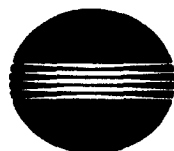


# **SPECTROPHOTOMETER CM-2002**

INSTRUCTION MANUAL



MINOLTA



## DESCRIPTION

The Minolta Spectrophotometer CM-2002 is a compact, handheld instrument for measuring the spectral reflectance of subjects. Combining measurement, data-processing, and display functions in a single unit, the CM-2002 is ideal for measurements both in the laboratory and in the field.

The CM-2002's d/8 (diffuse illumination/8° viewing angle) geometry conforms to ISO and DIN standards, and also meets the CIE recommendations for d/0 (diffuse illumination/0° viewing angle) geometry. In addition, this geometry allows the CM-2002 to offer easy switching between SCI (specular component included) and SEC (specular component excluded) measurements. The d/8 geometry, SCI/SCE switching capability, and  $\phi$ 8mm measuring area make the CM-2002 suitable for use in a wide variety of industrial and research fields.

Ultra-compact spectral sensors (developed by Minolta), hybrid IC analog circuitry, and a 32-bit, 16MHz microcomputer provide high-speed, high-accuracy measurements of spectral reflectance at wavelengths from 400 to 700nm. To ensure accuracy, the CM-2002 uses a double-beam feedback system, monitoring the illumination on the specimen at the time of measurement and automatically compensating for any changes in the intensity or spectral distribution of the light. The spectral reflectance over the entire wavelength range is measured simultaneously in as little as 4ms, and measurement results are shown on the display in 0.3 to 0.5 seconds. Power for the CM-2002 is provided by 4 AA-size batteries, so measurements can be taken almost anywhere.

Measurements can be calculated based on either the 2° or 10° Standard Observer and any of 11 illuminants (CIE Standard illuminants A, C, D<sub>50</sub>; and D<sub>65</sub>; Fluorescent illuminants F2, F6, F7, F8, F10, F11, and F12). Measurement results can then be displayed in a variety of ways: Graphically as spectral reflectance or color difference ( $\Delta L^* \Delta a^* \Delta b^*$ ), or as numerical absolute and/or difference values for XYZ, Y<sub>xy</sub>, L\*a\*b\*, L\*C\*H°, Hunter Lab, or L\*u\*v\* color spaces; metamerism index; Munsell notation; CMC (2:1) or (1:1); FMC-2; whiteness index (ASTM E 313 or CIE); or yellowness index (ASTM D 1925 or ASTM E 313).

A 128KB RAM card is used by the CM-2002 for data storage. This RAM card can contain data for up to 1000 measurements and 50 target colors, white calibration data, measurement conditions, and communication parameters, and has its own battery to maintain the stored data even when the card is removed from the CM-2002. The CM-2002 can also be connected directly to a computer; the computer can then control the operation of the CM-2002 and measurement data, etc. can be output by the CM-2002 to the computer. In addition, messages from the computer can be displayed on the CM-2002's display.

To take full advantage of the wide range of features offered by the CM-2002 and obtain the best measurement results, please read this manual thoroughly before using the CM-2002 for the first time and keep this manual handy for future reference.

## NOTES ON USING THIS MANUAL

### Color mode:

In this manual, the term "color mode" will be used to refer to the following color notations and color-difference formulas: XYZ,  $Y_{xy}$ ,  $L^*a^*b^*$ ,  $L^*C^*H^*$ , Hunter Lab,  $L^*u^*v^*$ , Munsell, metamerism index, whiteness index (ASTM E 313), whiteness index (CIE), yellowness index (ASTM E 313), yellowness index (ASTM D 1925), CMC (2:1), CMC (1:1), and FMC-2.

### SCI, SCE:

In this manual, SCI stands for "specular component included"; SCE stands for "specular component excluded".

## WARNING

- DO NOT USE THIS INSTRUMENT IN AN EXPLOSIVE ATMOSPHERE, SUCH AS ONE CONTAINING GASOLINE FUMES. USE IN SUCH AN AREA MAY RESULT IN AN EXPLOSION.
- DO NOT DISASSEMBLE THIS INSTRUMENT ON ATTEMPT TO REPAIR IT YOURSELF. THIS INSTRUMENT CONTAINS HIGH-VOLTAGE ELECTRICAL CIRCUITS AND THERE IS A RISK OF ELECTRICAL SHOCK IF THIS UNIT IS DISASSEMBLED BY UNQUALIFIED PERSONNEL. Any necessary repairs should be done only by a Minolta-authorized service facility.

## CAUTION

### CM-2002

- This instrument should be used at ambient temperatures of between 0 and 40°C (32 and 104°F) at a relative humidity of 85% (at 35°C/95°F) or less.
- This instrument should be used only with the exclusive AC adapter AC-A12 (included as a standard accessory). Do not use other AC adapters to supply power to this instrument.
- This instrument is not waterproof. Do not use this instrument in the rain or in areas subject to extremely high humidity. Do not spill liquid on this instrument.
- Do not use this instrument in extremely dusty areas.
- Do not leave this instrument in direct sunlight or near sources of heat, such as stoves, strong lights, etc. The internal temperature of the instrument may become much higher than the ambient temperature in such cases.
- Do not use this instrument near equipment which produces a strong magnetic field (such as speakers, large motors, etc.)
- Do not subject this instrument to strong shock or vibration.
- Do not press on the liquid crystal display.
- Because the measurement aperture and integrating sphere, as part of the optical system, are extremely precise parts, be very careful to keep anything from entering the measurement aperture or staining the inside of the integrating sphere. When this instrument is not in use, be sure to attach the white calibration cap to protect the measurement aperture and integrating sphere.
- Be sure to switch off this instrument when not in use.
- This instrument may cause interference if used near a television, radio, etc.

### White Calibration Cap

- The calibration data for the white calibration cap was measured at 23°C ± 1°C (73.4°F ± 1.8°F). For the highest accuracy when measuring absolute values, calibration and measurement should be performed at approximately the same temperature (23°C/73.4°F).
- To protect the white surface of the white calibration cap from being scratched, changing color due to ambient light, etc., be sure to cover the white calibration cap with the rubber cap after use. If the white surface becomes scratched or indelibly stained, purchase a replacement white calibration cap.

## Memory Card

- The life of the card's lithium battery is approximately 2 years. Since all data stored on the memory card will be erased if the battery power becomes too low, be sure to replace the battery at intervals of less than 2 years from the date written on the back of the card. (A built-in rechargeable auxiliary battery will maintain stored data for approximately 30 minutes while the lithium battery is changed.) Also, extremely important data should be backed up to another memory card or a floppy disk to avoid any chance of loss.

## CARE AND STORAGE

- If this instrument becomes dirty, it can be wiped with a clean, dry cloth. Do not allow alcohol or chemicals to touch the surface of the instrument.
- If the white calibration cap becomes dirty, it can be wiped with a clean, dry cloth. If the stain is difficult to remove, a soft cloth moistened with lens-cleaning fluid may be used. After cleaning the surface with lens-cleaning fluid, wipe the surface with a soft cloth moistened with water and then let the surface dry before use.
- This instrument should be stored in areas with temperatures between -20 and 55°C (-4 and 131°F). Do not store this instrument in areas subject to high temperatures, high humidity, or rapid changes in temperature, or where condensation may occur. For added safety, it is recommended that the instrument be stored with a drying agent (such as silica gel) in an area subject to a relatively constant temperature.
- Do not leave or store this instrument in direct sunlight, inside a closed motor vehicle, in the trunk of a motor vehicle, or in any area subject to extremely high temperatures.
- To avoid the possibility of battery leakage or corrosion, remove the batteries from the battery chamber if the instrument will not be used for longer than two weeks.
- To protect the instrument, always store the instrument in its case with the white calibration cap covering the measurement aperture.
- To prevent the white surface of the white calibration cap from changing color due to exposure to light (which may occur even in normal room light), always cover the white calibration cap with the included rubber cap after use.
- Be sure to keep all shipping materials (cardboard box, cushioning material, plastic bags, etc.) They can be used to protect the CM-2002 during transportation.

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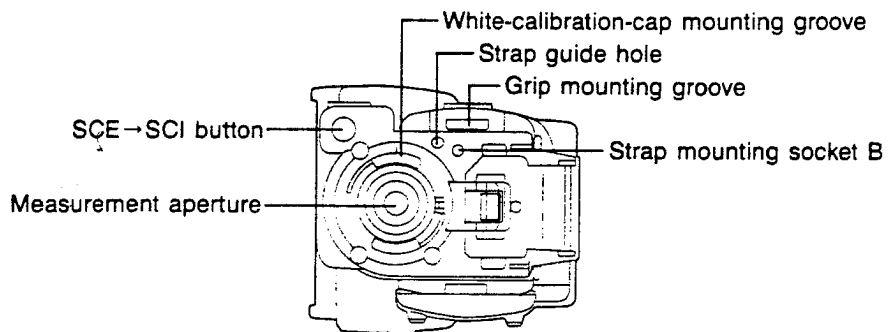
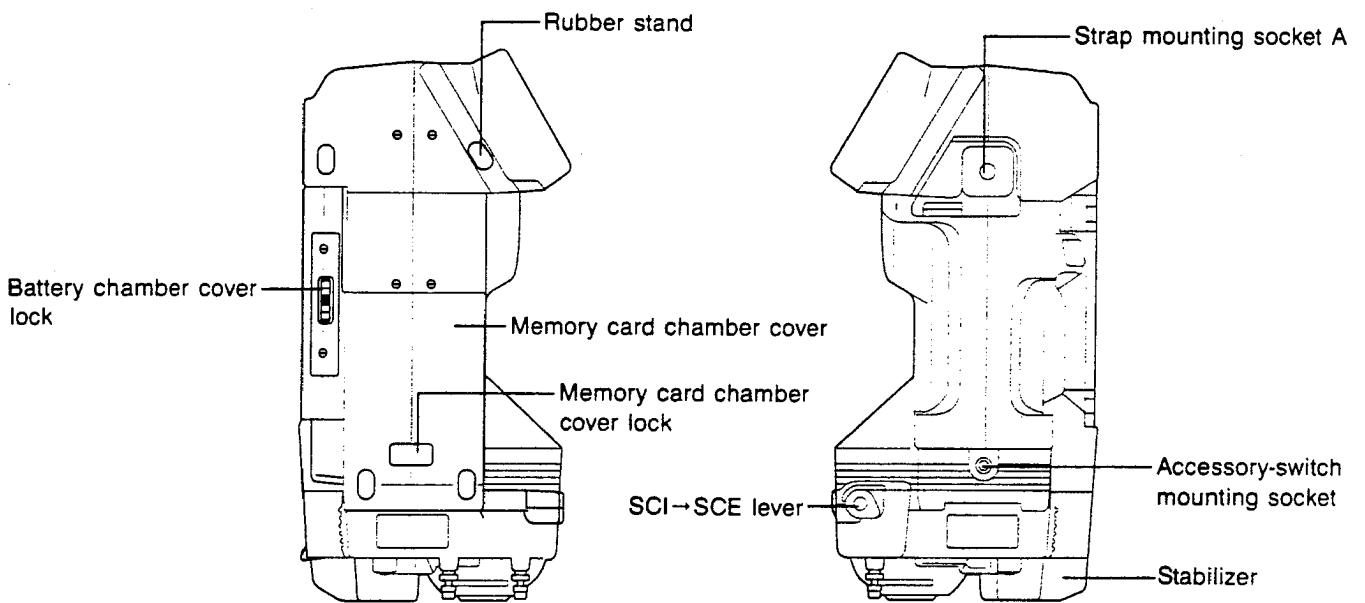
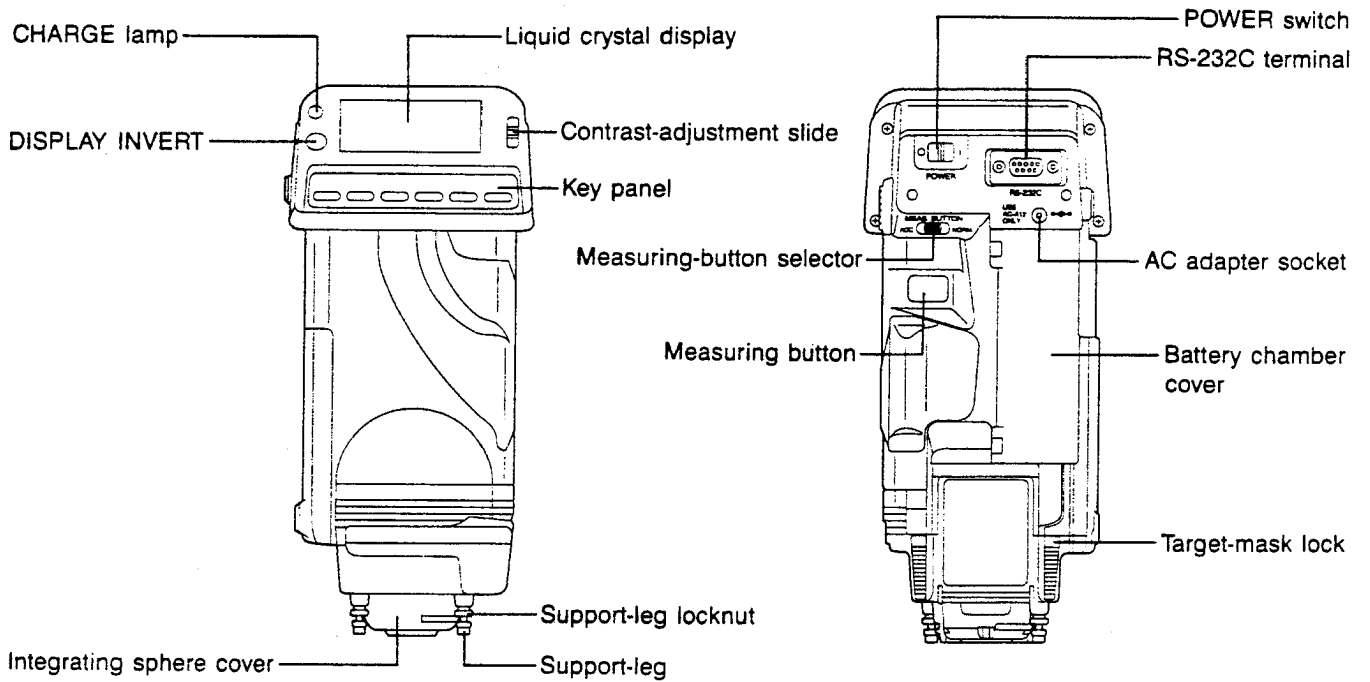


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# NAMES OF PARTS



## FUNCTIONS OF CONTROLS

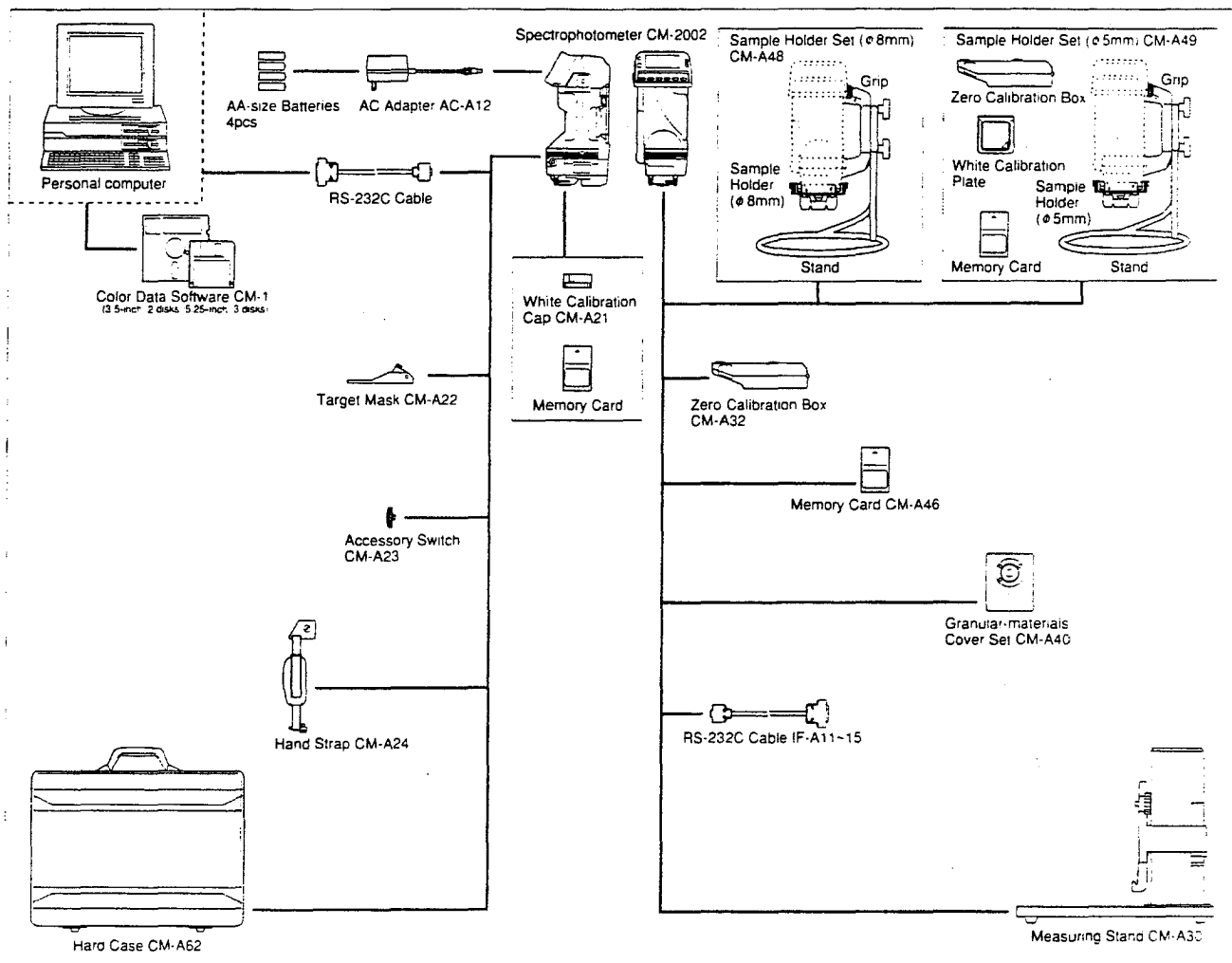
<b>DISPLAY INVERT</b>	Turns displayed information upside down.
Contrast-adjustment slide	Adjusts contrast of liquid crystal display.
Key panel	
<b>MODE</b>	Changes data display in MEASURE mode, TARGET MODE, or TOLERANCE mode; changes screen page in MENU mode or display-selection mode.
<b>MENU</b>	Changes to MENU mode.
<b>▷ AVG</b>	Moves cursor; starts/finishes manual averaging sequence; other functions depend on present mode and will be described in the display.
<b>▼</b>	Functions as ENTER key; exact functions depend on present mode and will be described in the display.
<b>▲</b>	Changes settings; exact functions depend on present mode and will be described in the display.
<b>BREAK/DELETE</b>	In MEASURE mode, enters SAMPLE DATA DELETE mode; in other modes, returns to next higher mode in mode flowchart.
POWER switch	Switches power on ( ) and off (○).
Measuring button	Takes measurement.
Measuring-button selector	Selects measuring button ( <b>NORM.</b> ) or Accessory Switch ( <b>ACC.</b> ).
<b>SCI→SCE</b> lever	Switches from SCI measurements to SCE measurements.
<b>SCE→SCI</b> button	Switches from SCE measurements to SCI measurements.

**KEY FUNCTION TABLE**

Display	Key	Measuring button	MODE	MENU	▷ AVG	▼	▲	BREAK/DELETE
Color mode displays (except MI)		Takes measurement.	Changes data display.	Changes to MENU mode.	Starts/ends manual averaging series.	Changes to next lower specimen number.	Changes to next higher specimen number.	Changes to SAMPLE DATA DELETE mode.
SPECTRAL	Moves graph cursor 10nm to the right.				Reduces graph scale.	Enlarges graph scale.		
COLOR GR.	Changes L' graph scale.				Reduces Δa', Δb' graph scale.	Enlarges Δa', Δb' graph scale.		
MI	Changes reference illuminant.				Changes test illuminant.			
SAMPLE DATA DELETE	—	—	—	—	Moves highlighted cursor.	Performs operation selected by cursor.	—	—
MENU	—	Switches between screen pages.	Changes to MENU mode.	—	—	—	—	Changes to MEASURE mode.
Data display select	—							Moves >> cursor.
CALIBRATION		Performs calibration and changes to MEASURE mode (if calibration performed from initial display) or to MENU mode (if CALIBRATION mode entered from MENU mode).	—	Does not function in initial display. Changes to MENU mode in other cases.	—	Performs zero calibration.	—	From initial display, changes to MEASURE mode. Returns to MENU mode if CALIBRATION mode was entered from MENU mode.
TARGET		Takes measurement of target specimen.	Changes data display.	Changes to MENU mode.	Starts/ends manual averaging series (except in SPECTRAL data display. In SPECTRAL data display, moves graph cursor 10nm to the right.	Changes to TARGET OPTION mode.	Increases target number.	Returns to MENU mode.
TARGET OPTION	—	—	—	—	Moves highlighted cursor.	Enters mode selected by highlighted cursor.	—	Returns to TARGET mode.
TARGET COMMENT	—	—	—	—	—	Changes character in reverse numerical/alphabetical order.	Changes character in numerical/alphabetical order.	Returns to TARGET OPTION mode.
TOLERANCE	—	—	Changes data display.	—	—	—	Increases character value.	—

Display	Key	Measuring button	MODE	MENU	▷ AVG	▼	▲	BREAK/DELETE
TARGET DATA DELETE		—	—	Changes to MENU mode.	Moves highlighted cursor.	Performs operation selected by cursor.	—	—
DATA SAVE		—	—		—	Performs DATA SAVE.	—	Returns to MENU mode.
DATA OUT		—	—		Moves highlighted cursor.	Enters mode selected by cursor.	—	
CARD DATA OUTPUT		—	—	—	—	—	—	Interrupts data output and returns to DATA OUT mode.
DATA OUT SET UP		—	—	Changes to MENU mode.	Moves highlighted cursor.	Changes setting of parameter selected by cursor.		Returns to DATA OUT mode.
REMOTE	(If enabled) Takes measurement.		—	—	—	—	—	Cancels REMOTE mode and returns to MENU mode.
OBS.,ILL.		—	—	Changes to MENU mode.	Moves bracket [ ] cursor.	Moves highlighted cursor to select setting.		Returns to MENU mode.
AUTO AVG. SET UP		—	—		Moves highlighted cursor.	—	—	
TARGET AUTO SELECT		—	—		—	—	Changes setting.	
REFL. CORRECTION		—	—		Moves highlighted cursor.	—	Changes value of highlighted character.	
CLOCK, BUZZER		—	—		—	Changes setting of highlighted item.		

