of the screen example on the previous page and in other example screens appearing in this manual is used to denote the flashing mode of operation, and informational prompt.

The numbers and letters that can be flashing alternately with the measurement mode symbol include:

A- A flashing "A" signifies that the **ALT** function is active and another key needs to be pressed. **ALT** functions use *blue* nomenclatures. These include:

ALT BACK - Moves the user back sequentially to the previous screen.

ALT LOCK - Used to reverse file status, i.e. "Locked (L)" to Unlocked (U), and vice versa.

Also, when used in other than a Data View Screen, it immediately retrieves the Data View screen for the last measurement taken.

ALT PRNT - Prints to screen, printer, or host PC.

ALT HOST - Currently an unassigned function.

S - A flashing “S” indicates that the next measurement taken will be placed in a Source file.

1 - A flashing “1" indicates that the next measurement taken will be placed in a Sample 1 file.

2 - A flashing “2" indicates that the next measurement taken will be placed in a Sample 2 file.

P - A flashing “P” indicates that the measurement data (either the Data View screen or all measurement data) is being sent to a printer or host PC (if a printer or host PC is properly connected via an RS-232 port).

? - A flashing “?” indicates that a Δ E function selection needs to be completed for a L*u*v* or L*a*b* measurement.

Current active keys in any screen are denoted by appropriate icons which appear at the bottom right hand corner of the menu screen. These screen icons include the “⇑ ⇓“ symbols for the up and down arrow keys, **F** for the **FRWD** key, and **E** for the **ENTR** key. Used with the ALT key, these symbols denote other alternate (ALT) functions as explained in the previous section.

This completes the section on general information for using the interactive screens. The next section explains how to set the time and date screen.

Time and Date Setup

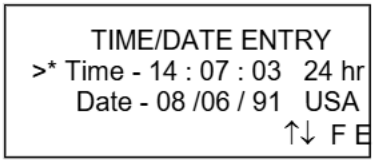
Time and date information is available from a real-time clock and is used to "time" stamp measurement files as they are made.

This clock is not backed-up by the battery; it uses a capacitor charged by the battery pack. Therefore, the user should be aware that removing the battery from the instrument for several days causes the clock to lose time and eventually stop. Keeping the battery adequately charged and in the unit prevents the user from having to internally change anything in the unit thereby lessening the chance of causing internal damage to the instrument.

Note: While setting the time and date, the user will notice that the Time field is not incrementing. However, the real time clock is still counting from the latest time set, and will update the time clock after the user has left this screen.

The TIME/DATE screen is shown below; time is always in a 24-hour format.

Time and Date Entry Screen (USA)



The following procedure explains how to set the time clock.

Setting the Time Clock:

Step 1 Press the **FRWD** key (or the **ALT BACK** keys) to access the TIME/DATE ENTRY screen (as shown on previous page).

Step 2 Press the ⇑ or ⇓ arrow keys to position the ">" (cursor) icon in front of the Time line.

Step 3 Press **ENTR** to cause the first Time digit to flash. (When selected, the "*" active selection icon also appears after the ">" cursor).

Step 4 Press the ⇑ or ⇓ arrow keys to scroll through the "wrap around" numbers 0, 1, 2 . . .etc.

Step 5 After arriving at the correct digit, press **ENTR** to cause the next Time digit to flash, then repeat Step 4 above.

Step 6 Continue this process until all Time field digits have been set.

Step 7 After setting the clock to the correct time, press **FRWD** to lock in this time.

After pressing the **FRWD** key, the Time line digits no longer flash, the "*" active selection icon disappears, and the internal clock automatically resets itself.

If already in the TIME/DATE screen, use the ⇑ or ⇓ arrow keys to move the ">" (cursor) icon to "point to" the Date line. Once a Date format has been selected (USA or INT), the date appears in the chosen format on subsequent power-ups and whenever a data file is created.

Note: The USA and INT date formats are:
USA= MM/DD/YY
INT =YY/MM/DD

Setting the Date or Selecting a Date Format:

Step 1 Press the **FRWD** key (or the **ALT BACK** keys) to access the TIME/DATE ENTRY screen.

Step 2 Press the ⇑ or ⇓ arrow keys to position the ">" (cursor) icon in front of the Date line.

Step 3 Press **ENTR** to cause the first Date digit to flash. (When selected, the "*" active selection icon also appears after the ">" cursor).

Step 4 Use the ⇑ ⇓ keys to change the displayed digit to the desired value.

Step 5 Press **ENTR** to accept the new value and cause the next digit to flash.

Step 6 Repeat Steps 4 and 5 up to and including the USA/INT selection.

Step 7 After setting the date, press **FRWD** to lock it in. The Date line digits stop flashing and the selected date format becomes the default parameter.

Power Options

There are two power selections available on the PR-650: "Standard" and "Energy Saving". Standard power means all power supplies are on constantly, giving at least two hours of continuous operation from a freshly charged battery with the back light off. Energy Saving means the instrument will automatically turn off three minutes from when the last key is pressed.

Note: Back lighting of the LCD screen can be set by quickly pressing the *red* 0/1 (On/Off) key. Each time this key is pressed, the LCD light changes to one of four different light levels.

Selecting a Power Option:

Step 1 Press the **FRWD** key until the POWER OPTIONS screen shown below appears:

Power Options Screen Example

```
     POWER OPTIONS
>* Standard
    Energy Saving
                 ↑↓ F  E
```

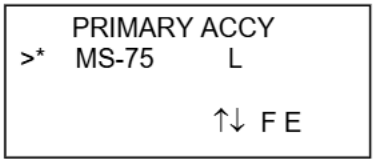
Step 2 Press the up or down arrow keys ⇑ ⇓ to position the ">" (cursor) icon in front of either the Standard or Energy Saving option.

Step 3 Press **ENTR** to place the "*" (active selection) icon next to the desired option and lock in the setting.

Accessories

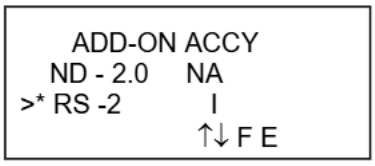
There are two classes of optical accessories, Primary and Add-On. The accessory screen(s) that appear will depend on the accessories ordered at the time of purchase. (Most optical accessories require factory calibration.) Various accessories determine the type of measurements that can be performed. For example, the MS-75 lens is used primarily to measure luminance, and an "L" (for luminance) appears next to the MS-75 lens designation on the Primary accessory menu. (See the example below:)

Primary Accessory Screen Example



Add-On accessories are used along with the Primary accessory in performing certain measurements. One example of an Add-On accessory is the ND-2.0 Neutral Density (ND) filter which extends the useful upper sensitivity range by two decades. Another example is the RS-2 Reflectance Standard which is used to make Illuminance/Chrominance, Irradiance and Reflectance measurements. In the example below, the RS-2 is selected with an "I" next to it (for incidence).

Add-On Accessory Screen Example



Selecting an Accessory:

Step 1 Press the **FRWD** key until the Primary (or Add-On) Accessory screen appears.

Step 2 Press the up or down arrow keys ⇑ ⇓ until the ">" (cursor) icon "points to" the desired option.

Step 3 Press **ENTR** to place the "*" (active selection) icon next to the desired option to designate it as the current default accessory.

Note: If additional Add-On accessories are selected, another accessory screen is added to the setup.

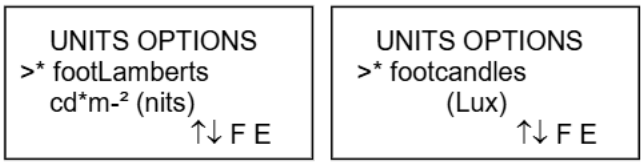
Up to three Add-On accessories may be simultaneously selected, but only one Primary accessory is allowed at a time.

For information on other accessories, refer to the appropriate Appendix describing their installation and use.

Units

The Units Options menu screen that appears depends on which accessory(ies) were ordered and selected in the Primary and Add-On accessory screens. For the MS-75 lens, the following UNITS OPTIONS screen will appear:

Units Options (Luminance/Illuminance)Screen



Note: English photometric units are footLamberts for luminance and footcandles for illuminance. Metric units are candelas per square meter (cd * m-²) and lux.

Selecting a Units Option

Step 1 Press the **FRWD** key until the UNITS OPTIONS screen appears.

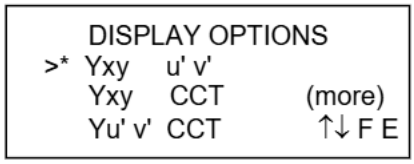
Step 2 Press the up or down arrow keys ⇑ ⇓ until the ">" (cursor) icon "points to" the desired option.

Step 3 Press **ENTR** to place the "*" (active selection) icon next to the desired option to signify that it is now the current units default.

Display Options and Data View Screens

Display Options Screens are interactive screens which let the user select which measurement data parameters are to be displayed in the corresponding calculated Data View screens when the MEASure key is pressed. (See Chapter 3 for a description of displayed parameters.)

The factory default which is set to Y, xy, u'v'. "Y" indicates luminance with the MS-75 lens, and can be set to either footLamberts (English units) or candelas per square meter [metric (SI) units]. Chromaticity coordinates, "x" and "y" are displayed from the CIE 1931 2o Observer, along with the CIE 1976 2o UCS chromaticity coordinates "u'" and "v'". See the example below:



The following procedure explains how to select a Display Option and gives examples of the four Display Options Screens.

Selecting a Display Option:

Step 1 Press the **FRWD** key until the desired DISPLAY OPTIONS screen appears.

Step 2 Use the up or down arrow keys ⇑ ⇓ to move the ">" (cursor) icon to the desired option.

Step 3 Press **ENTR** to place the "*" (active selection) icon next to the desired option to cause it to become the current (and default) parameter.

Step 4 Press the **FRWD** key to advance to the next screen or press the *blue* **ALT** key, then the **FRWD/BACK** key to return to the previous screen.

Step 5 *(Optional)* Press the MEASure key to make a measurement and display the corresponding Data View Screen for the selected Data Options.

The four Display Options Screens from which to select measurement parameters are shown below and on the following page.

Screen 1- Display Options (Illuminance/Luminance)

```
      DISPLAY OPTIONS
>   Yxy    u' v'
    Yxy    CCT        (more)
    Yu' v' CCT          ↑↓ F E
```

Screen 2 - Display Options (Illuminance/Luminance and Color Difference/Luminance)

selecting

```
   DISPLAY OPTIONS
>  XYZ        CCT
   L*u*v*     Δ E?   (more)
   L*a*b*     Δ E?   ↑↓ F E
```

Screen 3 - Display Options (Illuminance/Luminance and Color Difference/Luminance).

```
   DISPLAY OPTIONS
>  Δ Yxy      CCT
   Δ Yu' v'   CCT
   Δ YXZ      CCT   ↑↓ F E
```

Screen 4- Display OptionsRadiance/Irradiance)

```
   DISPLAY OPTIONS   (M/1)
> *Radiometric Data

                     ↑↓ F E
```

The following example of a Data View Screen calculated from of the measurement of an AC light source was taken in the AutoSync mode ( ) with a refresh rate of 120 Hz with English luminance units (footLamberts). The selected Display Option was Yxy u'v'.

Example 1

Y=100fL	120 Hz
x=.448	y=.407
u'=.256	v'=.524
FILE#100 U 2° ↓F E	

Resolution of the displayed parameters in the Data View Screens (luminance, illuminance, etc.), will be at least to 1% of the value, except below 1.00 where the resolution is 0.01 units. (For example, 1.00-1.01). All CIE coordinates are displayed to three decimal places.

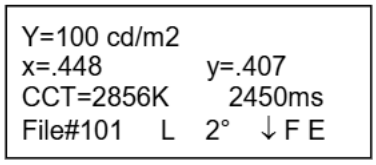
As shown in Example 1 above, the measurement file number (FILE#) is 100, and the file is unlocked as shown by the “U” to the right of the file number.

To lock or protect the file from being overwritten, the user would press the **ALT LOCK** keys. For more information on performing file operations, see Chapter 4, File Operations.

The next example Data View Screen shows the calculated data results of a measurement taken with the Display Options Screen set to Y,x,y, CCT (Correlated Color Temperature) with luminance in metric (SI) units of cd * m-².

A measurement integration time of 2450 milliseconds is shown to the right of the CCT value in Example 2. This parameter may or may not appear in other Data View screens depending on the selected Data Options.

Example 2



As Example 2 indicates, the file number of the measurement is 101, the file is locked and the measurement was taken in the Timed ( ) Mode (no frequency displayed).

In this example as well as in the first example, the symbols "↓ **F E**" appearing in the right hand bottom corner of the display indicates that the ⇓ down arrow key, the **FRWD** and **ENTR** keys and their alternate (ALT) functions are active from within this screen.

Detailed procedures on using the Data Options Screens to make and recall measurements are included in Chapter 4, Making Measurements.

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Chapter 3 - Theory of Operation

Overview

When making a measurement, the user must focus the instrument viewing eyepiece, align the target, and set measurement parameters from the Data Options Screen to produce the desired display data from the PR-650 Data View Screens. The order in which the user performs these steps normally depends on the type of measurement and the measurement conditions.

To aid the user in making accurate measurements, this chapter explains how the viewing system of the PR-650 works, the unique Auto Adaptive Sensitivity and AutoSync functions of the unit and a detailed explanation of how to correctly focus the eyepiece and target. The final section of this chapter discusses the CIE system and how it relates to the display parameters used in the PR-650 software.

Theory of Operation

The PR-650 is a fast scanning, spectroradiometric tele-colorimeter that acquires the spectrum of optical radiation from 380 nm to 780 nm simultaneously in parallel under CMOS microcomputer control. This permits accurate analysis of color and intensity of both steady-state (power) and repetitively pulsed (energy) light sources in a fraction of a second.

Each measurement cycle consists of two parts:

1) measurement of the optical radiation (Light), and

2) a measurement of equal length while no radiation is permitted to strike the detector (Dark).

The Dark measurement data is subtracted from the Light measurement data to yield relative point-to-point spectral data. The relative data is assigned to a wavelength band, corrected for wavelength accuracy and spectral intensity, then made available to other software functions (calculations, display, print, etc.).

Light Measurement

Optical radiation, or light from the object under test, passes through the objective lens of the PR-650. This radiation encounters the Pritchard-style mirror aperture. The user sees a bright erect image of the area under test with a black spot in the center. (See Figure 3-1 on the following page.)

Aperture and Viewing System

Only optical radiation being measured passes through the black spot (1° aperture) of the Pritchard mirror. The remainder of the light from within the 7° field-of-view is subsequently reflected to a second partially silvered mirror, where 40% of its energy is transmitted to the sync detector behind the partial mirror and 60% to the viewing eyepiece so the user can precisely and unambiguously align the measuring aperture on the target.

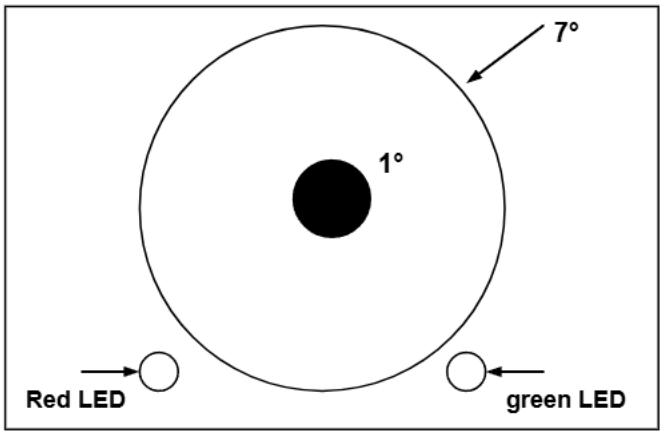


Figure 3-1: Aperture, Viewing Field and Status Indicators

The View Shutter Control is provided just forward of the viewing eyepiece on the eyepiece barrel. Pressing *down* (from the top) *closes* the eyepiece to prevent stray light from entering from behind the eyepiece. Pressing *up* (from below) *opens* the viewing shutter to view the target and aperture.

LED status indicators (that duplicate the LED status indicators on the display panel) are visible in the viewfinder, below the viewing field. Even if the View Shutter is closed, these indicators can be viewed when lit.

After the radiation to be measured passes through the aperture, it reaches the measuring shutter. When this shutter is *open*, optical radiation can reach the polychromator and detector for the Light measurement. This shutter automatically closes to exclude light during the Dark measurement (causing an audible "click").

Once radiation passes through the measuring shutter, it is shaped to a slit function, depolarized and directed to a concave holographic diffraction grating polychromator. The grating breaks (diffracts) the radiation into its constituent parts (colors) from 380 nm to 780 nm and focuses the diffracted spectrum onto a photodiode array, such that each end of the spectrum is permanently aligned with the detector array detector elements. (See Figure 3-2.)

Figure 3-2: Polychromator Wavelength Dispersion

Automatic Adaptive Sensitivity®

This patented feature of the PR-650 automatically determines the optimal dynamic range to maximize the signal-to-noise ratio by selecting the integration time based on available signal level— the stronger the signal, the shorter the integration time. This feature eliminates the guesswork in setting sensitivity.

Automatic Adaptive Sensitivity begins its cycle by performing a Light measurement using the minimum allowable Timed integration mode time of 10 milliseconds or multiples of the refresh rate period if in the AutoSync mode. The A/D converter values for each of the 128 detector elements are then analyzed. If the dynamic range for the peak element is less than optimal, integration time is increased by a calculated amount and another measurement is made. The process iterates until the optimal level or maximum allowable integration time is achieved.

If the maximum integration time is insufficient to optimally acquire low brightness targets, either a "Low Light" warning or a "Weak Signal" error will be displayed. (Weak Signal aborts the measurement.)

AutoSync

AutoSync (patent pending) is a unique feature of the PR-650 that allows the instrument to "lock" to and measure source refresh frequency over the range of 40 to 250 Hz.

Note: Because the Automatic Adaptive Sensitivity of the PR-650 optimizes dynamic range by varying the signal acquisition (integration) times, repetitively pulsed sources of high amplitude, low duty cycle or high spectral concentration may cause a "zero-beating" effect with the source frequency. Not only might this confuse the adaptive sensitivity algorithm, but it may also result in inaccurate measurements if partial refresh cycles are acquired.

AutoSync is not needed for acquisition times in excess of about a half a second since partial cycle errors will be averaged out. The integration times are displayed on the File Attributes screen and the source refresh frequency is presented on the Data View screen.

The AutoSync mode solves the problem by first determining the refresh frequency, then using a "phase locked loop" to insure that the Automatic Adaptive Sensitivity only uses integer multiples of the refresh rate. This insures that only full refresh cycles are captured. For example, a fluorescent lamp refreshes at twice the line rate. The 60 Hz line rate in the US has a period of 8.33 ms. With AutoSync enabled, Automatic Adaptive Sensitivity adjusts the instrument acquisition (integration time by integer multiples of 8.33 ms e.g., 16.67, 33.34, etc.)

Focusing

The following procedure explains how to correctly focus the viewing eyepiece.

Focusing the Viewing Eyepiece

Step 1 Place the View Shutter Control in the open (up) position by pressing up on the release button under the lens barrel.

Step 2 Hold a piece of white paper close to the objective lens.

Note: This allows easier focusing of the viewing eyepiece by removing any distracting background contrast.

Step 3 Looking through the viewing eyepiece, turn the eyepiece barrel until the vertical centerline of the aperture ("black spot"), not the target, is in sharp focus (the range of adjustment is -4 to +2 diopters).

Note: The horizontal centerline of the aperture may be slightly *OUT* of focus. Once the viewing eyepiece has been optimally focused, refocusing the eyepiece should not be required unless a different operator uses the instrument.

After focusing the viewing eyepiece, the user must get the target into sharp focus by either adjusting the MS-75 objective lens by rotating the lens barrel or by moving the target. The following procedure explains how to correctly focus the target.

Target Acquisition and Focusing

Step 1 Hold the PR-650 securely by hand or place on a sturdy tripod or other suitable support.

Step 2 Looking through the viewing eyepiece, align the instrument on the target to be measured.

Step 3 Focus the objective lens (NOT the eyepiece) by moving the target or by grasping the lens by the wide band (near the front of the lens), and rotating the lens barrel until the target is in sharp focus.

Note: For luminance/radiance or color measurement, the measuring area (the "black spot") should cover approximately *half* to *three quarters* of the area of interest in the target. If it does not, move the instrument either closer or further from the subject until it does, then refocus the objective lens. Also, keep the PR-650 on target until after the first audible "click" signifying that the measuring shutter has closed. The minimum working distance for the MS-75 lens is 14 inches.

The following section discusses displayed parameter theory which serves as the basis for the PR-650 Data Options and Data View Screens. Following this section are specific step-by-step procedures designed to help the user become quickly familiar with the PR-650 software.

Displayed Parameter Theory

The Display Options menu and Data View screens use many parameters that correspond to the CIE 1931 2° Observer chromaticity diagram shown in Figure 3-3.

The CIE system provides a linear transformation of the three primaries (Red, Green, and Blue) that enable the color to be visualized as it would be projected on a flat (two- dimensional) surface, the CIE chromaticity diagram.

The axes of this graph are the CIE chromaticity coordinates, (small) x and y, which are derived from the X, Y and Z tristimulus values using the following equations:

$$x = \frac{X}{X+Y+Z} = \frac{Red}{Red + Green + Blue}$$

$$y = \frac{Y}{X+Y+Z} = \frac{Green}{Red + Green + Blue}$$

In the CIE system, it is adequate to use only the "*x*" and "*y*" to specify chromaticity; "*z*" is always equal to 1- (x+y).

The center of the diagram is "white" (neutral or achromatic) and occurs at 0.333 "*x*" and "*y*". The hues (colors) become more saturated (pure) as you move from the center to the outside perimeter (the perimeter is called the spectrum locus) of the diagram.

Specification of the two CIE chromaticity coordinates "*x*" and "*y*" determine the color or chroma of a source or object: that is, its hue and saturation. The capital **Y** value - which derives from the y ( ) function - specifies the brightness (lightness) or luminosity. Together, these three numbers completely specify a color in the CIE system - values for hue, saturation, and lightness vectors.

Figure 3-3: CIE 1931 Chromaticity Diagram

Below and on the following page is a list of spectroradiometric and colorimetric calculations that correspond to the CIE recommendations and specifications:

1931 CIE:
$$x = X/(X+Y+Z)$$
$$y = Y/(X+Y+Z)$$
$$z = 1-(x+y)$$

1960 CIE:
$$u = \frac{4X}{X+15Y+3Z} = 4x/(-2x+12y+3)$$
$$v = \frac{6Y}{X+15Y+3Z} = 6y/(-2x+12y+3)$$

1976 CIE:
$$u' = \frac{4X}{X+15Y+3Z} = 4x/(-2x+12y+3)$$
$$v' = \frac{9Y}{X+15Y+3Z} = 9y/(-2x+12y+3)$$

Color difference equations, where E° is the color difference, are computed as follows:

$$\Delta E^*(L^* u^* v^*) = [(\Delta L^*)^2 + (\Delta v^*)^2]^{1/2}$$
$$L^* = 116(Y/N)1/3-16$$
$$U^* = 13L^* (u'-u')$$
$$v^* = 13L^* (v'-v')$$

$$\Delta E^*(L^* a^* b^*) = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$
$$L^* = 116Y(Y/Y)1/3-16$$
$$a^* = 500[(X/X)1/3-(Y/Y)1/3]$$
$$b^* = 200[(Y/Y)1/3-(Z/Z)1/3]$$

Where X , Y , Z , u' and v' are the coordinates of a CIE standard illuminant (such as D), Y/Y >0.008856.

Correlated Color Temperature (CCT) is derived from the u, v coordinates of the CIE 1960 UCS diagram and is interpolated from a "look-up" table. The 1976 UCS Chromaticity Diagram is a further linear transformation from the 1931 Diagram and is more perceptually uniform.

Color difference equations allow three dimensional vector difference comparisons to be made between two or more colored stimuli, given a reference illuminant.

The CIE – a nongovernmental international standards orginazation – has changed its calculations for color measurements over the years. All of the equations, however, use tristimulus values to compute chromaticity coordinates. These coordinates are then used to develop color difference equations.