## SYSTEM DIAGRAM



### Standard accessories

AA-size batteries (4)  
 AC Adapter AC-A12  
 White Calibration Cap CM-A21 (with rubber cap,  
 memory card containing calibration data, and  
 calibration data sheet)  
 Target Mask CM-A22  
 Accessory Switch CM-A23  
 Handstrap CM-A24  
 Hard Case CM-A62

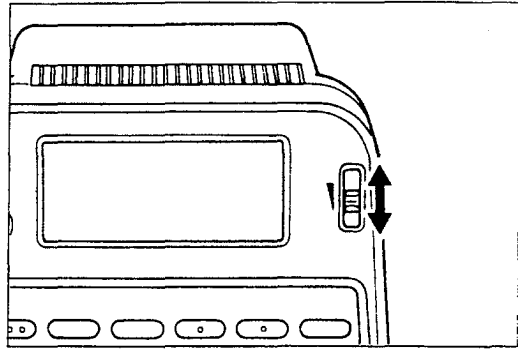
### Optional accessories

Measuring Stand CM-A30  
 Zero Calibration Box CM-A32  
 Granular-Materials Cover Set CM-A40  
 Grip CM-A42  
 Sample Holder Set ( $\phi$ 8mm) CM-A48 [consists of  
 Sample Holder ( $\phi$ 8mm) CM-A35, Stand CM-A34,  
 and Grip CM-A42]  
 Sample Holder Set ( $\phi$ 5mm) CM-A49 [consists of  
 Sample Holder ( $\phi$ 5mm) CM-A44, Zero Calibration  
 Box CM-A32, Stand CM-A34, Grip CM-A42, and  
 White Calibration Plate CM-A45 (with memory card  
 and data sheet of calibration data)]  
 Color Data Software CM-1  
 RS-232C Cable IF-A11 to IF-A15

## DISPLAY CONTRAST

The contrast of the display can be adjusted by moving the contrast-adjustment slide in either direction to obtain the best contrast for viewing.

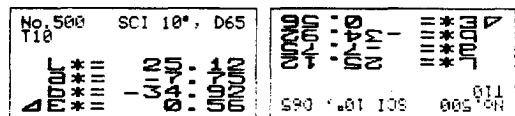
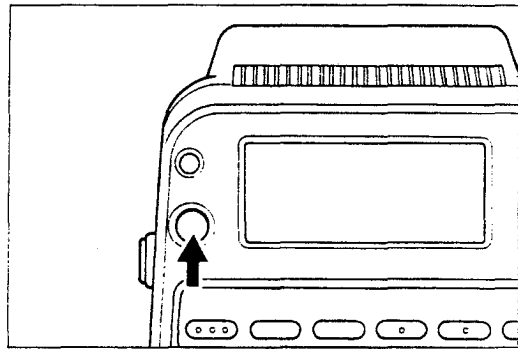
- The appearance of the display also varies according to the angle from which it is viewed.



## DISPLAY INVERT

Pressing **DISPLAY INVERT** causes displayed data to be shown upside-down in the display. Data can thus be easily read when measuring a vertical surface or using the CM-2002 in an inverted position.

- Display will not be inverted if **DISPLAY INVERT** is pressed while the CM-2002 is in **REMOTE** mode.

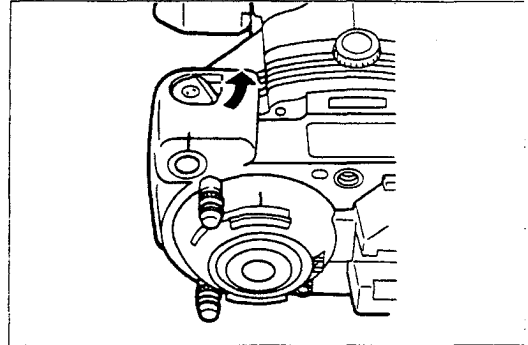




## SWITCHING BETWEEN SCI AND SCE

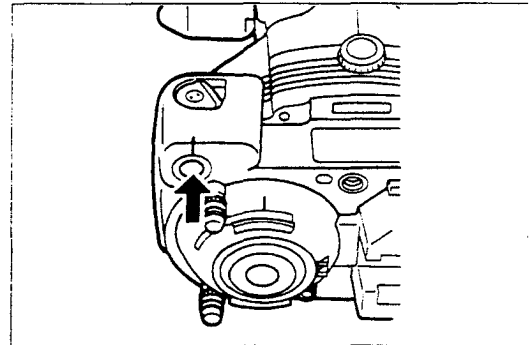
Either SCI (specular component included) or SCE (specular component excluded) measurements can be taken with the CM-2002. The SCI system minimizes the effects of the subject's surface condition on measured values; this system provides good results for color mixing or CCM (computerized color matching). The SCE system provides results which closely match those of visual evaluation; this system is good for general measurements of a wide variety of subjects, both those with gloss and those without gloss.

To switch from SCI measurements to SCE measurements, move the **SCI→SCE** lever so that the bar of the lever is aligned with SCE.



To switch from SCE measurements to SCI measurements, push the **SCE→SCI** button. The **SCI≅SCE** lever will turn so that the bar is aligned with SCI.

- Always use the **SCE→SCI** button to switch from SCE measurements to SCI measurements. Do not try to force the **SCI≅SCE** lever to turn without pushing the **SCE→SCI** button.

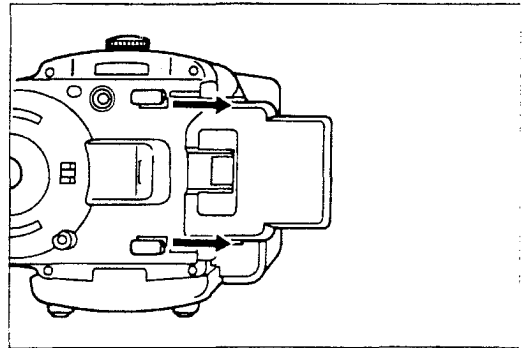


## STABILIZER

The CM-2002 is equipped with a stabilizer to help keep the CM-2002 steady when taking measurements of flat surfaces. The stabilizer can be removed if necessary to take measurements of concave surfaces.

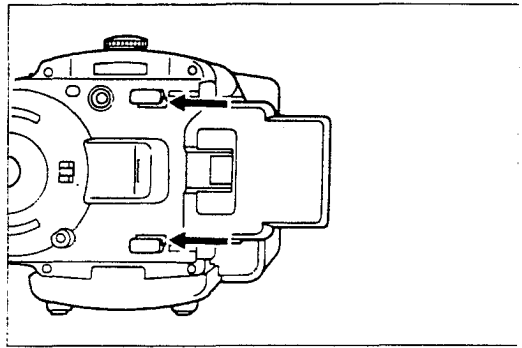
### Removing

To remove the stabilizer, slide the stabilizer away from the CM-2002 as shown.



### Attaching

1. Align the mounting grooves of the stabilizer with the stabilizer mounting guides.
2. Slide the stabilizer toward the measurement aperture as far as it will go.

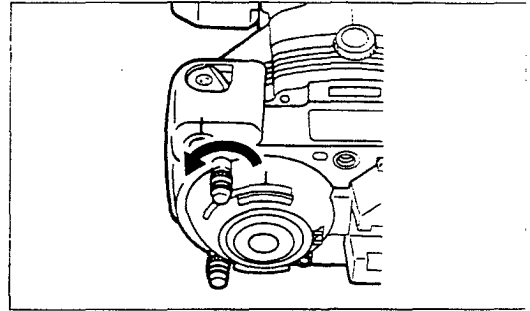


## SUPPORT LEGS

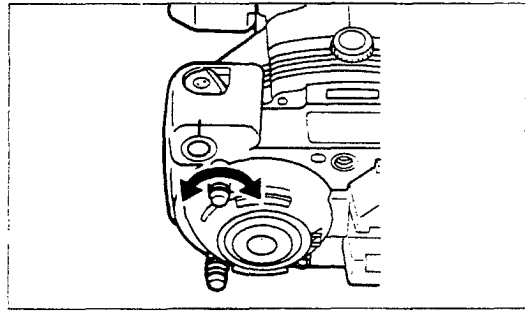
The support legs help to further stabilize the CM-2002 during measurements. They are especially useful when measuring curved or slightly convex surfaces.

### Adjusting Height

1. Loosen the support-leg locknut by turning it counterclockwise.

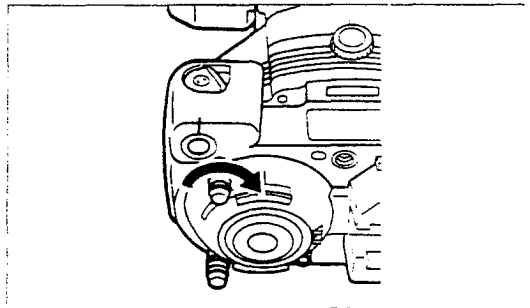


2. Turn the support leg clockwise (to shorten the legs) or counterclockwise (to lengthen the legs) to set the desired height.



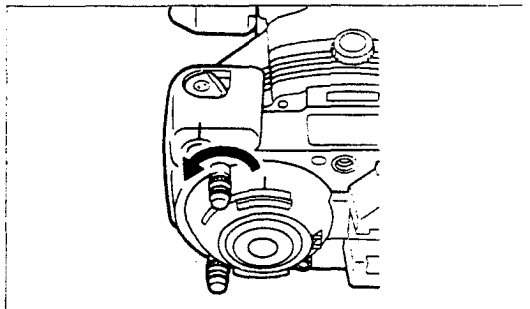
3. Turn the support-leg locknut clockwise until snug to lock the support leg at the set height.

- When measuring curved surfaces, if a subject with a different radius of curvature is measured, the height of the support legs should be readjusted to match the new radius of curvature.

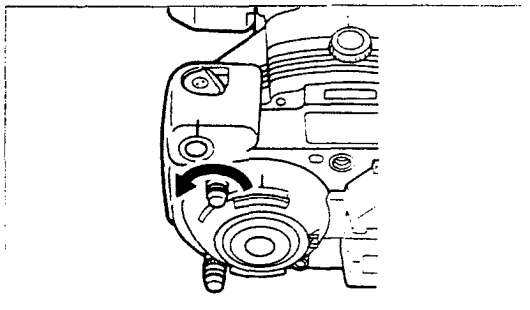


### Removing

1. Loosen the support-leg locknut by turning it counterclockwise.

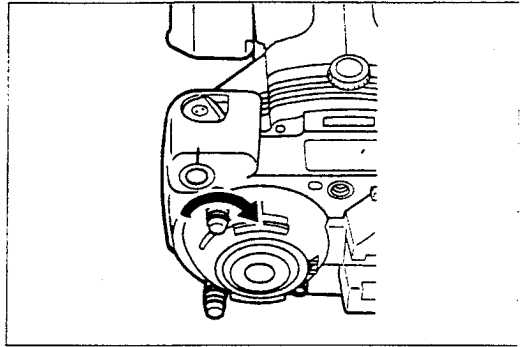


2. Turn the support leg counterclockwise until it is free of the CM-2002.



## Attaching

1. Align the support leg with the screw hole for the support leg and turn the support leg clockwise.
2. Adjust the height as desired according to the procedure on the previous page.



## WHITE CALIBRATION CAP

The white calibration cap must be attached to the CM-2002 to perform white calibration. In addition, it can be attached to the CM-2002 to prevent dust, etc. from entering the measuring aperture when the CM-2002 is stored.

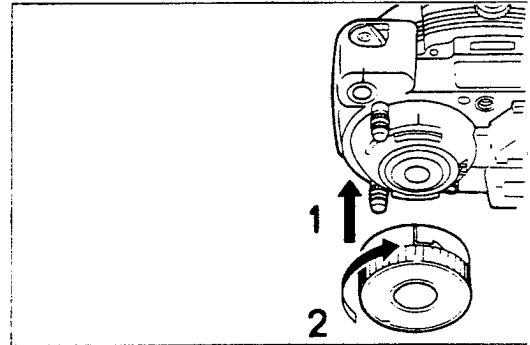
- When the white calibration cap is not attached to the CM-2002, be sure to attach the included rubber cap to the white calibration cap to protect the white calibration cap from changing color due to exposure to extraneous light.

### Removing

To remove the white calibration cap from the CM-2002, press the white calibration cap against the CM-2002 and turn the cap in the direction opposite to that of the arrow.

### Attaching

1. Align the index marks of the white calibration cap and the CM-2002's integrating sphere.
2. Press the white calibration cap against the CM-2002, and turn the cap in the direction of the arrow.



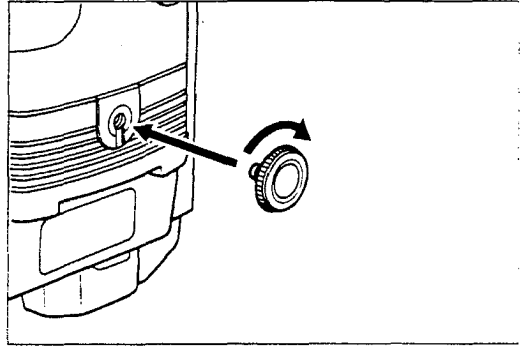
## ACCESSORY SWITCH

When attached to the CM-2002, the Accessory Switch can be used in place of the CM-2002's normal measuring switch. The Accessory Switch is especially convenient when measuring vertical or overhead surfaces and when supporting the CM-2002 with two hands.

- When using the Accessory Switch, set the measuring-button selector to **ACC**.

### Attaching

Align the screw of the Accessory Switch with the CM-2002's accessory-switch mounting socket and turn the switch clockwise until snug. Do not overtighten.



### Removing

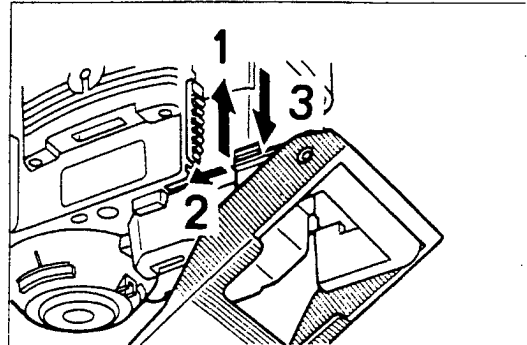
Turn the Accessory Switch counterclockwise until it is free of the CM-2002.

## TARGET MASK

The Target Mask indicates the area of the specimen surface to be measured, allowing more accurate positioning of the measuring head. When the target mask is attached, position the CM-2002 so that the area to be measured is in the center of the hole in the target mask, tilt the CM-2002 down so that the measurement aperture is flat against the specimen surface, and press the measuring button.

### Attaching

1. Slide target-mask locks up.
2. Slide the rails of the Target Mask into the slots of the CM-2002 as shown.
3. Slide target-mask locks down.



### Removing

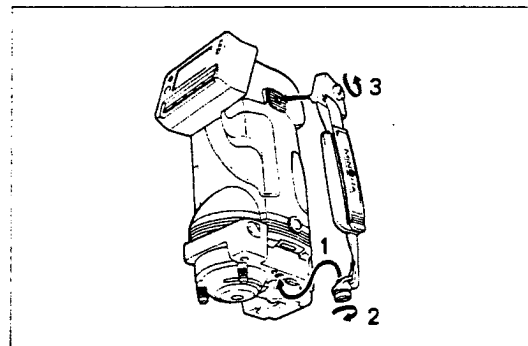
To remove the Target Mask, reverse the above procedure.

## HANDSTRAP

The Handstrap helps in firmly holding the CM-2002.

### Attaching

1. Align the pin of the Handstrap's lower mounting plate with the CM-2002's handstrap guide hole.
2. Align the Handstrap's mounting screw B with the CM-2002's handstrap mounting socket B and turn the screw clockwise until snug. Do not overtighten.
3. Align the Handstrap's mounting screw A with the CM-2002's handstrap mounting socket A and turn the screw clockwise until snug. Do not overtighten.



### Removing

To remove the Handstrap, reverse the above procedure.

## MEMORY CARD

The CM-2002 uses a 128KB RAM card for data storage. This RAM card meets the standards defined by JEIDA (Japan Electronic Industry Development Association).

The following data can be stored on the memory card:

Measurement data:1000 sets of data (stored automatically at time of measurement)

Each set of measurement data consists of the following:

- Spectral reflectance data
- Date and time of measurement
- Target number selected at time of measurement
- Reflectance correction value at time of measurement
- SCI or SCE selected at time of measurement
- Comment (11 characters; input using external device such as a computer)

Measurement conditions, target data, white calibration data, and data communication parameters: Stored by selecting "SAVE" in menu and pressing ▼ key (see p.40)

Target data:50 sets of data

Each set of target data consists of the following:

- Spectral reflectance data
- Date and time of measurement
- Reflectance correction value
- SCI or SCE selected at time of measurement
- Whether or not data is temporarily deleted
- Comment (8 characters)
- Tolerance values

Measurement conditions:

- Present data display
- Enabled data displays
- Presently selected target number
- Observer/illuminant conditions
- Number of measurements for automatic averaging
- Reflectance correction value
- Reference illuminant and test illuminant for metamerism calculations
- Scale of spectral or colorimetric graph
- Automatic target color select on or off
- Buzzer on or off

White calibration data

Data communication parameters

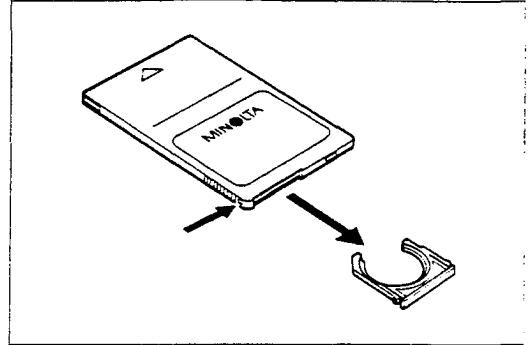
- Baud rate
- Character length
- Number of stop bits
- Parity
- Automatic data output on or off
- Output format (computer or printer)



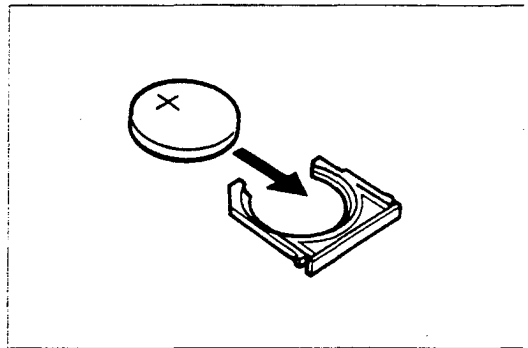
## Installing Battery

- The battery of the memory card included as a standard accessory with the CM-2002 was installed at the factory before shipment. The date written on the back of the memory card is the date the battery is expected to expire (two years from the date of installation). However, to ensure that data is not lost, it is good practice to replace the memory card battery even before the date written.

1. Press on the battery-case lock button to release the battery-case lock and slide the battery case out of the memory card.



2. Insert a battery (CR2325) into the battery case with the polarity as shown at right.



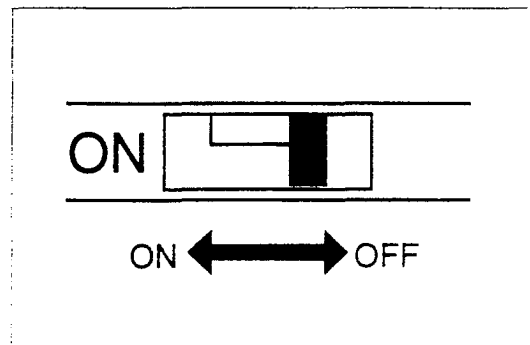
3. Reinsert battery case in memory card.

4. Write the date of battery installation on the back of the memory card.

- Battery life is approximately 2 years. Since all data stored on the memory card will be erased if the battery power becomes too low, be sure to replace the battery periodically at intervals of less than 2 years. Also, extremely important data should be backed up to another memory card or a floppy disk to avoid any chance of loss.
- The memory card has a built-in rechargeable auxiliary battery which will retain stored data for up to approximately 30 minutes while the main memory card battery is changed.
- To ensure that the auxiliary battery is sufficiently charged before changing the main battery, install the memory card in the CM-2002, set the CM-2002's POWER switch to | (on), and leave the card installed for at least 10 minutes.

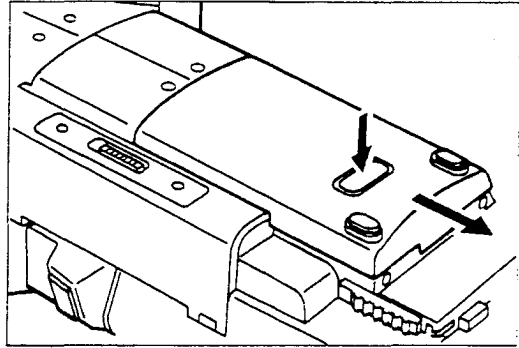
## Write Protect

The memory card is equipped with a write-protect switch which can be used to prevent stored data from being accidentally overwritten. When the write-protect switch is slid to ON and memory card has been selected on the CM-2002, the message "CARD ERR" will appear and data cannot be stored on the memory card. Sliding the write-protect switch away from ON (to the off position) will allow data to be stored on the memory card; however, previously stored data may be overwritten.

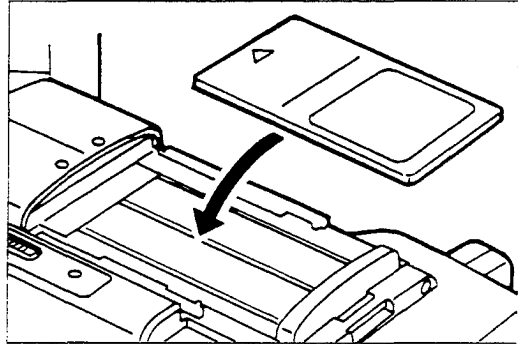


## Installing Memory Card

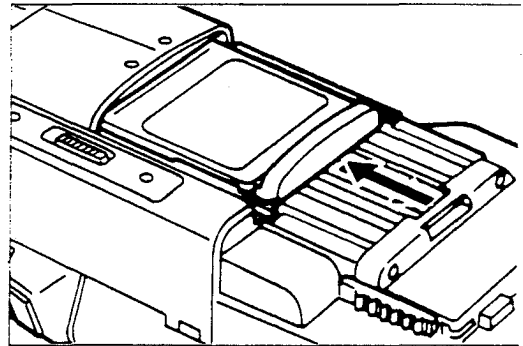
1. While pressing the memory card chamber cover lock, slide the memory card chamber cover down toward the integrating chamber and remove the memory card chamber cover.



2. Insert the memory card in the memory card chamber.



3. Slide the memory card insertion/removal slide up fully until the memory card clicks in place.



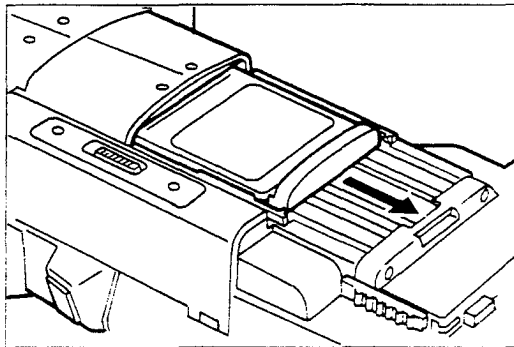
4. Replace the memory card chamber cover.

## Removing Memory Card

1. While pressing the memory card chamber cover lock, slide the memory card chamber cover down toward the integrating chamber and remove the memory card chamber cover.



2. Slide the memory card insertion/removal slide down and remove the memory card.



3. Replace the memory card chamber cover.

## Care and Storage

### MEMORY CARD

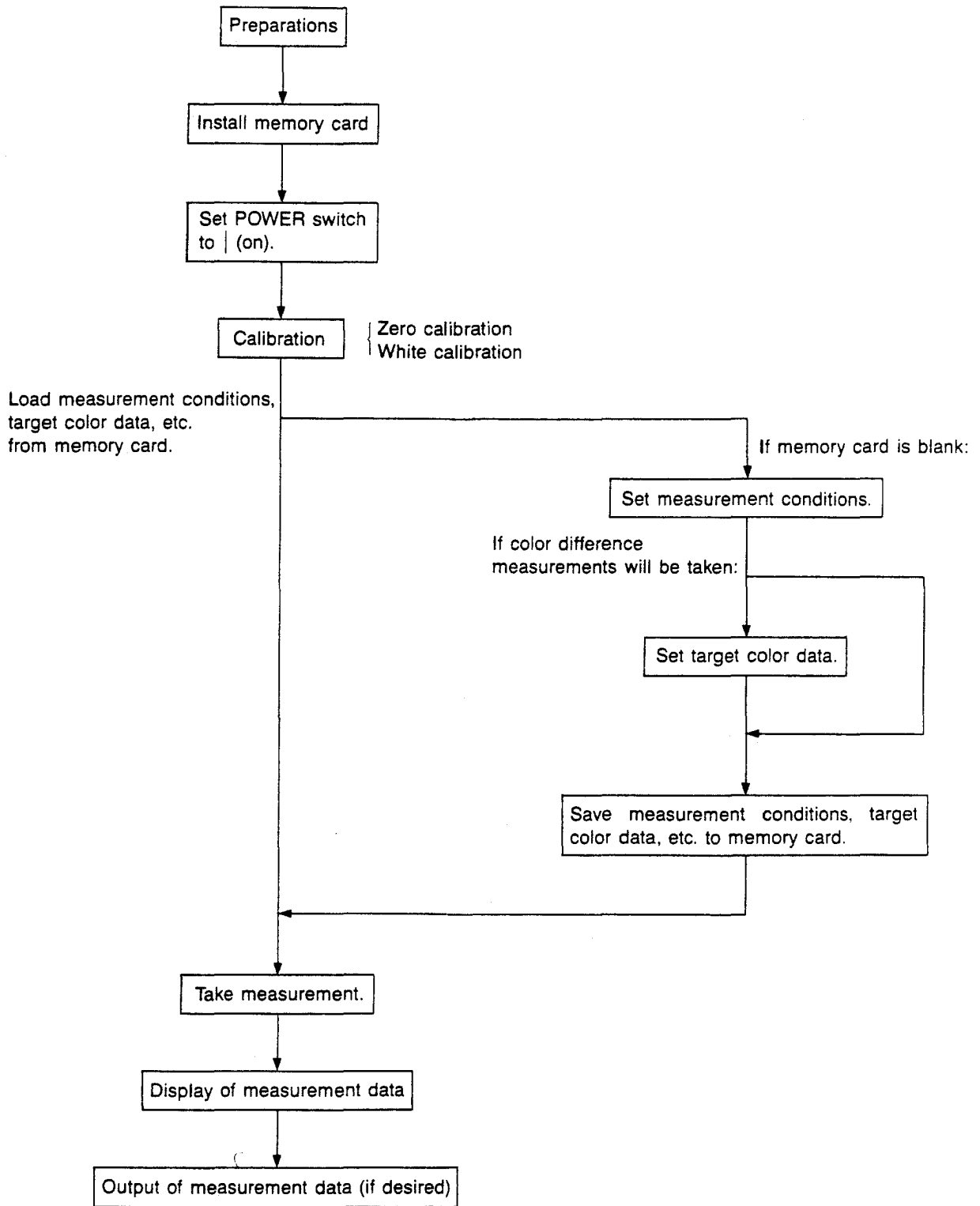
- The memory card should be used at temperatures between 10 and 40°C (50 and 104°F) at 30 to 85% relative humidity. The memory card should be stored at temperatures between -10 and 60°C (14 and 140°F) at 30 to 95% relative humidity. If the card is to be stored for a long period of time, it should be stored at a relatively constant temperature.
- Do not bend, drop, or throw the memory card, or subject it to strong shock.
- Do not leave the memory card in direct sunlight, near sources of heat, or in areas subject to high temperatures.
- Do not allow dust, oil, or moisture to enter the connector of the memory card. Do not touch the connector with your fingers.
- Do not use or store the memory card in areas subject to static electricity or large quantities of electrical noise. Use or storage in such areas may result in destruction of data.

### BATTERY

- **WARNING:** The battery used in this device may present a fire or chemical-burn hazard if mistreated. Do not recharge, disassemble, heat above 100°C (212°F), or incinerate.
- Replace battery only with one of the lithium batteries listed below. Use of another battery may present a risk of fire or explosion.
- Dispose of used battery promptly.
- Battery life is approximately 2 years.
- When installing a battery, be sure to check the battery polarity. The memory card may be damaged if battery is installed with polarity reversed.
- Remove exhausted batteries promptly. If an exhausted battery is left in the memory card for an extended period of time, battery leakage or corrosion may result.
- Keep batteries out of reach of small children or animals.
- Do not recharge, disassemble, or dispose of in fire.
- Never put batteries in mouth. If swallowed, contact your physician or local poison-control center.
- Replacement lithium batteries:

Manufacturer	Part No.
Fuji Electrochemical Co., Ltd.	CR 2325
Matsushita Electric Industrial Co., Ltd.	BR 2325
Duracell Inc.	DL 2325

# MEASUREMENT FLOWCHART



## BASIC OPERATION

### Calibration (p. 30)

1. Install the included memory card in the memory card chamber and set POWER switch to | (on). White calibration data will be loaded from the memory card.
2. Attach the white calibration cap to the CM-2002 (p. 21).
3. Select either SCI or SCE measuring system (p. 17).
4. Check that CHARGE lamp is lit. After it becomes lit, press the measuring button. Three measurements will be taken, and then calibration will be complete. The display will automatically change to the measurement display.

### Setting Measurement Conditions (p. 34)

The following measurement conditions should be set:

Item	Reference page
Enabled data displays	37
Observer/illuminant conditions	39
Number of measurements for automatic averaging	41
Reflectance correction factor	42
Clock/calendar and tone on/off	43
Automatic target color select on or off	54

### Absolute Measurements (p. 55)

1. Press **MODE** repeatedly to select desired data display.
2. Position CM-2002 on specimen with measurement axis normal to specimen surface.
3. Check that CHARGE lamp is lit. After it becomes lit, press the measuring button. A measurement will be taken and the results shown in the display.

### Color-Difference Measurements

#### Setting target color data (p. 44)

1. Press **MENU**. The display will change to the MENU display.
2. Press **> AVG** repeatedly to move the cursor to "TARGET"; press **▼** to change to the TARGET display.
3. Press **▲** repeatedly to select the desired target number.
4. Press **MODE** to select the desired data display.
5. Position CM-2002 on target specimen with measurement axis normal to specimen surface.
6. Check that CHARGE lamp is lit. After it becomes lit, press the measuring button. A measurement will be taken; the results will be shown in the display and stored as the target-color data.

#### Taking measurements (p. 55)

1. While in the TARGET display, press **▲** repeatedly to select the desired target number.
2. Press **MENU** or **BREAK/DELETE** to change to the MENU display, then press **BREAK/DELETE** to change to the measurement display.
3. Press **MODE** repeatedly to select desired data display.
4. Position CM-2002 on specimen with measurement axis normal to specimen surface.
5. Check that CHARGE lamp is lit. After it becomes lit, press the measuring button. A measurement will be taken and the results shown in the display.

## CALIBRATION

### WHITE CALIBRATION

After the CM-2002 has been switched on or after zero calibration has been performed, white calibration must be performed before measurements are taken. The white calibration standard for the CM-2002 is the white calibration cap included as a standard accessory. Calibration data for the white calibration cap are stored on the included memory card; a table of calibration data is also included.

- If measurements will not be taken, it is not necessary to perform white calibration. In this case, press **BREAK/DELETE** to skip calibration.
- Changes in temperature (both ambient temperature and the internal temperature of the CM-2002) may affect the measurement accuracy. For this reason, if the ambient temperature changes, white calibration should be performed again. In addition, when repeated measurements are taken over a relatively short period of time, the internal temperature of the CM-2002 may increase; in such case, white calibration should be performed fairly frequently to maintain measurement accuracy.

### Setting Calibration Data

Calibration data for the white calibration cap is stored on the included memory card and can be loaded into the CM-2002's memory according to the steps below.

- After the calibration data has been loaded into the CM-2002's memory, it remains in the memory until it is changed. Thus, if calibration data has been loaded once and the same white calibration cap is being used, it is not necessary to load calibration data again each time the CM-2002 is switched on. However, if a different white calibration cap is used, the calibration data for the new white calibration cap should be loaded.
  - Calibration data can also be set using a separate computer (p. 109).
1. Check that the POWER switch is set to  (off).
  2. Install the included memory card (containing calibration data for the white calibration cap) into the memory card chamber.
    - Check that the serial numbers of the white calibration cap and the memory card are the same.
  3. Slide the POWER switch to  (on). The calibration data will be automatically loaded into the CM-2002's memory from the memory card. After the copyright display is shown, the CM-2002 will automatically change to CALIBRATION mode.
    - Do not open the memory card chamber cover until the CM-2002 has changed to CALIBRATION mode.
    - If the CM-2002 was set to REMOTE mode the last time the power was switched off, the CM-2002 will automatically switch to REMOTE mode after the copyright display appears. In this case, CALIBRATION mode should be entered by returning to MENU mode and then selecting CALIB.

## Performing Calibration

- Calibration should be performed under the same conditions (temperature, etc.) under which measurements will be taken.
- If the CM-2002 and/or the white calibration cap have been recently moved from an area at a different ambient temperature, wait for the temperature of the units to reach the present ambient temperature before performing calibration.

1. Attach the white calibration cap (see p. 21).
2. Select either SCI or SCE measurements, according to which type of measurements will be taken (see p. 17).
3. To perform calibration immediately after switching power on:  
(after CM-2002 has automatically changed to CALIBRATION mode)

- a. Press the measuring button. Three measurements will be taken at approximately three-second intervals.
  - If power supply is low, the interval between measurements will be longer.
- b. After calibration has been completed, the CM-2002 will automatically change to MEASURE mode.

```
<CALIBRATION> SCI
MEAS --WHITE CALIB.
  ▼ --ZERO CALIB.
BREAK--MEASURE MODE
```

To perform calibration by selecting "CALIB." from menu:

- a. In MENU mode, press  $\triangleright$  **AVG** repeatedly to move cursor to "CALIB."
  - If "CALIB." is not shown in the displayed menu page, press **MODE** to change menu page.

```
<MENU> 1/2
MODE/NEXT PAGE
▶/SELECT ▼/EXECUTE
DISPLAY CALIB.
TARGET DATA SAVE
DATA OUT REMOTE
```

- b. Press  $\blacktriangledown$ . CM-2002 will change to CALIBRATION mode.

```
<CALIBRATION> SCI
MEAS --WHITE CALIB.
  ▼ --ZERO CALIB.
BREAK--MENU MODE
```

- c. Press the measuring button. Three measurements will be taken at approximately three-second intervals.
  - If power supply is low, the interval between measurements will be longer.
- d. After calibration has been completed, the CM-2002 will automatically return to MENU mode.

## WARNING

If **BREAK/DELETE** is pressed after the CM-2002 has started taking the measurements for calibration, the calibration process will be interrupted. If measurements are then taken without performing calibration again, the results of the previous completed calibration process will be used and "NO CAL" will appear in the display.

## ZERO CALIBRATION

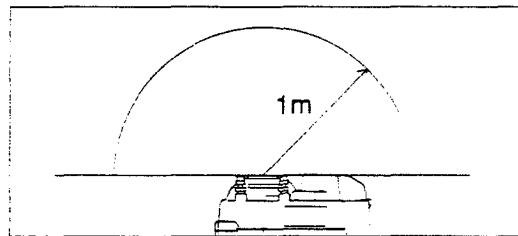
Zero calibration is performed to compensate for the effects of stray light due to the flare characteristics of the optical system. At the time of shipment, zero calibration data measured by Minolta are stored in an EEPROM in the CM-2002. However, since the flare characteristics will change over time due to dust, stains, etc. in the optical system, zero calibration should be performed periodically to enable the effects of stray light to be eliminated more accurately. Zero calibration should also be performed periodically to eliminate variations in measured values due to changes in ambient temperature or in the internal temperature of the CM-2002 due to repeated measurements, vibration, shock, etc. In addition, if the CM-2002 has not been used in a long time, it is recommended that zero calibration be performed to ensure the best possible accuracy.

- Measured zero calibration data will remain in the CM-2002's memory even if the POWER switch is set to ○ (off); however, if the CM-2002 is not used for a long period of time, all data in memory (including zero calibration data) may be lost. If this occurs, the zero calibration data measured by Minolta at the time of shipment will be used.
- If zero calibration is performed, white calibration should be performed afterward.

1. Remove white calibration cap (see p. 21) and target mask (see p. 23).
2. Select either SCI or SCE measurements, according to which type of measurements will be taken (see p. 17).
3. To perform zero calibration immediately after switching power on:  
(after CM-2002 has automatically changed to CALIBRATION mode)

```
<CALIBRATION> SCI
MEAS --WHITE CALIB.
  ▼ --ZERO CALIB.
BREAK--MEASURE MODE
```

- a. Aim the CM-2002's measurement aperture into the air so that there is no object within 1m (39 inches) of the measurement aperture.
  - Do not aim it toward a light source.
  - Zero calibration can also be performed using the Zero Calibration Box (sold separately).
- b. Press ▼. Three measurements will be taken (the pulsed xenon arc lamp will fire three times) at approximately three-second intervals.
  - If power supply is low, the interval between measurements will be longer.
- c. After zero calibration has been completed, the CM-2002 will automatically return to CALIBRATION mode. Perform white calibration (see p. 30).





To perform calibration by selecting "CALIB." from menu:

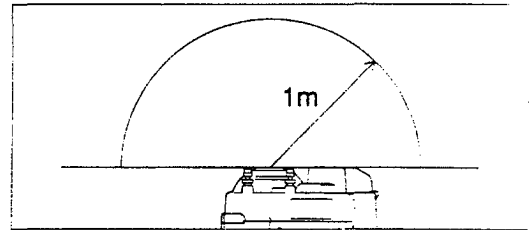
- a. In MENU mode, press  $\triangleright$  **AVG** repeatedly to move cursor to "CALIB."
  - If "CALIB." is not shown in the displayed menu page, press **MODE** to change menu page.

```
<MENU> 1/2
MODE/NEXT PAGE
▶/SELECT ▼/EXECUTE
DISPLAY CALIB.
TARGET DATA SAVE
DATA OUT REMOTE
```

- b. Press  $\blacktriangledown$ . CM-2002 will change to CALIBRATION mode.

```
<CALIBRATION> SCI
MEAS --WHITE CALIB.
▼ --ZERO CALIB.
BREAK--MENU MODE
```

- c. Aim the CM-2002's measurement aperture into the air so that there is no object within 1m (39 inches) of the measurement aperture.
  - Do not aim it toward a light source.
  - Zero calibration can also be performed using the Zero Calibration Box (sold separately).



- d. Press  $\blacktriangledown$ . Three measurements will be taken (the pulsed xenon arc lamp will fire three times) at approximately three-second intervals.
  - If power supply is low, the interval between measurements will be longer.
- e. After zero calibration has been completed, the CM-2002 will automatically return to CALIBRATION mode. Perform white calibration (see p. 30).

## MEASUREMENT CONDITIONS

- Previously set measurement conditions, target data, etc. will be kept in memory for up to 6 months even if the POWER switch is set to ○ (off), the battery power becomes too low for operation, batteries are removed, or the AC adapter is disconnected.

## SETTING MEASUREMENT CONDITIONS

### From MENU Mode

Measurement conditions can be checked and changed from MENU mode.

1. Press **MENU**. The CM-2002 will change to MENU mode.

```
<MENU> 1/2
MODE/NEXT PAGE
▶/SELECT ▼/EXECUTE
DISP.LAY CALIB.
TARGET DATA SAVE
DATA OUT REMOTE
```

2. Press **MODE** if necessary to select the MENU page containing the item to be set.
  - MENU mode consists of two display pages. Pressing **MODE** switches between the two pages.

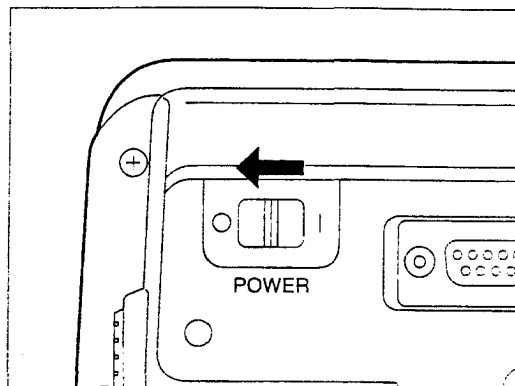
```
<MENU> 2/2
MODE/NEXT PAGE
▶/SELECT ▼/EXECUTE
OBS. TLL. AUTO AVG.
AUTO SEL. REFL. COR.
CLOCK, BUZ.
```

3. Press **▶** **AVG** repeatedly to move the cursor (highlighted block) to the item to be set.
4. Press **▼**. The CM-2002 will change to the mode corresponding to the item selected.
  - After setting the item as desired, press **BREAK/DELETE** to return to MENU mode.
  - To return to MEASURE mode, press **BREAK/DELETE** when MENU mode is displayed.

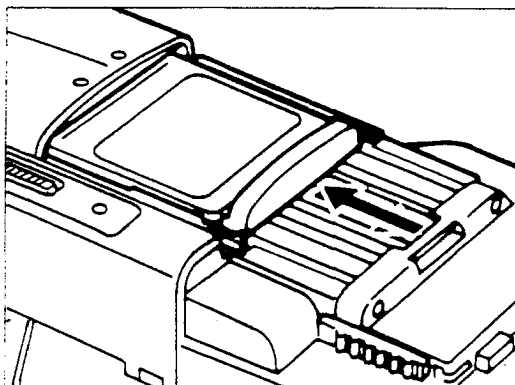
## Automatic Loading from Memory Card

If measurement conditions, target data, white calibration data, and data communication parameters are stored on the memory card using DATA SAVE (see p. 40), they will be automatically loaded from the memory card to the CM-2002's memory if the memory card is already installed when the POWER switch is set from ○ (off) to | (on).

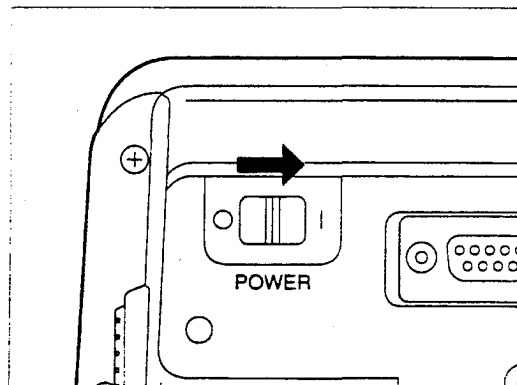
1. Check that the POWER switch is at ○ (off).



2. Install the memory card in the memory card chamber (see p. 26).



3. Set POWER switch to | (on). The measurement conditions, target data, white calibration data, and data communication parameters stored on the memory card will be automatically loaded into the CM-2002's memory.



- Installing the memory card after the POWER switch has already been set to | (on) will not cause any change in the settings stored in the CM-2002's memory.
- After the POWER switch has been set to | (on), do not open the memory card chamber cover until the CM-2002 has changed to CALIBRATION mode or REMOTE mode.

## Menu Items

### Page 1

- DISPLAY To enable or disable data displays for MEASURE mode, TARGET mode, or TOLERANCE mode. See p. 37.
- CALIB. To perform white calibration or zero calibration. See p. 30.
- TARGET To set target data and tolerance data. See p. 44.
- DATA SAVE To save measurement conditions, target data, etc. to memory card. See p. 40.
- DATA OUT To set communication parameters or to output all measurement data in memory via the RS-232C terminal. See p. 76.
- REMOTE To enter REMOTE mode. See p. 84.

### Page 2

- OBS.,ILL. To set observer and illuminant conditions. See p. 39.
- AUTO AVG. To set number of measurements to be automatically averaged. See p. 41.
- AUTO SEL. To set automatic target-color selection on or off. See p. 54.
- REFL.COR. To set reflectance correction factor. See p. 42.
- CLOCK,BUZ. To set clock/calendar and to set buzzer on or off. See p. 43.

## ENABLING/DISABLING DATA DISPLAYS

The type of data display for MEASURE mode, TARGET mode, and TOLERANCE mode can be selected in those modes by pressing **MODE**. To set the data displays which can be selected from, follow the steps below.