Photometric quantities (such as luminance, L) can be accurately computed from spectroradiometric data by the following formula:

$$L = 683 \quad P(\ ) - V(\ ) - d$$

where P( ) is the measured spectral radiance at wavelength , and V( ) is the CIE 1931 "Photopic luminous efficiency" function.

Colormetric quantities ("tristimulus values") are computed for three similar integrations of the measured spectral distribution data:

$$X = \quad P(\ ) \cdot \overline{x}(\ ) \cdot d$$

$$Y = \quad P(\ ) \cdot \overline{y}(\ ) \cdot d$$

$$Z = \quad P(\ ) \cdot \overline{z}(\ ) \cdot d$$

where P( ) is the measured spectral power distribution, and $\overline{x}(\ )$, $\overline{y}(\ )$ and $\overline{z}(\ )$ are the CIE 1931 color-matching functions.

Radiometric power in a given spectral band can be computed by simply integrating the spectroradiometric power between the desired wavelength limits, and .

$$P = \qquad P(\ ) \cdot d$$

The PR-650 computes CIE LUV and CIE LAB data and allows the user to optionally select Δ E color difference between two measurements.

The PR-650 also measures several "Δ " (delta) functions, such as Δ **Y,** Δ **x,** Δ **y,** Δ **CCT**, etc. The Δ (difference) is computed by subtracting the second measurement from the first measurement (Smp1 - Smp2). The %Y value is computed by dividing the Smp2 measurement by the Smp1 measurement and multiplying the result by 100 (Smp2/Smp1 * 100) to yield percent (as in transmission or reflectance).

The next chapter gives detailed procedures on how to set display options in the PR-650 software to make various measurements.

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Chapter 4 - Making Measurements

This chapter explains how to make various measurements using the PR-650. To simplify these procedures, detailed information on setting parameters and focusing have been condensed. It is suggested that the user read the previous two chapters to review this information if necessary prior to making a measurement.

The measurement procedures included in this chapter are presented in the order in which they appear in the PR-650 Display Options screens.

Performing Luminance/Illuminance Measurements

Step 1 Press the *red* **0/I** key to turn on the PR-650.

Step 2 Check the "Current Set-Up" parameters screen, and make changes as required by scrolling (pressing the **FRWD** key) to the appropriate set-up screens and making the desired selections.

Refer to Chapter 2, PR-650 Screens for more information on setting various parameters.

Step 3 Open the View Shutter Control.

Step 4 Focus the Viewing eyepiece and the target as explained in Chapter 3, Focusing.

Step 5 Scroll through the set-up screens to the desired Data Options screen.

Step 6 Use the up or down arrow keys ⇑ ⇓ to move the ">" (cursor) icon to select the desired Display Options screen.

Step 7 Press **ENTR** to place the "*" (active selection) icon next to the desired option to cause it to become the current (and default) parameter.

Step 8 Press the **MEAS** key.

Note: Do not depress the MEAS key too long or several measurements will be made. Just press the key once, then quickly release it.

Based on the Display Options chosen, the following Data View Screens will be automatically calculated and displayed.

Screen 1- Display Options (Illuminance/Luminance)

Selecting

```
          DISPLAY OPTIONS
> * Yxy    u' v'
    Yxy    CCT      (more)
    Yu' v' CCT       ↑↓ F E
```

produces Data View Screen

```
12.2fL
x =.414  y=.383 2680ms
u'= .245  v'= . 509
FILE#021  U    2°   ↓ F E
```

selecting

```
DISPLAY OPTIONS
    Yxy    u' v'
> * Yxy    CCT      (more)
    Yu' v' CCT       ↑↓ F E
```

produces Data View Screen

```
    12.2fL
    x = .413   y= .383
    CCT=3255 K    2700ms
    FILE#057   U   2°   ↓F E
```

selecting

```
DISPLAY OPTIONS
    Yxy    u' v'
    Yxy    CCT      (more)
> *Yu' v'  CCT       ↑↓ F E
```

produces Data View Screen

```
    12.2fL
    u'= .245   v'= . 509
    CCT=3252K     2670ms
    FILE#058   U   2°   ↓F E
```

The second Display Options screen includes an option to select the X,Y,Z, L*u*v*, L*a* b* calculation for Δ E color difference.

Screen 2 - Display Options (Color Difference / Luminance)

selecting

```
    DISPLAY OPTIONS
> * XYZ       CCT
    L*u*v*     Δ E?    (more)
    L*a*b*     Δ E?  ↑↓ F E
```

produces Data View screen

```
X= 4.52e+01
Y= 4.18e+01 CCT  3253K
Z= 2.23e+01    2660ms
FILE#059   U   2°   ↑↓ F E
```

where X,Y, and Z are CIE 2° values of Red, Green and Blue content of the measurement (Note: Y is in metric units.)

The second and third options in Screen 2, “L*u*v*” and “L*a*b*” involve performing additional steps for selecting a Reference Illuminant, and for calculating Δ E (CIE LUV and CIE LAB color difference), if desired, in three-dimensional color space.

For L*u*v* measurements, a Reference Illuminant must be selected to determine the Reference Values of Yo, u'o and v'o (Yo is set to 100.0 (cd * m-²). Then a measurement is made (or recalled) as Sample 1 and the values of Y1, u1' and v'o are computed. (See Displayed ParameterTheory). If color difference (Δ E) is required, a second measurement is made (or recalled) as Sample 2, and Y2, u'2, v'2 and Δ E vector sum difference are computed.

The following individual procedures explain how to complete L*u*v* L*a*b* measurements without calculating Δ E color difference and then with calculating Δ E color difference.

Performing L*u*v* Measurements without Calculating Δ E.

Step 1 Press the *red* **0/I** key to turn on the PR-650.

Step 2 Check the Current Set-Up parameters screen, and make changes as required by scrolling (pressing the **FRWD** key) to the appropriate set-up screens and making the desired selections.

Refer to Chapter 2, PR-650 Screens for more information on setting various parameters.

Step 3 Open the View Shutter Control.

Step 4 Focus the Viewing eyepiece and the objective lens as explained in *Chapter 3, Focusing.*

Step 5 Scroll through the Initial Set-up Screens until at the second Data Options Screen.

Use the up and down arrow keys ⇑ ⇓ to move the cursor ">" to select L*u*v* Δ E? and press the ENTR key:

select

```
   Y X Z       CCT
> * L*u*v*   ΔE?  (more)
   L*a*b*   Δ E?   ↑↓ F E
```

When the L*u*v* Δ E ? selection is made, the "?" changes to a flashing "y" and "n".

Use the up and down arrow keys ⇑ ⇓ to select "n" to forgo calculation of Δ E, and press the **ENTR** key.

Step 6 Press the **ENTR** key again to access the screen shown below:

```
> Ref Ill=D-75        (M/1)
  Measure Sample
  Recall Sample
  FILE#001
```

- ***If you wish to review the Illuminants and Sample data sets, press the FRWD key from this screen.***
- ***If you do not wish to change the Reference Illuminant, skip to Step 9.***

Step 7 Use the up and down arrow keys ⇑ ⇓ to move the ">" (cursor) icon to the Reference Illuminant field and press the **ENTR** key to select it (*).

After pressing the **ENTR** key, notice that the Illuminant (in this example, the "D-75") begins to flash, indicating this field is now active.

Press the ⇑ or ⇓ arrow keys to scroll through the available illuminants including the following:

A, B, C, D-55, D-65, D-75, or file #nnn (user-defined illuminant file)

If the user wants to use his own file, press the **ENTR** key to activate the file number field and the ⇑ or ⇓ arrow keys to enter the correct number of the file to be used.

Step 8 Press **FRWD** after selecting an illuminant to lock it in. (The "*" selection icon disappears and this illuminant becomes the default).

Note: If the user wishes to inspect the Reference Illuminant and Sample data sets, prior to making a measurement, continue to press the **FRWD** key.

Step 9 Use the up and down arrow keys ⇑ ⇓ to move the > (cursor) icon to select (*) either "Measure Sample" or "Recall Sample" and press **ENTR**.

The flashing "1" in the upper right hand corner signifies to the user that the next measurement taken or recalled will be Sample 1.

- ***If you wish to measure a new Sample, follow Step 10 below; to recall a Sample, skip to Step 10a.***

Step 10 Focus the target (Sample), and press the **MEAS** key.

Do not move the instrument until you hear an audible click signifying that the light measurement is complete. The L*u*v* calculation automatically appears as shown below:

L*=41.508	(M/1)
u*=27.541	
v*=27.284	Ill=D-75
FILE#061 U	2° ↓ F E

- ***If you wish to recall a Sample file, follow Steps 10a and 10b:***

Notes: After recalling a Sample file, the user can view its data sets by pressing the **FRWD** key from the "MesSmp1MesSrc" screen.

If the user is simply recalling files, then the green **LED** goes off, signifying to the user that no measurements are to take place.

Step 10a Press the **ENTR** key to select "Recall Sample"

Press the **ENTR** key again to cause the first digit in the File # field (in this example, "0") to begin flashing.

Press the ⇑ or ⇓ arrow keys to scroll through the "wrap around" numbers: 0, 9, 8, 7. . . etc., of the first digit of the File # field until you select the appropriate one.

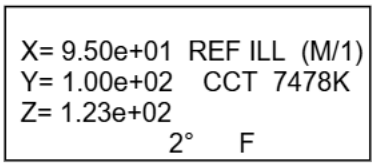
Press the **ENTR** key to lock in the first digit and move to the second which will begin flashing.

Repeat step for the second and third digits, and when you have entered the desired file number, press the **FRWD** key to lock it in.

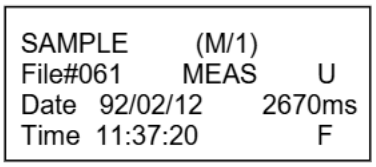
Step 10b Press the **FRWD** key again to recalculate the Data View screen for the selected File #.

Step 11 *(Optional)* Press the **FRWD** key repeatedly to sequentially access the remaining Data View and File Attributes Screens for the recalled file.

Reference Illuminant Data View Screen

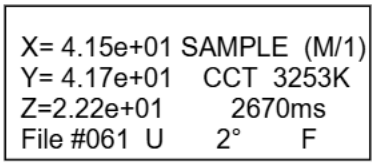


Sample File Attributes Screen



Notes: Date and time refer to the when the measurement was made.

Sample Data View Screen



Step 12 *(Optional)* If desired, press the ***blue*** **ALT LOCK** keys to reverse the locked/unlocked status of the file from a Data View Screen.

Step 13 Press **FRWD** again to return to the second Data Options screen (as shown in Step 5) to complete the measurement process.

This completes the procedure for making a L*u*v* measurement without calculating Δ E.

The following procedure explains how to make a L*u*v* measurement and calculate Δ E.

Performing L*u*v* Measurements with ΔE calculation.

Step 1 Press the *red* **0/I** key to turn on the PR-650.

Step 2 Check the Current Set-Up parameters screen; make changes as required by scrolling (pressing the **FRWD** key) to the appropriate set-up screens and making the desired selections.

Refer to Chapter 2, PR-650 Screens for more information on setting various parameters.

Step 3 Open the View Shutter Control.

Step 4 Focus the viewing eyepiece and the objective lens as explained in Chapter 3, Focusing.

Step 5 Scroll through the Initial Set-up Screens until at the second Data Options Screen.

Use the up and down arrow keys ⇑ ⇓ to move the cursor icon ">" to L*u*v* Δ E? and press **ENTR**.

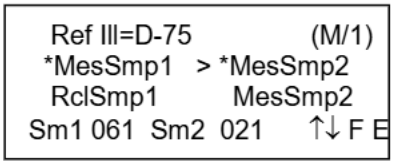
select

```
   Y X Z       CCT
> * L*u*v*   Δ E?  (more)
   L*a*b*   Δ E?    ↑↓ F E
```

When the L*u*v* Δ E ? selection is made, the "?" changes to a flashing "y" and "n".

Use the up and down arrow keys ⇑ ⇓ to select "y" to calculate Δ E, and press the **ENTR** key.

Step 6 Press the **ENTR** key again to access the screen shown below:



- ***If you wish to review the Illuminants and Sample data sets, press the FRWD key from this screen.***

- ***If you do not wish to change the Reference Illuminant, skip to Step 9.***

Step 7 Use the up and down arrow keys ⇑ ⇓ to move the ">" (cursor) icon to the Reference Illuminant field and press the **ENTR** key to select it (*).

After pressing the **ENTR** key, notice that the Illuminant (in this example, the "D-75") begins to flash, indicating this field is now active.

Press the ⇑ or ⇓ arrow keys to scroll through the available illuminants including the following:

A, B, C, D-55, D-65, D-75, or file #nnn (user-defined illuminant file)

If the user wants to use his own file, press the **ENTR** key to activate the file number field and the ⇑ or ⇓ arrow keys to enter the correct number of the file to be used.

Step 8 Press **FRWD** after selecting an illuminant to lock it in. (The "*" selection icon disappears and this illuminant becomes the default).

Note: If the user wishes to inspect the Reference Illuminant and Sample data sets, prior to making a measurement, continue to press the **FRWD** key.

Step 9 Use the up and down arrow keys ⇑ ⇓ to move the ">" (cursor) icon to "MesSmp1" or, "RclSmp1" and "MesSmp2" or "RclSmp2" and press **ENTR** to make your selections (*).

Depending on whether the user is recalling files and measuring files or using a combination of the two, the flashing number in the upper right hand corner of the screen will be either a "1" or a "2".

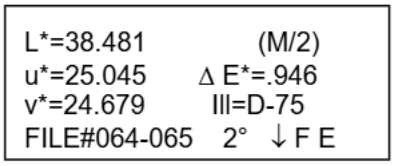
- ***If making two new Sample measurements, follow Steps 10, and 10a; to recall Samples, skip to 10b.***

Step 10 Focus the target (Sample 1) and press the **MEAS** key.

Do not move the instrument until you hear an audible click signifying that the light measurement is complete. The L*u*v* calculation automatically appears.

Step 10a Focus the target (Sample 2) and press the **MEAS** key again.

When the measurement is complete, the Data View Screen shown below appears showing the Δ E vector sum difference between the Samples.



- ***If recalling Sample files, follow Steps 10b, 10c, 10d, and 10e.***

Notes: After recalling a Source or Sample file, the user can view them by pressing the **FRWD** key from the "MesSmp1 MesSrc" screen.

If the user is simply recalling files, then the *green* **LED** goes off, signifying to the user that no measurements are to take place.

Step 10b Press the **ENTR** key to select "RclSmp1"

Press the **ENTR** key again to cause the first digit in the File # field (in this example, "0") to begin flashing.

Press the ⇑ or ⇓ arrow keys to scroll through the "wrap around" numbers: 0, 9, 8, 7. . . etc., of the first digit of the File # field until you select the appropriate one.

Press the **ENTR** key to lock in the first digit and move to the second which will begin flashing.

Repeat this process for the second and third digits, and when you have entered the desired file number, press the **FRWD** key to lock it in.

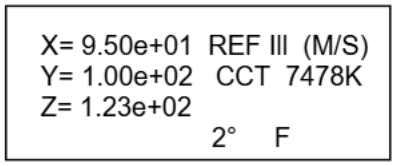
Step 10c Using the up and down arrow keys ⇑ ⇓, select RclSmp2, and press the **ENTR** key.

Repeat the process for entering a File # as explained in the previous step.

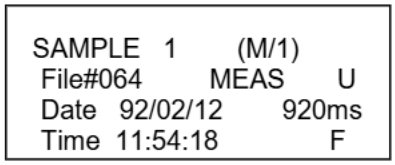
Step 10d Press the **FRWD** key to make the calculation.

Step 10e *(Optional)* Press the **FRWD** repeatedly to sequentially access the remaining Data View and File Attributes Screens for Samples 1 and 2.

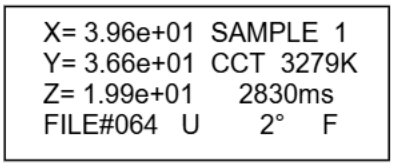
Reference Illuminant Data View Screen



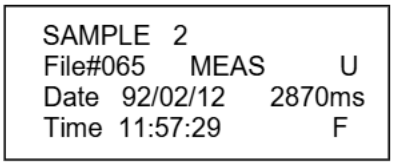
Sample 1 File Attributes Screen



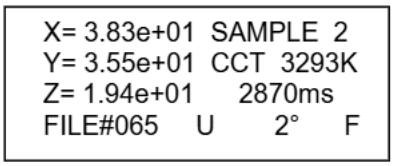
Sample 1 Data View Screen



Sample 2 File Attributes Screen



Sample 2 Data View Screen



Step 11 *(Optional)* If desired, press the ***blue*** **ALT LOCK** keys to reverse the locked/unlocked status of the files from a Data View Screen.

Step 12 Press **FRWD** again to return to the second Data Options screen (as shown in Step 5) to complete the measurement process.

Performing L*a*b* Measurements

Overview

CIE LAB is a method comparing two similar color samples using an instrument. Applications include color matching of paints, textiles, and plastics, etc.

Typically, a sample is illuminated by a source in a sample chamber. The resulting spectral distribution is measured in the spectrophotometer mode, by dividing out the illumination source's spectral response. A second sample is similarly measured. These data are then compared to each other given a Reference Illuminant, normally the viewing environment or daylight.

Δ E color difference then represents the three dimensional vector difference of the two samples given the Reference Illuminant.

The following procedures explain how to complete L*a*b* measurements first without calculating Δ E color difference and then with calculating Δ E color difference between two samples.

Performing L*a*b* Measurements Without Δ E Color Difference Calculation.

Step 1 Press the *red* **0/I** key to turn on the PR-650.

Step 2 Check the Current Set-Up parameters screen, and make changes as required by scrolling (pressing the **FRWD** key) to the appropriate set-up screens and making the desired selections.

Refer to Chapter 2, PR-650 Screens for more information on setting various parameters.

Step 3 Open the View Shutter Control.

Step 4 Focus the viewing eyepiece and the objective lens as explained in Chapter 3, Focusing.

Step 5 Scroll through the Initial Set-up Screens until at the second Data Options Screen.

Use the up and down arrow keys ⇑ ⇓ to select L*a*b* Δ E? and press the **ENTR** key:

select

Y X Z	CCT	
L*u*v*	Δ E?	(more)
> * L*a*b*	Δ E?	↑↓ F E

When the L*a*b* Δ E ? selection is made, the “?” changes to a flashing “y” and “n”.

Use the up and down arrow keys ⇑ ⇓ to select "n" to forgo calculation of Δ E, and press the **ENTR** key.

Step 6 Press the **ENTR** key again to access the screen shown below:

```
> Ref Ill=File001      (M/S)
  Mes Smp1  Mes Src
  Rcl Smp1  Rcl Src
 Smp1 069/Src068    ↑↓ F E
```

- ***If you do not wish to change the Reference Illuminant, skip to Step 9.***
- ***If you wish to review the Illuminants, Source and Sample data sets, press the FRWD key from this screen.***

Step 7 Use the up and down arrow keys ⇑ ⇓ to move the ">" (cursor) icon to the Reference Illuminant field and press the **ENTR** key to select it.

After pressing the **ENTR** key, notice that the the Illuminant (in this example, the "File001") begins to flash, indicating this field is active.

Press the ⇑ or ⇓ arrow keys to scroll through the available illuminants including the following:

A, B, C, D-55, D-65, D-75, or file #nnn (user-defined illuminant file)

If the user wants to use his own file, press the **ENTR** key to activate the file number field and the ⇑ or ⇓ arrow keys to enter the correct number of the file to be used.

Step 8 Press **FRWD** after selecting an illuminant to lock it in. (The "*" selection icon will disappear and this illuminant becomes the default).

Note: If the user wishes to inspect the Reference Illuminant and Sample and Source data sets prior to making a measurement, continue to press the **FRWD** key.

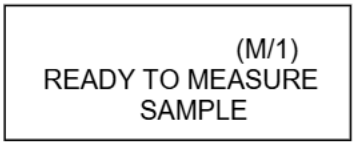
Step 9 Use the up and down arrow keys ⇑ ⇓ to move the ">"(cursor) icon to the "MesSmp1" or "RclSmp1" and "MesSrc" or "RclSrc" and press **ENTR** to make your selections (*).

Depending on whether the user is recalling or measuring a source or sample, a flashing "S" or "1" will appear in the upper right hand corner of the screen.

- ***If making a new Sample measurement and Source, follow Steps 10 and 10a; if recalling Samples or Source files, skip to 10b.***

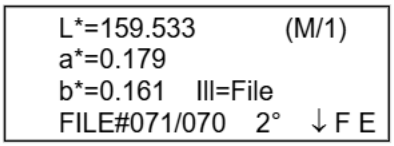
Step 10 Focus the target (Source) and press the **MEAS** key.

When the measurement is complete, the following prompt appears onscreen:



The flashing “1" in the upper right hand corner signifies to the user that the next measurement taken will be saved as Sample 1.

Step 10a Focus the target (Sample) and press the **MEAS** key again to measure the Sample. The following Data View Screen appears:



- ***If you wish to recall a Source or Sample file, follow Steps 10b, 10c, 10d, and 10e.***

Notes: Prior to recalling a Source or Sample file, the user can view them by pressing the **FRWD** key from the “MesSmp1 MesSrc” screen.

If the user is simply recalling files, then the *green* **LED** goes off and the (M/A) disappears from the screen signifying to the user that no measurements are to take place.

Step 10b Press the **ENTR** key to select “RclSmp1".

Press the **ENTR** key again to cause the first digit in the File # field (in this example, “0") to begin flashing.

Press the ⇑ or ⇓ arrow keys to scroll through the “wrap around” numbers: 0, 9, 8, 7. . . etc., of the first digit of the File # field until you select the appropriate one.

Repeat this process for the second and third digits, and when you have entered the desired file number, press the **FRWD** key to lock it in.

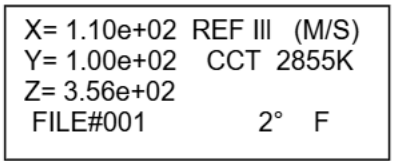
Step 10c Using the up and down arrow keys ⇑ ⇓, select RclSrc, and press the **ENTR** key.

Repeat the process for entering a File # as explained in the previous step.

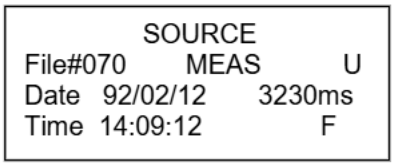
Step 10d Press the **FRWD** key to make the calculation.

Step 10e *(Optional)* Press the **FRWD** repeatedly to sequentially access the remaining Data View and File Attributes Screens for the Source and Samples.

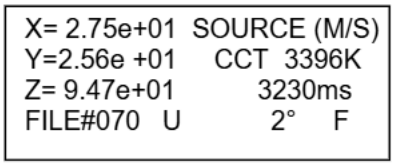
Reference Illuminant Data View Screen



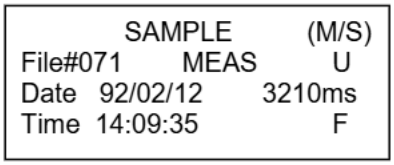
Source File Attributes Screen



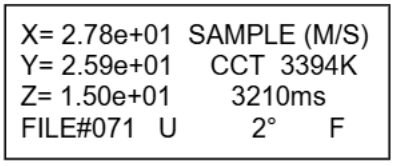
Source Data View Screen



Sample 1 File Attributes Screen



Sample 1 Data View Screen



Step 11 *(Optional)* If desired, press the blue **ALT** **LOCK** keys to reverse the locked/unlocked status of the files from a Data View Screen.

Step 12 Press **FRWD** again to return to the second Data Options screen to complete the measurement process.

This completes the procedure for making L*a*b* measurements without calculating Δ E color difference. The following procedure explains how to make L*a*b* measurements and calculate Δ E color difference.

Performing L*a*b* Measurements with Δ E Color Difference Calculation

Step 1 Press the *red* **0/I** key to turn on the PR-650.

Step 2 Check the Current Set-Up parameters screen, and make changes as required by scrolling (pressing the **FRWD** key) to the appropriate set-up screen and making the desired selections.

Refer to Chapter 2, PR-650 Screens for more information on setting various parameters.

Step 3 Open the View Shutter Control.

Step 4 Focus the viewing eyepiece and the objective lens as explained in Chapter 3, Focusing.

Step 5 Scroll through the Initial Set-up Screens until at the second Data Options Screen.

Use the up and down arrow keys ⇑ ⇓ to select L*a*b* Δ E? and press the **ENTR** key:

select

	Y X Z	CCT	
	L*u*v*	Δ E?	(more)
>	*L*a*b*	Δ E?	↑↓ F E

When the L*a*b* Δ E ? selection is made, the “?” changes to a flashing “y” and “n”.

Use the up and down arrow keys ⇑ ⇓ to select "y" to calculate Δ E, and press the **ENTR** key.

Step 6 Press the **ENTR** key again to access the screen shown below:

```
> Ref Ill=D-75          (M/S)
  Mes Smp1     Mes Src
  Rcl Smp1     Rcl Src
Smp1 071/Src070      ↑↓ F E
```

- ***If you wish to review the Illuminants, Source and Sample data sets, press the FRWD key from this screen.***

- ***If you do not wish to change the Reference Illuminant, skip to Step 9.***

Step 7 Use the up and down arrow keys ⇑ ⇓ to move the ">" (cursor) icon to the Reference Illuminant field and press the **ENTR** key to select it.

After pressing the **ENTR** key, notice that the Illuminant (in this example, the "D-75") begins to flash, indicating this field is active.

Press the ⇑ or ⇓ arrow keys to scroll through the available illuminants including the following:

A, B, C, D-55, D-65, D-75, or file #nnn (user-defined illuminant file)

If the user wants to use his own file, press the **ENTR** key to activate the file number field and the ⇑ or ⇓ arrow keys to enter the correct number of the file to be used.

Step 8 Press **FRWD** after selecting an illuminant to lock it in. (The "*" selection icon will disappear and this illuminant becomes the default).

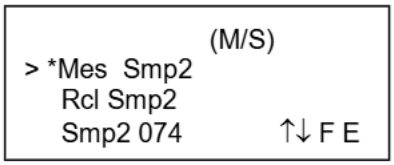
Note: If the user wishes to inspect the Reference Illuminant and Sample and Source data sets prior to making a measurement, continue to press the **FRWD** key.

Step 9 Use the up and down arrow keys ⇑ ⇓ to move the ">" (cursor) icon to the "MesSmp1" or "RclSmp1" and "MesSrc" or "RclSrc" and press **ENTR** to make your selections (*).

Depending on whether the user is recalling or measuring a source or samples, a flashing "S", "1" or "2" will appear in the upper right hand corner of the screen.

- ***If making new Sample and Source measurements, follow Steps 10, 10a, 10b, 10c, and 10d; if recalling Sample and Source files, skip to 10e.***

Step 10 Press the **FRWD** key from this screen to access the following screen:



Step 10a Select "Mes Smp2", and press **ENTR**.

A flashing "S" in the upper right hand corner signifies to the user that the next measurement taken will be saved as the Source.

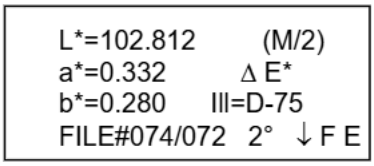
Step 10b Focus the target (Source) and press the **MEAS** key.

When the measurement is complete, the following prompt appears onscreen:



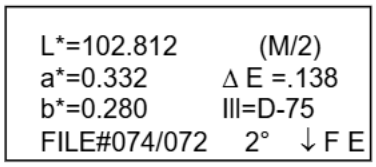
A flashing “1" in the upper right hand corner signifies to the user that the next measurement taken will be saved as the Sample 1.

Step 10c Focus the target (Sample 1) and press the **MEAS** key again to measure the Sample. The following Data View screen appears:



A flashing “2" in the upper right hand corner signifies to the user that the next measurement taken will be saved as the Sample 2.

Step 10d Focus the target (Sample 2) and press the **MEAS** key. The following Data View screen appears with the Δ E color difference calculated.

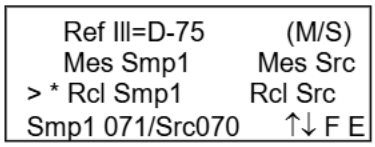


- ***If you wish to recall a Source or Sample file, follow Steps 10e, 10f, 10g, and 10e.***

Notes: Prior to recalling samples, the user can view them by pressing the **FRWD** key from the "MesSmp1 MesSrc" screen.

If the user is simply recalling files, then the green **LED** goes off, signifying to the user that no measurements are to take place.

Step 10e From the "MesSmp1 MesSrc, etc" screen, select "Rcl Smp1" and press the **ENTR** key.



Press the **ENTR** key again to cause the first digit in the Smp 1 File # field (in this example, "0") to begin flashing.

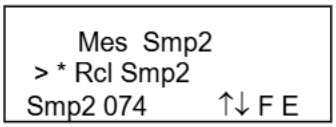
Press the ⇑ or ⇓ arrow keys to scroll through the "wrap around" numbers: 0, 9, 8, 7. . . etc., of the first digit of the File # field until you select the appropriate one; then press the **ENTR** key to lock it in and cause the next digit to start flashing.

Repeat this process for the second and third digits, and when you have entered the desired file number, press the **FRWD** key to lock in the final File number.

Step 10f Using the up and down arrow keys ⇑ ⇓, select "Rcl Src", and press the **ENTR** key.

Repeat the process for entering a File # as explained in the previous step.

Step 10g Press the **FRWD** key from this screen to access the following screen:

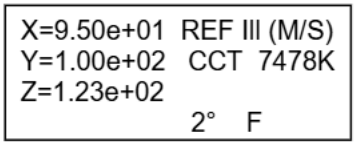


Repeat the process for entering a File # as explained in the Step 10e.

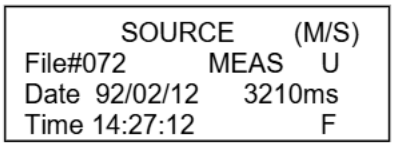
Step 10h Press the **FRWD** key to make the calculation.

Step 11 *(Optional)* Press the **FRWD** key again to sequentially access the remaining Data View and File Attributes Screens for the recalled source and samples.

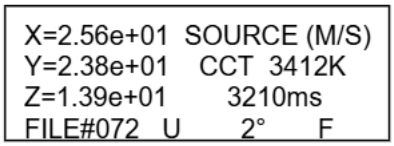
Reference Illuminant Data View Screen



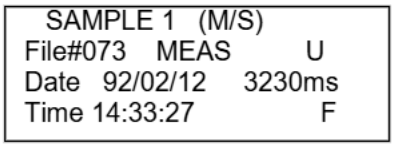
Source File Attributes Screen



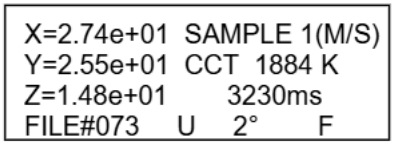
Source Data View Screen



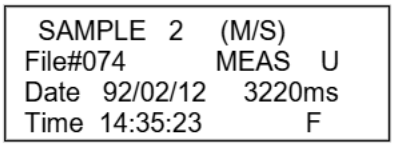
Sample 1 File Attributes Screen



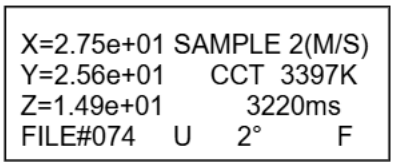
Sample 1 Data View Screen



Sample 2 File Attributes Screen



Sample 2 Data View Screen



Step 11a *(Optional)* If desired, press the blue **ALT LOCK** keys to reverse the locked/unlocked status of the files from a Data View Screen.

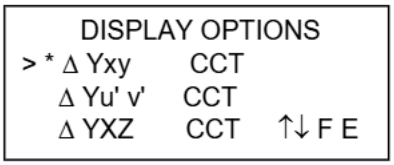
This completes the procedure for making L*a*b* measurements and calculating Δ E, and completes the last option selection in the second Display Options screen.

The next section explains the Options and Data View screens in the third Display Options screen.

Performing Delta Measurements

The third Display Options screen includes “delta” display options as shown below:

Screen 3 - Display Options (Illuminance/Luminance and Color Difference/Luminance)



Delta options allow two measurements to be compared, Sample 1 and Sample 2. (Sample 1 - Sample 2) and %Y, (Sample 2/ Sample 1) * 100.

Since each delta measurement calculation uses essentially the same software procedure for calculation of the delta value, all of these measurements will be included in the following Delta Measurement Procedure.

Delta Measurement Procedure

Step 1 Press the *red* **0/I** key to turn on the PR-650.

Step 2 Check the Current Set-Up parameters screen, and make changes as required by scrolling (pressing the **FRWD** key) to the appropriate set-up screens and making the desired selections.

Refer to Chapter 2, PR-650 Screens for more information on setting various parameters.

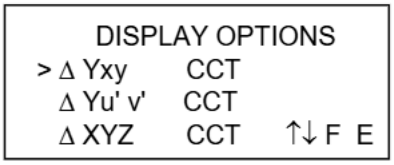
Step 3 Open the View Shutter Control.

Step 4 Focus the viewing eyepiece and the objective lens as explained earlier in this chapter.

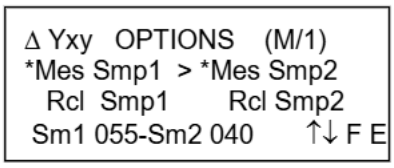
Step 5 Scroll through the Initial Set-up Screens until at the third Display Options screen.

Use the up or down arrow keys ⇑ ⇓ to move the ">" (cursor) icon to next to either the "ΔYxy", "ΔYu'v'" or "ΔXYZ" options, and press **ENTR** to make the selection (*).

select



Step 6 Press the **ENTR** key to access the screen shown below:



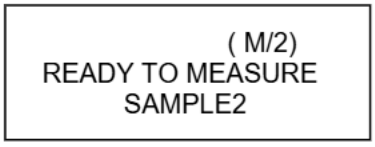
The flashing “1" in the upper right hand corner signifies to the user that the next measurement taken or recalled will be saved as Sample 1.

Step 7 Use the up or down arrow keys ⇑ ⇓ to move the “>” (cursor) icon to the “MesSmp1" and the ”MesSmp2” options, and press **ENTR** to place the “*” (active selection) icon next to them.

- ***If you wish to review the Sample data sets, press the FRWD key from this screen.***

- ***If making new Sample measurements, follow Steps 8, 8a, and 8b; if recalling Sample files, skip to 8c.***

Step 8 Focus the target (Sample 1) and press the **MEAS** key.
When the measurement is complete, the following prompt appears onscreen:



The flashing “2" in the upper right hand corner signifies to the user that the next measurement taken will be saved as Sample 2.

Step 8b Focus the target (Sample 2) and press the **MEAS** key. The following delta calculations appear:

```
Δ Y=0.01  %Y=100.1 (M/2)
Δ x=.000  Δ y=.000
Δ CCT= 1 K
FILE#077-078  2°     ↑↓ F E
```

- ***If you wish to recall a Sample file, follow Steps 8c, 8d, and 8e.***

Notes: After recalling samples, the user can view them by pressing the **FRWD** key from the “MesSmp1 MesSrc” screen.

If the user is simply recalling files, then the *green* **LED** goes off, signifying to the user that no measurements are to take place.

Step 8c From the “MesSmp1 and MesSmp2", select “RclSmp1" and press the **ENTR** key.

Press the **ENTR** key again to cause the first integer in the File # field (in this example, “0") to begin flashing.

Press the ⇑ or ⇓ arrow keys to scroll through the “wrap around" integers: 0, 9, 8, 7. . . etc., of the first integer of the File # field until you select the appropriate integer.

Repeat this process for the second and third integers, and when you have entered the desired file number, press the **FRWD** key to lock it in.

Step 8d Using the up and down arrow keys ⇑ ⇓, select "Rcl Smp2", and press the **ENTR** key.

Repeat the process for entering a File # as explained in the previous step.

Step 8e Press the **FRWD** key to make the calculation.

```
Δ Y=1.84        %Y=103.8
Δ x=.001   Δ y=.000
Δ CCT= 10 K
FILE#005-006   2°   ↓F E
```

Step 8f *(Optional)* Press the **FRWD** key again to sequentially access the remaining File Attributes Screens.

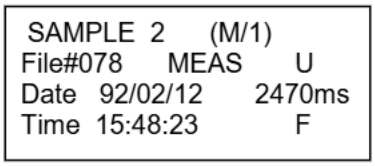
Sample 1 File Attributes Screen

```
SAMPLE 1   (M/1)
File#077   MEAS       U
Date  92/02/12     2500ms
Time  15:47:27          F
```

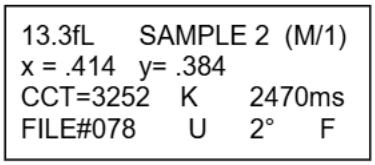
Sample 1 Data View Screen

```
13.3fL    SAMPLE1    (M/1)
x = .414   y= .383
CCT=3253   K     2500ms
FILE#077   U    2°      F
```

Sample 2 File Attributes Screen



Sample 2 Data View Screen



Step 9 *(Optional)* If desired, press the blue **ALT LOCK** keys to reverse the locked/unlocked status of the files from a Data View Screen.

Step 10 Press the **FRWD** key to return to the third Data Options screen thus completing this measurement sequence.

Use the previous procedure for calculating the other Delta functions from within the third Data Options Screen.

The fourth and final Display Options Screen allows the user to select a calculation for Radiometric Data. This procedure is explained on the following page.

Calculating Radiometric Data

Step 1 Press the **FRWD** key until the following Data Options screen appears:

Screen 4- Display Options (Radiance/Irradiance)

selecting

```
  DISPLAY OPTIONS  (M/1)
> *Radiometric Data
              ↑↓ F E
```

Step 2 Press the **ENTR** key to produce the following screen displaying the radiometric calculations.

The radiometric calculations include: 1) integrated radiance (irradiance) from 380-780nm; 2) the peak wavelength (in nanometers); and 3) the peak radiance (irradiance) value.

```
1.43e+01w/m2
Peak WL=768nm   1550ms
Peak Irrad=1.33e-02
FILE#001  U      2°  ↓F E
```

This completes the section on selecting and making initial measurements using the four Data Options screens. The following section explains how to access and set the Number of Files to Average Option.

Number of Cycles to Average

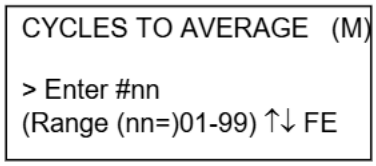
This screen enables the user to select a number of measurements to be taken consecutively and then averaged to give one overall answer. Up to 99 measurement cycles can be averaged. This procedure is recommended when measuring very high, very low, or unstable sources. Usually 4 to 10 measurements result in a good average.

The uncertainty improves with the square root of the number of measurements averaged. (For example, averaging 4 cycles has 2 times the signal-to-noise ratio as a single measurement.) High light levels result in short integration times. For bright pulsing sources, it is better to average many cycles and use an optional Neutral Density Add-on accessory and/or the AutoSync mode.

Note: The Cycles to Average screen is at the end of the menu screen sequence. It can easily be reached by holding down the ALT and BACK keys and back-scrolling to the "Home" position. Then press the ALT and then the BACK key a few more times to arrive at the Cycles to Average Screen.

Setting the Number of Cycles to Average

Step 1 Press **FRWD** (or **ALT** and **BACK**) until the following screen appears:



Step 2 Press **ENTR** to cause the first digit in the "Enter #nn" field to flash.

Step 3 Press the ⇑ or ⇓ arrow keys until the desired number appears.

Step 4 Press **ENTR** and repeat this process for the second numeral in the field.

Pressing **ENTR** again causes the numeral of the first field to begin flashing again.

Step 5 Press **FRWD** to complete the process and lock in the desired number of cycles to average.

Step 6 Press the **FRWD/BACK** key again to advance to the next screen or press the blue **ALT** key, then the **FRWD/BACK** key to return to the previous screen.

If it is necessary to make a correction, repeat the necessary steps from Steps 2 through 6.

The next chapter, File Operations includes information on automatic locking and unlocking of files, how to search for a specific file, and also how to copy and swap files when using delta measurement options.

Chapter 5 - File Operations

Overview

The PR-650 software provides various methods for protecting data from being overwritten and for searching for specific data files. These options include Auto Locking functions, and partitioning of data blocks for file searching. This chapter discusses how files are stored, how the user can protect data and various procedures for accessing certain files.

Measurement Storage

Measurement data is automatically stored sequentially in a data file after each measurement. Measurement data files are actually memory areas on the ICM Card and each is assigned a "File Number". There are a minimum of 150 total file storage spaces on the 256K Card and 580 on the 512K Card.

Any measurements over about 150 (or 580) will "wrap around" and begin overwriting "unlocked" or unprotected files. Therefore, the next available memory area not tagged with an "L" (for locked) and tagged with a "U" (for unlocked) can be overwritten following a measurement when the ICM card measurement storage area is full.

Locking Files

The ENTR key is used as the "LOCK" key when the *blue* **ALT** key is pressed. The **ALT LOCK** combination actually acts as a toggle to reverse the current status of a file, i.e. "L" or "U" (Locked/Unlocked). Normally, this function is only active in Data View screens that contain the "L" and "U" letters, except when using the special **ALT ENTR** function.

When the user presses the **ALT ENTR** keys, from other than a Data View screen, it causes the Data View screen from the last measurement taken to appear with the file status (Locked/Unlocked) reversed. The user can then change the status as desired by pressing the **ALT ENTR** keys again.

File Options - Auto Lock/Auto Unlock

In order to automatically lock (or unlock) all measurement files as they are being written, the user accesses the following File Options screen to set an auto "lock" or "unlock" option:

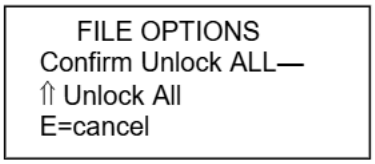
```
   FILE OPTIONS
 * Auto Locked
   Auto Unlocked
 > Unlock ALL     ↑↓ F E
```

The File Options Screen shown above is sequentially accessed by pressing the **FRWD** key. It is the first screen to appear after the Data Options screens. Options in this screen are selected in the same manner as other interactive screens, that is by using the up and down ⇑ ⇓ arrow keys to move the cursor icon (>) to the desired option; then pressing **ENTR** to make it the active selection (*).

Unlock ALL

In addition to providing a automatic lock or unlock file option to the user, the software also provides an "Unlock ALL" file option which serves as a method of allowing all old data files to be overwritten by "unlocking" or unprotecting them. Once unlocked, files can be over-written by subsequent measurements when the measure-ment storage area is full.

If the user selects the **Unlock ALL** file option and presses the **ENTR** key, the screen shown below appears:



To complete the unlocking of all files, the user presses the up arrow. The message "Unlock ALL in Process" appears briefly on the screeen while the files are being unlocked. To cancel the Unlock ALL procedure, the user presses the **ENTR** key and the message "Unlock ALL cancelled" briefly appears on the screen.

Another method of deleting files by overwriting them is accomplished using the "Meas Start" function. With "Meas Start", the user can separate a block of measurement files from other data set files by telling the software to begin overwriting files at a specified file number. The following procedure explains how to use this function.

Note: Only unlocked files beginning with the Meas Start # will be overwritten when new measurements are performed. To prevent files from being overwritten, verify that the last Meas Start # entered is greater than the "Unlocked" file number that must be saved.

To insure that a file is not overwritten, verify that it is locked before proceeding.

Using the Meas Start Function

Step 1 Press the **FRWD** key until the File Options screen shown below appears:

File Options Screen Example

```
        FILE OPTIONS
    Enter File    # 001
> * Meas Start #  001
                  ↑↓ F E
```

Step 2 Press the ⇑ or ⇓ arrow keys to position the ">" (cursor) icon before "Meas Start # 001".

Step 3 Press **ENTR** to select this option (*) and cause the first digit of the Meas Start File # field to begin flashing (first "0" of 001).

Step 4 Press the ⇑ or ⇓ arrow keys to scroll through the "wrap around" digits: 0, 9, 8, 7 . . . etc., until the desired one appears.

Step 5 Press **ENTR** to lock in this digit and cause the next digit to flash.

Step 6 Repeat Steps 4 and 5 until the desired file number appears on the screen.

Step 7 Press the **FRWD** key to lock in the "Meas Start" File number. (Notice that the selection icon "*" disappears after the **FRWD** key is pressed.)

Subsequent measurements will now be sequentially stored in unlocked files starting with the Meas Start #.

Note: If an invalid File# is entered, the message "Illegal File Number" appears. Press the **FRWD** key to return to the Enter File#/Meas Start# screen.

Entering the file number of a locked file causes the error message "Warning Locked File" to appears. Press **FRWD** to return to the Enter File#/Meas Start# screen.

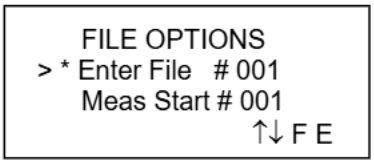
This completes the explanation of how to use the Meas Start function to separate or group together a certain number of files.

The next section explains how to recall a file number when the user knows the exact number of the file.

Recalling Files by File Number

Step 1 Press **FRWD** until the File Options screen shown below appears:

File Options Screen Example



Step 2 Press the up and down ⇑ ⇓ arrow keys to position the ">" (cursor) icon before "Enter File # 000".

Step 3 Press **ENTR** to select this option (*) and cause the first digit of the Enter File # field to begin flashing.

Step 4 Press the up and down ⇑ ⇓ arrow keys to scroll through the "wrap around" digits: 0, 9, 8, . . etc., until the desired one appears.

Step 5 Press **ENTR** to lock in this digit and cause the next one to flash.

Step 6 Repeat Steps 4 and 5 until the desired file number appears on the screen.

Step 7 Press **FRWD** to bring up the File Attributes screen for the previously input file number as shown below:

File Attributes Screen Example

```
     FILE ATTRIBUTES    (M)
File #  001   MEAS     U
Date  08/06/91     1273 ms
Time  14:14:03           F E
```

Step 8 Press **FRWD** to view the Data View screen. The parametric data from the measurement appears in the format currently selected for the Display Options and Units Options screens, as shown in the example below:

Parametric Data View Screen Example

```
Y = 100 fL  120 Hz       (M)
x  = .448    y = .407
u' = .256   v' = .524
File # 100   U       2° ↓F E
```

Notes: Exceptions to this step include L*u*v*, L*a*b*, and all ΔE functions. Data sets for these measurements can only be viewed from specific screens. Refer to Chapter 3, Making Measurements for more details.

Press the **ALT ENTR** keys to reverse the locked/unlocked status of the file from this screen.

Step 9 Press **FRWD** again to return to the Enter File #/ Meas Start # screen.

The next procedure explains how to use the "File Search" method to recall data when the file number is unknown, but the date time, and file status of the measurement are known. This method allows the user to incrementally step through file numbers and display the date, time, and file status (U or L) of each selected file until the correct file is found.

For example, if the user enters the number "10" as a step increment and presses the arrow keys, the software searches through the files (either Locked (**L**), Unlocked (**U**), or Both (**B**), depending on the user's preference) stopping at every tenth file to allow the user to view the attributes of that file.

The following procedure explains how to recall a file using the File Search method.

Recalling Files Using File Search

Step 1 Press **FRWD** until the File Search Screen as shown below appears:

File Search Screen Example

```
        FILE SEARCH
    92/02/27      13:04:56
    SEARCH #156       U
> * STEP 10   B       ↑↓ F E
```

Step 2 Press the up and down ⇑ ⇓ arrow keys until the " >" (cursor) icon is positioned in front of the "**STEP** nn" (Step Increment) field.

Step 3 Press **ENTR** to select this option (*) and cause the first digit of the STEP (Increment) field to begin flashing.

Step 4 Press the up and down ⇑ ⇓ arrow keys to scroll through the "wrap around" digits: 0, 9, 8, . . . etc., until the desired one appears.

Step 5 Press **ENTR** to lock in this digit and cause the second one to flash.

Step 6 Repeat Steps 4 and 5 to enter the desired STEP (Increment) number (Range=01-99).

Step 7 Press **ENTR** again to cause the file status field (for Locked (L), Unlocked (U), or Both (B)) to flash.

Note: During File Search, the software searches files according to file status (L, U or B) as well as the step increment.