- In MENU mode, press **▷ AVG** repeatedly to move cursor (highlighted block) to "DISPLAY".
  - If "DISPLAY" is not shown in the displayed menu page, press **MODE** to change menu page.

```

<MENU>                                1/2
MODE/NEXT PAGE
▶/SELECT   ▼/EXECUTE

DISPLAY    CALIB.
TARGET     DATA SAVE
DATA OUT   REMOTE
  
```

- Press **▼**. The CM-2002 will change to the display-selection mode.

```

MODE/NEXT PAGE                                1/4
▶/SELECT   ▲/ ON-OFF

XYZ  -->>ABS  ▲
Yxy  --  ABS  ▲
L*a*b* --  ABS  ▲
  
```

- Press **MODE** if necessary to select the page containing the data display to be selected.
  - Display-selection mode consists of four display pages. Each time **MODE** is pressed, the CM-2002 will change to the next display page; if **MODE** is pressed when display page 4 is displayed, CM-2002 will return to display page 1.

```

MODE/NEXT PAGE                                2/4
▶/SELECT   ▲/ ON-OFF

L*C*Ha -->>ABS  ▲
Lab  --  ABS  ▲
L*u*v* --  ABS  ▲
  
```

- Press **▷ AVG** repeatedly to move cursor (">>") to the desired data display. "ABS" (absolute measured data) and/or "Δ" (difference between measured data and target data) can be selected for the color modes on display pages 1 and 2; if both are selected, both will be shown in the same display.

```

MODE/NEXT PAGE                                3/4
▶/SELECT   ▲/ ON-OFF

>>SPECTRAL   COLOR GR.
MUNSELL      MI
  
```

- Press **▲** to enable or disable the data display selected by the cursor (">>"). When the color mode is enabled, it will be highlighted and can be selected in MEASURE mode by using **MODE**; when the color mode is disabled, it will not be highlighted and cannot be selected in MEASURE mode.

```

MODE/NEXT PAGE                                4/4
▶/SELECT   ▲/ ON-OFF

>>WI(E313)  WI(CIE)
YI(E313)    YI(D1925)
CMC(2:1)    CMC(1:1)
FMC2
  
```

- Repeat steps 3 through 5 until all data displays have been enabled or disabled as desired.

- Press **BREAK/DELETE** or **MENU** to finish settings and return to MENU mode.

- If no data display is selected when step 7 is performed, a warning buzzer will sound, the message "NONE SELECTED" will be shown in the display, and MENU mode cannot be returned to.

## Data Displays

ABS	Absolute measured data
$\Delta$	Difference between measured data and target data
XYZ	XYZ tristimulus values (difference data also includes $\Delta E^*_{ab}$ )
Yxy	CIE 1931 Yxy color system (difference data also includes $\Delta E^*_{ab}$ )
L*a*b*	CIE 1976 L*a*b* color system (difference data also includes $\Delta E^*_{ab}$ )
L*C*H°	CIE 1976 L*C*H° color system (difference data shown as $\Delta L^*$ , $\Delta C^*$ , $\Delta H^*$ , and $\Delta E^*_{ab}$ )
Lab	Hunter Lab color system (difference data also includes $\Delta E_{ab}$ )
L*u*v*	CIE 1976 L*u*v* color system (difference data also includes $\Delta E^*_{uv}$ )
SPECTRAL	Graph of spectral reflectance
COLOR GR.	Graph of color-difference data in the L*a*b* color system
MUNSELL	Munsell color notation
MI	Metamerism index
WI(E313)	ASTM E 313 whiteness index
WI(CIE)	CIE whiteness index
YI(E313)	ASTM E 313 yellowness index
YI(D1925)	ASTM D 1925 yellowness index
CMC(2:1)	CMC color difference with $\ell=2$ and $c=1$
CMC(1:1)	CMC color difference with $\ell=1$ and $c=1$
FMC2	FMC-2 color difference

## SETTING OBSERVER AND ILLUMINANT CONDITIONS

The observer and illuminant conditions under which measurements will be taken can be selected by following the steps below.

1. In MENU mode, press  $\triangleright$  **AVG** repeatedly to move cursor (highlighted block) to "OBS.,ILL."
  - If "OBS.,ILL." is not shown in the displayed menu page, press **MODE** to change menu page.

```
<MENU> 2/2
MODE/NEXT PAGE
▶/SELECT ▼/EXECUTE
OBS.,ILL. AUTO AVG.
AUTO SEL. REFL. COR.
CLOCK, BUZ.
```

2. Press  $\blacktriangledown$ . The CM-2002 will change to OBS.,ILL. mode.

To set observer condition:

3. Press  $\triangleright$  **AVG** to move brackets ("[ ]") to "OBS."

```
<OBS., ILL.>
▶/[ ] ▲▼/CHANGE
[OBS.] ILL.
  [ ] [ ] D65 F7 F11
          C F2 F8 F12
10° D50 F6 F10
```

4. Press  $\blacktriangle$  or  $\blacktriangledown$  to move cursor (highlighted block) to the desired observer condition ("2°" or "10°").

To set illuminant condition:

3. Press  $\triangleright$  **AVG** to move brackets ("[ ]") to "ILL."
4. Press  $\blacktriangle$  or  $\blacktriangleleft$  repeatedly to move cursor (highlighted block) to the desired illuminant condition ("A", "C", "D50", "D65", "F2", "F6", "F7", "F8", "F10", "F11", or "F12").

```
<OBS./ILL.>
▶/[ ] ▲▼/CHANGE
OBS. [ILL.]
  [ ] [ ] D65 F7 F11
          C F2 F8 F12
10° D50 F6 F10
```

5. After observer and illuminant conditions have been set as desired, press **MENU** or **BREAK/DELETE** to finish settings and return to MENU mode.

## SAVING MEASUREMENT CONDITIONS, TARGET DATA, ETC. TO MEMORY CARD

After all measurement conditions, target data, and data communication parameters have been set as desired, they can be saved to a memory card. After this has been done, the CM-2002 will automatically be set to these settings if the memory card has been installed in the memory card chamber when the POWER switch is set from ○ (off) to | (on). To save the measurement conditions and target data, follow the steps below.

- Although they cannot be set manually, white calibration data will also be saved to the memory card when DATA SAVE is performed. This allows white calibration data to be copied to other memory cards.

1. Install memory card in memory card chamber (see p. 26).
2. Set all measurement conditions and target data as desired.
3. In MENU mode, press ▷ **AVG** repeatedly to move cursor (highlighted block) to "DATA SAVE".
  - If "DATA SAVE" is not shown in the displayed menu page, press **MODE** to change menu page.

```
<MENU> 1/2
MODE/NEXT PAGE
▶/SELECT ▼/EXECUTE
DISPLAY CALIB.
TARGET DATA SAVE
DATA OUT REMOTE
```

4. Press ▼. The CM-2002 will change to DATA SAVE mode and the message "Save measurement conditions and target data to memory card." will appear.

```
<DATA SAVE> ▼/EXECUTE
Save measurement con-
ditions and target
data to memory card.
```

5. Press ▼. All measurement conditions and target data will be saved to the memory card.
6. Press **MENU** or **BREAK/DELETE** to finish settings and return to MENU mode.



## SETTING NUMBER OF MEASUREMENTS FOR AUTOMATIC AVERAGING

When AUTO AVG. is set to a number other than one, pressing the measuring button once will cause the selected number of measurements to be taken (at approximately three-second intervals) and averaged. The average of the measurements will then be treated as one measurement by the CM-2002.

1. In MENU mode, press **▷** **AVG** repeatedly to move cursor (highlighted block) to "AUTO AVG."
  - If "AUTO AVG." is not shown in the displayed menu page, press **MODE** to change menu page.

```
<MENU> 2/2
MODE/NEXT PAGE
▶/SELECT ▼/EXECUTE
OBS., ILL. AUTO AVG.
AUTO SEL. REFL. COR.
CLOCK; BUZ.
```

2. Press **▼**. The CM-2002 will change to AUTO AVG. SET UP mode.

```
<AUTO AVG. SET UP>
▶/SELECT
1 3 5 8
```

3. Press **▷** **AVG** repeatedly to move the cursor (highlighted block) to the desired number of measurements (1, 3, 5, or 8).
4. Press **MENU** or **BREAK/DELETE** to finish setting number of measurements to be automatically averaged and return to MENU mode.

- When AUTO AVG. has been set to a number other than one, the selected number of measurements will be taken and averaged each time the measuring button is pressed in TARGET or MEASURE mode. While the CM-2002 is in the process of taking the series of measurements, "A \_ AVG:" followed by the number of completed measurements will be displayed. Do not move the CM-2002 until the entire series of measurements has been completed.
- When using batteries to power the CM-2002, the interval between measurements will become longer than three seconds as the battery power decreases.

## SETTING REFLECTANCE CORRECTION FACTOR

The reflectance correction factor is used to calculate data corresponding to SCE measurement data from SCI measurement data. When the reflectance correction factor is set to a value other than 0.0%, the factor is subtracted from the SCI measurement data at each wavelength interval. The reflectance correction factor can be set between 0.0 and 9.9%.

Although the CM-2002 can be set to take either SCI or SCE measurements, it is standard practice in certain industries to obtain data corresponding to SCE measurement data by taking SCI measurements and then subtracting a reflectance correction factor from the reflectance values at each wavelength interval. By setting the CM-2002's reflectance correction factor to the appropriate value, this process can be done automatically.

1. In MENU mode, press **▷** **AVG** repeatedly to move cursor (highlighted block) to "REFL.COR."
  - If "REFL. COR." is not shown in the displayed menu page, press **MODE** to change menu page.

```
<MENU> 2/2
MODE/NEXT PAGE
▷/SELECT ▼/EXECUTE

OBS., ILL. AUTO AVG.
AUTO SEL. REFL. COR.
CLOCK, BUZ.
```

2. Press **▼**. The CM-2002 will change to REFL. COR RECTION mode.

```
<REFL. CORRECTION>
▷/CURSOR ▲/CHARACTER

-4. 0%
SCI ONLY
```

3. Press **▲** repeatedly to set the desired value for the first digit. The value can be set between 0 and 9.
  4. Press **▷** **AVG** to move cursor (highlighted block) to the second digit.
  5. Press **▲** repeatedly to set the desired value for the second digit. The value can be set between 0 and 9.
  6. Press **MENU** or **BREAK/DELETE** to finish setting reflectance correction factor and return to MENU mode.
- If the reflectance correction factor is set to 0.0, no compensation calculations will be performed and the measured data will be SCI data.
  - When the reflectance correction factor has been set to a value other than 0.0, "SCI" will be highlighted in MEASURE mode or TARGET mode.
  - Measurement data are stored on the memory card as unadjusted SCI data, regardless of the setting of the reflectance correction factor.

## SETTING BUZZER AND CALENDAR/CLOCK

1. In MENU mode, press **▷ AVG** repeatedly to move cursor (highlighted block) to "CLOCK, BUZ."
  - If "CLOCK, BUZ." is not shown in the displayed menu page, press **MODE** to change menu page.

```
<MENU> 2/2
MODE/NEXT PAGE
▶/SELECT ▼/EXECUTE
OBS., ILL. AUTO AVG.
AUTO SEL. REFL. COR.
CLOCK, BUZ.
```

2. Press **▼**. The CM-2002 will change to CLOCK, BUZZER mode. Cursor (highlighted block) will be on buzzer setting ("OFF" or "ON").

### To set buzzer on or off:

- If cursor has been moved after entering CLOCK, BUZZER mode, press **▷ AVG** repeatedly to move cursor to present buzzer setting.
3. Press **▲** or **▼** to change buzzer setting between "ON" and "OFF".

```
<CLOCK, BUZZER>
▶/CURSOR ▲▼/ ON-OFF
2002/02/22 14:38:10
BUZZER ON
```

### To set calendar/clock:

3. Press **▷ AVG** repeatedly to move cursor to setting (year, month, day, hour, minute, or second) to be changed.
  - Clock will stop when cursor is moved to any of the calendar/clock settings.
4. Press **▲** or **▼** repeatedly to change the value of the setting.
5. Repeat steps 3 and 4 as necessary to set the correct date and time.
6. Press **▷ AVG** to move cursor to buzzer setting. Clock will start again.
7. After buzzer and calendar/clock have been set as desired, press **MENU** or **BREAK/DELETE** to finish settings and return to MENU mode.

```
<CLOCK, BUZZER>
▶/CURSOR ▲▼/ CHARACTER
2002/02/22 14:38:10
BUZZER ON
```

## TARGET COLOR DATA

### SETTING TARGET COLOR DATA

Before taking difference measurements, it is necessary to set a target color. The CM-2002 has memory space for 50 target colors. Target color data can be set by measurement according to the procedure below, or by inputting data from a separate computer (see p. 128). In addition, if target color data have been previously saved to the memory card which is already installed when the POWER switch is set from  $\circ$  (off) to  $|$  (on), the target color data will be automatically loaded from the memory card into the CM-2002's memory.

- Perform white calibration before setting target color data.
- Target color data should be set under the same conditions (temperature, etc.) under which calibration was performed and measurements will be taken.
- Once target color data have been set, they will be kept in memory for up to 6 months even if the POWER switch is set to  $\circ$  (off), the battery power becomes too low for operation, batteries are removed, or the AC adapter is disconnected.

1. In MENU mode, press  $\triangleright$  **AVG** repeatedly to move cursor (highlighted block) to "TARGET".
  - If "TARGET" is not shown in the displayed menu page, press **MODE** to change menu page.

```
<MENU> 1/2
MODE/NEXT PAGE
▶/SELECT ▼/EXECUTE

DISPLAY CALIB.
TARGET DATA SAVE
DATA OUT REMOTE
```

2. Press  $\blacktriangledown$ . The CM-2002 will change to TARGET mode.

3. Use  $\blacktriangle$  to select the desired target number. The target number will change by one each time  $\blacktriangle$  is pressed; if  $\blacktriangle$  is held pressed continuously, target number will change by one for the first five changes, then by five until  $\blacktriangle$  is released. Present target color data for the selected target number will be shown in the display.
  - If the present target color data is as desired, press **MENU** or **BREAK/DELETE** to return to MENU mode after selecting the target number.

```
<TARGET> ▼/OPTION
No.10 SCI 10°, D65
COMMENT:CM 2002

L* = 24.57
a* = 7.70
b* = -34.80
```

4. Press **MODE** repeatedly to select the desired data display.
  - The data display can be selected only from among the enabled data displays (see p. 37).
  - If CMC(2:1) or CMC(1:1) was enabled, target color data will be displayed in L\*C\*H°; if FMC2 was enabled, target color data will be displayed in XYZ; if COLOR GR. or MI was enabled, target color data will be displayed in L\*a\*b\*.
5. Place the measuring aperture flat against the surface of the target specimen.

6. Press the measuring button. A measurement will be taken and the measurement results will appear in the display.
  - Do not move the CM-2002 until measurement has been completed.
  - If "SCI" is highlighted in the display, the displayed target color data was recalculated using the presently set reflectance correction factor (see p. 42).
  - If AUTO AVG. is set to a value other than 1, the specified number of measurements will be automatically taken and averaged, and the average will be displayed and used as the target color data. In this case, do not move the CM-2002 until the entire series of measurements have been completed.
- To input a comment, set tolerance levels, or temporarily delete target data, press ▼ to enter TARGET OPTION mode (p. 47) after target color data has been set.
- To return to MENU mode, press **MENU** or **BREAK/DELETE**. The target color data for the target number selected when **MENU** or **BREAK/DELETE** was pressed will be used as the target color data when determining color difference (when AUTO SELECT is set to OFF).

## Setting Average of Measurements as Target Color Data

The average of a series of measurements can also be set as target color data. The series of measurements to be averaged can be taken automatically (according to the setting of AUTO AVG.) when the measuring button is pressed once, or each measurement in the series can be taken manually, pressing the measuring button to take each measurement.

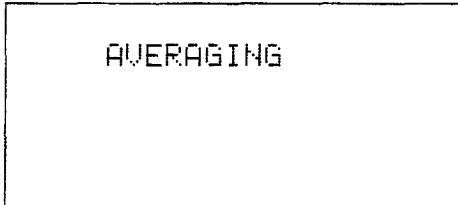
### AUTOMATICALLY TAKING A SERIES OF MEASUREMENTS FOR AVERAGING

A series of measurements of the same point on a specimen surface can be measured automatically and averaged to improve measurement accuracy. To do this, set AUTO AVG. to a value other than 1 (see p. 41), and follow the procedure on the previous page for setting target color data. The specified number of measurements will then be automatically taken at approximately three-second intervals when the measuring button is pressed once. While the series of measurements are being taken, "A\_AVG." followed by the number of measurements completed will appear in the display. After the series of measurements has been completed, the average of the series of measurements will be calculated and displayed, and stored as the target color data.

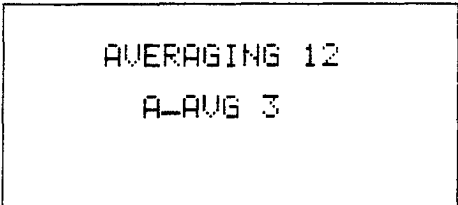
### MANUALLY TAKING A SERIES OF MEASUREMENTS FOR AVERAGING

If the color of a specimen varies slightly according to the point measured, a series of measurements of different points can be taken manually and averaged to improve measurement accuracy. To do this, follow the steps below.

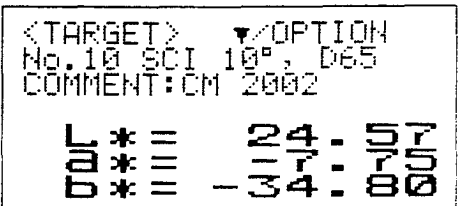
1. After entering TARGET mode and selecting the desired target number and data display, press  $\triangleright$  **AVG** to enter AVERAGING mode. "AVERAGING" will appear in the display.
  - AVERAGING mode cannot be entered if CM-2002 is in SPECTRAL, COLOR GR., or MI data display.
2. Place the measuring aperture flat against the surface of the target specimen.
3. Press the measuring button. A measurement will be taken and "AVERAGING" followed by the number of measurements taken so far will appear in the display. If AUTO AVG. is set to a value other than 1, "A\_AVG" will also be shown while measurements are taken.
  - Do not move the CM-2002 until the measurement has been completed.
  - If AUTO AVG. is set to a value other than 1, the specified number of measurements will be automatically taken and averaged, and the average of the automatic series will be displayed and used as the data for that measurement. In this case, do not move the CM-2002 until the entire series of measurements have been completed.
4. Repeat steps 2 and 3 until the desired number of measurements has been taken.
  - Up to 100 measurements (or series of measurements if AUTO AVG. is set to a value other than 1) can be taken manually for averaging.
5. After the desired number of measurements have been taken, press  $\triangleright$  **AVG**. The average of the measurements will be calculated and displayed, and stored as the target color data.
  - If "SCI" is highlighted in the display, the displayed target color data was recalculated using the presently set reflectance correction factor (see p. 42).



AVERAGING



AVERAGING 12  
A-AVG 3



<TARGET>     $\nabla$ /OPTION  
No.10 SCI 10°, D65  
COMMENT:CM 2002  
  
L\* = 24.57  
a\* = 17.70  
b\* = -34.80

## TARGET OPTIONS

Pressing ▼ in TARGET mode causes the CM-2002 to change to TARGET OPTION mode.

```
<TARGET OPTION> NO.50
▶/SELECT   ▼/EXECUTE

COMMENT    TOLERANCE
DELETE
```

**COMMENT** To input or change comment for presently selected target number  
**TOLERANCE** To set tolerance values for presently selected target number. Tolerance values can be set separately in each data display.  
**DELETE** To temporarily delete data for presently selected target number.

In TARGET OPTION mode, the following information can be set for each of the CM-2002's 50 target colors:

1. Comment (up to 8 characters)
2. Tolerance values:
  - $\Delta X$ ,  $\Delta Y$ ,  $\Delta Z$ ,  $\Delta E^*_{ab}$
  - $\Delta Y$ ,  $\Delta x$ ,  $\Delta y$ ,  $\Delta E^*_{ab}$
  - $\Delta L^*$ ,  $\Delta a^*$ ,  $\Delta b^*$ ,  $\Delta E^*_{ab}$
  - $\Delta L^*$ ,  $\Delta C^*$ ,  $\Delta H^*$ ,  $\Delta E^*_{ab}$
  - $\Delta L$ ,  $\Delta a$ ,  $\Delta b$ ,  $\Delta E$
  - $\Delta L^*$ ,  $\Delta u^*$ ,  $\Delta v^*$ ,  $\Delta E^*_{uv}$
  - $\Delta L^*$ ,  $\Delta C^*$ ,  $\Delta H^*$ , CMC(2:1)
  - $\Delta L^*$ ,  $\Delta C^*$ ,  $\Delta H^*$ , CMC(1:1)
  - $\Delta L$ ,  $\Delta RG$ ,  $\Delta YB$ , FMC-2
  - MI
  - $\Delta WI$  (ASTM E 313)
  - $\Delta WI$  (CIE)
  - $\Delta YI$  (ASTM E 313)
  - $\Delta YI$  (ASTM D 1925)
3. Whether or not target data is temporarily deleted

## Inputting Comment

1. In TARGET mode, press ▲ repeatedly to select the target number for which a comment will be input.
2. Press ▼. The CM-2002 will change to TARGET OPTION mode.
3. Press ▷ **AVG** repeatedly to move cursor (highlighted block) to "COMMENT".

```
<TARGET OPTION> NO. 50
▶/SELECT   ▼/EXECUTE
COMMENT    TOLERANCE
DELETE
```

4. Press ▼. The CM-2002 will change to TARGET COMMENT mode.
5. Press ▷ **AVG** repeatedly to move cursor to the desired position. The comment may be up to 8 characters long; if ▷ **AVG** is pressed when the cursor is at position 8 (the rightmost position), the cursor will return to position 1 (the leftmost position).
6. Press ▲ or ▼ repeatedly to select the desired character: "A" through "Z", " " (space), "0" through "9".  
When ▲ is pressed, character will change in the following order:  
...→"A"→"B"→...→"Z"→"0"→"1"→...→"9"→  
" " (space)→"A"→...  
When ▼ is pressed, character will change in the reverse order.  
If either key is held pressed, character will change more quickly.
7. Repeat steps 5 and 6 to set the desired characters for all positions.
8. Press **BREAK/DELETE** or **MENU** to finish setting comment. If **BREAK/DELETE** is pressed, the CM-2002 will return to TARGET OPTION mode; if **MENU** is pressed, the CM-2002 will return to MENU mode.

```
<TARGET COMMENT> NO. 50
▶/CURSOR ▲▼/CHARACTER
INPUT CHARACTER
[ CM 2002 ]
```



## Setting Tolerance Values

1. In TARGET mode, press ▲ repeatedly to select the target number for which tolerance values will be set.
2. Press ▼. The CM-2002 will change to TARGET OPTION mode.
3. Press ▷ **AVG** repeatedly to move cursor (highlighted block) to "TOLERANCE".

```

<TARGET OPTION> NO.50
▶/SELECT   ▼/EXECUTE

COMMENT    TOLERANCE
DELETE
    
```

4. Press ▼. The CM-2002 will change to TOLERANCE mode.
5. Press **MODE** repeatedly to select the data display for which tolerance values will be set.
  - Some tolerance values are common to several data displays. Refer to the tolerance value examples on the following pages for more information.
  - Tolerance values cannot be set for MUNSELL data display.

```

<TOLERANCE> NO.50
▶/CURSOR   ▲/CHARACTER

▲▲▲L*— — + 0000
▲▲▲D*— — + 0000
▲▲▲E*— — + 0000
    
```

6. Press ▷ **AVG** repeatedly to move cursor to the first digit of the tolerance value which will be set.
7. Press ▲ repeatedly to set the desired value for the selected digit.
 