Step 8 Press the ⇑ ⇓ up or down arrow keys until the desired letter (L, U or B) appears, then press the **FRWD** key to lock it in.

If it is necessary to make corrections, repeat Steps 3 through 8.

Initiating the File Search

Step 9 Press the up and down ⇑ ⇓ arrow keys until the ">" (cursor) icon is positioned in front of the "SEARCH" field, then press **ENTR** to select it.

The word "SEARCH" begins flashing indicating that this mode is now active.

Step 10 Press the up and down ⇑ ⇓ arrow keys to begin searching for the desired file using the previously set STEP Increment.

Press and hold either the up (⇑) or down (⇓) arrow keys for automatic scrolling.

Note: The software skips over empty data files.

As the user searches through the files, the data in the File Search screen changes to reflect the attributes of the file currently accessed.

These attributes include the Time and Date the file was created (in USA or INT format), the three digit file number and the file status, i.e., locked or unlocked. See the example below:

File Search Screen Example

```
      FILE SEARCH
   92/03/03      16:22:56
   SEARCH #007     U
> * STEP 10  B   ↑↓ F E
```

Step 10a *(Optional)* If the desired file is *between* the previously input STEP Increment, press **FRWD** and repeat the necessary steps from 2 through 12 to set a smaller increment and restart the File Search process.

Once the desired file has been reached, the user can view the parametric data from the measurement file in the format currently selected for the Display Options and Units Options screens.

Step 11 With the word "SEARCH" still flashing, press the **ENTR** key to end the search and display the selected file. See the example below:

Parametric Data Screen Example

```
Y = 100 fL  120 Hz      (M)
x  = .448     y = .407
u' = .256    v' = .524
File # 100    U        2°   F E
```

Note: Press ALT LOCK to reverse the file status (Locked/Unlocked) from this screen.

Step 12 Press the **FRWD** key to return to the File Search screen.

This completes the section on how to use the File Search option to retrieve files.

This completes the chapter on File Operations. The next chapter explains how to setup and use the PR-650 print options.

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Chapter 6 - Print Options

Overview

The PR-650 can be connected to a serial RS-232 printer for hard copy printouts using an optional RS-232 printer cable (PC-650), or can be connected to a PC to transfer data using the RS-232 CTRL/XFER cable (included with the system) and a communications program (e.g. Procomm Plus).

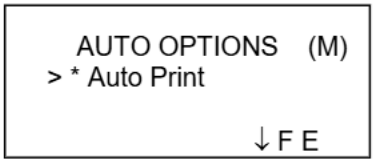
Depending on the software print selections set by the user, complete or partial data reports can be automatically or manually sent to either the printer or the PC.

Setting the system to auto print causes each measurement to be printed after the measurement is completed.

The following procedures explain how to set up the software options to select auto printing (or transfer) of partial or complete data to a printer or to a PC communications program, and then information on setting up the desired hardware connections.

Using Auto Print

Step 1 Press **FRWD** until the following screen appears:



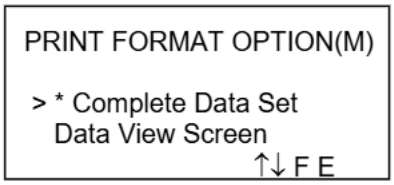
Step 2 Press the up or down ⇑ ⇓ arrow keys until the ">" (cursor) icon is positioned in front of "Auto Print".

Step 3 Press **ENTR** to cause the "*" (active selection) icon to appear indicating that Auto Print has been selected and that data will automatically be printed out after each measurement.

To deselect Auto Print, press **ENTR** again and the icon will disappear.

Note: AutoPrint will also send the report to a PC.

Step 4 Press the **FRWD** key to access the Print Format Option Screen shown below:



Step 5 Use the ⇑ ⇓ up and down arrow keys to move the cursor icon (>) to the desired option and press the **ENTR** key to select it (*).

If the user selects "Complete Data Set" all photometric, colorimetric, radiometric, and spectral data will be printed for each measurement along with the file number, date and time of the measurement. See a printout example included at the end of this chapter.

If the user selects "Data View Screen", a printout of the Data View display is sent only while the Data view Screen is being displayed.

After selecting print option defaults in the software, the user can setup his printer or PC configuration. The following procedures explain how to connect the PR-650 to a printer, and to a PC.

Note: The RS-232 connector on the PR-650 is not fixed and does have some play in it. This is not a defect.

Printing to a Printer

Step 1 Connect the PR-650 to a serial printer using the standard cable configuration below (or the optional RS-232 printer cable).

Figure 6-1: Printer Cable Configuration

Refer to Figure 1-1 in Chapter 1 to locate the RS-232 connector on the PR-650.

If the user has selected the Auto Print Option, data will automatically be printed to the printer after a measurement is completed.

Step 2 *(Optional)* If the user has not selected Auto Print, then it is necessary to press the ALT PRNT keys after a measurement to print data in the selected format (i.e., Complete Data Set or Data View Screen).

If desired, the user can have data sent to a PC for viewing on screen, or for logging to a disk file. The following procedure explains how to set up the system for this print method.

Printing to a PC

Step 1 Connect the PR-650 to a computer using the optional (PC-650) Printer Cable. If using the supplied CTRL/XFER cable, set the CTRL/ XFER switch to the CTRL position. (See Figure 5-2 on page 5-6).

Note: See the procedure at the end of this chapter for information on connecting the CTRL/XFER cable.

Step 2 Load the RS-232 communications software (e.g. PROCOMM PLUS). The communications line configuration must be set as shown below:

Baud Rate:	**9600**
Parity:	**None**
Data Bits:	**8**
Stop Bits:	**1**

Note: If using a communications program, such as Procomm Plus, it is advisable to modify the translation table such that the form feed character (H0C or D012) is translated to a carriage return (H0D or D013). If not, the screen will blank out as the result of a form feed character being sent from the PR-650 at the end of the report.

If the user has selected the Auto Print Option, data will automatically be sent to the PC for viewing after a measurement is completed.

Step 2a *(Optional)* If the user has not selected Auto Print, then the ALT PRNT key must be pressed after each measurement in order to send data to be viewed on the PC.

Alternatively, the data can be saved to a disk file by setting the communications data logging feature to ON.

The RS-232 cable is equipped with a 25-pin "D type" connector containing a CTRL/XFER switch for connection to the PC, and a round snap-on 12-pin connector for connection to the PR-650.

The following procedure explains how to properly connect the RS-232 cable to the PC.

Step 1 Connect the 25-pin, sub D type connector to an appropriate RS-232 port on the Host PC. ("Gender changers", and a 25 to 9-pin conversion connector may be required). Complete the connection by tightening the two side screws.

Step 2 Connect the round 12-pin male connector to the RS-232 Cable Connection on the PR-650 (Refer to Figure 1-1.) Align the keyway on the cable connector to the keyway on the PR-650 connector and press firmly until an audible "click" is heard, indicating that the cable is locked into place.

Step 3 To remove the 12-pin connector, pull back on the spring-loaded knurled ring, then gently pull the entire connector straight out of the PR-650 unit.

The switch on the Host side of the RS-232 connector used for remote control of the unit (**CTRL**) by the Host computer, for downloading measurement data to the Host and for restoring the ICM Card program software (**XFER**), must be set to the CTRL position when sending data to the PC.

Figure 6-2: CTRL/ZFER Host Cable Connector

Sample Printouts

Data View Screen Printout Example

38.1Fl
x=.419 y=.393 1230ms
u' = .244 v' = .514
File# 003 U 2deg

Complete Data Set Printout Example

PHOTO RESEARCH – The Light Measurement People
Instrument : PR-650 Average Cycles : 1
Serial Number : 2222 Integration Time : 1229 msec
Measurement Date : 92/03/05 Frequency : DC
Measurement Time : 16:37:49 File Num/Protect : 3 U
Accessory : MS-75

PHOTOMETRIC DATA----------
Luminance =3.808e+01 footLamberts
  =1.305e+02 candelas per square meter

COLORIMETRIC DATA
CIE 1931: X = 1.394e+02x =.419(2 degree observer)
  Y = 1.305e+02y =.393
  Z = 6.247e+01z =.188

CIE/UCS 1960: u = .244 v = .343 CIE/UCS 1976:
  u'= .244 v'= .514

Correlated Color Temperature = 3221 Kelvins

RADIOMETRIC DATA
Integrated Radiance : 3.905e-01 w/sr/m2
Peak Wavelength : 584 nm
Peak Radiance : 3.131e-03 w/sr/m2/nm

SPECTRALDATA – Corrected Spectral Radiance (w/sr/m2/nm)

380	6.492e-05	460	6.816e-04	540	1.036e-03	620	1.920e-03	700	3.145e-04	384	2.300e-05
464	7.570e-04	544	1.108e-03	624	1.804e-03	704	3.009e-04	388	1.702e-05	468	8.11e-04
548	1.368e-03	628	1.690e-03	708	2.938e-04	392	3.921e-05	472	8.506e-04	552	2.193e-03
632	1.551e-03	712	2.898e-04	396	4.781e-05	476	8.472e-04	556	2.639e-03	636	1.419e-03
716	2.923e-04	400	6.958e-05	480	8.206e-04	560	2.236e-03	640	1.296e-03	720	2.825e-04
404	9.677e-05	484	7.907e-04	564	2.132e-03	644	1.183e-03	724	2.605e-04	408	1.992e-04
488	7.722e-04	568	2.346e-03	648	1.073e-03	728	2.463e-04	412	4.510e-04	492	7.824e-04
572	2.585e-03	652	9.603e-04	732	2.476e-04	416	5.895e-04	496	8.018e-04	576	2.773e-03
656	8.676e-04	736	2.484e-04	420	4.861e-04	500	8.236e-04	580	2.941e-03	660	7.846e-04
740	2.674e-04	424	3.825e-04	504	8.375e-04	584	3.131e-03	664	7.126e-04	744	2.808e-04
428	3.899e-04	508	8.494e-04	588	3.088e-03	668	6.438e-04	748	2.805e-04	432	4.389e-04
512	8.598e-04	592	2.812e-03	672	5.745e-04	752	2.759e-04	436	5.348e-04	516	8.781e-04
596	2.577e-03	676	5.218e-04	756	2.843e-04	440	1.017e-03	520	8.968e-04	600	2.455e-03
680	4.712e-04	760	2.700e-04	444	1.854e-03	524	9.138e-04	604	2.347e-03	684	4.260e-04
764	2.248e-04	448	1.744e-03	528	9.359e-04	608	2.243e-03	688	3.901e-04	768	1.925e-04
452	1.005e-03	532	9.630e-04	612	2.151e-03	692	3.551e-04	772	2.011e-04	456	6.624e-04
536	9.934e-04	616	2.027e-03	696	3.340e-04	776	2.001e-04				
								780	2.276e-04		

Additional procedures relared to the CTRL/XFER switch are explained in *Appendix B, Remote Mode Commands and Chapter 7, Saving and Restoring Data.*

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Chapter 7 - Saving and Restoring Data

Saving Data

All measurement data files, whether locked (L) or unlocked (U), and reference illuminant files can be transferred from the PR-650 to a Host (PC) disk by utilizing the SAVE650 program which resides on the enclosed 3 1/2" floppy diskette labeled, SAVE/RESTORE DISK.

Data from the PR-650 are transferred to the Host (IBM PC or compatible) over an RS-232 serial interface and saved as two disk files in a binary format that can later be transferred back to the PR-650 ICM Card by the RESTORE (RESTR650) program. The Host file(s) created by the SAVE650 program are not designed to be used by off-line software such as spreadsheets, databases, or custom application programs.

Required Equipment

1 - IBM PC/XT/AT/386/PS-2 or compatible personal computer (Host) running under DOS. OS/2 & UNIX are not supported.

2 - RS-232 port with a 25-pin (or 9-pin) connector available on the Host as COM1: or COM2:.

3 - PR-650 RS-232 cable with CTRL/XFER switch.

4 - SAVE650 executable program (SAVE/RESTORE DISK).

Procedure

Step 1 Connect the 25-pin, sub D connector on the CTRL/XFER cable to the RS-232 port on the Host (COM1: or COM2: only).

Step 2 Set the CTRL/XFER switch located on the side of the 25-pin connector to XFER.

Step 3 Connect the other end of the CTRL/XFER cable to the RS-232 connector on the PR-650 (see Figure 1-1).

This is accomplished by aligning the keyway on the connector and pressing inward until an audible "click" is heard.

Step 4 Go to the directory containing the program SAVE650.EXE.

Step 5 Type **SAVE650 [optional switches], then press ENTER.**

A complete list of the PR-650 program options can be viewed online by typing:

SAVE650 <CR>

All switches must be separated by a space.

Example: save650 -c1 -sc:\650\spectral.dat

Optional switches include:

[-c <num>]- Specifies which Host COMM port is being used. Allowable values for <num> are 1 or 2.

[-I <str>] - Specifies the file name, including disk and path, of the Host disk file that will contain transferred reference illuminant data. If omitted, no reference illuminant files are saved.

[-s <str>] - Specifies the file name, including disk and path if necessary, of the Host disk file that will contain transferred PR-650 measure-ment data. If omitted, no measurement files are saved.

Step 6 Press **ENTER** to start the SAVE program and intiate the process of transfer<$ITransferring data;using RS-232 CTRL/XFER cable>ring data from the PR-650 to the Host.

A screen display similar to the one shown below appears on the PC:

```
Q:\CAL\save650 -c1 -ic:\650\refillum.dat -sc:\650\measfile.650
PR-650 RAM CARD Data Saver Program. Version 1.00
Copyright (c) Photo Research. All rights reserved.

Initializing host serial interface and the PR-650.....done
Getting and saving common area...done
Getting and saving stored measurement index area...done
Getting and saving stored measurements
processing file xxx  done   n  stored measurements written
Getting and saving reference illuminants
processing file yy  done   m  illuminants  written
The PR-650 RAM CARD is saved to disk
```

Notes: *xxx* and *yy* are updated to reflect the current PR-650 file number being transferred. *n* and *m* are the total number of files transferred at the end of the procedure.

Pressing Ctrl C exits the SAVE 650 program.

During the transfer process, the following message appears on the PR-650 display screen:

```
PR650 REMOTE MODE
     (XFER)

CMD XX  ACK
```

The notation ACK shown in the example PR-650 screen display above informs the user that all is proceeding normally. XX represents the current command sent to the PR-650 from the Host. *If NAK appears (replacing ACK), turn the PR-650* **OFF**, *then* **ON**, *and restart the SAVE650 program from the Host.*

This completes the procedure for transferring data using the PR-650 software.

Restoring The ICM Card

If the data in the ICM Card becomes corrupted for any reason, the original program information, as well as reference illuminant and measurement files (transferred to the Host using the SAVE650 program), may be RESTORED to the ICM Card. This is accomplished using the program RESTR650.EXE located on the enclosed diskettes supplied with the PR-650 and labeled SAVE/RESTORE DISK.

Note: Press Ctrl C to exit the RESTORE program.

Procedure

Step 1 Connect the 25-pin, sub D connector on the CTRL/XFER cable to the RS-232 port on the Host (Gender changers and a 25 to 9-pin adapter may be required).

Step 2 Set the CTRL/XFER switch located on the side of the 25-pin connector to XFER.

Step 3 Connect the other end of the HOST/XFER cable to the RS-232 connector on the PR-650 (see Figure 1-1) on COM1: or COM2: only.

This is accomplished by aligning the keyway on the connector with that on the PR-650 RS-232 port and pressing inward until an audible "click" is heard.

Note: The RS-232 connector on the PR-650 does have some play in it. This is part of the design and not a defect.

Step 4 Go to the direcory containing the program RESTR650.EXE.

Step 5 Type **RESTR650 *nnnnnnnn*** [optional switches], then press **ENTER**.

nnnnnnnn represents the serial number of the PR-650.

A file named *nnnnnnnn*.RAM containing program information for this instrument is included on the SAVE/RESTORE DISK , where *nnnnnnnn* is the serial number of the instrument.

If no serial number is specified only the -i, -s, or -t options (if present) will be honored.

Note: A complete list of these options may be obtained on line by typing RESTR650 <ENTER>

Optional switches include:

[-c <num>] - Specifies which Host COM port is being used. Allowable values for <num> are 1 or 2. If omitted, COM 1: is used.

Example: RESTR650 nnnnnnnn -c
or RESTR650 nnnnnnnn -c1

[-I <str>] - Specifies the file name, including disk and path, of the Host disk file that contains reference illuminant data to be transferred to the PR-650. If omitted, no reference illuminant files are restored.

Example: RESTR650 nnnnnnnn -c1 -ic:\650\refillum.dat
(The file supplied on the SAVE/RESTORE (nnnnnnnn.RAM) DISK contains all reference illuminant files.)

[-r <str>] - Disk path containing original factory program data with the file name *nnnnnnnn*.RAM where *nnnnnnnn* is the serial number of the PR-650. If omitted, the current disk path of the Host is accessed.

Example: RESTR650 12345678 -c1 -rc:\650

[-s <str>] - Specifies the file name, including disk and path if necessary, that contains measurement files to be transferred to the PR-650. If omitted, no measurement files are restored.

Example: RESTR650 -c2 -sc:\650\measfile.650

[-t <num>] - If <num> = 1, set the PR-650 time of day clock from the Host's clock. If this option switch is omitted or <num> = 0, the PR-650 time of day clock is left unchanged.

Step 6 After pressing **ENTER**, the program begins the process of transferring the data from the Host to the PR-650.

A screen display similar to the one shown below appears on the PC informing the user of the step-by-step progress of the program.

```
Q:\CAL>restr650 2222   - rc:\650  -ic:\650\refillum.dat -sc\650\
measfile.650   -ti
PR-650 RAM CARD Data Restorer Program. Version 1.00
Copyright (c) Photo Research. All rights reserved.

Reading file c:\650|222.ram from disk...done

Initializing host serial interface and the PR650.....done
Sending 112592 bytes of program and the data to the PR650
(This will take approximately 2.0 minutes)….done

The PR650 is now running in RAM

Initializing stored measurements and illuminant area...done
173 total stored measurements and illuminants are reserved
Sending reference illuminant files
  Sending illuminant file yy     done    m illuminant files sent
Sending common area to PR-650...done
Sending stored measurement index...done
Sending stored measurements
  Sending file xx  done   n measurement files sent

The PR-650 time of day clock is :  mm/dd/yy  hh:mm:ss
                                   09/04/91    15:12:57

The PR650 RAM CARD is restored
```

Note: *xx* and *yy* are updated to reflect the current PR-650 file number being transferred. *n* and *m* are the total number of files transferred at the end of the procedure.

During the procedure, the following screen appears on the PR-650 display:

PR-650 Remote Mode Screen Example

```
PR650 REMOTE MODE
  (XFER)

CMD XX  ACK
```

The notation ACK shown in the example PR-650 screen display above informs the user that all is proceeding normally. *XX* represents the current command sent to the PR-650 from the Host. *If NAK appears (replacing ACK), turn the PR-650* **OFF**, *then* **ON**, *and restart the SAVE650 program from the Host.*

This completes the procedure for restoring data to the ICM card.

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Chapter 8 - Maintenance

Routine Maintenance

The PR-650 SpectraColorimeter has been designed to give long, trouble-free service requiring minimal routine maintenance. The following section gives guidelines for insuring optimum service from the PR-650.

Cleaning Lenses / Optical Accessories

Step 1 Keep the PR-650 clean and dust-free.

Store the PR-650 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.

Step 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-650 is designed to maintain stable calibration for long periods of time. 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 six-month 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).

Notes: Any *unauthorized* tampering with the instrument, including opening of the case, automatically voids the warranty.

Batteries are not covered under the warranty.

Before returning the instrument to Photo Research, it is recommended that the user perform a RAM RESTORE operation since a corrupted RAM card could possibly cause the unit to malfunction. Please see the section entitled Restoring the ICM Card beginning on page 7-3 for a detailed explanation of this procedure.

After contacting the Customer Service Department for a Return Material Authorization (RMA) number, 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 PR-650 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.

Out-of-Warranty Repair

If the instrument is out of warranty, contact the Customer Service Department for a Return Authorization (RMA) number. The instrument should be brought or shipped prepaid to the Photo Research Service Department (or call Photo Research for information as to authorized repair facilities in your area).

Pack the PR-650 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.

Appendix A
Error Codes

Overview

If the PR-650 malfunctions for whatever reason, the *red* LED flashes and one of the following messages will appear on-screen to help identify the problem. Pressing the FRWD key causes the previous menu screen to appear, but the *red* LED will continue to flash and measurements cannot be made until the error is corrected.

For the following error messages, try retaking the measurement several times. If the messages continue to appear, it may indicate a problem with the hardware or software.

The following error codes are generally time-out errors, and indicate a failure of the PR-650 hardware:

- NO EOS START - No end-of-scan at start up.
- NO START - Not enough start pulses in 2X integration time.
- NO EOS TIME - No end-of-scan during timed mode.
- DMA FAILURE - Direct Memory Address failure.
- NO EOS SYNC - No end-of-scan during AutoSync measurement.
- NO EOS START/TIME/SYNC - No end of scan pulse from the detector. Indicates failure of detector or associated circuitry. Consult Photo Research Service Dept.

For the following messages, try increasing the intensity of the source being measured.

- WEAK SIGNAL - Signal-to-noise is too low to make a good measurement. Measurement is aborted.
- TOO MUCH TIME - Unit requires too much time to perform a measurement due to the low light level of the measured light source.
- LOW LIGHT LEVEL - *Not* an error, but a warning that signal-to-noise is in the marginal range. The measurement is completed and the data can be viewed by pressing the FRWD key.

For the following error messages, try re-entering the file number.

- ILLEGAL FILE NUMBER
- NO FILE FOUND

If one of the following messages appear, it's possible that an AutoSync measurement may not be completed. Sometimes holding the instrument extremely still and repeating the measurement several times will work. If one of the following messages is repeated while trying to make AutoSync measurements, change to Timed mode.

- UNABLE TO SYNC - Could not get a sync "lock". Can be caused by low light level, multiple pulsing sources or a non-pulsing source.
- SYNC LOST - Sync lock could not be maintained.
- VARYING LIGHT - Source is not a repetitively pulsing light source or its pulse (refresh) rate is varying too much. This prevents the sync mode from working.

The warning messages are as follows:

OVERLOAD - Turn down the intensity of the measured source or install the optional Neutral Density Filter Add-On Accessory.

RAM CARD DATA CORRUPTED - Fatal error with ICM Card and requires ICM Card to be restored from a Host PC. See Chapter 6 for instructions on how to restore the ICM Card.

ALL FILES FULL - Some files will have to be changed to unlocked files so that they can be written over to make room for new files, or a newly restored ICM Card can be installed.

PRINTER OFF LINE - Check printer power or cables.

DATA CORRUPTED - File has somehow been damaged.

DUPLICATE ACCESSORY - Select only one accessory.

BATTERY LOW - Battery should be replaced with another freshly charged battery or use the optional AC Adaptor.

OPERATOR ABORT - Indicates that the user pressed the ALT key and then the MEASure key to terminate a measurement.

RAM CARD IS MISSING OR WRITE PROTECTED - ICM Card is not properly installed. Turn power *off*. Remove ICM Card, verify that it is *not* write protected (WP) and reinsert.

SERIAL NUMBERS DON'T MATCH - An ICM Card from a different PR-650 has been installed in the unit. Turn power ***OFF***, remove the card and replace it with the proper card. The serial numbers on the PR-650 unit and the ICM Card must match or the unit will not operate.

Appendix B
Remote Mode Commands

Overview

The PR-650 can be set up to operate in Remote Mode using an RS-232 line in either of two methods. These include: an RS-232 terminal (or a computer emulating one), or an applications program running in a Host computer supporting asynchronous communications over an RS-232 serial line. Both of these methods must provide the capability of sending and receiving ASCII characters.

Whichever method is selected, communications are conducted using the supplied CTRL/XFER RS-232 cable.

Communications Configuration

The following communications line configuration must be observed for successful communications with the PR-650:

Baud rate	:	9600
Parity	:	None
Data Bits	:	8
Stop Bits	:	1
Full duplex	:	The PR-650 can be commanded to echo characters it receives.

PR-650 CTRL/XFER Cable Pinouts

TD (DB25 pin 2)	Serial data to the PR-650
RD (DB25 pin 3)	Serial data from the PR-650
RTS (DB25 pin 4)	Input to the PR-650. When this line is driven low, the PR-650 initiates a 0.1 second RESET putting it into a known state.
DTR (DB25 pin 20)	Input to the PR-650. Data will be sent from the PR-650 only when the DTR line is high. If not driven, this signal is high.
GND (DB25 pin 7)	Signal ground.

The following section explains how to connect the hardware and CTRL/XFER cable to allow remote operation of the unit.

Hardware Set-Up Procedure

Step 1 Connect the 25-pin, sub D connector on the CTRL/XFER cable to the RS-232 port on the Host. (For some computers, it may be necessary to use 25 to 9 pin reduction connectors, and/or "gender changers").

Step 2 Set the CTRL/XFER switch, located on the side of the 25-pin connector to **CTRL**.

Step 3 Connect the other end of the CTRL/XFER Cable to the RS-232 connector on the PR-650 (see Figure 1-1). This is done by aligning the keyway on the connector and pressing inward until an audible "click" is heard.

Note: The RS-232 connector on the PR-650 is not fixed and does have some play in it. This is normal and not a defect.

This completes the information on setting up the hardware.

The next section describes the procedure for operating the PR-650 in Remote Mode.

Remote Mode Startup

Overview

Whenever the CTRL/XFER cable is connected to the PR-650, the unit automatically "wakes up" after power up in Remote Mode whether connected to a PC or not. However, if the unit is not connected to a PC, or a command is not sent to establish and maintain Remote operations, the PR-650 reverts to normal operating mode.

Note: During Remote Mode, the only active key on the PR-650 control panel is the O/1 (on/off) key.

From an Applications Program

1 - Turn on the PR-650

2 - Set the RTS line high.

3 - Set the RTS line low. This charge causes the PR-650 to reset.

Leave the RTS line low for a minimum of 50 ms.

4 - Set the RTS line high.

Send a command within 5 seconds to start communicating with the PR-650.

For example, send the command 'S' (upper or lower case). If a command is not received within 5 seconds, the PR-650 reverts to normal operating mode. See Figure B-1.

Figure B-1: Remove Mode Timing Diagram

5 - The application program should now read the Response Code relevant to the command sent. Refer to Appendix B sections, **ASCII Commands** and **Responses Codes** for more detailed information.

The following sections give examples of how to start Remote Mode operation of the PR-650 by (1) using terminal emulation, or (2) from an application program.

In Terminal Emulation Mode

1 - Turn on the terminal, or load the asynchronous communications program (e.g., PROCOMM PLUS).

2 - Check the communications protocol (9600 baud, no parity, 8 data bits, 1 stop bit, full duplex).

3 - Turn on the PR-650.

4 - Within 5 seconds, send the letter 'E' (upper or lower case) to the PR-650. This puts the PR-650 in echo mode so that all characters sent to the PR-650 can be viewed on the screen.

5 - If the PR-650 reverts to normal mode, (command not sent within 5 seconds), turn off the PR-650 by pressing and holding the the red 0/1 button until the screen goes blank, then repeat Steps 3 and 4.

6 - To reset the PR-650, turn off the terminal, or exit the communications software.

The following sections give examples of how to start Remote Mode operation of the PR-650 by: 1) using terminal emulation, or 2) from an application program.

Starting Remote Mode Using Terminal Emulation

This example illustrates how to initiate Remote Mode from an IBM PC in terminal emulation mode. It consists of a batch file (650.BAT) and two command files (650.ASP and 650-1.ASP) written for PROCOMM PLUS. The batch file first loads PROCOMM using the 650.ASP commands which exits PROCOMM forcing RTS low. The batch file then loads PROCOMM again using the commands in 650-1.ASP which sets up the communications protocol, waits for the PR-650 internal reset cycle and sends the "E" (ECHO) command thereby forcing the 650 to remain in Remote Mode.

650.BAT Listing

```
PCPLUS /F650
PCPLUS /F650-1
```

650.ASP Listing

```
QUIT    ;Exit PROCOMM thereby setting the RTS
        ;line low and triggering remote on the 650
```

650-1.ASP Listing

```
SET PORT COM1          :Set RS-232 communications to COM1:
SET BAUDRATE 9600      ;Set BAUD rate for 9600
SET DATABITS 8         ;Set Data Bits to 8
SET PARITY NONE        ;Set Parity to NONE
SET STOPBITS 1         ;Set Stop Bits to 1
EMULATE ANSI           ;Emulate ANSI terminal
PAUSE .500             ;wait 500 ms
TRANSMIT "EM"          ;Send an "E" (ECHO) and carriage
                       ;return to the 650
```

PR-650 Remote Mode ASCII Commands

Command messages from the Host begin with a letter which is not case sensitive. Some commands are optionally followed by one or more parameter fields. Fields are separated by commas and the message is terminated by a carriage return (<CR>) character which is used as the End of Message (EOM) byte. Fields may be absent but their commas must be present. For example, the command message 'S1,,,,,2' <CR> is valid. Note that this message format is variable in length. A line feed character <LF> may be appended to the EOM character, but is otherwise ignored.

Some messages have Response Code parameters which specify the format of the Response (output from PR-650 following a command). Responses sent from the PR-650 to the Host are a FIXED length for ease of decoding within the Host. Responses terminate with a <CR> followed by a <LF>. Some Response Codes have multiple carriage returns or line feeds depending on the number of lines in the Response.

All values sent from the PR-650 are displayed without identifying labels or measuring units. Refer to the **Response Codes** section of this Appendix for format information of Responses from the PR-650.

The word 'send' refers to data sent from the PR-650 to the Host. The word 'set' refers to the PR-650 setting some internal value in response to data from the Host.

'[ ]' Indicates optional parameters. Default values of optional parameters are specified for each command message in the following descriptions.

'< >' encases single parameter names

Command Summary

Code	Command
S	Set-Up Measurement Parameters
M	Measure Light
D	Send Miscellaneous Data from PR-650
F	Measure Frequency
E	Echo Command
B	Backlight Command (Adjust LCD Backlight)

'S' Command - Set-Up Measurement Parameters

Use the S (and optional parameters) to set up measurement variables such as accessory in use, sync frequency, fixed integration time, units type (footLamberts or cd * m-2) etc. Note that a variable may be omitted and replaced with a comma (,) which also serves as the field delimeter.

Format - S [<1st acc number>], (integer)
[<2nd acc number>], (integer)
[<3rd acc number>], (integer)
[<4th acc number>], (integer)
[<nom sync frequency>], (integer)
[<integration time>], (integer)
[<avg cnt>], (integer)
[<units type>] <CR> (character)

1st acc number-Number of first (Primary) accessory attached to the PR-650 for this measurement. This number must represent a Primary Accessory (MS-75 lens, CR-650, LA-650 or FP-650).

Default = 01 (Standard Objective Lens, typically MS-75).
Allowable values: 01 - 12

2nd acc number-Number of second accessory (if any) attached to the PR-650 for this measurement. This and all following accessories are Add-on Accessories or those that can be used
in conjunction with a cPrimary Accessory.

Default is no second accessory attached (,). Allowable values: 02 - 12

3rd acc number-Number of third accessory (if any) attached to the PR-650 for this measurement.

Default is no third accessory attached.
Allowable values: 02 - 12

4th acc number-Number of fourth accessory (if any) attached to the PR-650 for this measurement.

Default is no fourth accessory attached.
Allowable values: 02 - 12

nom sync frequency-

Nominal sync frequency in Hertz (Hz) for synchronized measurements. If this field is absent ((,) default) no synchronization is used, i.e. DC source measurement.

Allowable values: 1, 40 - 250 (Hz).
1 = Use the frequency measured by the last "F" command.

integration time

Measurement integration time in milliseconds.

Allowable values:
0 - Use adaptive integration time where the PR-650 determines the optimal integration time.
10-6000 - Use a fixed integration time between 10 and 6000 milliseconds. Integration times are multiples of ten milliseconds in TIMED mode and multiples of 2Xperiod in SYNC mode. Specifying an integration time that is not a multiple of the appropriate value will cause the next lower multiple to be used.

For example: mode = SYNC and freq =50Hz. A fixed integration time of 50 milliseconds is specified causing a fixed integration time of 40 milliseconds to be used.
(1/50 Hz * 2 = 0.040 seconds)

The integration time specification set by this field is used only in Remote Mode. In normal mode, Adaptive Integration time is used.

avg cnt — Number of measurements to average.
Default = 01
Allowable values: 01 - 99.

units type — Specifies CIE Y values (English or SI)
Default = 0 (English)

Allowable values:
0 - (English) - footLamberts or footcandles
1 - (metric SI) - cd * m-2 or lux

See Response Code 201 for the formatted output returned from the PR-650 following this command line.

M Command - Measure Light Under Conditions defined by the 'S' command line.

Format - M[<Response Code>] <CR>

Default Response Code = 01

Allowable Response Codes = 01 - 98
For this version, use Response Codes 1-6 and 19 with the 'M' Command. If using response code 19, the application must be ready to accept the binary structure. See Response Code 19 for more information.

See the Response Codes section of this Appendix for full details of formatted output of the PR-650 following the "M" command and optional Response Code parameter.

D Command - Output Data to the Host

Use this command to retrieve data from the PR-650. This enables the programmer to see several data reports from a single measurement. If the response code specifies measurement data, that data is taken from the last measurement performed by the PR-650.

Note: The "D" command does not initiate measurements.

Format – D <Response Code> <CR>
Allowable Response Codes - ALL

See the Response Codes section of this Appendix for full details of formatted output of the PR-650 following the "D" command and optional Response Code parameter.

F Command - Measure Frequency of the Sync Signal

For synchronized measurements of non-DC sources, use this measurement command to measure the period and return a value in Hz. This value is used for sync measurements when "1" is specified in the "nom sync frequency" field of the 'S' command.

Format – F <CR>
Response Code = 101

E Command - Echo Command

All characters sent to the PR-650 are echoed back to the host computer or terminal after an "E" is sent. There is no method of returning to a non-echo (half duplex) state short of a reset. When the PR-650 is ready to receive a command the " >" character is sent as a prompt. All characters returned from the 650 are converted to uppercase when applicable.

It is recommended the user not send this command from an application program, since it then becomes necessary to receive characters echoed from the PR-650. This method is most useful in the terminal emulation mode so command characters can be viewed on the Host screen.

Format – E <CR>
Response Code = none

B Command - Set Backlight Level

Use the "B" command to remotely set the PR-650 display backlight level. Four levels (including off) can be set remotely.

Format - B[M] <CR>
M = 0 - Backlight off
1 - Backlight on minimum brightness
2 - Backlight on medium brightness
3 - Backlight on maximum brightness

Default = 0 (Backlight off)
Response Code = 101

R Command - Retrieve Stored Measurement

When a measurement is retrieved using this command, it acts like "last measurement" data. That is, it remains the last measurement until another one is retrieved, or a new measurement in remote mode is made.

Multiple response codes may be used via the 'D' command to display contents of the measurement in various formats.

Format - Rffff,ccc <CR> <LF>

Where:

ffff = file number of the stored measurement to retrieve

ccc =response code to display the retrieved data

Default = Response Code 1

Example:

R2,4 <CR> <LF> (retrieves measurement #2 and displays luminance and CCT data)

D5 (displays spectral data)

Response Codes

Following a command sent to the PR-650 (with the exception of the "E" command), formatted data is sent back from the PR-650 in one of the following Response codes.

Numerical response values that may have a wide range are expressed in scientific notation of the form: *.***Esee where:

*.*** = mantissa of value. This value represents specific data depending on the Response Code returned from the PR-650.

E = Letter 'E' (signifies exponential notation)

s = Sign of power of 10 (+ or -)

ee = Exponent value

The symbol < /- > (blank space or minus sign) indicates the value may be positive or negative. If positive, a blank will be the first character of the field. If negative, a minus sign (-) will be the first character.

Response Code 0

This is a null response code indicating that the command has been received and acted upon.

Format: 000 <CR> <LF>

Response Code 1

Luminance and 1931 CIE x and y. Returned after sending the 'M' or 'D' command and the character '1'(M1 or D1) to the PR-650.

Format:qq,U,Y.YYYEsee,.xxxx,.yyyy <CR> <LF>

qq = Measurement quality code (00=okay)
U = 0 for luminance (units = footLamberts or cd * m-2)
= 1 for illuminance (units = footcandles or lux)
= 2 Uncalibrated

Y.YYYEsee = 1931 CIE Y (units indicated by 'U')
.xxxx = 1931 CIE x
.yyyy = 1931 CIE y

Response Code 2

1931 CIE X,Y, and Z. Returned after sending the 'M' or 'D' command and the character '2' (M2 or D2) to the PR-650.

Format: qq,U,X.XXXEsee,Y.YYYEsee,Z.ZZZE see <CR> <LF>

qq = Measurement quality code (00=okay)
U = 0 for luminance (units = footLamberts or cd * m-2)
= 1 for illuminance (units = footcandles or lux)
= 2 for uncalibrated

X.XXXEsee, Y.YYYEsee, Z.ZZZEsee = 1931 CIE X, Y and Z values respectively

Response Code 3

Luminance and 1976 CIE u' and v'. Returned after sending the 'M' or 'D' command and the character '3' (M3 or D3) to the PR-650.

Format:qq,U,Y.YYYEsee,.uuuu,.vvvv <CR> <LF>
qq = measurement quality code (00=okay)
U = 0 for luminance (units = footLamberts or cd * m-2)
= 1 for illuminance (footcandles or lux)
= 2 Uncalibrated

Y.YYYEsee = 1931 CIE Y in units indicated by 'U'
.uuuu = 1976 CIE u'
.vvvv = 1976 CIE v'

Response Code 4

Luminance and Correlated Color Temperature. Returned after sending the 'M' or 'D' command and the character '4' (M4 or D4) to the PR-650.

Format: qq,U,Y.YYYEsee,ttttt., / - d.dddd <CR> <LF>
qq = Measurement quality code (00=okay)
U = 0 for luminance (units = footLamberts or cd * m-2)
= 1 for illuminance (footcandles or lux)
= 2 Uncalibrated

Y.YYYEsee = 1931 CIE Y in units indicated by 'U'
ttttt = Correlated color temperature in Kelvins
/-d.dddd = Deviation of color coordinates from an ideal Planckian radiator in 1960 CIE u-v units.
(+ indicates the coordinates lie above the Planckian locus.)

Response Code 5

Radiometric (spectral) data. Returned after sending the 'M' or 'D' command and the character '5' (M5 or D5) to the PR-650.

Format: qq,U <CR>i.iiiEsee <CR> <LF>
wwww.,r.rrrEsee <CR> <LF>
wwww.,r.rrrEsee <CR> <LF>

qq = Measurement quality code (00=okay)

U = 0 for spectral radiance
(units = W * m-2 * sr-1 * nm-1)
= 1 for spectral irradiance
(units = W * m-2 * nm-1)
= 2 Uncalibrated

i.iiiEsee = Integrated intensity (total area under spectral curve) in units specified by 'U'.

wwww. = Wavelength in nanometers. There will be one line with wavelength and corrected spectral intensity for each data point, delimited by a comma.

Response code 120 provides the starting and ending wavelengths and wavelength increment

r.rrrEsee = Spectral intensity in units indicated by 'U'

Response Code 6

Luminance, 1931 CIE x and y and 1976 CIE u'v'. Returned after sending the 'M' or 'D' command and the character '6' (M6 or D6) to the 650.

Format: qq,U,Y.YYYEsee,.xxxx,.yyyy,.uuuu,.vvvv
<CR> <LF>

qq = Measurement quality code (00=okay)

U = 0 for luminance (units = footLamberts or cd * m-2)
= 1 for illuminance (footcandles or lux)
= 2 Uncalibrated

Y.YYYEsee = 1931 CIE Y in units indicated by 'U'

.xxxx = 1931 CIE x

.yyyy = 1931 CIE y

.uuuu = 1976 CIE u'

.vvvv = 1976 CIE v'

Response Code 19

Sends the last measured or retrieved data to the host in binary format. File RMT_STRU.H contains a description of the binary data as a C language structure. The data is transmitted from the PR-650 with all 8 data bits used. The receiving computer must be able to accept 8-bit binary data to use this response. Can be used with 'M' command since the RMT_STRU.H files contains the conversion function.

Note: At the bottom of the RMT_STRU.H file is a machine independent conversion function (CNV_FLPT.C) which converts the floating point binary data into the internal float representation of any computer with an ANSI compiler.

RMT_STRU.H and CNV_FLPT.C are supplied on the SAVE/RESTORE disk.

Response Code 99

This response is sent whenever the first byte of a command is NOT one of the command codes recognized by the PR-650.

Format: Unknown Command <CR> <LF>

Response Code 101

Sync Frequency returned after sending the 'F' command.

Format: qq,hhh.hh <CR> <LR>

qq	= Measurement quality code (00=okay)
hhh.hh	= Frequency of sync signal in Hz

Response Code 110

Serial Number of the PR-650. Returned after sending 'D110' to the PR-650.

Format: ######## <CR> <LF>

######## = 8-character instrument serial number (the serial number may contain letters and other ASCII symbols). If the field is less than 8 characters trailing blanks are automatically added.

Response Code 111

Model Number of the instrument in use. Reserved for later use if other versions of the PR-600 line are introduced. Returned by the PR-650 whenever the 'D111' command is sent.

Format: mmmmmm <CR> <LF>

mmmmmm = 6-character instrument model number. If the field is less than 6 characters trailing blanks are automatically added.

Response Code 112

Number of Calibrated Accessories for this instrument. Returned if the 'D112' command is sent to the 650.

Format: nn <CR> <LF>

nn = Number of accessories calibrated for this instrument (Primary and Add-on). Range of values is 01 - 12.

Response Code 113

List of calibrated accessories for this instrument inculding Primary and Add-On Accessories. Returned by the PR-650 when the 'D113' command is sent. One line of the following format is sent for each accessory. Lines are separated by a <CR> <LF>.

Format: aaaaaa,T,U <CR> <LF>

aaaaaa = name of accessory (exactly 6 characters, including any trailing blanks)
T = 0 for Primary Accessory
= 1for Add-on accessory
U = Accessory Calibration Units
= 0 for Radiance (or luminance)
= 1 for Irradiance (or illuminance)
= 2 for Uncalibrated accessories
= 3 for not applicable accessories

Response Code 114

The version of the PR-650 software is sent in response to a 'D114' command.

Format: vvvvv <CR> <LF>

vvvvv =5 character software version

Response Code 115

This response code is sent whenever the command 'D115' is received by the PR-650. It reports the Main Battery and ICM Card Low Battery status.

Format: m, i <CR> <LF>

m = Main Battery status
i = ICM Card battery status

Possible Values for **m** and **i**:

0 =OK
1 =Low Battery

Response Code 120

Spectral range of this instrument (for the PR-650, 380 - 780 nm). Returned when the 'D120' command is sent to the PR-650.

Format: pppp,bbb.b,ffff.,wwww.,iii. <CR> <LF>

pppp = Number of spectral data points
bbb.b = Bandwidth of the instrument in nm
ffff. = Wavelength of first spectral data point in nanometers (380nm)
wwww. = Wavelength of last spectral data point in nm (780nm)
iii. = Width of each spectral data point in nm (4nm)

Response Code 130

Integration Time and Operating Temperature during the last measurement. Returned if the 'D130' command is sent to the PR-650.

Format: iiii.iii,tt.tt <CR> <LF>

iiii.iii = The actual integration time used during the last measurement in milliseconds.

tt.tt = Temperature of the detector array during last measurement in degrees Celsius.

Response Code 201

Returned by the PR-650 whenever the 'S' command is sent.

Format: pp <CR> <LF>

pp = 00 = All okay

= 01 - 08 number of parameter in 'S' command that is invalid.

= 50 either: No Primary accessory specified, or more than one Primary Accessory was specified or the first accessory is not a Primary Accessory.

Response Code 301

Sends the directory of stored measurements to the host computer.

Format: nnnn <CR> <LF>
ffff mm/dd/yy hh:mm:ss t p <CR> <LF>

where

nnnn = The number of measurements currently stored in the PR-650. This is also the number of lines of output following this one for response code 301.

ffff = The file number of this stored measurement. Use this number to retrieve the measurement data for this measurement.

mm/dd/yy = Date of the measurement (The year 200 is represented as 00).

hh:mm:ss = Time of the completion of the measurement (24 hour system)

t = Measurement type

Possible values:
M - a measurement made with this PR-650
I - a pre-stored reference illuminant
U - an uploaded measurement or the result of arithmetic applied to one or more stored measurements (such as ratio).

p = Permanent flag

Possible values:

L - measurement is locked and may not be overwritten.

U - measurement is unlocked.

Note: The file number is the identification of the storage slot within the PR-650 that holds the measurement.

Because sequential measurements may not be represented by sequential file numbers, it is advisable to check the time/date stamp on the data in addition to the file number to assure that the proper data is transferred.

PR-650 ASCII Mode Measurement (qq) Quality Codes

Code	Meaning
00	Measurement okay
1	No EOS signal at start of measurement
03	No start signal
04	No EOS signal to start integration time
05	DMA failure
06	No EOS after changed to SYNC mode
07	Unable to sync to light source
08	Sync lost during measurement
10	Weak light signal
12	Unspecified hardware malfunction
13	Software error
14	No sample in L*u*v* or L*a*b* calculation
16	Adaptive integration taking too much time finding correct integration time indicating possible variable light source.
17	Main battery is low
18	Low light level
19	Light level too high (overload)
20	No sync signal
21	RAM error
29	Corrupted data
30	Noisy signal

This completes the section on Remote Mode operations.

Appendix C
Illuminance/Chrominance, Irradiance and Reflectance Measurements with the RS-3 Reflectance Standard

Introduction

The RS-3 Reflectance Standard has an absolute reflectance of 99% (± 1%) from 370 to 780 nanometers. Focusing the PR-650 on the plaque allows the luminance reading, in footLamberts (or candelas per square meter), 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.

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 times luminance (in candelas per square meter).

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 telecolori-meter does not need to be in the same physical location as the plaque.

△ ***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 to prolong life.

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

Illuminance/Chrominance, Irradiance and Reflectance

Measuring Procedure

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

Step 1 Remove the protective cover from the reflectance standard plaque and set it in the plane in which it is desired to measure the illuminance/ chrominance, irradiance or reflectance.

Step 2a For direct single source measurements: place the RS-3 in the measurement plane.

Arrange the PR-650 so that it is oriented at approximately 45o to the white surface of the plaque, 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.

OR

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

Arrange the PR-650 so that it is oriented perpendicular to the white surface of the plaque, 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.

Step 3 Hold the PR-650 securely by hand or place it on a sturdy tripod or other suitable support.

Step 4 Looking through the viewing eyepiece, align the instrument so that the aperture is centered on the Reflectance Standard white area.

Note: The MS-75 objective lens must be adjusted until the target is in sharp focus after the eye accommodation has been properly set for the current operator.

Step 5 Focus the objective lens (NOT the eyepiece) by grasping the lens by the large knurled band (the lens end with the writing), and rotating the lens barrel until the target is in sharp focus.

Step 6 Turn the instrument on by pressing the *red* **0/1** key and wait until the "Press MEASure..." screen appears.

Note: For reflectance measurements, it is not necessary to select RS-3 as an accessory since the measurements are ***relative*** rather than ***absolute***. However, it is necessary to select a "color difference" DISPLAY OPTION (delta Yx y, delta Yu' v', or delta YXZ)

Step 7 Use the FRWD key to advance the menus to the ADD-ON ACCY screen.

Step 8 Press the up or down arrow key until the ">" (cursor) icon points to the RS-3 option (The "**I**" (for incidence) next to "RS-3" on the screen indicates an illuminance/irradiance accessory.)

Step 9 Press ENTR to cause the "*" (active selection icon) to appear next to the RS-3.

Step 10 Change the UNITS OPTIONS and DISPLAY OPTIONS as required.

Step 11 Press the MEASure key 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.

Step 1 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

Step 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.

Step 2 Sand until the surface is totally hydrophobic (water beads and runs off the material immediately).

Step 3 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. Also, if the SRS-3 is refinished, if will be necessary to recalibrate if the standard is to be used under higher accuracy conditions.