The value changes in the following order:  
 ...→"0"→"1"→...→"9"→"\*"→"0"→...

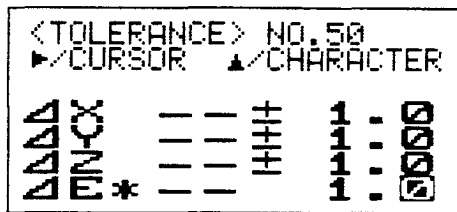
If ▲ is held pressed, the value will change more quickly.

  - If "\*" is set for any or all of the digits of a tolerance value, no tolerance value is set.
8. Repeat steps 5 through 7 to set all tolerance values as desired.
9. Press **BREAK/DELETE** or **MENU** to finish setting tolerance values. If **BREAK/DELETE** is pressed, the CM-2002 will return to TARGET OPTION mode; if **MENU** is pressed, the CM-2002 will return to MENU mode.

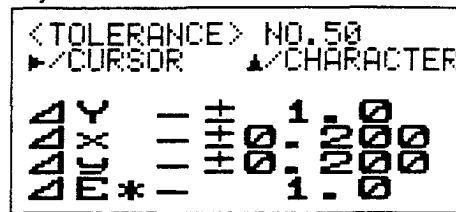
TOLERANCE VALUE EXAMPLES

1. XYZ, Yxy, L\*a\*b\*, and L\*C\*H° data displays:

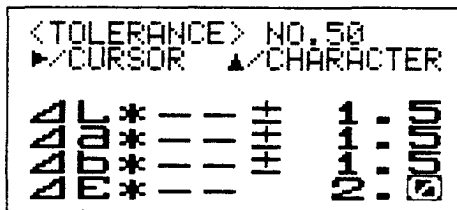
XYZ



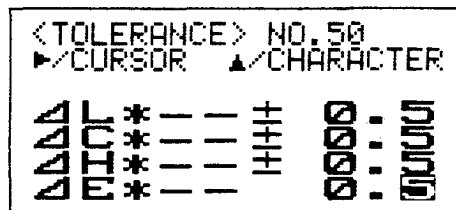
Yxy



L\*a\*b\*



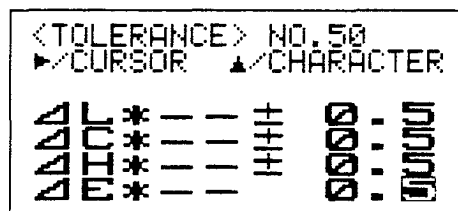
L\*C\*H°



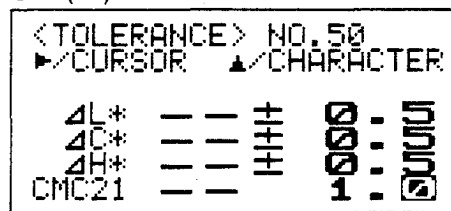
- $\Delta E^*_{ab}$  values can be set independently for each of these data displays.

2. L\*C\*H°, CMC(2:1), and CMC(1:1) data displays:

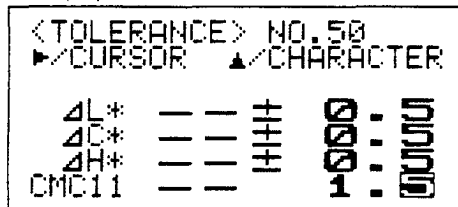
L\*C\*H°



CMC(2:1)



CMC(1:1)



- $\Delta L^*$ ,  $\Delta C^*$ , and  $\Delta H^*$  values are common to all three data displays;  $\Delta E^*_{ab}$ , CMC(2:1), and CMC(1:1) can be set independently.

3. SPECTRAL, COLOR GR., and L\*a\*b\* data displays:

For SPECTRAL and COLOR GR. data displays, tolerance values are set as  $\Delta L^*$ ,  $\Delta a^*$ ,  $\Delta b^*$ , and  $\Delta E^*_{ab}$  values.

SPECTRAL

```

<TOLERANCE> NO.50
  ▸/CURSOR  ▲/CHARACTER
                SPECTRAL
  ΔΔΔL* * - - - HHH  1 1. 00
  ΔΔΔa* * - - - HHH  1 1. 00
  ΔΔΔb* * - - - HHH  1 1. 00
  ΔΔΔE* * - - - HHH  1 1. 00
  
```

COLOR GR.

```

<TOLERANCE> NO.50
  ▸/CURSOR  ▲/CHARACTER
                COLOR GR.
  ΔΔΔL* * - - - HHH  1 1. 00
  ΔΔΔa* * - - - HHH  1 1. 00
  ΔΔΔb* * - - - HHH  1 1. 00
  ΔΔΔE* * - - - HHH  1 1. 00
  
```

L\*a\*b\*

```

<TOLERANCE> NO.50
  ▸/CURSOR  ▲/CHARACTER
                L*a*b*
  ΔΔΔL* * - - - HHH  1 1. 00
  ΔΔΔa* * - - - HHH  1 1. 00
  ΔΔΔb* * - - - HHH  1 1. 00
  ΔΔΔE* * - - - HHH  1 1. 00
  
```

- $\Delta L^*$ ,  $\Delta a^*$ ,  $\Delta b^*$ , and  $\Delta E^*_{ab}$  values are common to all three data displays.

4. MUNSELL data display

MUNSELL

```

<TOLERANCE> NO.50
                MUNSELL
  ——— CANNOT SET ———
  
```

- Tolerance values cannot be set for MUNSELL data display.

### Temporarily Deleting Target Data

1. In TARGET mode, press ▲ repeatedly to select the target number for which target color data will be temporarily deleted.
2. Press ▼. The CM-2002 will change to TARGET OPTION mode.
3. Press ▷ **AVG** repeatedly to move cursor (highlighted block) to "DELETE".

```
<TARGET OPTION> NO.50
▶/SELECT   ▼/EXECUTE
COMMENT    TOLERANCE
DELETE
```

4. Press ▼. The CM-2002 will change to TARGET DATA DELETE mode.
5. Press ▷ **AVG** to move cursor to  
"No.xx  
DELETE"  
(xx is the target number.)

```
<TARGET DATA DELETE>
▶/SELECT   ▼/EXECUTE
NO.50
DELETE     ESC
```

- If it is decided to not delete target color data, press ▷ **AVG** to move cursor to "ESC" and then press ▼. The CM-2002 will return to TARGET OPTION mode.
6. Press ▼. The target color data for the displayed target number will be temporarily deleted.  
"No.xx DELETED"  
will appear for a moment in the display, and then the CM-2002 will return to TARGET mode.  
"\_\_\_\_\_ DELETED \_\_\_\_\_"  
will be shown in place of target color data.
- If **MENU** or **BREAK/DELETE** is pressed while this display is shown,  
"NO TARG."  
will appear in the display for a moment and the CM-2002 will not return to MENU mode. To return to MENU mode, press ▲ to change to a different target number, then press **MENU** or **BREAK/DELETE**.
  - If **MENU** is pressed at any time before step 6 is performed, the CM-2002 will return to MENU mode.

### Recovering Temporarily Deleted Data

1. In TARGET mode, press ▲ repeatedly to select the target number for which target color data will be recovered.
2. Press ▼. The CM-2002 will change to TARGET DATA RECOVER mode.
3. Press ▷ **AVG** to move cursor to  
"No.xx  
RECOVER"  
(xx is the target number.)
  - If it is decided to not recover target color data, press ▷ **AVG** to move cursor to "ESC" and then press ▼. The CM-2002 will return to TARGET mode.
4. Press ▼. The target color data for the displayed target number will be recovered.  
"No.xx RECOVERED"  
will appear for a moment in the display, and then the CM-2002 will return to TARGET mode, with the recovered data shown in the display.
  - If **MENU** or **BREAK/DELETE** is pressed while the CM-2002 is in TARGET mode and target color data for the selected target number have been deleted (so that " \_\_\_\_\_ DELETED \_\_\_\_\_ " is shown instead of target color data),  
"NO TARG."  
will appear in the display for a moment and the CM-2002 will not return to MENU mode. To return to MENU mode, press ▲ to change to a different target number, then press **MENU** or **BREAK/DELETE**.
  - If **MENU** is pressed in TARGET DATA RECOVER mode before step 4 is performed,  
"NO TARG."  
will appear in the display for a moment and the CM-2002 will not return to MENU mode. To return to MENU mode, press ▲ to change to a different target number, then press **MENU** or **BREAK/DELETE**.



## TARGET COLOR AUTO SELECT FUNCTION

The target color auto select function automatically determines which of the 50 target colors stored in the CM-2002 is closest (in terms of  $\Delta E^*_{ab}$ ) to the measured data for the specimen. The target number of the selected target color is then shown in the measurement display. With this function, specimens can be easily sorted according to color, such as for grading fruits and vegetables.

- If target color data has been temporarily deleted, it will not be used by the target color auto select function.
- Color difference measurements with a single target color selected by the user can be taken by setting the target color auto select function off.

To set target color auto select function on or off:

1. In MENU mode, press  $\blacktriangleright$  **AVG** repeatedly to move cursor (highlighted block) to "AUTO SEL."
  - If "AUTO SEL." is not shown in the displayed menu page, press **MODE** to change menu page.

```
<MENU> 2/2
MODE/NEXT PAGE
▶/SELECT ▼/EXECUTE
OBS., ILL. AUTO AVG.
AUTO SEL. REFL. COR.
CLOCK, BUZ.
```

2. Press  $\blacktriangledown$ . The CM-2002 will change to TARGET AUTO SELECT mode.
3. Press  $\blacktriangle$  to switch setting of "AUTO SELECT" between "ON" and "OFF".

```
<TARGET AUTO SELECT>
▶/ ON-OFF
AUTO SELECT ON
```

4. Press **MENU** or **BREAK/DELETE** to finish setting and return to MENU mode.
  - When the target color auto select function is on, the "T" before the target color number in the measurement display will be highlighted.

## TAKING MEASUREMENTS

- White calibration should be performed before taking measurements.
- Measurements should be taken under the same conditions under which white calibration was performed and target color data were set.
- When measuring fluorescent materials, measurement accuracy may be lower.

1. Check that memory card has been installed. If it has not, install memory card according to the procedure on p. 26.

2. If CM-2002 is in any mode other than MENU mode, press **MENU** to return to MENU mode.

- If automatic target color selection will be used, set automatic target color selection function (AUTO SEL.) on according to the procedure on p. 54. If automatic target color selection will not be used, set automatic target color selection function (AUTO SEL.) off.

```

<MENU>                                1/2
MODE/NEXT PAGE
▶/SELECT   ▼/EXECUTE
DISPLAY   CALIB.
TARGET     DATA SAVE
DATA OUT   REMOTE
    
```

- If color difference measurements will be taken with a target color selected by the user, select the target color as follows:

a. In MENU mode, press **▷ AVG** repeatedly to move cursor (highlighted block) to TARGET.

- If "TARGET" is not shown in the displayed menu page, press **MODE** to change menu page.

```

<MENU>                                1/2
MODE/NEXT PAGE
▶/SELECT   ▼/EXECUTE
DISPLAY    CALIB.
TARGET   DATA SAVE
DATA OUT   REMOTE
    
```

b. Press **▼**. The CM-2002 will change to TARGET mode.

c. Press **▲** repeatedly to select desired target color. If **▲** is held down continuously, target number will change by 1 for the first five changes, and then by 5 until **▲** is released.

```

<TARGET>   ▼/OPTION
No.10 SCI 10°, D65
COMMENT:CM 2002

L* = 24.57
a* = 17.75
b* = -34.8
    
```

d. Press **MENU** or **BREAK/DELETE** to return to MENU mode.

```

<MENU>                                1/2
MODE/NEXT PAGE
▶/SELECT   ▼/EXECUTE
DISPLAY    CALIB.
TARGET   DATA SAVE
DATA OUT   REMOTE
    
```

3. Press **BREAK/DELETE**. The CM-2002 will change to MEASURE mode.

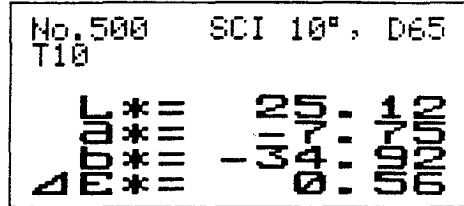
```

No. DATA SCI 10°, D65
T10

L* =
a* =
b* =
    
```

4. Select SCI or SCE measurements (see p. 17).

5. If measurements will be taken using the measuring button, set the measuring button selector to NORM.; if measurements will be taken using the accessory switch, attach the accessory switch (see p. 22) and set the measuring button selector to ACC.
6. Place the measuring aperture of the CM-2002 flat against the specimen to be measured.
7. After the CHARGE lamp becomes lit, press the measuring button. A measurement will be taken and the measurement results will appear in the display.



- Do not move the CM-2002 until the measurement is completed.
- If AUTO AVG. is set to a value other than 1, the specified number of measurements will be automatically taken and averaged, and the average will be displayed and used as the measurement data. In this case, do not move the CM-2002 until the entire series of measurements have been completed.
- The target number is indicated by "T" followed by the target number. If "T" is highlighted, the automatic target color selection function is on.
- The measuring method (SCI or SCE) will be indicated in the display. If "SCI" is highlighted, the reflectance correction factor has been set to a value other than 0.0.
- Data will be automatically stored in the memory card.
  - If the memory card's write-protect switch is set to the ON (protect) position, "CARD ERR" will appear in the display and data will not be stored to the memory card.
  - The memory card can hold up to 1000 sets of measurement data. If the card already has 1000 measurements stored on it, "CARDFULL" will appear in the display and the data for measurement number 1000 will be overwritten.
- Only the latest measurement is stored in the CM-2002's internal memory.
- Measured data can be viewed in other data displays by pressing **MODE**. Each time **MODE** is pressed, the display will change to the next enabled data display. If all data displays are enabled, the display will change in the following order:  
 ... → XYZ → Yxy → L\*a\*b\* → L\*C\*H° → Lab → L\*u\*v\* → SPECTRAL → COLOR GR. → MUNSELL → MI → WI(E313) → WI(CIE) → YI(E313) → YI(D1925) → CMC(2:1) → CMC(1:1) → FMC-2 → XYZ → ...
- Examples of measurement displays are shown on pages 59 through 65.

### Key Functions

- |                     |   |
|---------------------|---|
| <b>MODE</b>         | Changes data display to next enabled data display.  |
| <b>MENU</b>         | Changes to MENU mode  |
| <b>▷ AVG</b>        | <ul style="list-style-type: none"> <li>• In any color mode data display, starts/finishes manual measurement series for averaging.</li> <li>• In SPECTRAL data display, moves cursor in 10nm steps.</li> <li>• In COLOR GR. data display, changes scale of <math>\Delta L^*</math> graph.</li> <li>• In MI data display, changes reference illuminant.</li> </ul>                                |
| <b>▼</b>            | <ul style="list-style-type: none"> <li>• In any color mode data display, changes to lower specimen number.</li> <li>• In SPECTRAL data display, changes graph scale in decreasing order.</li> <li>• In COLOR GR. data display, changes scale of <math>\Delta a^*</math>, <math>\Delta b^*</math> graph in decreasing order.</li> <li>• In MI data display, changes test illuminant.</li> </ul>  |
| <b>▲</b>            | <ul style="list-style-type: none"> <li>• In any color mode data display, changes to higher specimen number.</li> <li>• In SPECTRAL data display, changes graph scale in increasing order.</li> <li>• In COLOR GR. data display, changes scale of <math>\Delta a^*</math>, <math>\Delta b^*</math> graph in increasing order.</li> <li>• In MI data display, changes test illuminant.</li> </ul> |
| <b>BREAK/DELETE</b> | Changes to SAMPLE DATA DELETE mode.   |



## Averaging Measurements

The average of a series of measurements can also be calculated and stored as a single measurement. The series of measurements to be averaged can be taken automatically (according to the setting of AUTO AVG.) when the measuring button is pressed once, or each measurement in the series can be taken manually, pressing the measuring button to take each measurement.

### AUTOMATICALLY TAKING A SERIES OF MEASUREMENTS FOR AVERAGING

A series of measurements of the same point on a specimen surface can be measured automatically and averaged to improve measurement accuracy. To do this, set AUTO AVG. to a value other than 1 (see p. ), and follow the procedure on the previous page for setting target color data. The specified number of measurements will then be automatically taken at approximately three-second intervals when the measuring button is pressed once. While the series of measurements are being taken, "A\_AVG." followed by the number of measurements completed will appear in the display. After the series of measurements has been completed, the average of the series of measurements will be calculated and displayed, and stored as the measurement data.

### MANUALLY TAKING A SERIES OF MEASUREMENTS FOR AVERAGING

If the color of a specimen varies slightly according to the point measured, a series of measurements of different points can be taken manually and averaged to improve measurement accuracy. To do this, follow the steps below.

1. In MEASURE mode, press  $\triangleright$  **AVG** to enter AVERAGING mode. "AVERAGING" will appear in the display.
  - AVERAGING mode cannot be entered if CM-2002 is in SPECTRAL, COLOR GR., or MI data display.
2. Place the measuring aperture flat against the surface of the target specimen.
3. Press the measuring button. A measurement will taken and "AVERAGING" followed by the number of measurements taken so far will appear in the display. If AUTO AVG. is set to a value other than 1, "A\_AVG." will also be shown while measurements are taken.
  - Do not move the CM-2002 until measurement has been completed.
  - If AUTO AVG. is set to a value other than 1, the specified number of measurements will be automatically taken and averaged, and the average of the automatic series will be displayed and used as the data for that measurement. In this case, do not move the CM-2002 until the entire series of measurements have been completed.
4. Repeat steps 2 and 3 until the desired number of measurements has been taken.
  - Up to 100 measurements (or series of measurements if AUTO AVG. is set to a value other than 1) can be taken manually for averaging.
5. After the desired number of measurements have been taken, press  $\triangleright$  **AVG**. The average of the measurements will be calculated; this average will be displayed as the measurement data and will be stored in the memory card.
  - If "SCI" is highlighted in the display, the displayed measurement data was recalculated using the presently set reflectance correction factor (see p. 42).

AVERAGING

AVERAGING 12  
A-AVG 3

No. 500	SCI 10°, D65
T10	
L*	39.12
a*	13.24
b*	11.13
Y	24.26
X	0.0000
Z	0.0000

## Tolerance Checking

If a tolerance value has been set for the presently displayed data display, the CM-2002 will check to see whether or not the measurement is within the tolerance limits. If the measurement is within the tolerance limits, "PASS" will be displayed; if the measurement is not within the tolerance limits, "FAIL" will be displayed, the  $\Delta$  data corresponding to the exceeded tolerance will be highlighted, and the buzzer will sound (if BUZZER is set to ON). If no tolerance values are set for the presently selected data display, tolerance will not be checked and neither "PASS" nor "FAIL" will be displayed.

- Tolerance is checked only in the presently selected data display, even if tolerance values have been set for other enabled data displays. To check whether or not the measurement is within tolerance in other data displays, press **MODE** to change to the desired data display.