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Appendix D
Illuminance/Irradiance and Luminous Intensity Measurements with the CR-600 Cosine Receptor



CR-600 Cosine Receptor

Introduction

The Cosine Receptor is an accessory that mounts on the front of the objective lens to measure the integrated illuminance/irradiance from all sources in the forward hemisphere. It is accurately cosine-corrected; i.e. the correct illuminance/ irradiance reading will be obtained regardless of where in the forward hemisphere the light sources are located. The energy from each source will be appropriately weighted by the cosine of the angle of incidence to the Cosine Receptor.

Illuminance/Irradiance and Luminous Intensity Measurements Procedure

Step 1 Remove the MS-75 objective lens by grasping the lens by the small band (embossed with "Photo Research") near the threaded end and turning it *counter-clockwise*. (The *wide* band is used for focusing.)

Step 2 Install the CR-600 Cosine Receptor by grasping the accessory, aligning the threads and turning it *clockwise* until securely tightened.

Step 3 Turn the instrument ON by pressing the *red* **0/1** key and wait until the "Press MEASure.." screen appears.

Step 4 Use the FRWD key to advance the menus to the PRIMARY ACCY screen.

Step 5 Press the up or down arrow key until the ">" (cursor) icon is positioned in front of the CR-600 option.

Step 6 Press ENTR to cause the "*" (active selection icon) to appear next to the option CR-600.

Step 7 Change the UNITS OPTIONS and DISPLAY OPTIONS as required.

Step 8 Press the MEASure key to make a measurement.

Luminous Intensity

The luminous intensity of a single light source in a given direction - called "directional candlepower" - can be computed from the previous illuminance measurement, provided the distance between the source and the Cosine Receptor is accurately known.

The following formula can then be used to compute the luminous intensity using the "inverse square law":

$$CP = E \times d^2$$

where

CP = Luminous Intensity - "candlepower" in the specified direction, expressed in candelas

E = Illuminance (as previously measured)

d = Distance between the light source and the front of the CR-600 Cosine Receptor (expressed in Feet for measurements in footcandles, and expressed in Meters for measurements in lux)

This completes Appendix D.

Appendix E
Luminance/Radiance Measurements with the LA-600 Luminance Adaptor



LA-600 Luminance Adaptor

Introduction

The Luminance Adaptor enables the PR-650 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.

Luminance/Radiance Measurements Procedure

Step 1 Remove the MS-75 objective lens by grasping the lens by the small band (embossed with "Photo Research") near the threaded end and turn the lens *counter-clockwise*. (The wide band is used for focusing.)

Step 2 Install the LA-600 Luminance Adaptor by grasping the accessory, aligning the threads and turning it *clockwise* until securely tightened.

Step 3 Turn the instrument ON by pressing the *red* **0/I** key and wait until the "Press MEASURE ..." screen appears.

Step 4 Use the FRWD key to advance the menus to the PRIMARY ACCY screen.

Step 5 Press the up or down arrow key until the **">"** (cursor) icon is positioned in front of the LA-600 option.

Step 6 Press ENTR to cause the **"*"** (active selection icon) to appear next to the LA-600.

Step 7 Change the UNITS OPTIONS and DISPLAY OPTIONS as required.

Step 8 Place the cup of the accessory in contact with the backlit source to be measured.

Step 9 Press the MEAS key to make a measurement.

Appendix F
Luminance/Radiance Measurements with the FP-650 Flexible Probe

Introduction

The Flexible Probe enables the PR-650 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.

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 30o 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.

Luminance/Radiance Measurements Procedure

Step 1 Remove the MS-75 objective lens by grasping the lens by the small knurled band near the threaded end and turn the lens counter- clockwise (the wide knurled band is used for focusing).

Step 2 Install the FP-650 Flexible Probe by grasping the accessory, aligning the threads and turning it clockwise until securely tightened.

Step 3 Turn the instrument on by pressing the *red* **0/1** key and wait until the "Press MEASURE ..." screen appears.

Step 4 Use the FRWD key to advance the menus to the PRIMARY ACCY screen.

Step 5 Press the up or down arrow key until the **">"** (cursor) icon points to the FP-650 option.

Step 6 Press ENTR to cause the **"*"** (active selection) icon to appear next to the FP-650.

Step 7 Change the UNITS OPTIONS and DISPLAY OPTIONS as required.

Step 8 Place the tip of the probe in contact with the backlit source to be measured.

Step 9 Press the MEASure key to make a measurement.

Appendix G
Remote Reset Operation of the PR-650

Overview

The PR-650 is only able to enter "REMOTE MODE" when the CTRL/XFER Host Cable is connected to the unit. Refer to Appendix B, Remote Mode Commands, for information on connecting the Host Cable. After connection of the Host Cable, the PR-650 can go into its "REMOTE MODE" by either of the following methods:

1. By powering up of the PR-650 unit.
2. By causing the RS-232's RTS signal to go low for at least 50ms, and then returning the RTS signal to its high state.

Once the PR-650 enters the "REMOTE MODE", the user has approximately 5 seconds to send a "valid message" to the PR-650 from the Host; otherwise, the PR-650 will automatically advance to its normal mode of operations. See Appendix B, "Remote Mode Commands" for more information concerning valid messages.

Remote Reset

In situations where the PR-650 is not readily accessible by the Host Operator, or if the Host program cannot manipulate the RTS as described previously, the above mentioned methods for entering "REMOTE MODE" may not be appropriate.

In these situations, the recommended method of getting the PR-650 to operate in "REMOTE MODE" is to build a reset box which will enable the Host Operator to remotely cause the PR-650 to enter "Remote Mode" by momentarily depressing the reset button.

Figure G-1 shows how the reset box can be installed in series with the Host Cable.

Figure G-2 on the following page is a schematic diagram for the reset box.

Figure G-1. Host Cable/Reset Box Connection Diagram

Note: Although Figure G-1 shows the reset switch mounted on the box, it can be mounted separately based on exact user requirements.

Figure G-2. Reset Box Schematic Diagram

where

Rx DATA (Received Data)
Tx DATA (Transmitted Data)
DTR (Data Terminal Ready)

This completes Appendix G.

Appendix H
AC Adaptor and Rapid Charger

Overview

The AC Adaptor and Rapid Charger is designed with a universal input to provide recharging of the standard 12 volt 700 milliamp NiCad battery in 45 to 50 minutes.

In addition, while either one or two batteries are charging, the Adaptor can provide power for operation of the PR-650 through insertion of a battery eliminator into the PR-650 battery compartment. See Figure H-1 below:

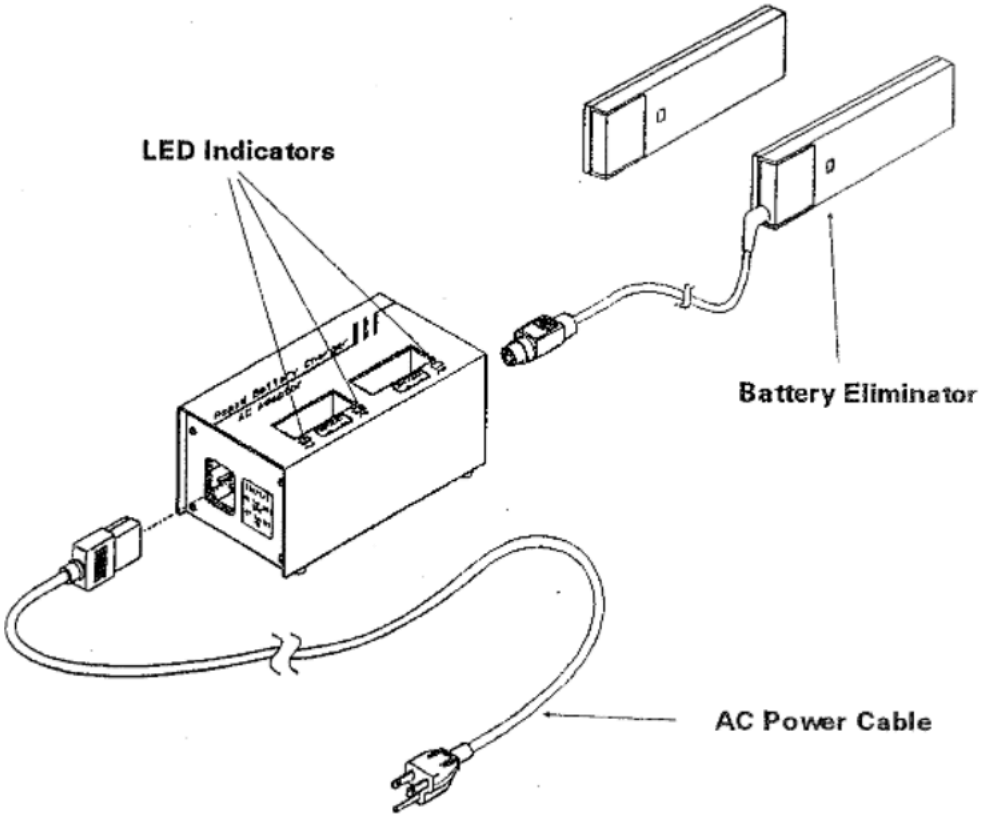


Figure H-1. AC Adaptor and rapid Charger

An *amber* LED indicator for each battery receptacle will light when a battery is correctly inserted into the Battery Charger. When the battery is fully charged, the *amber* LED indicator will begin flashing.

Input specifications for the unit are 90 to 264 VAC and 47 to 63 Hz. The output specification is 12 VDC 800 milliamps.

△ It is recommended that output power from this unit never exceed 800 milliamps.

Charging the Battery

Step 1 Plug the AC power cable into a suitable power outlet. The *red* LED will light indicating that the unit is receiving power.

Step 2 Place the battery into the battery receptacle so that the contacts on the battery are facing the contacts in the battery receptacle. When inserted correctly, the *amber* LED will light.

Note: The battery cannot be harmed if placed into the battery receptacle incorrectly.

Step 3 Remove the battery when the *amber* LED begins flashing.

Note: Power should be left *ON* if there is a battery in the Battery Charger receptacle.

Using the AC Adaptor and Rapid Charger to Power the PR-650

Step 1 Turn off power to the PR-650 by pressing and holding down the *red* 0/1 button on the front of the display panel until the screen goes blank (about one second).

Step 2 Remove the battery.

Step 3 Insert the battery eliminator into the battery compartment on the right side of the unit. Refer to Figure 1-1 on page one of the PR-650 manual for location of the battery compartment.

Step 4 Insert the round 6-pin connector into the connector plug on the AC Adaptor/ Rapid Charger located on the side of the unit. See Figure H-1 on the previous page.

Step 5 Verify that the AC power cable is connected to a suitable power outlet.

Step 6 Power on the PR-650 by pressing the *red* 0/1 key on the display panel.

△ *Never* insert the battery eliminator into a battery receptacle of the AC Adaptor and Battery Charger.

Appendix I
PR-650 DC Power Supply Adaptor

Overview

The DC Power Supply Adaptor is used to power the PR-650 using a linear, regulated DC Power Supply.

Setup Procedure

Connecting DC Adaptor to DC Power Supply

Step 1 Turn off power to the DC Power Supply.

Step 2 Connect the **black** and **white** wires to the **negative** post (-) on the DC Power Supply.

Step 3 Connect the **red** wire to the **positive** (+) post on the DC Power Supply.

Step 4 Set the DC Power Supply to a range of 13.0 volts (± 0.5 volts).

Note: The DC Power Supply should supply minimum power of 800 milliamps to correctly power the PR-650.

Using DC Adaptor with PR-650

Note: Steps 1 and 2 are optional and pertain only if the user has been using the PR-650 with the Nicad battery.

Step 1 Turn off power to the PR-650 by pressing and holding down the *red* 0/1 key on the front display panel until the screen goes blank (about one second).

Step 2 Remove the Nicad battery.

Step 3 Insert the DC Adaptor into the battery compartment of the PR-650 with the locking notch facing to the right or towards the hand strap on the PR-650.

When inserted correctly, there will be a "click" as the DC Adaptor locks into place.

Step 4 Turn ON power to the PR-650 by pressing the *red* 0/1 key on the front display panel.

The PR-650 is now ready for use.

Appendix J
Remote ON/OFF Interface

Overview

A special option for the PR-650, the Remote ON/OFF Interface enables the user to remotely control the following functions:

- Power ON/OFF and back light
- Measurements
- CTRL/XFER functions

In addition, a terminal block provides the user with custom switching capability (user supplied). The diagram in Figure J-1 shows the cabling configuration.

Figure J-1. Remote Interface Cabling Configuration

Cables

Two ten foot cables are provided with the Remote ON/OFF Interface (Figure J-1). The 12- pin circular connector on the end of one cable is connected to the port of the PR-650 and a 15-pin male D-type connector on the other end connects to the Remote Control Box. This allows the user to remotely turn the unit ON and OFF and make measurements with the unit in Normal Mode.

An additional cable terminates on either end with male and female 9-pin D-type connectors allowing for Computer control of the PR-650 through an RS-232 connection. It is necessary for the system to be connected to a Computer when using SpectraView or the remote XFER/CTRL optional control of the unit. Please refer to Appendix B for detailed information on Remote Mode operation of the unit using the XFER/CTRL option.

Schematics showing the pin setting of each cable are included at the end of this appendix.

Cable Connections

Step 1 Verify that the PR-650 power is OFF.

Step 2 Connect the 12-pin round connector to the PR-650 port located directly in front of the hand strap. Align the keys on the connector and gently apply pressure until an audible "click" is heard indicating that the connector is locked into place.

Step 3 Connect the 15-pin male D-type on the other end of the cable to the 15-pin female D-type connector labeled PR650 on the Interface Remote Control Box.

Step 4 Connect the male 9-pin D-type-type connector on the remaining cable to the connector labeled "RS-232" on the Interface Remote Control Box.

Step 5 Connect the female 9-pin D-type connector to an appropriate RS-232 port on the HOST (e.g. PC).

△ **Prior to operating the PR-650 with the Interface, verify that the PR-650 is connected to a continuous power source (AC-650 or DC-650) to avoid accidental power-off caused by a low battery condition.**

Before operation, set the Power Option to Standard to avoid power-off caused by inactivity (no PR-650 key pressed) for more than 3 minutes. See Page 2-13 of the Manual for more details.

Remote Operation

Power Button

The PR-650 is turned ON or OFF using the Power Button on the Interface Remote Control Box. Additionally, back light levels can be controlled in the same manner as if the 0/I LITE key on the main body of the PR-650 were in use. See page 1-13 of the Operating Manual for more details.

On initial power-up with the Interface connected, the PR-650 will "wake up" in Remote Mode. The PR-650 will revert to Normal mode after 6 seconds if not commanded to remain in Remote from a Host computer. Please refer to Appendix B for complete details on using the unit in Remote Mode.

XFER/CTRL Switch

Use the XFER/CTRL switch in the same way as the CTRL/XFER switch on the standard CTRL/XFER cable supplied with the PR-650.

For Remote Mode or SpectraView operations, set the switch to the "CTRL" position. For SAVE RESTORE functions, the switch must be set to the "XFER" position. See Appendix B for full Remote Mode details, or see Chapter 7 for SAVE/RESTORE details.

MEAS Button

The MEAS button enables the user to make measurements remotely with the PR-650 running in NORMAL mode. It has no effect with the PR-650 in Remote Mode or under the control of SpectraView.

Terminal Block

A five pin terminal block is provided in the event the user wishes to wire custom switches to the Remote ON/OFF Interface.

Connecting Wires

Step 1 Loosen the desired screw at the top of the terminal block.

Step 2 Insert the wire into the end opposite the terminal labels (e.g. ON-OFF SW*), and tighten the screw. Gently pull on the wire to verify a proper connection.

Terminal Connections

ON-OFF SW* and ON-OFF RTN

These terminals are wired in parallel to the POWER button on the Interface. Use of a momentary switch is recommended. Polarity need not be observed.

+5V

This connection supplies 5V DC from the PR-650. It is +5 volts with respect to the GND terminal adjacent to it. This 5V supply should not be used to drive an external device, but can be monitored as a PR-650 ON/OFF status indicator if direct visual verification is not possible.

GND

This pin serves as the common connection for the +5V and MEAS terminals.

MEAS-SW*

Connect a momentary switch to this terminal and the GND terminal to provide to provide the same function as the MEAS button on the Interface. Please note that the MEAS button and these terminals are wired in parallel.

Figure J-2. Remote Box Schematic

Figure J-3. Remote Cable 12-pin and 15-pin Assembly

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Appendix K
GPIB-232 - IEEE-488 to RS-232 Converter

The GPIB-232 is designed to provide the user with the capability of controlling the Pritchard PR-650 over an IEEE-488 interface using Remote Mode commands (see Appendix B for more information concerning Remote Mode operation).

There are two eight position dip switches located on the side of the interface that control the IEEE-488 (SW1 or left most set of dip switches) and RS-232 (SW2 or left most set of dip switches) protocols.

The dip switches are set at the Photo Research factory to honor the following conditions :

IEEE-488

IEEE-488 Address:	**5**
SRQ:	**Disabled**
Buffer:	**Large**
Operating Mode:	**D**

RS-232

Baud:	**9600**
Parity:	**None**
Data Bits:	**8**
Stop Bits:	**1**
XON/XOFF:	**Disabled**

The default switch settings are illustrated in Figure K-1 on the following page.

Note: **Consult the National Instruments (GPIB-232CV-A) Instruction Manual supplied with this interface for further information.**

K-1. GPIB Factory Switch Settings

Operating Instructions

1. Connect the IEEE-488 cable (not supplied) from the Host computer to the appropriate connector on the GPIB-232.

2. Connect the RS-232 (provided) from the appropriate connector on the GPIB-232 to the RS-232 port on the PR-650.

3. Connect the AC cable from the GPIB-232 to an appropriate AC supply.

CAUTION: Make sure attention is paid to the AC Voltage rating of the GPIB-232 located on the label on the bottom of the interface. Inserting the AC cable into an incorrect AC supply may cause irreversible damage!

4. Turn on the GPIB-232 using the O/I switch.

5. Press the **0/I /LITE** key to turn on the PR-650.

6. Align and focus the PR-650 on the sample.

7. Use standard Remote Mode commands over the IEEE-488 interface bus to make measurements and retrieve measurement results.

Appendix L
IS-600 Integrating Sphere

Overview

The IS-600 is a 3 inch sphere designed to measure the total luminous flux (lumens) of LEDs. This accessory consists of a sphere with baffle and LED Mounting Tube (See Figure 1). 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.

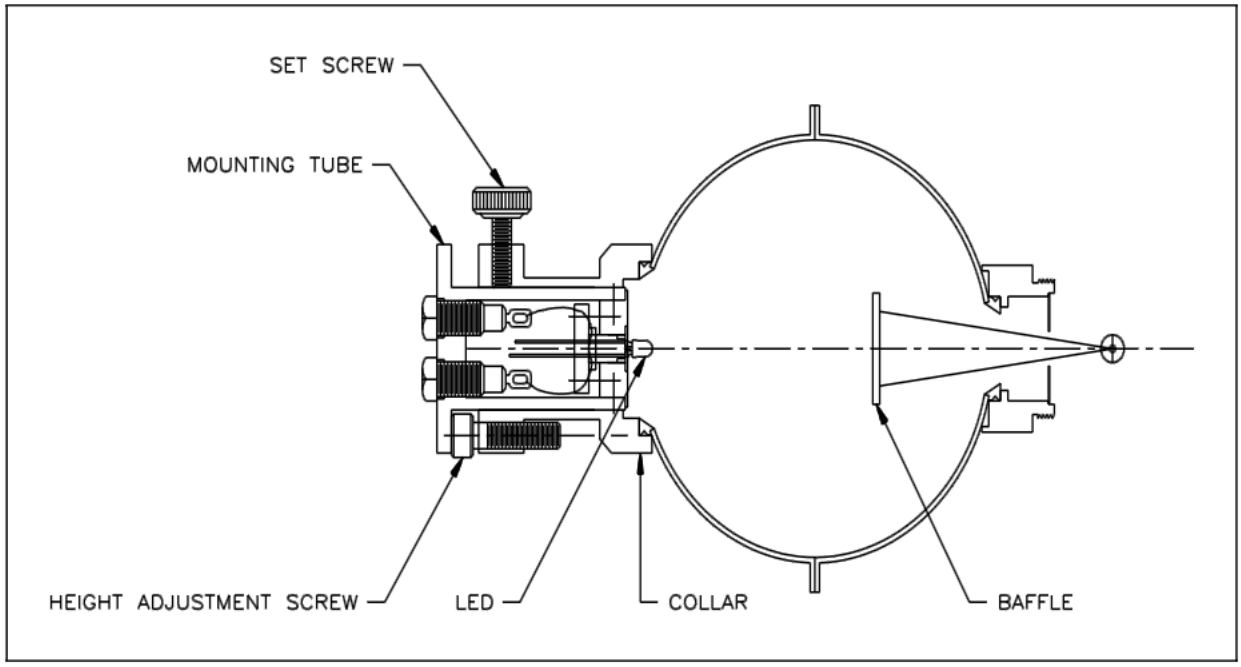


Figure 1 – IS-600 INTEGRATING SPHERE

Installing the IS-600

Step 1 Remove the current optical accessory from the PR-650 by turning counter-clockwise.

Step 2 Install the IS-650 by carefully threading clockwise into the C mount ring located in the front of the PR-650.

Mounting the LED

Step 1 Loosen the Set Screw (Figure 1) by turning it counter-clockwise.

Step 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.

Step 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 LED 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

Step 1 Referring to Figure 2, 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.

Step 2 Adjust the Height Adjustment Screw so that it is just touching the end of the Mounting Tube next to the LED.

Step 3 Attach the LED current source (not supplied) to the Mounting Tube using appropriate miniature banana plugs paying attention to the polarity.

Step 4 Supply the appropriate current to the LED and allow at least 10 minutes warm-up. Make sure the LED is properly lit.

Step 5 Insert the Mounting Tube into the Collar until the Mounting Tube just touches the top of the Height Adjustment Screw.

Step 6 Tighten the Set Screw to hold the Mounting Tube in place. **DO NOT OVER TIGHTEN!**

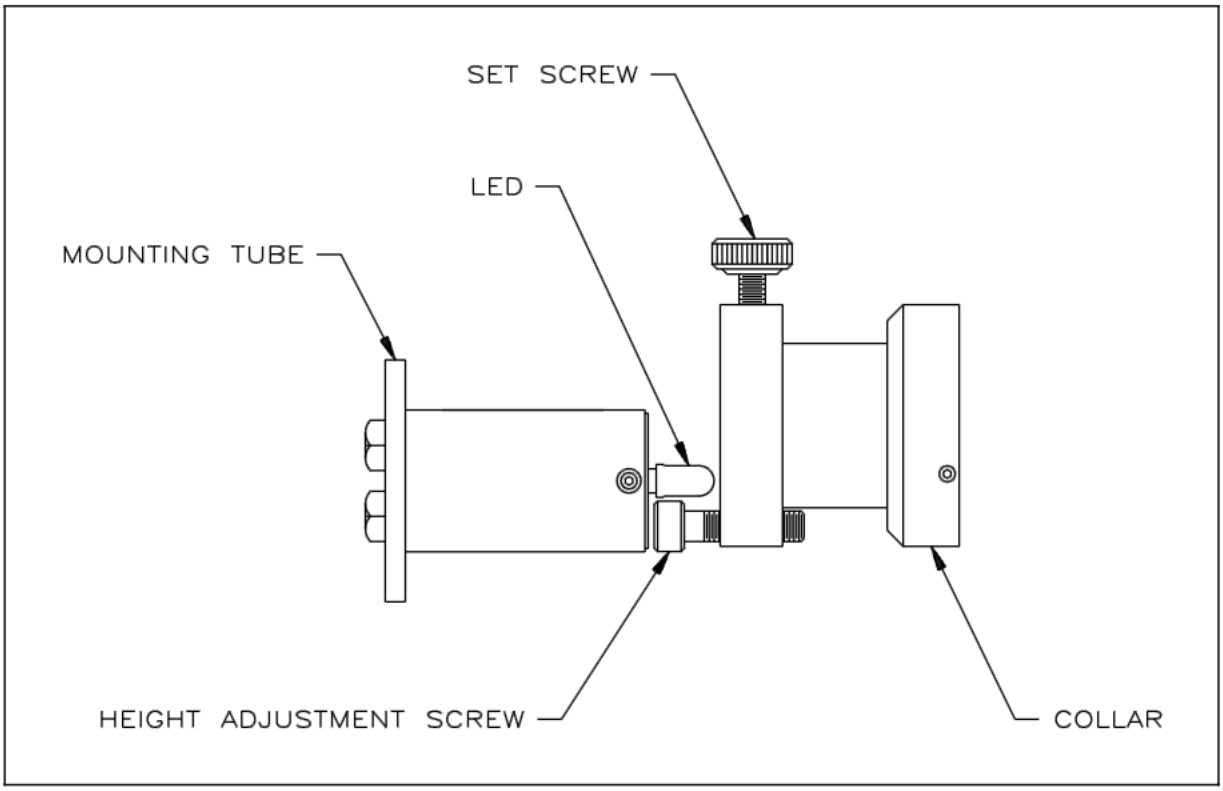


FIGURE 2 - HEIGHT ADJUSTMENT

Making a Measurement

Step 1 Turn on the PR-650 by pressing the 0/1 key (red key).