**Display Examples**

XYZ

Target number (if "T" is highlighted, automatic target color selection is set to on)  
 SCI or SCE measurement (if "SCI" is highlighted, the reflectance  
 correction factor is set to a value other than 0.0)

	Specimen number	Observer	Illuminant	
ONLY ABS. ENABLED	No. 500 T10	SCI 10°, D65		X = 3.69 Y = 4.45 Z = 15.89 $\Delta E^*_{ab} = 0.56$
ONLY $\Delta$ ENABLED	No. 500 T10	SCI 10°, D65		$\Delta X = 0.15$ $\Delta Y = 0.17$ $\Delta Z = 0.48$ $\Delta E^*_{ab} = 0.56$
BOTH ABS. AND $\Delta$ EN- ABLED	No. 500 T10 SCI 10°, D65			

Yxy

ONLY SBS. ENABLED	No. 500 T10	SCI 10°, D65		Y = 4.45 X = 0.1536 y = 0.1853 $\Delta E^*_{ab} = 0.56$
ONLY $\Delta$ ENABLED	No. 500 T10	SCI 10°, D65		$\Delta Y = 0.17$ $\Delta x = 0.0012$ $\Delta y = 0.0012$ $\Delta E^*_{ab} = 0.56$
BOTH ABS. AND $\Delta$ EN- ABLED	No. 500 T10 SCI 10°, D65			

L\*a\*b\*

ONLY ABS.  
ENABLED

No. 500	SCI 10°, D65
T10	
$L^*$	25.12
$a^*$	-7.75
$b^*$	-34.92
$\Delta E^*_{ab}$	0.56

$L^* = 25.12$   
 $a^* = -7.75$   
 $b^* = -34.92$   
 $\Delta E^*_{ab} = 0.56$

ONLY  $\Delta$   
ENABLED

No. 500	SCI 10°, D65
T10	
$\Delta L^*$	0.55
$\Delta a^*$	0.00
$\Delta b^*$	-0.12
$\Delta E^*_{ab}$	0.56

$\Delta L^* = 0.55$   
 $\Delta a^* = 0.00$   
 $\Delta b^* = -0.12$   
 $\Delta E^*_{ab} = 0.56$

BOTH ABS.  
AND  $\Delta$  EN-  
ABLED

No. 500	$L^* = 25.12$
T10 SCI	$a^* = -7.75$
10°, D65	$b^* = -34.92$
	$\Delta L^* = 0.55$
	$\Delta a^* = 0.00$
	$\Delta b^* = -0.12$
	$\Delta E^*_{ab} = 0.56$

L\*C\*H°

ONLY ABS.  
ENABLED

No. 500	SCI 10°, D65
T10	
$L^*$	25.12 (Metric lightness)
$C^*$	35.77 (Metric chroma)
$H^\circ$	257.49 (Metric hue angle)
$\Delta E^*_{ab}$	0.56

$L^* = 25.12$  (Metric lightness)  
 $C^* = 35.77$  (Metric chroma)  
 $H^\circ = 257.49$  (Metric hue angle)  
 $\Delta E^*_{ab} = 0.56$

ONLY  $\Delta$   
ENABLED

No. 500	SCI 10°, D65
T10	
$\Delta L^*$	0.55
$\Delta C^*$	0.12
$\Delta H^\circ$	0.00
$\Delta E^*_{ab}$	0.56

$\Delta L^* = 0.55$   
 $\Delta C^* = 0.12$   
 $\Delta H^\circ = 0.00$   
 $\Delta E^*_{ab} = 0.56$

BOTH ABS.  
AND  $\Delta$  EN-  
ABLED

No. 500	$L^* = 25.12$
T10 SCI	$C^* = 35.77$
10°, D65	$H^\circ = 257.49$
	$\Delta L^* = 0.55$
	$\Delta C^* = 0.12$
	$\Delta H^\circ = 0.00$
	$\Delta E^*_{ab} = 0.56$

Lab

ONLY ABS.  
ENABLED

No. 500	SCI 10°, D65
T10	
$L$	21.10
$a$	-4.56
$b$	-32.75
$\Delta E$	0.46

$L = 21.10$   
 $a = -4.56$   
 $b = -32.75$   
 $\Delta E = 0.46$

ONLY  $\Delta$   
ENABLED

No. 500	SCI 10°, D65
T10	
$\Delta L$	0.42
$\Delta a$	-0.04
$\Delta b$	-0.20
$\Delta E$	0.46

$\Delta L = 0.42$   
 $\Delta a = -0.04$   
 $\Delta b = -0.20$   
 $\Delta E = 0.46$

BOTH ABS.  
AND  $\Delta$  EN-  
ABLED

No. 500	L = 21.10
T10	SCI
10°, D65	
$\Delta L$	-0.14
$\Delta a$	-0.04
$\Delta b$	-0.20
$\Delta E$	0.46

L\*u\*v\*

ONLY ABS.  
ENABLED

No. 500	SCI 10°, D65
T10	
L*	25.12
u*	-23.78
v*	-42.56
$\Delta E^*_{uv}$	0.80

$L^* = 25.12$   
 $u^* = -23.78$   
 $v^* = -42.56$   
 $\Delta E^*_{uv} = 0.80$

ONLY  $\Delta$   
ENABLED

No. 500	SCI 10°, D65
T10	
$\Delta L^*$	0.55
$\Delta u^*$	-0.29
$\Delta v^*$	-0.50
$\Delta E^*_{uv}$	0.80

$\Delta L^* = 0.55$   
 $\Delta u^* = -0.29$   
 $\Delta v^* = -0.50$   
 $\Delta E^*_{uv} = 0.80$

BOTH ABS.  
AND  $\Delta$  EN-  
ABLED

No. 500	L* = 25.12
T10	SCI
10°, D65	
$\Delta L^*$	0.55
$\Delta u^*$	-0.29
$\Delta v^*$	-0.50
$\Delta E^*$	0.80

MUNSELL

No. 500	SCI 2°, C
T10	
HUE	3.3R
VALUE	2.2
CHROMA	8.8

Hue = 3.3R  
 Value = 2.2  
 Chroma = 8.8

WI(E313)

No. 501	SCI 2°, C
T10	
(ASTM E 313)	
WI	86.28
$\Delta WI$	-0.49

WI = 86.28 (Whiteness index of specimen)  
 $\Delta WI = -0.49$  (Difference between whiteness indices of specimen and target)

WI(CIE)

```

No.502   SCI 10°, D65
T10

(CIE)
WI = 80.86
ΔWI = -0.33

```

WI = 80.86 (Whiteness index of specimen)  
 $\Delta WI = -0.33$  (Difference between whiteness indices of specimen and target)

- If the color of the specimen exceeds the range of the standard (p. 159), '---' will be displayed in place of a measured value.

YI(E313)

```

No.501   SCI 2°, C
T10

(ASTM E 313)
YI = -9.18
ΔYI = 0.27

```

YI = -9.18 (Yellowness index of specimen)  
 $\Delta YI = 0.27$  (Difference between yellowness indices of specimen and target)

- If the color of the specimen exceeds the range of the standard (p. 160), '---' will be displayed in place of a measured value.

YI(D1925)

```

No.501   SCI 2°, C
T10

(ASTM D 1925)
YI = -9.50
ΔYI = 0.27

```

YI = -9.50 (Yellowness index of specimen)  
 $\Delta YI = 0.27$  (Difference between yellowness indices of specimen and target)

- If the color of the specimen exceeds the range of the standard (p. 161), '---' will be displayed in place of a measured value.

CMC(2:1)

```

No.500   SCI 10°, D65
T10

ΔL* = 0.55
ΔC* = 0.12
ΔH* = 0.00
CMC21 = 0.40

```

$\Delta L^* = 0.55$   
 $\Delta C^* = 0.12$   
 $\Delta H^* = 0.00$   
 CMC21 = 0.40 [Color difference calculated according to CMC(2:1) formula]

CMC(1:1)

```

No.500   SCI 10°, D65
T10

ΔL* = 0.55
ΔC* = 0.12
ΔH* = 0.00
CMC11 = 0.79

```

$\Delta L^* = 0.55$   
 $\Delta C^* = 0.12$   
 $\Delta H^* = 0.00$   
 CMC11 = 0.79 [Color difference calculated according to CMC(1:1) formula]

FMC-2

```

No.500   SCI 10°, D65
T10

ΔL = 0.92
ΔRG = 0.93
ΔYB = 0.35
FMC2 = 1.35

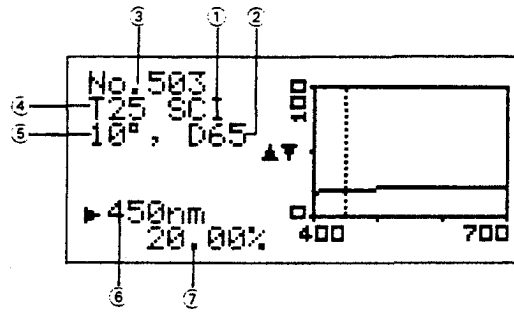
```

$\Delta L = 0.92$  (Lightness difference)  
 $\Delta RG = 0.93$  ( $\Delta C_{r-g}$ ; difference in red-green direction)  
 $\Delta YB = 0.35$  ( $\Delta C_{y-b}$ ; difference in yellow-blue direction)  
 FMC-2 = 1.35 (Total color difference calculated according to FMC-2 formula)

- If the color of the specimen exceeds the range of the standard (p. 163), '---' will be displayed in place of a measured value.

## SPECTRAL

In SPECTRAL data display, the measured spectral reflectance of the specimen is displayed on a graph. In addition, the spectral reflectance at the cursor position is shown.

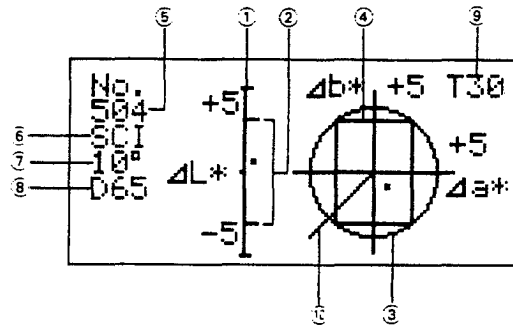


- ① SCI or SCE measurement (if "SCI" is highlighted, the reflectance correction factor is set to a value other than 0.0)
- ② Illuminant
- ③ Specimen number
- ④ Target number (if "T" is highlighted, automatic target color selection is set to on)
- ⑤ Observer
- ⑥ Cursor position (wavelength)
- ⑦ Reflectance at cursor position

- The scale of the graph can be changed by pressing ▲ or ▼. Six different graph scales can be set: 2%, 10%, 20%, 50%, 100%, and 200% (full-scale reflectance). Pressing ▲ causes the graph scale to change in increasing order; if ▲ is pressed when graph scale is 200%, graph scale will change to 2%. Pressing ▼ causes the graph scale to change in decreasing order; if ▼ is pressed when graph scale is 2%, graph scale will change to 200%.
- The cursor position can be changed in 10nm increments by pressing > AVG; if > AVG is held pressed continuously, cursor position will change more quickly. If > AVG is pressed when cursor is at 700nm, cursor will move to 400nm. The reflectance at the cursor position is also displayed.

## COLOR GR.

In COLOR GR. data display, measured data are plotted on a  $\Delta L^*$  bar graph and on a  $\Delta a^*$ ,  $\Delta b^*$  graph. The center points of both graphs are the positions corresponding to the target color data. The tolerance values are also indicated on the graphs.



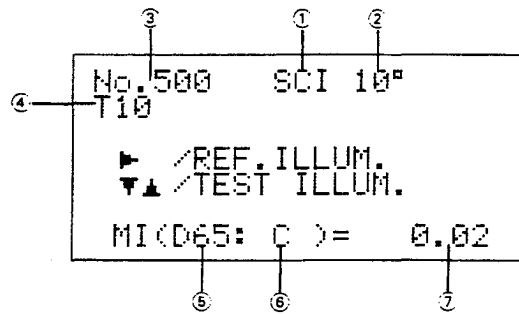
- ①  $\Delta L^*$  graph
- ②  $\Delta L^*$  tolerance values
- ③  $\Delta a^*$ ,  $\Delta b^*$  graph
- ④  $\Delta a^*$ ,  $\Delta b^*$  tolerance values
- ⑤ Specimen number
- ⑥ SCI or SCE measurement (if "SCI" is highlighted, the reflectance correction factor is set to a value other than 0.0)
- ⑦ Observer
- ⑧ Illuminant
- ⑨ Target number (if "T" is highlighted, automatic target color selection is set to on)
- ⑩ Direction of origin of  $a^*$ ,  $b^*$  color plane

- The scale of the  $\Delta L^*$  graph can be changed by pressing  $\triangleright$  **AVG**. Three different graph scales can be set:  $\pm 1$ ,  $\pm 3$ , and  $\pm 5$  (full scale). If  $\triangleright$  **AVG** is pressed when graph scale is  $\pm 5$ , graph scale will change to  $\pm 1$ .
- The scale of the  $\Delta a^*$ ,  $\Delta b^*$  graph can be changed by pressing  $\blacktriangle$  or  $\blacktriangledown$ . Three different graph scales can be set:  $\pm 1$ ,  $\pm 3$ , and  $\pm 5$  (full scale).  $\blacktriangle$  changes the graph scale in increasing order; if  $\blacktriangle$  is pressed when graph scale is  $\pm 5$ , graph scale will change to  $\pm 1$ .  $\blacktriangledown$  changes the graph scale in decreasing order; if  $\blacktriangledown$  is pressed when graph scale is  $\pm 1$ , graph scale will change to  $\pm 5$ .
- If measured data exceeds the display range of either the  $\Delta L^*$  graph or the  $\Delta a^*$ ,  $\Delta b^*$  graph, "\*" will appear at the center of the corresponding graph.
- If there is no data, graph scale is not shown and cannot be changed.



## MI

The CM-2002 can determine the metamerism index (MI) based on any reference illuminant and test illuminant selected from among the 11 illuminants available on the CM-2002.



- ① SCI or SCE measurement (if "SCI" is highlighted, the reflectance correction factor is set to a value other than 0.0)
- ② Observer
- ③ Specimen number
- ④ Target number (if "T" is highlighted, automatic target color selection is set on)
- ⑤ Reference illuminant
- ⑥ Test illuminant
- ⑦ Metamerism index

- The reference illuminant can be changed by pressing **▷ AVG**. Illuminant changes in the following order:  
...→A→C→D50→...→F11→F12→A→...
- The test illuminant can be changed by pressing **▲** or **▼**. Pressing **▲** causes the illuminant to change in the following order:  
...→A→C→D50→...→F11→F12→A→...  
Pressing **▼** causes the illuminant to change in the opposite order.

## Measurement Data Storage

Two types of memory are available for storing measurement data when using the CM-2002: the CM-2002's internal memory and a memory card. The internal memory of the CM-2002 can store data for one measurement (the latest measurement since the CM-2002 was switched on); data in the internal memory are erased when the CM-2002's power is switched off. The memory card can store data for 1000 measurements, and is equipped with a battery to maintain data even when the memory card is removed from the CM-2002. The two types of memory are separate: measurement data are stored in both at the time of measurement, but recalling data for a previous specimen from the memory card does not change the internal memory of the CM-2002. Thus, if data for a previous specimen is recalled from the memory card to the display and then the memory card is removed, the displayed data will change to the measurement data in the internal memory (the data for the latest measurement). Also, if a different memory card is installed after the power has been switched on, the measurement data for the highest specimen number for which there is data will be recalled and displayed. If the newly installed memory card contains no measurement data, the displayed data will be the measurement data in the internal memory (the data for the latest measurement); if no measurement has been taken since power was switched on, "NO DATA" will appear in the display.

- No specimen number will be shown if the displayed data is the data in the CM-2002's internal memory and no memory card is installed.
- For more information on memory cards, see p. 24.

## MEMORY EXAMPLES

Operation	Measurement data in memory card	CM-2002's internal memory	Display
		Empty	
Set POWER switch from O (off) to   (on)	1 Empty		
	2 Empty		
	3 Empty		
	4 Empty		
	5 Empty		
	6 Empty		
	1000 Empty		
Take measurement (first)	1 Specimen data #1	Measured specimen data #1	Specimen data #1
	2 Empty		
	3 Empty		
	4 Empty		
	5 Empty		
	6 Empty		
	1000 Empty		
Take measurement (second)	1 Specimen data #1	Measured specimen data #2	Specimen data #2
	2 Specimen data #2		
	3 Empty		
	4 Empty		
	5 Empty		
	6 Empty		

Take measurement  
(third)

1000	Empty
1	Specimen data #1
2	Specimen data #2
3	Specimen data #3
4	Empty
5	Empty
6	Empty
.	.
.	.
.	.
1000	Empty

Measured specimen  
data #3

Specimen data #3

1. Remove memory card

Insert other  
memory card  
a. Memory card  
contains data

1	Specimen data #1'
2	Specimen data #2'
3	Specimen data #3'
4	Specimen data #4'
5	Specimen data #5'
6	Empty
.	.
.	.
.	.
1000	Empty

Measured specimen  
data #3

Specimen data #3  
(no specimen number  
displayed)

Take measurement

1	Specimen data #1'
2	Specimen data #2'
3	Specimen data #3'
4	Specimen data #4'
5	Specimen data #5'
6	Specimen data #6'
7	Empty
.	.
.	.
.	.
1000	Empty

Measured specimen  
data #6'

Specimen data #6'

b. Memory card contains no data

1 Empty  
2 Empty  
3 Empty  
4 Empty  
5 Empty  
6 Empty

1000 Empty

Measured specimen data # 3

Specimen data #3  
(no specimen number displayed)

Take measurement

1 Specimen data #1  
2 Empty  
3 Empty  
4 Empty  
5 Empty  
6 Empty

1000 Empty

Measured specimen data #1''

Specimen data #1''

2. After three measurements have been taken, recall specimen data #2.

1 Specimen data #1  
2 Specimen data #2  
3 Specimen data #3  
4 Empty  
5 Empty  
6 Empty

1000 Empty

Measured specimen data #3

Specimen data #2

Remove memory card.

Measured specimen data #3

Specimen data #3  
(no specimen number displayed)

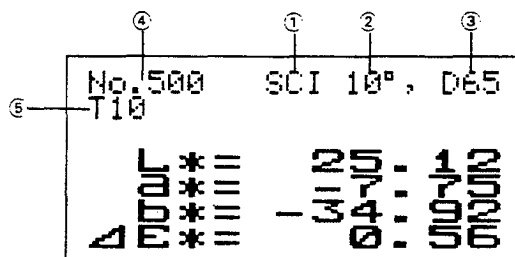
3. No measurements taken after power was switched on and memory card contains no measurement data

	1	Empty	Empty	
	2	Empty		
	3	Empty		
	4	Empty		
	5	Empty		
	6	Empty		
		.		
		.		
	1000	Empty		
Change memory card to one containing measurement data	1	Specimen data #1	Empty	Specimen data #2
	2	Specimen data #2		
	3	Empty		
	4	Empty		
	5	Empty		
	6	Empty		
			.	
		.		
	1000	Empty		
Remove memory card			Empty	

## MEASUREMENT DATA RECALL

If a memory card containing measurement data is installed, the CM-2002 will display the latest measurement data when the display is first changed to MEASURE mode after the POWER switch is set from O (off) to I (on). When data display is any color mode, previous measured data can be recalled in MEASURE mode at any time using ▲ or ▼. ▲ changes the specimen number in increasing order; ▼ changes the specimen number in decreasing order. Specimen number is changed by 1 each time either key is pressed; holding either key pressed continuously changes specimen number by 1, then by 10, then by 50, then by 100.

- Previously measured data cannot be recalled if data display is SPECTRAL, COLOR GR., or MI.



- Measurement method (SCI or SCE) selected at time of measurement
  - Indicated method (SCI or SCE) may not be the same as presently set method.
  - If "SCI" is highlighted, the reflectance correction factor is set to a value other than 0.0. In this case, displayed data is data recalculated using the presently set reflectance correction factor, which may not be the same as the reflectance correction factor set at the time of measurement.
- Presently set observer
- Presently set illuminant
  - Presently displayed data are calculated based on the presently set observer and illuminant, which may not be the same as the observer and illuminant set at the time of measurement.
- Specimen number of presently displayed data
  - Data for other specimen numbers can be recalled by pressing ▲ or ▼; pressing ▲ causes specimen number to change in increasing order, pressing ▼ causes specimen number to change in decreasing order.
- Presently selected target number
  - Presently displayed difference data are calculated based on the target color data for the presently selected target number, which may not be the same as the target color data or target number selected at the time of measurement.
  - If "T" is highlighted, the automatic target color selection function is presently set to on.

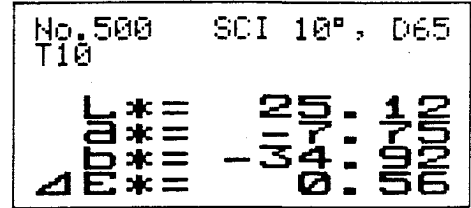
## DELETING MEASUREMENT DATA

Measurement data for a single specimen number or all measurement data stored on a memory card can be deleted if desired by following the steps below.

- Deleted measurement data cannot be recovered.

### Deleting Measurement Data for a Single Specimen Number

- In MEASURE mode, press **▲** or **▼** repeatedly to select the specimen number for which data will be deleted.



- Press **BREAK/DELETE**. The CM-2002 will change to SAMPLE DATA DELETE mode.



- Press **▶ AVG** to move cursor (highlighted block) to "No. xxxx DATA DELETE"

(xxxx is the specimen number.)

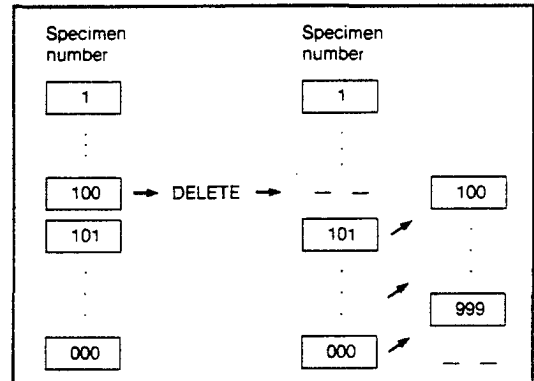
- To return to MEASURE mode without deleting data, press **▶ AVG** to move cursor to "ESC" and then press **▼**.

- Press **▼**. Data for the selected specimen number will be deleted from the memory card.

"No. xxxx DATA DELETED"

will appear in the display for a few seconds and then the CM-2002 will automatically return to MEASURE mode. The remaining measurement data on the memory card will be rearranged to fill the space left by the deleted data, with all specimen numbers higher than that of the deleted data being reduced by one as the data is moved. (See diagram at right.)

- If the write-protect switch of the memory card is at the ON (protected) position when step 4 is performed, "CARD ERR" will appear in the display and data will not be deleted.



## Deleting All Measurement Data on the Memory Card

1. In MEASURE mode, press **BREAK/DELETE**. The CM-2002 will change to SAMPLE DATA DELETE mode.
2. Press  $\triangleright$  **AVG** to move cursor (highlighted block) to "ALL DATA DELETE"
  - To return to MEASURE mode without deleting data, press  $\triangleright$  **AVG** to move cursor to "ESC" and then press  $\blacktriangledown$ .
3. Press  $\blacktriangledown$ . A confirmation display will appear, as shown at right. To delete all data from the memory card, press  $\triangleright$  **AVG** to move the cursor to "YES".
  - If it is decided to not delete all data from the memory card, press  $\triangleright$  **AVG** to move cursor to "NO" and then press  $\blacktriangledown$ . The CM-2002 will return to SAMPLE DATA DELETE mode.
4. Press  $\blacktriangledown$ . All measurement data will be deleted from the memory card and "ALL DATA DELETED" will appear in the display for a few seconds. The CM-2002 will then automatically return to MEASURE mode.
  - If the write-protect switch of the memory card is at the ON (protected) position when step 4 is performed, "CARD ERR" will appear in the display and data will not be deleted.

```
<SAMPLE DATA DELETE>
▶/SELECT   ▼/EXECUTE
NO.500
DATA
DELETE | ALL DATA DELETE | ESC
```

```
▶/SELECT   ▼/EXECUTE
ALL DATA DELETE OK?
YES      NO
```



## DATA COMMUNICATION

The CM-2002 is equipped with an RS-232C terminal for connection to a separate computer or printer. Once connected, data can be output to the computer or printer; in addition, commands and/or messages can be input to the CM-2002 from the computer.

### CONNECTIONS

- When connecting the CM-2002 to a computer or printer, be sure the power of both the CM-2002 and the computer or printer are switched off.
- Check that the connector and the terminal are correctly positioned in relation to each other before connecting. They can be connected in only one position.
- After connecting, tighten the screws of the connector to securely fasten the connecting cable to both the CM-2002 and the computer or printer to prevent the cable from being accidentally disconnected.
- Do not touch the pins of the connecting cable or the CM-2002's RS-232C connector.
- Do not apply excessive force to the pins of the connecting cable or the CM-2002's RS-232C connector.
- Be sure that the length of the connecting cable is sufficient to connect the CM-2002 to the computer or printer. If the cord is short and there is strain on the cable, the connection may not be good or an internal wire may break, resulting in data errors.
- When disconnecting the cable, be sure that the power of both the CM-2002 and the computer or printer are switched off, loosen the connector screws completely, and pull on the plug of the cable to disconnect the cord.
- Never pull on the cable itself; also, do not apply excessive force to the cable or bend the cable too sharply.

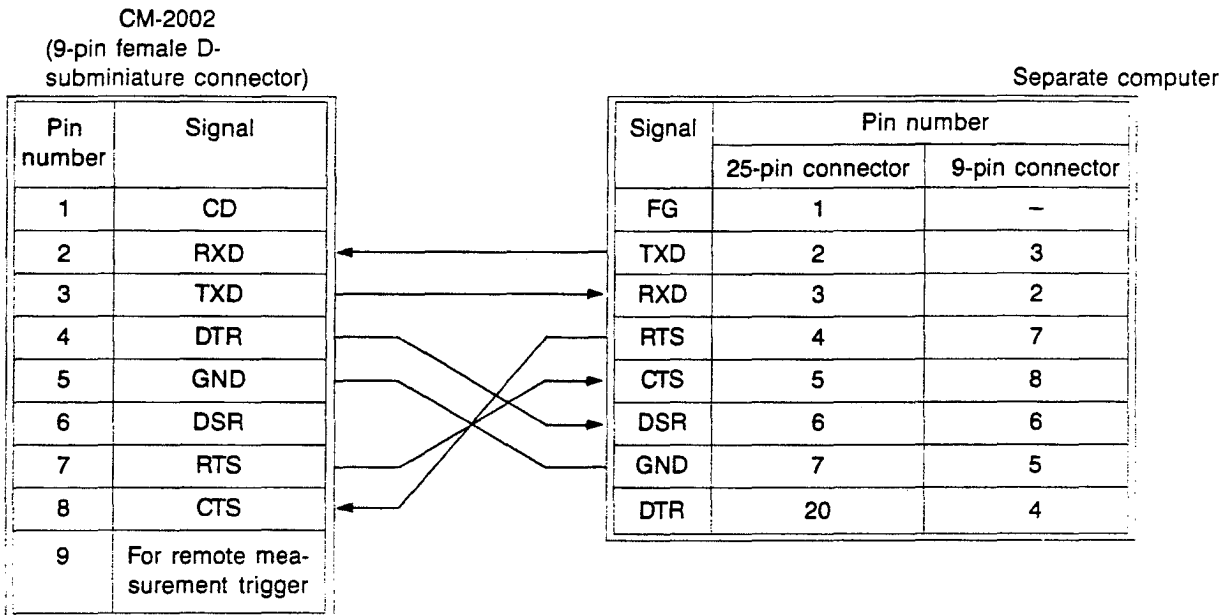
### RS-232C Terminal

The pin diagram of the CM-2002's RS-232C terminal is shown below.

Pin number	Signal	Input/output	Purpose
1	CD	Input	Carrier detect
2	RXD	Input	Received data
3	TXD	Output	Transmitted data
4	DTR	Output	Data terminal ready
5	GND		Signal ground
6	DSR	Input	Data set ready
7	RTS	Output	Request to send
8	CTS	Input	Clear to send
9			For remote measurement trigger

## Connection to a Separate Computer

The CM-2002 should be connected to a separate computer according to the diagram below.



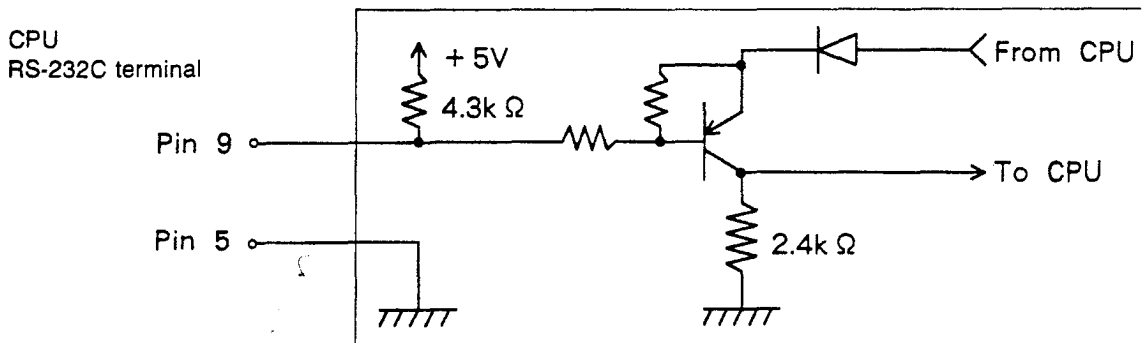
- Optional RS-232C Cables IF-A11 to IF-A15 have the correct internal connections for connecting the CM-2002 to a computer. RS-232C Cable IF-A11 (length: 5m/16.4 ft.) has a 25-pin D-subminiature connector at the computer end for connection with an NEC 9801 computer; RS-232C Cables IF-A12 (length: 2m/6.6 ft.) and IF-A13 (length: 5m/16.4 ft.) have 9-pin D-subminiature male connectors at the computer end for connection with an IBM PC-AT computer; RS-232C Cables IF-A14 (length: 2m/6.6 ft.) and IF-A15 (length: 5m/16.4 ft.) have 25-pin D-subminiature male connectors at the computer end for connection with an IBM PS/2 computer. If a connecting cable other than those available as optional accessories for the CM-2002 is used, check that the internal connections are as shown in the above diagram.

## Circuit Diagram for Remote Measurement Trigger

Short-circuiting pins 5 (GND) and 9 (for remote-measurement trigger) will cause the CM-2002 to react in the same way as if the measuring button were pressed.

- Do not apply any voltage to pin 9.

CM-2002



## Connection to a Printer

The CM-2002 can be connected directly to a printer via the CM-2002's RS-232C terminal. The format for data output can then be set for output directly to a printer instead of to a computer. Printers which can be used with the CM-2002 must meet the following specifications:

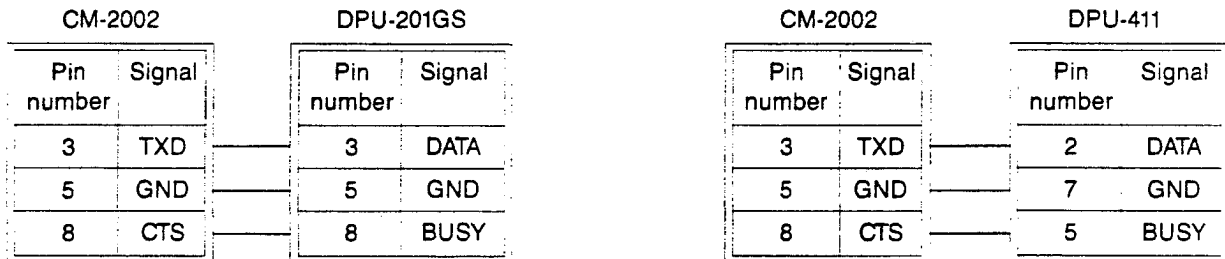
Number of printed columns: At least 27  
 Data input: RS-232C  
 Data control: BUSY  
 Baud rate: 1200, 2400, 4800, 9600, or 19200  
 Character length<sup>1</sup>: 7 or 8 bits  
 Parity<sup>1</sup>: Even, odd, or none  
 Number of stop bits<sup>1</sup>: 1 or 2  
 Basic operating codes: CR (OD<sub>H</sub>): Carriage return

<sup>1</sup> Any of the following combinations of character length, parity, and number of stop bits can be used:

7, even, 1	8, even, 1
7, odd, 1	8, odd, 1
7, none, 2	8, none, 1
	8, none, 2

For example: Seiko Instruments Inc. Standalone Thermal Printer Unit DPU-201GS or DPU-411

Connections:



- When using the DPU-210GS, if the communication parameters are not set correctly or the connecting cable was connected to the printer while the printer was switched on, "?" may be printed out. In this case, check the communication parameters of the CM-2002, switch both the CM-2002 and the printer off and then check the connecting cable and the printer's communication parameters, then switch both units on again.

## SETTING COMMUNICATION PARAMETERS OF CM-2002

1. In MENU mode, press  $\triangleright$  **AVG** to move cursor (highlighted block) to "DATA OUT".
  - If "DATA OUT" is not shown in the displayed menu page, press MODE to change menu page.

```

<MENU>                                1/2
MODE/NEXT PAGE
▶/SELECT                               ▼/EXECUTE

DISPLAY                                CALIB.
TARGET                                 DATA SAVE
DATA OUT                               REMOTE
    
```

2. Press  $\blacktriangledown$ . The CM-2002 will change to DATA OUT mode.
3. Press  $\triangleright$  **AVG** to move cursor to "SET UP".

```

<DATA OUT>
▶/SELECT                               ▼/EXECUTE

DUMP                                   SET UP
    
```

4. Press  $\blacktriangledown$ . The CM-2002 will change to DATA OUT SET UP mode.

5. Press  $\triangleright$  **AVG** to move cursor to parameter to be set. Cursor will move down each time  $\triangleright$  **AVG** is pressed.
  - "Parity", "Character", and "Stop Bit" are set together as one parameter.

```

<DATA OUT SET UP>
Baud Rate                               5500
Parity                                   NONE
Character                                 8
Stop Bit                                  1
Auto Out                                  ON
Output to                                PRINTER
    
```

6. Set each parameter by pressing  $\blacktriangle$  or  $\blacktriangledown$ .
  - a. "Baud"
 

Pressing  $\blacktriangle$  causes the baud rate to change in the following order:  
 ... $\rightarrow$ 1200 $\rightarrow$ 2400 $\rightarrow$ 4800 $\rightarrow$ 9600 $\rightarrow$ 19200 $\rightarrow$ 1200 $\rightarrow$ ...

Pressing  $\blacktriangledown$  causes the baud rate to change in the reverse order.
  - b. "Parity", "Character", "Stop Bit"
 

"Parity", "Character", and "Stop Bit" are set together as one parameter. Settings available are listed in the table below.

	①	②	③	④	⑤	⑥	⑦
Parity	NONE	ODD	EVEN	NONE	NONE	ODD	EVEN
Character	7	7	7	8	8	8	8
Stop Bit	2	1	1	1	2	1	1

Pressing  $\blacktriangle$  causes the setting of the combined parameter to change in the following order:

... $\rightarrow$ ① $\rightarrow$ ② $\rightarrow$ ... $\rightarrow$ ⑦ $\rightarrow$ ① $\rightarrow$ ...

Pressing  $\blacktriangledown$  causes the setting to change in the reverse order.

- c. "Auto Out"
 

Setting "Auto Out" to "ON" causes data to be output automatically after each measurement; when "Auto Out" is set to "OFF", data is not automatically output. To change the setting of "Auto Out" between "ON" and "OFF", press  $\blacktriangle$  or  $\blacktriangledown$ .

- d. "Output to"  
The setting of "Output to" determines how the output data is formatted. When data will be output to a separate computer, set "Output to" to "PC"; when data will be output to a printer, set "Output to" to "PRINTER".
7. Repeat steps 5 and 6 to set all parameters as desired.
8. Press **MENU** or **BREAK/DELETE** to finish setting communication parameters. Pressing **MENU** causes the CM-2002 to return to MENU mode; pressing **BREAK/DELETE** causes the CM-2002 to return to DATA OUT mode.

## AUTOMATIC DATA OUTPUT

Data will be automatically output to a separate computer or a printer if the "Auto Out" communication parameter is set to "ON".

- In MENU mode, press  $\triangleright$  **AVG** to move cursor (highlighted block) to "DATA OUT".
  - If "DATA OUT" is not shown in the displayed menu page, press **MODE** to change menu page.

```

<MENU>                                1/2
MODE/NEXT PAGE
▶/SELECT    ▼/EXECUTE

DISPLAY     CALIB.
TARGET      DATA SAVE
DATA OUT    REMOTE
  
```

- Press  $\blacktriangledown$ . The CM-2002 will change to DATA OUT mode.

- Press  $\triangleright$  **AVG** to move cursor to "SET UP".

```

<DATA OUT>
▶/SELECT    ▼/EXECUTE

        DUMP    SET UP
  
```

- Press  $\blacktriangledown$ . The CM-2002 will change to DATA OUT SET UP mode.

- Press  $\triangleright$  **AVG** to move cursor to setting for "Auto Out". Cursor will move down each time  $\triangleright$  **AVG** is pressed.

```

<DATA OUT SET UP>
Baud Rate      9600
Parity         NONE
Character      8
Stop Bit       1
Auto Out       ON
Output to      PRINTER
  
```

- Press  $\blacktriangle$  or  $\blacktriangledown$  to set "Auto Out" to "ON".

- Check that all other communication parameters are set correctly. (See p. 76.)

- Press **MENU** or **BREAK/DELETE** to finish settings. Pressing **MENU** causes the CM-2002 to return to MENU mode; pressing **BREAK/DELETE** causes the CM-2002 to return to DATA OUT mode.

- While data is being output, "BUSY" will be shown in the display.
- If the CTS input signal remains off, data will not be output; "BUSY" will be shown in the display for approximately six seconds and then be replaced by "TIME OUT".
- To interrupt data output, press **BREAK/DELETE** until a tone sounds.
- Data for all enabled data displays will be output in the following order:
  - Specimen number  $\rightarrow$  Spectral reflectance data  $\rightarrow$  XYZ  $\rightarrow$  Yxy  $\rightarrow$  L\*a\*b\*  $\rightarrow$  L\*C\*H\*  $\rightarrow$  Lab  $\rightarrow$  L\*u\*v\*  $\rightarrow$  CMC(2:1)  $\rightarrow$  CMC(1:1)  $\rightarrow$  FMC2  $\rightarrow$  MI  $\rightarrow$  MUNSELL  $\rightarrow$  WI(E313)  $\rightarrow$  WI(CIE)  $\rightarrow$  YI(E313)  $\rightarrow$  YI(D1925)
  - If both ABS and  $\Delta$  are enabled for XYZ, Yxy, L\*a\*b\*, L\*C\*H\*, Lab, or L\*u\*v\*, ABS data will be output before  $\Delta$  data.
  - If SPECTRAL data display is enabled, spectral reflectance data will be output.
  - If COLOR GR. data display is enabled, absolute and color-difference values in L\*a\*b\* color space will be output.
  - If CMC(2:1) or CMC(1:1) data display is enabled,  $\Delta L^*$ ,  $\Delta C^*$ , and  $\Delta H^*$  data will also be output at the same time.

The output data format is shown on the following page.

## Output Format

If all data displays (including ABS and  $\Delta$  when available) are enabled, data will be output in the following format.

- The number of values output depends on the enabled data displays.
- If no memory card has been installed when the measurement is taken, the delimiter code will be output immediately after "No."
- The characters in quotes (" "), with the exception of "No.", indicate the data display for which data will be output.
- <CR> indicates delimiter code. The delimiter code is set to CR (carriage return) when the power is first switched on. When "Output to" is set to PRINTER, the delimiter code is fixed as CR. When "Output to" is set to PC, the delimiter code will be set to the delimiter code input to the CM-2002 from the computer in REMOTE mode; if REMOTE mode is not used, the delimiter code will remain set as CR.
- For MI (rrr:ttt), rrr (length may be 1 to 3 characters) indicates the reference illuminant and ttt (length may be 1 to 3 characters) indicates the test illuminant.
- When "Output to" is set to PRINTER and CMC(2:1) or CMC(1:1) is enabled,  $\Delta L^*$ ,  $\Delta C^*$ ,  $\Delta H^*$  data will be output in the "dLCH" position.

### FORMAT FOR OUTPUT TO PC

Number of values	Output
1	"No."Specimen number<CR>
1	Spectral reflectance data at 400nm<CR>
1	Spectral reflectance data at 410nm<CR>
	.
	.
1	Spectral reflectance data at 690nm<CR>
1	Spectral reflectance data at 700nm<CR>
4	"XYZ"<CR>X value<CR>Y value<CR>Z value<CR>
5	"dXYZ"<CR> $\Delta X$ value<CR> $\Delta Y$ value<CR> $\Delta Z$ value<CR> $\Delta E^*_{ab}$ value<CR>
4	"Yxy"<CR>Y value<CR>x value<CR>y value<CR>
5	"dYxy"<CR> $\Delta Y$ value<CR> $\Delta x$ value<CR> $\Delta y$ value<CR> $\Delta E^*_{ab}$ value<CR>
4	"L*a*b*"<CR>L* value<CR>a* value<CR>b* value<CR>
5	"dL*a*b*"<CR> $\Delta L^*$ value<CR> $\Delta a^*$ value<CR> $\Delta b^*$ value<CR> $\Delta E^*_{ab}$ value<CR>
4	"LCH"<CR>L* value<CR>C* value<CR>H° value<CR>
5	"dLCH"<CR> $\Delta L^*$ value<CR> $\Delta C^*$ value<CR> $\Delta H^*$ value<CR> $\Delta E^*_{ab}$ value<CR>
4	"Lab"<CR>L value<CR>a value<CR>b value<CR>
5	"dLab"<CR> $\Delta L$ value<CR> $\Delta a$ value<CR> $\Delta b$ value<CR> $\Delta E$ value<CR>
4	"L*u*v*"<CR>L* value<CR>u* value<CR>v* value<CR>
5	"dL*u*v*"<CR> $\Delta L^*$ value<CR> $\Delta u^*$ value<CR> $\Delta v^*$ value<CR> $\Delta E^*_{uv}$ value<CR>
5	"CMC(2:1)"<CR> $\Delta L^*$ value<CR> $\Delta C^*$ value<CR> $\Delta H^*$ value<CR>CMC(2:1) value<CR>
5	"CMC(1:1)"<CR> $\Delta L^*$ value<CR> $\Delta C^*$ value<CR> $\Delta H^*$ value<CR>CMC(1:1) value<CR>
5	"FMC2"<CR> $\Delta L$ (FMC-2) value<CR>RG value<CR> $\Delta YB$ value<CR>FMC-2 value<CR>
2	"MI "(rrr:ttt)"<CR>MI value<CR>
2	"HVC"<CR>Munsell notation (hue value/chroma)<CR>
3	"WI - E313"<CR>WI (E 313) value<CR> $\Delta WI$ (E 313) value<CR>
3	"WI - CIE"<CR>WI (CIE) value<CR> $\Delta WI$ (CIE) value<CR>
3	"YI - E313"<CR>YI (E 313) value<CR> $\Delta YI$ (E 313) value<CR>
3	"YI - D1925"<CR>YI (D 1925) value<CR> $\Delta YI$ (D 1925) value<CR>

Total: 117  
(maximum)

- indicates a space.

PRINTER OUTPUT EXAMPLE

```

No. 103
400nm 16.09 410nm 18.77
420nm 20.68 430nm 22.62
440nm 26.69 450nm 31.59
460nm 34.66 470nm 34.59
480nm 32.65 490nm 29.15
500nm 24.43 510nm 19.15
520nm 14.37 530nm 10.68
540nm 8.20 550nm 6.71
560nm 5.90 570nm 5.39
580nm 4.94 590nm 4.96
600nm 5.10 610nm 5.08
620nm 4.77 630nm 4.99
640nm 5.40 650nm 5.67
660nm 5.14 670nm 4.73
680nm 4.80 690nm 4.38
700nm 3.72
X 7.19 Y 7.75
Z 10.38
dX -0.01 dY -0.02
dZ -0.03
dE* 0.10
Y 7.75 x .2940
y .3062 dx .0002
dY -0.02
dy .0002
dE* 0.10
L* 33.46 a* -11.64
b* -47.34 da* 0.05
dL* -0.03
db* 0.08
dE* 0.10
L* 33.46 C* 48.75
H 256.18 dC* -0.09
dL* -0.03
dH* 0.03
dE* 0.10
L 27.84 a -8.00
b -29.54 da 0.02
dL -0.03
db 0.09
dE 0.09
L* 33.46 u* -30.35
v* -31.75 du* 0.08
dL* -0.03
dv* 0.08
dE* 0.12
CMC(2:1) 0.04
CMC(1:1) 0.05
dL(FMC2) -0.05 DRG 0.15
dYB 0.06
FMC2 0.17
MI (D65:A) 0.07
HUC 4.5 PB 3.6/9.6
WI(E313) 87.52
dWI(E313) -0.31
WI(CIE)
dWI(CIE)
YI(E313) -199.87
dYI(E313) 0.39
YI(D1925) -242.69
dYI(D1925) 0.43

```



## OUTPUTTING ALL MEASUREMENT DATA ON THE MEMORY CARD

All measurement data on the memory card can be output by selecting DUMP in DATA OUT mode.

1. In MENU mode, press **▷ AVG** to move cursor (highlighted block) to "DATA OUT".
  - If "DATA OUT" is not shown in the displayed menu page, press **MODE** to change menu page.

```
<MENU> 1/2
MODE/NEXT PAGE
▶/SELECT ▼/EXECUTE
DISPLAY CALIB.
TARGET DATA SAVE
DATA OUT REMOTE
```

2. Press **▼**. The CM-2002 will change to DATA OUT mode.
3. Press **▷ AVG** to move cursor to "SET UP" and press **▼** to change to DATA OUT SET UP mode. Check that all communication parameters are set correctly. (See p. 76.)
4. Press **BREAK/DELETE** to return to DATA OUT mode.
5. Press **AVG** to move cursor to "DUMP".

```
<DATA OUT>
▶/SELECT ▼/EXECUTE
DUMP SET UP
```

6. Press **▼**. All measurement data stored on the memory card will be output.
  - While data is being output, "CARD DATA OUTPUT" will be shown in the display.
  - If no memory card is installed or memory card battery is in low voltage, "NO CARD" will be shown in the display for a few seconds, and then the CM-2002 will return to DATA OUT mode.
  - If there is no data on the memory card, "NO DATA" will be displayed for a few seconds and output will be performed according to the output format.
  - If there is no response from the computer or printer within approximately six seconds, "TIME OUT" will be shown in the display for a few seconds and then the CM-2002 will return to DATA OUT mode.
  - To interrupt data output, press **BREAK/DELETE** until a tone sounds.
7. After all data has been output, "COMPLETED" will be shown in the display for a few seconds and then the CM-2002 will return to DATA OUT mode.
  - To return to MENU mode, press **MENU** or **BREAK/DELETE**.