Step 2 Press the FRWD key on the PR-650 local keyboard until the first PRIMARY ACCY menu that lists the IS-600 is displayed.

Step 3 Use the UP/DOWN keys to position the **">"**character next to the IS-600 selection.

Step 4 Press the ENTR key to select the IS-600. A "*"character should now be to the left of "IS-600".

Step 5 Press the FRWD key to scroll through the ADD-ON ACCY menus. Make sure no ADD-ON accessories are selected when using the IS-600. If any of the ADD-ON accessories listed have a "*" character to the left of the description, de-select that accessory by using the UP/DOWN arrow keys to place the ">"character to the left of the accessory name, then press the ENTR key.

Step 6 Scroll the remaining menus to select the appropriate set-up options such as DISPLAY OPTIONS.

Step 7 Press the MEAS key on the PR-650 to make a measurement and display the results.

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Appendix M
CD-650 Battery Charger/Discharger

Overview

The CD-650, standard equipment on PR-650 systems, is an intelligent charger / discharger for the PR-650 NiCad battery pack (BP-650). The CD-650 consists of the charger module and universal input power supply.

During use, the PR-650 will signal a "Low Battery" condition when the battery potential drops to approximately 11.8 volts. The full discharge for the battery pack is approximately 8.8 volts. If the battery is not periodically fully discharged, the useful life of a full charge will be shortened. Therefore, we recommend fully discharging the battery pack periodically to retain peak performance of your BP-650. To shorten the discharge time, use the battery in the PR0650 until the "Low Battery" warning appears, then place it in the CD-650 and press the Discharge (DISCHG) button. The CD-650 will automatically discharge then fully charge the BP-650.

If the battery has been in disuse for more than six months, it is recommended that several discharge / charge cycles be performed to restore optimum performance.

Segment LED Display

7 Segment Display Truth Table:

0 – 9 - Per cent charge / discharge. For example, “2” represents 20%. During discharge, a red dot appears next to the integer value.
E - Error Condition
F - Full (charge)

Status LED

The STATUS LED is a dual color (Green and Red) LED and indicates process status. The following truth table provides the meaning of the various states of the STATUS LED.

FUNTION	GREEN	RED
No Battery Present	Off	Off
Charge Pending	Off	Flashing
Discharging	Off	On (steady)
Charging	Flashing	Off
Charge Complete	On (steady)	Off
Fault	Off	Off
Trickle Charge	On (steady)	Off

DISCHG Button

Press this button to begin a full discharge / charge cycle.

Procedure

1. Plug the AC Power cord from the CD-650 Power Supply into an appropriate AC receptacle (100 – 240 VAC, 50 / 60 Hz).

2. Insert the round connector from the CD-650 power supply into the receptacle on the CD-650.

3. Insert the BP-650 in the slot provided on the CD-650. Make sure the contacts on the BP-650 face the front of the CD-650.

4. To begin a discharge / charge cycle, press the **DISCHG** button. Otherwise, the CD-650 will automatically begin charging the BP-650.

Specifications:

CD-650 Power Supply –
Input: 100 –240 Volts AC, 50/60 Hz
Output: 18 VDC

CD-650
Input: 18 VDC
Charge Rate (fully discharged battery): 1½ hours.
Discharge Rate: (fully charged battery) 7 – 8 hours
(Low Battery state from PR-650): 60 minutes..

Appendix N - LR-127 LED Analyzer

Overview

The LR-127 is designed to characterize discrete LEDs per 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.

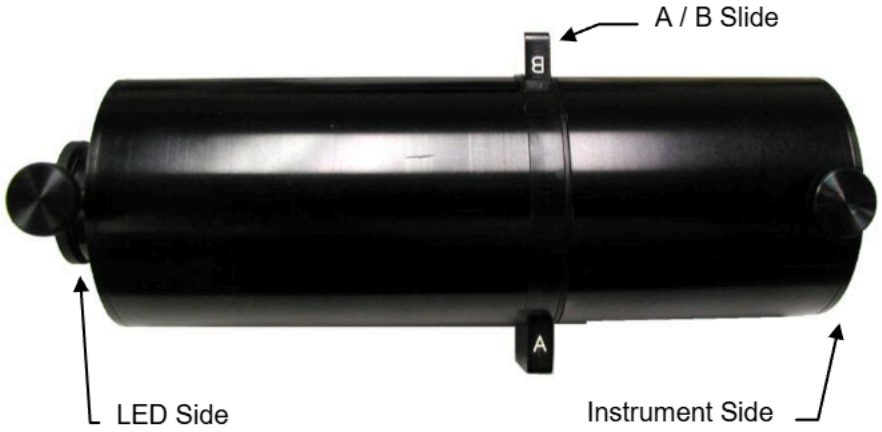


Figure 1 - LR-127

Installing the LR-127

Step 1. Remove the current optical accessory from the PR-650 by turning counter-clockwise.

Step 2. Remove the lens mount (Instrument Side – see Figure 1) by loosening the thumb screw that secures the mount to the main section of the LR-127.

Step 3. Screw the lens mount into the PR-650 lens ring. DO NOT OVERTIGHTEN the mount.

Step 4. Slide the main section of the LR-127 onto the lens mount.

Step 5. Rotate the main section until the slide is approximately horizontal and tighten the thumb screw.

Inserting the LED

Step 1. Tighten the small screw in the LED adapter until the ball tip slightly protrudes into the channel. This will achieve a snug fit of the LED by pushing it against the opposite wall of the adapter.

Step 2. Insert the LED adapter into the main section of the LR-127 (LED Side – *see Figure 1)* then tighten the thumb screw to secure it.

Step 3. Gently insert the T1.75 (5 mm) LED into the acceptance port of the adapter.

Step 4. Energize the LED to the desired current and allow sufficient warm up.

Making a Measurement

Step 1. Turn on the PR-650 by pressing the 0/1 key (red key). Allow at least 5 minutes warm up before making critical measurements.

Step 2. Press the FRWD key on the PR-650 keyboard until the first PRIMARY ACCY menu that lists the LR-127 is displayed.

Step 3. Use the UP/DOWN keys to position the **">"**character next to **LR-127A** (Condition A) or LR-127B (Condition B) then press the ENTR key.

Step 4. Press the FRWD key to scroll through the ADD-ON ACCY menus. Make sure no ADD-ON accessories are selected when using the LR-127. If any of the ADD-ON accessories listed have a "*" character to the left of the description, de-select that accessory by using the UP/DOWN arrow keys to place the ">"character to the left of the accessory name, then press the ENTR key.

Step 5. Scroll through the remaining menus to select the appropriate set-up options such as DISPLAY OPTIONS, number of cycles to average etc.

Step 6. Press the MEAS key on the PR-650 to make a measurement and display the results. The photometric values for the LR-127 are given in *luminous intensity (millicandelas)* units.

Step 7. Record the reading.

Step 8. Repeat Step 3 to select **LR-127B.**

Step 9. Press the MEAS key to make a measurement. Record the results.

Step 10. Find the average of the readings from Steps 6 and 9.

Table 1 - LR-127 Sensitivity Chart in millicandelas

		Aperture	
(LED) WL	**CIE 127 Condition**	**1°**	**1/2°**
470 nm	**A**	**40**	**10**
	B	**4**	**1**
525 nm	**A**	**40**	**10**
	B	**4**	**1**
594 nm	**A**	**50**	**12.5**
	B	**5**	**1.25**
638 nm	**A**	**60**	**15**
	B	**6**	**1.5**
			millicandelas

Appendix U
User Self-Calibration for the PR-650

Overview

The User Self-Calibration program for the PR-650 offers the user a single module software package designed to completely recalibrate the PR-650 and all associated accessories.

Pull-down menus allow the user to easily select and define parameters. Online help screens and color-coded pass /fail calibration indicators simplify the calibration procedure while greatly reducing the possibility of error.

The following minimum hardware requirements apply:

- **PR-650 Colorimeter and CTRL/XFER cable**
- **IBM PC/XT, AT (386,486) with 640K memory running DOS 3.3 or higher and RS-232 interface**
- **1 Megabyte of Hard Disk space**
- **CGA, EGA, VGA Card and Color Monitor**
- **Floppy Disk Drive (3½)**
- **Helium (He) spectral line source**
- **Spectral Calibration Source (LRS-455 or equivalent)**

Cable Connections

The User-Self Calibration program communicates with the PR-650 using the CTRL/XFER cable set to the CRTL position. The following section explains how to make the cable connections to the PR-650 and the Host Computer (PC).

Step 1 Connect the 25-pin sub D connector on the PR-650 CTRL/XFER cable to the RS-232 port of the PC (Host). Use COM1: or COM2: only.

Chapter 2 Figure 1. PR-650 SpectraColorimeter RS-232 Port

Note: A 25 to 9-pin connector and/or "gender changer" may be needed to make the connection. These are available at most computer stores or contact Photo Research for assistance.

Step 2 Set the CTRL/XFER switch located on the side of the 25-pin connector to CTRL.

Chapter 3 Figure 2. CTRL/XFER Host Cable Connector

Step 3 Connect the other end of the CTRL/XFER cable to the RS-232 connector on the PR-650. Align the key way on the connector and press until hearing it “click” into place.

After checking the connections from the PR-650 Spectra-Colorimeter to the PC, the user is ready to install the User Self-Calibration software.

The next section explains how to install and load the PR-650 User Self-Calibration software on either a hard disk or floppy disk-based system.

Installing and Loading PR-650 User Self-Cal

Making Backup Copies

The User-Self Calibration software is contained on a single diskette (3½") and can be installed to a hard disk or run from a high-density (1.4 Meg) floppy drive.

Note: **It is strongly recommended that a backup copy be made of the disk containing the User Self-Calibration program before performing the installation.**

Hard Disk Installation

Use the DOS xcopy command to automatically create all subdirectories under the subdirectory USC650 (e.g. xcopy A:*.* C:\USC650 /s/e), or follow the steps below to install User Self-Cal on a Hard Disk system.

Step 1 Create a subdirectory for the User Self-Cal files on the hard disk (e.g. md C:\ usc650)

Step 2 Insert the diskette into the appropriate floppy drive and use the DOS copy command to copy the files from the distribution diskette to the desired Drive: [path]\ (e.g. copy A: *.* C:\USC650).

Floppy Disk Installation

Insert the program diskette (3½") into the appropriate floppy drive and type the letter of the drive to access the program files, that is, at the C prompt (C:>), type A: and press Enter.

Loading the Calibration Program

Hard Disk
To load the User Self-Calibration program from a hard disk, change to the appropriate drive (C:\[path]), type 650usc and press Enter.

Floppy Disk
To load the User Self-Calibration program from a floppy disk drive, change to the appropriate path by typing cd usc650 and pressing Enter. At the prompt (A:> usc650), type 650usc and press Enter.

When using the software for the first time, the program requests information concerning the Com Port number and the Default data directory.

Step 1 The initial prompt asks the user to input the number of the COM port (serial port) to be used for connection of the PR-650 to the Host computer.

Input either a 1 or 2 and press Enter.

Step 2 The next prompt asks the user to enter the path where the PR-650 Serial # and calibration data files should be stored (e.g. C:\usc650).

Input the desired path and press Enter.

Following the successful installation and specification of the system configuration for the User Self-Calibration program, the user is returned to the appropriate DOS prompt (e.g. C:\usc650).

Step 3 At the DOS prompt (C:\usc650 >) type 650usc and press Enter to load the program.

User Self-Calibration Program

Step 1 After typing 650usc to load the program, the first screen to appear contains general information about the software.

Step 2 Press any key from this introductory screen to access the Main Menu Screen shown below in Figure 3.

Figure 3. User Self-Cal Main Menu

The Main Menu consists of five menu selections explained in the next section.

Main Menu

The Main Menu includes all functions needed to set up and perform a complete or partial recalibration of the PR-650. They include:

Setup Cal Mode Reports Utilities Exit

To make a selection, use the left/right cursor arrow keys ( ) to move the highlight bar. The submenu options available under each menu selection appear when a Main Menu item is highlighted.

Help is available by pressing the F10 function key.

Setup

As shown in Figure 3 on the previous page, the Setup function contains the following items:

Serial Number
Com port
Set-up constants
Set-up accessories

The fields for the Serial Number and Com Port are read in from the software during the system initialization and do not have to be entered by the user.

Step 1 Use the down arrow key to highlight the Set-up Constants option and press Enter to access the set-up constants submenu as shown in Figure 4 on the following page.

Chapter 4 Figure 4. Setup Constants Example

Step 2 Press Enter twice to accept the highlighted choices for Model name (PR-650) and Aperture name. These are automatically read in during initialization and do not need to be entered by the user.

The next item, Average count, is automatically highlighted.

Step 3 Input the desired number of measurements to average (Range =1-99) for the calibration, and press Enter.

Note: **Until changed, the 650USC program defaults to 10 measurements averaged, which is the recommended value. When a new value is entered and accepted, it becomes the default.**

The next item, Lamp file name, is automatically highlighted.

Step 4 Input the name of the DOS file (e.g. lamp.dat) containing the spectral data for the standard of spectral radiance and press Enter.

Note: The lamp.dat file must reside in the User Self-Cal subdirectory and can be generated using the PR-650 INDATA program. The data must be in 1nm increments.

The format for the spectral data must be as follows:

Line 1	3.70000e+002	Beginning wavelength
Line 2	790.000e+004	Ending wavelength
Line 3	7.45546e - 004	1st Data point information
	.	
.		
Line 424		Last Data point information

Step 5 Use arrow keys to highlight the next item, Set-up Accessories.

Step 6 Press Enter to access the table allowing the user to input up to twelve accessories for calibration with the PR-650. (See Figure 5 on the following page). Review the next section for specific instructions on how to correctly enter accessory information.

After an accessory is defined in this table, each time an accessory entry is required during the calibration, this table appears allowing the user to select the desired accessory.

Figure 5. User Self-Cal Main Menu

Guidelines for Inputting Accessories

Each line in the accessory menu contains four fields used for describing the accessory. They include, from left to right: Name (e.g. MS-75), Mode, Type, and a field which is used for recording the data and time of the last calibration (not shown). The first time the User Self-Cal program is loaded, this field is blank.

The user inputs this information by pressing the Enter key with the acc-0 line highlighted to access a submenu used to select information about the specified accessory.

The submenu contains the following fields.

Name:	(MS-75, CR-650, etc.)
Mode:	(Luminance, Illuminance, or NA)
Type:	(Primary, Add-on or NA)
Source:	(Measured or File Data)
EXIT:	(exit this submenu)

Step 1 Press Enter with the item, Name:, highlighted to open the Name window.

Step 2 Type in the name of the accessory (maximum of 6 characters), using the accepted abbreviation (e.g. MS-75).

Notes: **The first accessory listed must be the MS-75 lens which is a luminance (primary) accessory.**

All accessories listed after the last valid accessory must be set to "unassigned" in the Type field, as any accessories that follow an "unassigned" accessory are not recognized by the software. This is due to the fact that all data on the PR-650 RAM card must be accessed sequentially.

Step 3 Press Enter to close the window and return to the submenu.

Step 4 Use the down arrow key to move the highlight bar to the Mode field, and press Enter to open the Mode options window.

Note: **NA should be selected for the Mode field when calibrating an ND- filter.**

Step 5 Use the arrow keys to highlight either Luminance Illuminance, or NA (not applicable) and press Enter to close the window and return to the submenu.

The following table lists the classifications of all accessories that can be calibrated with the PR-650.

Table 1. Accessory Classifications

Accessory	Mode	Type
MS-75 Lens	Luminance	Primary
SL-1X Lens	Luminance	Primary
MS-2.5X Lens	Luminance	Primary
CR-650	Illuminance	Primary
FP-650	Luminance	Primary
LA-650	Luminance	Primary
IS-650	Lum. Flux	Primary
LR-650	Lum. Inten.	Primary
ND-650 (ND-2)	NA	Add-on
RS-3	Illuminance	Add-on
SRS-3	Illuminance	Add-on

Step 6 Use the arrow keys to move the highlight bar to the Type field and press Enter to open a window allowing the user to specify whether the accessory is an Add-On, Primary, or NA.

Note: **An NA selection in the Type field makes that accessory unavailable for calibration.**

Generally, a Primary accessory is one that is attached to the pr-650 unit. An Add-on accessory or secondary accessory is used in conjunction with or is measured by a primary accessory (RS-3, SRS-3, ND-650-10).

Step 7 Highlight the desired selection and press Enter to close the window and return to the submenu.

Step 8 Use down arrow key to move the highlight bar to the Source selection and press Enter to open the window listing the Source options: Calibration by measurement and Calibration uses file data. See Figure 6 on the following page.

The selection, Calibration uses file data, is used only for the RS-3 or SRS-3. All other accessories must be set to the Calibration by Measurement selection.

For reflectance standards such as the RS-3 or SRS-3, the data file must be formatted exactly like the Source data file. The data must be the reciprocal of the absolute reflectance of the standard.

Figure 6. User Self-Cal Main Menu

Step 9 Use the arrow key to move the highlight bar to the desired selection and press Enter to close the window.

Step 10 Use the arrow key to move the highlight bar down to the EXIT option and press Enter to accept the current selections and return to the main accessory table (See Figure 7 on the following page).

Note: **The accessories must be defined in ascending order. If not, the software will automatically assign the next available slot to the last entry.**

Figure 7. User Self-Cal Main Menu

This completes the section on accessory parameter definition.

Cal Mode

Use the arrow key to move the highlight bar to the Cal Mode option and view the submenu selections as shown in Figure 8 below:

The Cal Mode options submenu includes the various calibrations necessary to perform a complete calibration of the accessories defined in the Set up menu.

Figure 8. User Self-Cal Main Menu

Note: **Each of the calibrations must be performed in the order that they appear in the menu in Figure 8. Otherwise an error message appears warning the user that the calibration is not valid and will not proceed.**

The following sections identify and explain the processes involved for each calibration.

DAC Calibration *(optional)*

The DAC (Digital to Analog Converter) calibration locates and sets the optimal digital offset and gain for the PR-650 internal electronic amplifiers. The program seeks an offset value that makes the average A/D dark counts as close as possible to 40 at an integration time of 10 milliseconds.

△ **Following a DAC Calibration, the user must either continue with all calibrations (i.e., Wavelength, Relative, etc.), save the calibration files and download them to the PR-650, or restore the RAM card with the latest calibration values to ensure that the digital offset and gain values are restored.**

Step 1 To perform this calibration, verify that the DAC Calibration selection is highlighted and press Enter.

The following prompt appears:

Enter DAC gain setting: [128]

The number shown above in brackets is reverse highlighted in the actual software with a blinking cursor under the initial number, and represents the gain default.

Note: **Please contact Photo Research prior to changing this gain offset number.**

Step 2 Press Enter to accept the default and perform the calibration. The new values are immediately written to RAM so they can remain valid for the rest of the calibrations.

After the calibration is completed, the menu item is updated with a DONE statement.

Wavelength Calibration

The Wavelength calibration must be performed using the first accessory in the Accessory Table on page 13, the MS-75.

This calibration maps the 128 individual elements on the PR-650 detector to actual wavelengths measured during the calibration scan. It requires the use of a pure helium spectral line source. Since it's not necessary that the source be calibrated for intensity, a Wavelength Calibrator (WC-650 or WC-704) is sufficient for this purpose.



Executing this routine invalidates previous calibrations

Step 1 Turn on the helium source and wait at least 15 minutes for the lamp to reach intensity.

Step 2 Align and focus the PR-650 on the source. See Chapter 3 of the PR-650 Operating Manual for instructions on how to accurately focus the instrument.

Step 3 Highlight the Set up Constants item in the Set up menu, type in the number 10 under Average count, and press Enter.

Note: **An average of 10 counts is recommended to obtain a sufficient degree of accuracy.**

Step 4 Use the arrow keys to move the highlight bar to the Cal Mode selection in the Main menu, then to Wavelength Calibration and press Enter.

A window below the menu opens which shows a scale representing the percentage of saturation of the detector and a red or green colored bar. See Figure 9 below.

Figure 9. PR-650 Spectral Range Scale Example

The user is prompted to adjust the lamp and/or the PR-650 to come within the recommended range of saturation of the detector (between 70% - 90%).

A green bar signifies that the unit is within the optimum saturation range.

Step 5 When the bar is green, press the Enter key and *hold it down* until the bar disappears. This initiates the wavelength calibration.

The PR-650 measures each of the 5 peaks of the He Source individually averaging 10 counts for each peak (50 measurements or the number of peaks times the number of counts the user entered in Step 1).

The PR-650 then determines the centroids for each peak and generates a centroids report as shown in Figure 10.

Figure 10. Wavelength Calibration Report Example

The user can check the grating alignment by verifying that the centroid for peak number 3 falls on or near Pixel 64.

Step 6 Press Esc. The software reports the Wavelength calibration as DONE and returns the user to the Cal Mode menu.

Note: **The Wavelength calibration report can also be generated from the Reports selection in the Main Menu.**

Relative Calibration

The Relative calibration establishes correction factors for the spectral distribution of the PR-650 for each accessory listed in the Set up menu. It must be performed for each accessory.

Use a spectral source with a known illuminant (e.g. LRS-455) and a file of its spectral distribution data points (e.g. lamp.dat) to perform this calibration.

Note: **The lamp file must contain spectral radiance (or irradiance) values for the standard being used. If the standard is changed i.e. from radiance to irradiance, the file name must be changed prior to performing the calibration.**

△ **Executing this routine invalidates previous Absolute calibrations for chosen accessories.**

Step 1 Turn on the lamp standard and allow at least a 15 minute warm-up.

Step 2 Align and focus the PR-650 on the diffuse surface of the standard (or exit port of the integrating sphere for LRS-455).

Note: **For irradiance (illuminance accessories), set the plane of the accessory at the recommended distance from the lamp [e.g. 50 cm (19.7")] for the CR-650 Cosine Receptor.**

For the FP-650 and LA-650, align the tip orthogonal to, and in, the plane of the exit port (for integrating sphere types). For opal glass type sources, place the probe tip flush against the glass.

See *Chapter 3* of the PR-650 Operating Manual for instructions on how to accurately focus the unit.

Step 3 Highlight the Set up Constants item in the Set up menu, Type in the number 10 under Average count and press Enter.

Note: **An average of 10 counts is recommended to obtain the highest degree of accuracy.**

Step 4 Use the down arrow key to highlight Relative Calibration and press Enter to access the table listing the accessories as shown in the example in Figure 11.

Figure 11. Accessory Selection Example

Step 5 Highlight the appropriate accessory and press Enter.

Note: **If an Add-on accessory is chosen, the software prompts you to indicate the Primary accessory to calibrate it with.**

If an Add-on Accessory is selected (e.g. RS-2 or SRS-2), that was assigned as a "File" type, the user is prompted to input the file name.

For RS-2 accessories, the data file must have a value of 1.0 at each wavelength. For SRS-2 accessories, the file must contain the inverse of the absolute reflectance of the SRS-2 at 1 nm intervals. The file must be formatted exactly like the Source data file.

Step 6 Press Enter to begin the Calibration for the selected accessory.

Step 7 Type Y when prompted to initiate a measurement by the PR-650 with the newly generated correction factors.

Step 8 The program then displays a table as shown in the example in Figure 12 on the following page showing measurement data for CCT, X, Y, Z, x, y, and z.

Please refer to the section on Displayed Parameter Theory, pages 3-9 through 3-12, of the PR-650 Operating Manual for a detailed explanation of the measurement data shown in the table in Figure 12.

Figure 12. Relative Calibration Values Example

Step 9 Press any key to have the software repeat the previous prompt asking if you want to initiate a measurement using the newly generated correction factors.

Press N. The software then reports the Relative Calibration as DONE.

The user can view the Relative Calibration report by highlighting this selection from the Reports menu item and pressing the Enter key.

Linearity Calibration

The MS-75 accessory must be used for the Linearity calibration which performs a calibration on the PR-650 detector and generates temporal (time) correction factors.

The factors are determined by making measurements at: 10 ms, 20 ms, 50 ms, 80 ms, 100 ms, 200 ms, 400 ms, 600 ms, 800 ms, 1000 ms, 2000 ms, 3000 ms, 4000 ms, and 6000 ms.

The standard must be able to display the luminance being measured, and should range from 0.0 to 10,000 foot-Lamberts. A variable linear luminance standard such as the LRS-455 should be used.

Note: **The DAC and Wavelength calibrations invalidate the Linearity calibration; Relative and Absolute calibrations do not.**

Step 1 Turn on the luminance standard and wait at least 15 minutes for the lamp to stabilize.

Step 2 Align and focus the PR-650 on the standard using the Standard Objective Lens (MS-75). See Chapter 3 of the PR-650 Operating Manual for instructions on how to accurately focus the unit.

Step 3 Verify that the Linearity Calibration selection is highlighted and press Enter.

Step 4 Enter the current Lamp Source voltage and press Enter to store it in response to the software prompt.

Note: **This value is stored for future reference if the operator should need to change one of the time values after completing the calibration.**

Step 5 Adjust the light source to its brightest level and press Enter in response to the next prompt.

The software now proceeds to make the first measurement for the 10 ms time zone.

The Lamp Adjustment Screen appears as shown in Figure 13 below.

Figure 13. Lamp Adjustment Screen Example

This screen displays an analog scale of the results of the measurement just taken in terms of AD converter counts for the mid-range detector elements (pixel #50 - #64).

An arrow (←) indicates the acceptable range between 13500 and 14000 counts. The indicator bar turns green when the value falls within this range.

Step 6 If within range, the user accepts the value by pressing Y.

Step 6a If not within range, the user presses N, adjusts the intensity of the lamp, then presses Enter to remeasure.

Note: **This process can be repeated as many times as needed until within range.**

At the 100 ms time zone the user is prompted to input the temperature in C°. The ambient tempurature entered should be 20° C.

A measurement scan (based on the Set up Constants count) is taken at the 10 ms time zone.

Step 7 Input the temperature again at the second prompt request. The second request is made to account for possible drift.

Step 8 Another scan is made and the user is prompted to enter the current luminance in footLamberts as shown in Figure 14.

Figure 14. Linearity Calibration Example

Step 9 Type in the luminance for the time zone and press Enter.

The software calculates a correction factor for this integration time and then increments to the next integration time. This process is repeated until all the integration times have been completed.

Note: **Certain light sources are sometimes not bright enough to provide sufficient signal at low integration times (10-100 milliseconds). In this instance, the user must accept the counts (by inputting a Y) with the source set to the highest level.**

Step 10 After completion of all the integration times, the software returns the user to the Main menu and reports the Linearity Calibration as DONE in the Cal Mode Menu.

Step 11 Highlight Linearity Calibration again and press Enter to view a table containing all the integration time zones, the corresponding light levels calibrated with each time zone and the current correction factor. See the example in Figure 15.

Figure 15. Table of Correction Factors Example

As shown in the far left of Figure 15, the user has the option to redo all the time zones, a range of time zones (specifying first and last zone), and a single time zone.

The following procedure explains how to calibrate a Single Time Zone:

1- Highlight Linearity Calibration and press Enter to access the screen shown in Figure 15.

2- Highlight the first time zone for the beginning of the range of time zones you want to recalibrate and press Enter.

3- Highlight the last time zone for the end of the range of time zones you want to recalibrate and press Enter.

Note: If you want to calibrate a single time zone, the first and last time zone selections must be the same.

4- The software proceeds to measure the first time zone, and the analog intensity bar graph appears.

5- If intensity is within the acceptable range, press Y.

OR

5a- If the intensity is not within the acceptable range, press N, re-adjust the lamp standard and make another measurement. Repeat this process until within the correct range.

6- Type in the luminance value and press Enter to recalculate the correction factors for the desired integration times.

This completes the section on Linearity calibration. The next section explains the optional temperature calibration procedure.

Temperature Calibration *(optional)*

Temperature calibration for the PR-650 is optional and need only be performed if it is necessary to use the PR-650 in an environment where extreme ambient temperature variations could affect measurement results.

This calibration requires the use of an environmental chamber and variable luminance standard. The chamber must be large enough for the PR-650, equipped with a clear aperture (outport) at least 1.5" in diameter, and the temperature range must be variable between 10° C and 40° C. The luminance standard (e.g. LRS-455) is used outside the chamber and is measured through the clear aperture in the chamber. In addition, the PR-650 must be able to measure the source set to 2856K and 400 fL through the chamber outport.

If this cannot be accomplished, the user can make a temperature measurement at 20° C to determine the correction factor for that temperature and then use the Auto Function option to estimate the correction factors for the other temperatures.

Step 1 Connect the CTRL/XFER cable to the PR-650, place the PR-650 inside the chamber and run the CTRL/XFER cable from the unit to the RS-232 port of the Host.

Note: **If not using the battery pack, insert the battery eliminator and plug into the AC Adaptor/ Rapid Charger, or use the DC Power Supply Adaptor. Refer to the PR-650 Operating Manual Appendices H and I for more information.**

Step 2 Turn on the lamp standard and wait at least 15 minutes for the lamp to stabilize.

Step 3 Set the luminance standard approximately 51 cm (20”) from the PR-650.

Step 4 Align and focus the PR-650 through the clear aperture on the standard using the Standard Objective Lens (MS-75). See Chapter 3 of the PR-650 Operating Manual for instructions on how to accurately focus the unit.

Step 5 Verify the Temperature Calibration selection is highlighted and press Enter to view the table showing the various temperatures and correction factors as shown in the example in Figure 16.

Figure 16. Table of Correction Factors Example

Step 6 Highlight the first temperature zone to calibrate, then press Enter.

Step 7 Type the lamp voltage (or current) of the luminance standard and press Enter.

Step 8 Adjust the temperature for the value of the first temperature zone at the prompt.

(Allow at least 45 minutes for the PR-650 to stabilize).

Step 9 Set the standard for the recommended luminance and press Enter. (All calibration scans will be done at this level).

Step 10 Repeat Steps 6 and 7 for the rest of the temperature zones.

Step 11 When the last temperature zone is successfully completed, the word DONE will appear next to the Temperature Calibration selection.

An alternative to doing a complete temperature calibration is to use the auto-function option to estimate the correction factors for other temperatures based on a temperature calibration of the PR-650 at 20° C (ambient).

Note: **This method is not as accurate as performing the actual calibration.**

Use the steps below to complete this procedure.

1- Follow the first five steps of the Temperature Calibration procedure on the previous pages to set up the PR-650 and the source.

2- Allow the PR-650 to stabilize for at least 45 minutes at 20° Centigrade.

3- Verify that the Temperature Calibration selection is highlighted and press Enter.

4- Highlight the 20° C temperature zone and press Enter.

5- Press Y in response to the prompt asking if the user wants to use the auto-function option.

The software calculates the temperature correction factors for the 20° C time zone, estimates correction factors for the other time zones and reports the temperature calibration as DONE.

Absolute Calibration

The absolute calibration creates a single absolute luminance/ illuminance correction factor for each accessory.

It requires the use of an adjustable luminance or illuminance standard (e.g. LRS-455) or a luminance bench darkroom.

Step 1 Turn on the standard and wait at least 15 minutes for the lamp to stabilize.

Step 2 Align and focus the PR-650 on the standard using the Standard Objective Lens (MS-75). See Chapter 3 of the PR-650 Operating Manual for instructions on how to accurately focus the unit.

Note: **If calibrating the CR-650 (Cosine Receptor), place the front plane of the CR-650 (white surface) at the recommended distance from the lamp. See Appendix D of the PR-650 Operating Manual.**

For the FP-650 and LA-650, align the tip orthogonal to and in the plane of the exit port (for integrating sphere types). For opal glass type sources, place the probe tip flush against the glass.

Step 3 Verify that the Absolute Calibration selection is highlighted and press Enter.

A prompt appears asking the user if Temperature Compensation Factors are to be used. If a Temperature calibration was performed, press Y, if not press N.

Step 4 In the table that appears next, highlight the accessory to be calibrated and press the Enter key.

Note: **For Add-on accessories, the user is also prompted to select the primary accessory it is to be calibrated with. In the case of the SL-1X, SL-2.5X, or ND-650, the primary accessory is the MS-75 lens.**

Step 5 The user presses Y in response to the next prompt to perform the calibration for the selected accessory.

The program measures the number of cycles defined under the number input in the Set up constants selection.

Step 6 Type in the level of the luminance standard (in footLamberts), of illuminance standard (in footcandles) and press Enter.

The user is then returned to the Main menu.

Step 7 To verify the calibration, highlight Absolute calibration and press Enter.

Step 8 Press N when prompted to do the absolute calibration measurement.

Step 9 Press Y at the next prompt, Check with Current Factors?

Press Enter to accept the default of one [1] at the next prompt which asks how many cycles to average.

The PR-650 takes the measurements and a window opens showing a table similar to the example in Figure 17.

Note: **The measured luminance or illuminance is represented by the "Y" value in the table.**

Step 10 Press any key to continue, then press ESC to return to the Main Menu.

Step 11 Press Y at the next prompt to perform the calibration of the selected accessory.

Step 12 After all accessories have been calibrated, the word DONE appears after the Absolute calibration as shown in Figure 17.

Figure 17. Table of Correction Factors Example

The following section gives some examples of calibration reports.

Report Menus

After the user has completed a calibration, the information can be viewed, printed, or written as an ASCII file using the Reports menu as shown in Figure 18 below:

Figure 18. Reports Menu

The Reports generated provide an excellent means for tracking the performance of the PR-650 from calibration to calibration.

Use the cursor arrow keys to move the highlight bar to the desired selection in the Reports submenu, then press Enter.

DAC Report

The DAC Report specifies the gain values for each pixel with Pixel 0 being at the blue end of the spectrum.

When the DAC Report options Write (to file) or View (on CRT) have been selected, an ASCII file is created with the file extension .DCR. This file is automatically saved in the data directory (e.g. C:\650USC\DATA) and contains the serial number of the instrument in addition to the complete DAC calibration data.

Select View on CRT to show the initial screen. Press PgDn to view additional screens. See the example in Figure 19.

Figure 19. DAC Report Example

The remaining Reports, Wavelength, Relative, and Linearity are accessed in the same manner.

Examples of how each of these reports would appear on the display (View) is shown on the following pages.

The Wavelength Calibration Report extends through 14 screens and includes information on the following: peak wavelength of the helium spectral line measured; the pixel of the measured centroid; the calculated centroid; the difference between measured and calculated centroids in pixels; the difference between the measured and calculated centriods in nanometers; the beginning and ending pixels used for the measurements and the integration time for the measurement in milliseconds. See Figures 20, 20a, and 20b.

When the Wavelength report options Write (to file) of View (on CRT) have been selected, an ASCII file is created with the file extension .WPR. This file is automatically saved in the data directory (e.g. C:\650USC\DATA) and contains the serial number of the instrument in addition to the complete Wavelength calibration data.

Figure 20. Wavelength Calibration Report Example

Figure 20a. Wavelength Calibration Report Example

Figure 20b. Wavelength Calibration Report Example

The Relative Calibration Report as shown in Figure 21 creates a file using the Instrument serial number with the file extension that identifies the accessory (e.g. 28E9104.IP1). This file, stored in ASCII format, contains correction factors for the relative intensity of the real and virtual pixels for the chosen accessory (in this case the MS-75 Objective Lens). This file is saved in the data directory (e.g. C:\650USC\DATA). See Figure 21.

Note: **Files created with the file extensions .ac1, .ac2, .ac3, etc. are in binary format.**

Figure 21. Relative Calibration Report for MS-75 Lens

The relative spectral correction factors and instrument responsivity for pixels 1 through 100 at wavelengths from 380 nanometers to 780 nanometers is also included in the rest of the table. Press PgDn or the down arrow key to view this information as shown in Figure 21a on the following page.

Figure 21a. Relative Calibration Report for MS-75 Lens

The Linearity Calibration Report shows the Time Scale Linearization performed at 20° C including the luminance, calculated correction factors, gain, and raw data for peak values and averaged intensity for all integration times. A file beginning with the serial number of the PR-650 with the file extension .LPR is saved to the data directory (e.g. C:\650USC\DATA) if the options Write (to file) or View (on SRT) have been selected. This file also includes the date and time of the measurements. See Figure 22 on the following page.

If a Temperature Calibration was performed, this information is appended to the Linearity report and is accessed by pressing the PgDn key. If no Temperature Calibration was performed, there will be no additional screen. A sample Temperature Calibration Report is shown in Figure 22a on the following page.

Figure 22. Linearity Calibration Report Example

Figure 22a. Temperature Calibration Report Example

Utilities Menu

The Utilities option allows the user to create a RAM file (*.RAM) containing the newly created calibration factors, and the ability to download these factors to the PR-650 ICM card. The software uses the eight digit serial number of the unit to identify the file (e.g. 12345678.RAM).

The RAM file must be downloaded to the PR-650 ICM card or the PR-650 will not utilize the new factors during measurements.

The following procedure explains how to download the calibration factors.

Step 1 Using the cursor arrow keys move the highlighted bar to Utilities and press Enter with Make RAM file highlighted. (See Figure 23 Below).

Figure 23. Utilities Menu Options

The software advises the user that a RAM file is being generated. When completed, the user is returned to the Main Menu.

△ **It is recommended that you save your original RAM calibration files should you need to RESTORE the ICM card at a later time, or if for some reason your new calibration files don't work correctly.**

Refer to Chapter 7, of the PR-650 Operating Manual for information on how to save and restore data.

Step 2 Verify that the switch on the PR-650 interface cable is set to the XFER position.

Step 3 Move the highlight bar to Send RAM file to 650, and press Enter.

The program screen reports the status of the file transfer, then copies the Reference Illuminant files to the ICM card.

Step 4 Press any key to return to the Main Menu.

The PR-650 ICM card is now updated with the latest calibration information.

The next section discusses the options available in the EXIT menu option.

Exit Menu

The Exit Menu is used to access the DOS shell (Gateway to DOS) to perform other operations without leaving the User Self-Cal program, or to quit the program (EXIT) as shown in Figure 24 below.

Figure 24. Exit Menu Options

To use the Gateway to DOS option, the user highlights this option and presses Enter. All DOS commands can now be executed without losing any measurement data.

To return to the program, the user simply types the word exit and presses the Enter key.

If Exit this program is highlighted and the Enter key is pressed, the user exits the software program completely. The current Set up Menu parameters are saved and become the calibration program default.

This completes the instructions on how to use the PR-650 User Self-Calibration program.

The following Calibration example gives a condensed procedure for performing the Calibration of the PR-650 with an MS-75 Objective lens as the primary accessory and an ND-2 (Neutral Density) filter as the Add-on (secondary accessory).

Condensed Calibration Procedure for the MS-75 Lens and the ND-2 Filter

Step 1 Make the computer and PR-650 cable connections.

Step 2 *(Optional)*
Set the DAC Offset and gain.

Step 3 Set up the PR-650 with the MS-75.

Step 4 Calibrate Wavelength for MS-75.

Step 5 Calibrate Relative Intensity for MS-75.

Step 6 Set up the PR-650 with the ND-2 filter.

Step 7 Calibrate Relative Intensity for the ND-2 filter.

Step 8 Calibrate Linearity for the MS-75.

Step 9 Calibrate Absolute Intensity for the MS-75.

Step 10 Calibrate Absolute Intensity for the ND-2 filter.

Step 11 Make RAM file.

Step 12 Download the RAM file to the PR-650 to the ICM card.

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Bandwidth (BW) – (full width – half maximum) A measure of the optical power resolution function (optical width) of a spectrometer system (in nanometers) given by the difference between the two extreme values of the independent variable (wavelength) of which the dependent variable (optical power) is equal to half of its maximum value.

Blackbody (Full Radiator) – An ideal body which completely absorbs all incident radiation and reflects none, therefore appearing perfectly black at all wavelengths.

Blackbody Curve – With respect to a chromaticity diagram, this is the curve of points that represent the chromaticities of blackbodies possessing different color temperatures (cd).

Candela (cd) – The SI unit of luminous intensity defined as 1/60 the normal intensity of one square centimeter of a blackbody at the solidification temperature of platinum.

cd*m-² - Candelas per meter squared.

CIE – Commission Internationale de l'Eclairage (International Commission on Illumination).

Chrominance – The difference between any color and a specified reference color of equal brightness; in color television, this reference color is white having coordinates x= 0.310 and y= 0.316 on the chromaticity diagram.

Chromaticity – Properties of light having to do with hue and saturation, but not luminance (brightness).

Chromaticity Coordinates – The ratios of each of the tristimulus values of a color to the sum of the trisimulus values.

Color Difference – The magnitude and direction of the difference between two psycholphysical color stimuli and their components computed from tristimulus values, or chromaticity coordinates and luminance factor, by means of a specifed set of color-difference equations.

Color Space – A geometric space, usually of three dimensions, in which colors are arranged systematically.

Color Stimulus – A radiant flux capable of producing a color sensation.

Color Temperature – (of a source) Temperature (usually in kelvins) of a blackbody radiator that would emit light of the same chromaticity as the test source.

Color Tolerance – The permissible color difference between sample and specified color.

Colorimetric – Term used to refer to measurements that are converted to psychophysical descriptions of color and color relationships.

Correlated Color Temperature (CCT) – Temperature (usually expressed in Kelvins) of a blackbody radiator which produces the chromaticity nearest to that emitted by the light test source.

Dark Current – The current that flows in a photodetector when there is no incident optical radiation on the detector.

Flux, Luminous – The time rate of flow of light energy; luminous power.

Flux, Radiant – The time rate of flow radiant energy; radiant power.

Footcandle (fc) – English unit of illuminance equal to one lumen per square foot. The preferred unit of luminance is the SI unit lux (one lumen per square meter).

FootLambert (fL) – English unit of luminance equal to 1/ candela per square foot.

Hue – The attribute of color perception by means of which a color is judged to be red, orange, yellow, green, blue, purple, or intermediate between adjacent pairs of these, considered in a closed ring (red purple being an adjacent pair).

Illuminance – Luminous flux incident per unit area of a surface (lumens per square area).

Illuminant – A luminous flux, specified by its spectral distribution, used, in principle, to illuminate, but may be defined for computational purposes and may not correspond to a real source.

Incidence – Flux incident per unit area of a surface.

Intensity, Luminous – Luminous flux per unit solid angle (candlepower ar candelas).

Intensity, Radiant – Radiant flux per unit solid angle (watts per steradian).

Irradiance – Radiant flux incident per unit area of a surface.

Irradiance, Spectral – The radiance flux per unit wavelength interval, incident on unit area.

ISO temperature Line – Orthogonal lines to the Planckian locus (blackbody radiator curve) in the 1960 UCS that correlate chromaticities close to the Planckian locus.

LED – (Light emitting diode). A P-N junction device that gives off light radiation when forward biased.

Light – Electromagnetic radiant energy that is visually detectable by the normal human observer, radiant energy having wavelengths from about 380 nm to about 780 nm.

Lightness – The attribute of color perception by which a non-self-luminous body is judged to reflect more or less light.

Luminance – Luminous intensity of reflected or transmitted light a given direction per unit of projected area of the source as viewed from that direction (candelas per unit area).

LuvLab – The three dimensional graphic display of color (visible light) standardized by dividing out ambient light and multiplying by a standard illuminant (also CIELUV/CIELAB and L* u* v* / L* a* b*).

Lux (lx) – Illuminance corresponding to a luminous flux density of one lumen per square meter. SI unit of illuminance.

Nanometer (nm) – unit of length equal to 10- meter commonly used for identifying wavelenghts of the visible portion of the electromagnetic spectrum.

Photometric – pertaining to the measurement of the intensity of light.

Planckian Locus – Locus of points on a chromaticity diagram that is defined by the chromaticities of blackbody radiators.

Polychromator – A spectrograph, in which a multielement detector is placed in the focal plane, to detect the dispersed electromagnetic radiation that is spread over a full range of frequencies.

Purity, Colorimetric – The fraction of spectrally pure light in an additive mixture with reference achromatic (white) light to produce a color that matches that of the color stimulus considered.

Purity, Excitation – The ratio, of the lengths of line segments NC to ND, obtained when a straight line is drawn on the CIE chromaticity diagram from the achromatic (neutral) point (N), through the point (C) representing the color stimulus considered, to the intersection (D) with the spectrum locus or the straight boundary of nonspectral colors, as the case may be.

Radiance – Radiant power per unit source area per unit solid angle. Usually expressed in watts*m-^{2} *steradian- (watts per steradian per meter squared).

Radiance, Spectral – Radiance per unit wavelength interval at a given wavelength expressed in watts per steradian per unit area per wavelength interval.

Radimetric – Pertaining to the measurement of radiation (optical power).

Refference Luminance (Yn) – Luminance level of the Reference Illuminant in candelas per meter squared.

Reflectance – Ratio of the intensity of reflected radiant energy to that reflected from a defined reference standard.

Saturation – Attribute of a visual sensation according to which an area appears to exhibit more or less chromatic color, judged in proportion to its lightness or brightness.

SI Unit – International System of Units. Also known (in French) as Systéme International d'Unités.

Source – An object that produces light or other radiant flux.

Spectrophotometry – Quantitative measurement of reflection or transmission properties as a function of wavelength.

Spectraradiometry – Pertainting to the measurement of the absolute amounts of radiant flux at each wavelength of the spectrum.

Spectroradiometer – An instrument used to measure the radiant energy from a source at each wavelength troughtout a pre-defined portion of the electromagnetic spectrum.

Standard Illuminant A – Colorimetric illuminant, representing the full radiation at 2855.6K, defined by the International Comission on Illuminantion in terms of a relative spectral power distribution.

Standard Illuminant B – Colorimetric illuminant, representing direct sunlight with a correlated color temperature of 4874 K, defined by the International Commission on Illumination in terms of a relative spectral power distribution.

Standard Illuminant C – Colorimetric illuminant, representing daylight with a correlated color temperature of 6774 K, defined by the International Commission on Illuminantion in terms of a relative spectral power distribution.

Standard Illuminant D - Colorimetric illuminant, representing daylight with a correlated color temperature of 6504 K, defined by the International Commission on Illumination in terms of a relative spectral power distribution.

Standard Observer – An ideal observer having visual response described by the CIE tristimulus functions.

Tint – A color produced by the mixture of white pigment or paint with a chromatic pigment of paint. (A tint of a chromatic color is, therefore, lighter and less saturated than the chromatic color).

Transmittance – The amount of emitted light of a specific wavelength which is not reflected or absorbed, but passes through a substance.

Translucent – Transmitting light diffusely, but not permitting a clear view of objects beyond the specimen and not in contact with it.

Tristimulus Values, CIE – Percentage amounts of the three standard or matching stimuli designated as X, Y, and Z necessary in a three additive mixture required for matching a color.

Uniform Color Space (UCS) – Schematic arrangement of colors in space in which spatial intervals between points correspond to visual differences between colors represented by those points.

Wavelength – Of an electromagnetic wave, the distance, along the direction of propagation, between nearest points in an electromagnetic wave for which the electric field has the same phase. The unit generally used in spectrophotometry/ spectroradiometry related to colorimetery is the nanometer (nm). Unless otherwise stated, values of wavelength are generally those in air.

Wavelength, Complementary – Wavelength of a spectrally pure light, that when added to the light reflected or transmitted by the sample, produces a combination that color matched the reference illuminant.

Wavelength, Dominant – Wavelength of a spectrally pure light which when additively mixed with a reference illuminant and adjusted for luminance (light intensity) matches a specimen light.

Peak Wavelength – The wavelength at which the radiant intensity is maximum.

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