## Output Format

- <CR> indicates delimiter code. The delimiter code is set to CR (carriage return) when the power is first switched on. When "Output to" is set to PRINTER, the delimiter code is fixed as CR. When "Output to" is set to PC, the delimiter code will be set to the delimiter code input to the CM-2002 from the computer in REMOTE mode; if REMOTE mode is not used, the delimiter code will remain set as CR.

"S" <CR>

"No." Specimen number <CR>

Spectral reflectance data at 400nm <CR>

Spectral reflectance data at 410nm <CR>

.

.

.

Output for each specimen number for which data is stored on the memory card.

Spectral reflectance data at 690nm <CR>

Spectral reflectance data at 700nm <CR>

Data ID <CR>

Comment <CR>

Data for each enabled color mode data display <CR>

"E" <CR>

If there is no measurement data on the memory card, the following will be output:

"S" <CR>

"E" <CR>

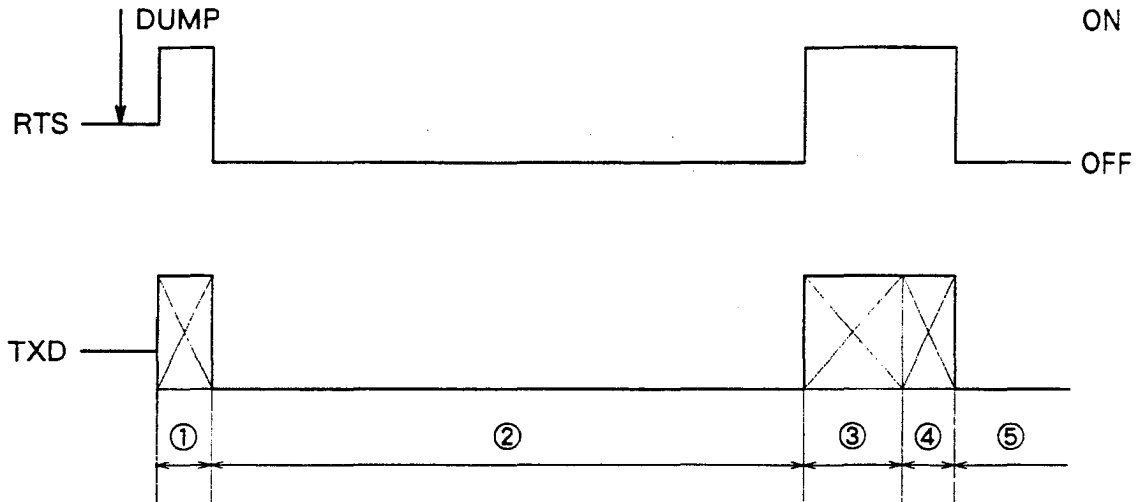
- The same output format is used regardless of whether "Output to" is set to "PC" or "PRINTER".
- To interrupt data output, press **BREAK/DELETE** until a tone sounds. When output is interrupted, "E" will be output at the point where output was interrupted.
- For information on data ID, see p. 93.
- Comment can be up to 11 characters long. See p. 93 for more information.
- Data for all enabled color mode data displays will be output in the following order:  
XYZ → Yxy → L\*a\*b\* → L\*C\*H° → Lab → L\*u\*v\* → CMC(2:1) → CMC(1:1) → FMC2 → MI → MUNSELL →  
WI(E313) → WI(CIE) → YI(E313) → YI(D1925)
- If both ABS and Δ are enabled for XYZ, Yxy, L\*a\*b\*, L\*C\*H°, Lab, or L\*u\*v\*, ABS data will be output before Δ data.
- If COLOR GR. data display is enabled, absolute and color-difference values in L\*a\*b\* color space will be output.
- If CMC(2:1) or CMC(1:1) data display is enabled, ΔL\*, ΔC\*, and ΔH\* data will also be output at the same time.

For the data format of each data display, see p. 79.

## Output Timing Chart

### Conditions:

- Communication parameters:
  - Baud rate: 600bps
  - Parity: None
  - Character length: 8
  - Stop bits: 1
- All color mode data displays are enabled.
- Connected device (computer or printer) is ready to receive data (CTS signal is ON).



- |   |   |                           |
|---|---|---------------------------|
| ① | Output of spectral reflectance data, data ID, and comment for specimen number 1 | Approximately 0.4 seconds |
| ② | Calculations for color mode data displays for specimen number 1                 | Approximately 3.2 seconds |
| ③ | Output of calculated values for color mode data displays for specimen number 1  | Approximately 0.8 seconds |
| ④ | Output of spectral reflectance data, data ID, and comment for specimen number 2 |                           |
| ⑤ | Calculations for specimen number 2  |                           |

## REMOTE MODE

When the CM-2002 is set to REMOTE mode, all operations (except for switching between SCI and SCE measurements) are controlled by the connected computer. Commands, data, and messages for display can be input to the CM-2002 from the computer, and the CM-2002 will respond accordingly.

- Before entering REMOTE mode, ensure that the communication parameters are set correctly. (See p. 76.)
1. In MENU mode, press  $\triangleright$  **AVG** to move cursor (highlighted block) to "REMOTE".
    - If "REMOTE" is not shown in the displayed menu page, press **MODE** to change menu page.
  2. Press  $\blacktriangledown$ . The CM-2002 will change to REMOTE mode and "/REMOTE/" will appear in the lower right of the display. The CM-2002 can then be controlled by the computer.
    - The CM-2002 consumes about 50% more power in REMOTE mode than in other modes. For this reason, it is recommended that the AC adapter be used to supply power to the CM-2002 in REMOTE mode.
    - In REMOTE mode, **DISPLAY INVERT** does not function.
    - If the CM-2002 is switched off while set to REMOTE mode, it will start up in REMOTE mode when it is switched back on.
    - While data is being output, "/REMOTE/" will be replaced by "/OUTPUT/" in the display.

To cancel REMOTE mode, press **BREAK/DELETE**. The CM-2002 will change to MENU mode.

```
<MENU> 1/2
MODE/NEXT PAGE
▶/SELECT ▼/EXECUTE
DISPLAY CALIB.
TARGET DATA SAVE
DATA OUT REMOTE
```

```
/REMOTE/
```

## Inputting Commands

Operation of the CM-2002 can be controlled by a computer using the commands listed below and on the following page.

- Commands related to displaying messages in terminal mode are listed on p. 131.

### TABLES OF COMMANDS

Commands related to calibration:

Command	Function	Page
CAL	Prepares CM-2002 for white calibration.	109
UZC	Prepares CM-2002 for zero calibration.	130
CDS	Prepares CM-2002 to receive white calibration data.	109
CDR	Requests output of white calibration data presently stored in the CM-2002's memory.	109

Commands related to measurement conditions and menu settings:

Command	Function	Page
PDS	Prepares CM-2002 to receive data display parameters (enable/disable data displays).	121
PDR	Requests output of data display parameters presently set on CM-2002.	120
OIS	Prepares CM-2002 to receive observer and illuminant condition settings.	119
OIR	Requests output of observer and illuminant conditions presently set on CM-2002.	119
AVE	Prepares CM-2002 to receive setting of number of measurements to be taken for automatic averaging.	107
RCS	Prepares CM-2002 to receive reflectance correction factor.	122
RCR	Requests output of reflectance correction factor presently set on CM-2002.	122
BZE	Enables CM-2002's buzzer.	108
BZD	Disables CM-2002's buzzer.	108
MIS	Prepares CM-2002 to receive settings of reference and test illuminants for MI (metamerism index) data display.	117
MIR	Requests output of reference and test illuminants for MI data display mode presently set on CM-2002.	117

Commands related to target data:

Command	Function	Page
TDS	Prepares CM-2002 to receive target color data for presently set target number.	128
TDR	Requests output of target color data of presently set target number.	128
TNS	Prepares CM-2002 to receive target number.	129
TNR	Requests output of presently set target number.	129
TGD	Prepares CM-2002 to receive target number for which target color data will be temporarily deleted.	128
TGR	Prepares CM-2002 to receive target number for which target color data will be recovered.	129
LDS	Prepares CM-2002 to receive tolerance values for presently set target number.	114
LDR	Requests output of tolerance values for presently set target number.	113
ATE	Sets target color auto select function on.	107
ATD	Sets target color auto select function off.	107

Commands related to measurements and measurement data:

Command	Function	Page
MSC	Causes the CM-2002 to take a measurement and output both spectral and colorimetric measurement data to the computer. Measurement data is automatically saved in the memory card.	118
MES	Causes the CM-2002 to take a measurement and output spectral data to the computer. Measurement data is not automatically saved to the memory card.	116
AVG	Indicates the start or end of a series of measurements to be taken manually and averaged.	108
MDS	Prepares the CM-2002 to receive measurement data to be stored in the space for the presently set specimen number.	115
MDR	Requests output of measurement data for the presently set specimen number.	114
SNS	Prepares the CM-2002 to receive specimen number.	125
SNR	Requests output of the presently set specimen number.	125
SDS	Prepares CM-2002 to receive measurement data to be stored in the space for a series of specimen numbers.	124
SDR	Requests output of the measurement data for a series of specimen numbers.	123
DQR	Requests the number of specimen numbers containing data on the memory card.	111

Commands related to memory card:

Command	Function	Page
SAV	Causes CM-2002 to perform DATA SAVE (p. 40); measurement conditions, target color data, etc. are saved to the memory card.	122
CMS	Prepares CM-2002 to save 128KB of data (the capacity of 1 memory card) to the memory card.	111
CMR	Requests output of the entire 128KB of data stored on the memory card.	110

Commands related to status of CM-2002:

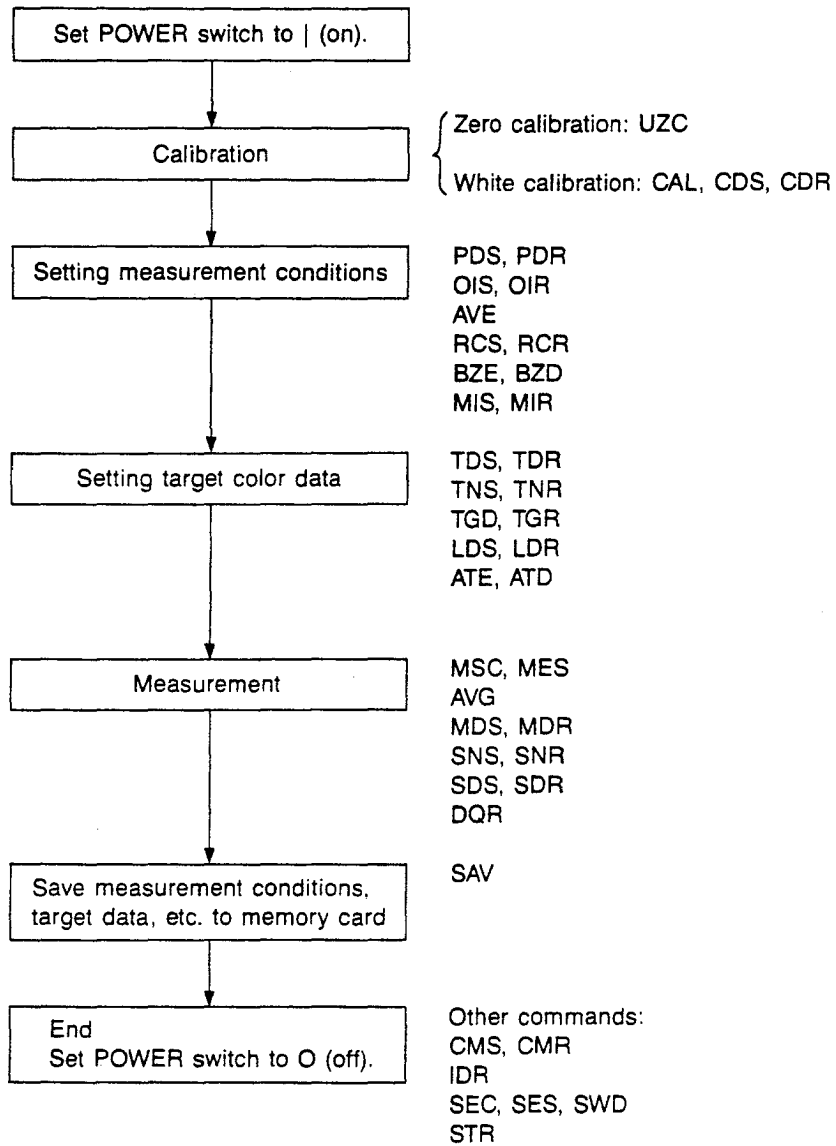
Command	Function	Page
IDR	Requests output of the serial number of the CM-2002.	112
SEC	Enables CM-2002's measuring button (or Accessory Switch). When the measuring button is pressed, the CM-2002 will perform as if the command MSC was input.	124
SES	Enables CM-2002's measuring button (or Accessory Switch). When the measuring button is pressed, the CM-2002 will perform as if the command MES was input.	125
SWD	Disables CM-2002's measuring button (and Accessory Switch).	127
STR	Requests output of status information.	126

## BREAK CODE

The break code (03<sub>H</sub>: <sub>H</sub> indicates hexadecimal notation) is an operation code and must be input as the hexadecimal number 03 instead of the characters "03". It can be used for the following purposes:

- a. To cancel white calibration mode or zero calibration mode without performing calibration.  
White calibration mode is entered using the command "CAL" and is automatically ended when white calibration has been performed. Zero calibration mode is entered using the command "UZC"; after zero calibration has been performed, zero calibration mode is automatically ended and the CM-2002 automatically enters white calibration mode. The break code can be input to cancel either mode without actually performing calibration; if the break code is input in zero calibration mode, zero calibration mode is canceled and the CM-2002 does not change to white calibration mode.
- b. To interrupt input of command and data.  
Input of data after inputting a command which requires data input can be interrupted by inputting the break code at any time before the final delimiter code (the delimiter code following the last word of data required for the command). If the break code is input to interrupt the input of data, all data previously input in the series of data for the command will be canceled (previous data will be returned to) and a new command can be input.
  - When using the "SDS" command to input data for multiple specimen numbers, only the data for the present specimen number (the not-yet-completed data for a specimen number) will be canceled. The data for the previous specimen number (for which input of data was completed) will remain as input.
- c. To interrupt output of data.
- d. To interrupt operation in response to a command.  
A series of measurements to be manually taken and averaged (started using the command "AVG") can be interrupted by inputting the break code. Previously measured data in the series will be canceled.
  - The break code cannot be used to interrupt a series of measurements taken automatically (for white calibration, zero calibration, or automatic averaging). To interrupt such a series of measurements, press **BREAK/DELETE** on the CM-2002.
- e. To cancel terminal mode (p. 131).
- f. To clear the CM-2002's communication buffer.
  - The error-check code (p. 91) will be output in response to the break code in any of the above cases.

FLOWCHART OF COMMAND USAGE DURING OPERATION





## PROCEDURE

Each of the commands listed in the tables of commands (p. 85) consists of three upper-case characters. When one of these commands is input to the CM-2002, it must be followed by one of the three delimiter codes below:

1. <CR> (carriage return)
2. <LF> (line feed)
3. <CR> and <LF>

Any of the above delimiter codes may be used. In the examples in this manual, <CR> is used to indicate the delimiter code.

- The delimiter code used by the CM-2002 when outputting the error-check code or data will be set according to the delimiter code used when the command and data were input. If a measurement is taken, or if the input command requires data output, the required data will be output after the error-check code. Data input format is described on p. 90; data output format is described on p. 91.
- When the CM-2002 is not ready to accept commands or data, it sets its RTS output (which is connected to the CTS input of the computer) to OFF. Therefore, before sending a command or data, always check that the computer's CTS input is ON. If a command or data is input while the CTS input of the computer is OFF, the command or data may not be received correctly by the CM-2002 and a command error (error-check code "E00Y" or "E00N") may occur. If this occurs, input the break code 03<sub>H</sub> (p. 87) and then input the command or data again after the computer's CTS input becomes ON.

After a command (and any input data associated with the command) has been received by the CM-2002, the CM-2002 outputs an error-check code (see p. 91).

- The error-check code should always be accepted by the computer before another command is input.

### Command Input Format

The format for inputting a command is shown below:

Command (3 upper-case characters) <CR>

Only three upper-case characters will be accepted. If more than three characters are input, if lower-case characters are input, or if the command is preceded or followed by a space, the CM-2002 will not consider the command correct. The following input commands would not be considered correct:

"MEES" <CR>  
"mes" <CR>  
"MES " <CR>  
" MES" <CR>           ( indicates a space.)

If an incorrect command is input, the CM-2002 will output the error-check code for command error:

"E00Y" <CR> or "E00N" <CR>

- If a command is input to the CM-2002 and the CM-2002 does not respond, check if any of the following commands were input without being followed by input of the associated data:  
"CDS", "AVE", "MDS", "SNS", "SDS", "PDS", "OIS", "TDS", "TNS", "TGD", "TGR", "LDS", "RCS",  
"MIS", or "CMS"  
If this is the case, input the break code 03<sub>H</sub> (p. 87) and then input the desired command.
- If a command was properly input but the error-check code "E00Y" or "E00N" (command error) was output by the CM-2002, input the break code 03<sub>H</sub> (p. 87), and then input the command again. If the error-check code "E00Y" or "E00N" is output again, check the following two points:
  - Are the communication parameters of the CM-2002 and the computer set the same? If the communication parameters are set differently, the command may be received incorrectly by the CM-2002 even if the command is input correctly by the computer. See p. 76 for information on setting communication parameters.
  - Was the RTS output of the CM-2002 (CTS input of the computer) on? Always check that the RTS output of the CM-2002 (CTS input of the computer) is off before inputting a command or data.



## Comment

A comment can be set by the user to describe measurement or target data. Input of a comment is required for the commands "MDS", "SDS", and "TDS". Input format is as follows:

Comment < CR >

- For "MDS" and "SDS", the comment is an 11-character data word for describing the specimen data; the comment cannot be viewed in the CM-2002's display, but it will be saved to the memory card along with the specimen data. If more than 11 characters are input, only the first 11 characters will be accepted and the remaining characters will be ignored.
- For "TDS", the comment is an 8-character data word for describing the target data; it can be viewed in the CM-2002's display and can also be set directly on the CM-2002. If more than 8 characters are input, only the first 8 characters will be accepted and the remaining characters will be ignored.

## OUTPUT FORMAT

### Error-Check Code

The error-check code is output by the CM-2002 in response to all commands except most commands related to terminal mode (p. 131). It is output immediately after the command (if no input of related data is required) or the last data word of related data has been received; it is also output immediately after a measurement is taken using the measuring button or Accessory Switch.

The error-check code consists of four characters which indicate whether or not the requested procedure can be performed, the possible problem if the procedure cannot be performed, whether or not the power is sufficient, and when the procedure can be performed but data may not be correct.

- "OK" will be output as the first two characters if the requested procedure can be performed. The next character will be a space, and the fourth character will be "Y" (if power is sufficient) or "N" (if power is insufficient).
- "E" will be output as the first character if the requested procedure cannot be performed. In this case, the second and third characters will be an error number, indicating the possible problem as shown in the table on the following page. The fourth character will be "Y" (if power is sufficient) or "N" (if power is insufficient).
- "W" will be output as the first character if it was possible to perform the requested procedure but there is a possibility that data may not be correct. The second and third characters will be a warning number, indicating the reason that data may not be correct, as shown in the table on the following page. The fourth character will be "Y" (if power is sufficient) or "N" (if power is insufficient).

### Error Numbers

Error number	Meaning	Solution
00	The command or data was input using the wrong format.	Input the command or data using the correct format.
	An unacceptable command was input.	Input a correct command.
	The characters of the input command or data were changed.	Check that the communication parameters of the CM-2002 (p. 76) and those of the computer are the same.
02	Illumination circuit has not finished charging.	Wait until the CM-2002's CHARGE lamp is lit before inputting the "MSC" or "MES" command or pressing the CM-2002's measuring button or Accessory Switch.
05	CM-2002's pulsed xenon arc lamp did not flash.	Perform measurement or calibration again. If this error number is output again, contact the nearest Minolta authorized service facility.
10	Measurement data cannot be output because there is no data on the memory card.	Take a measurement
11	White calibration or zero calibration was not performed correctly.	Perform white calibration or zero calibration correctly. If this error number is output again, contact the nearest Minolta authorized service facility.
13	Error in CM-2002's A/D conversion circuits.	Set POWER switch to O (off) for a moment, then set it back to   (on). If this error number is output again, contact the nearest Minolta authorized service facility.
18	Data in CM-2002's EEPROM was destroyed.	Contact the nearest Minolta authorized service facility.
19	<ul style="list-style-type: none"> <li>• Memory card is not installed.</li> <li>• Memory card contains no measurement data.</li> <li>• Memory card's write-protect switch is at ON.</li> <li>• Memory card chamber cover is not closed.</li> <li>• Memory card's battery power is low.</li> </ul>	Check status code (p. 126). Then perform the appropriate action below. <ul style="list-style-type: none"> <li>• Install memory card.</li> <li>• Set memory card's write-protect switch to OFF.</li> <li>• Close cover of memory card chamber.</li> <li>• Install a new battery in the memory card.</li> </ul>
21	Error occurred when writing to memory card.	Try writing to the memory card again or try using another memory card. If this error number is output again, contact the nearest Minolta authorized service facility.

### Warning Numbers

Warning number	Meaning	Solution
00	The quantity of light inside the integrating chamber detected by the sensor for monitoring illumination was too low. The interior surface of the integrating chamber may be dirty or the pulsed xenon arc lamp may need replacement.	Contact the nearest Minolta authorized service facility.
01	White calibration was not performed since POWER switch was set to   (on).	Perform white calibration.

### Single Data Word

For many of the commands, only a single data word of data will be output in response. In such cases, the data format is:

Data word <CR>

- For detailed information regarding the data word corresponding to the command, refer to the page describing the command in detail (detailed command descriptions start on p. 107).

### Spectral Reflectance Data

Spectral reflectance data will be output after a measurement is taken or in response to the command "CDR", "MDR", "SDR", or "TDR". Data format for spectral reflectance data is as follows:

Spectral reflectance data at 400nm <CR>

Spectral reflectance data at 410nm <CR>

31 data words

Spectral reflectance data at 690nm <CR>

Spectral reflectance data at 700nm <CR>

- Spectral reflectance data are percent values; values are from 0 to 175.00.
- Spectral reflectance data will have two decimal places.

### Data ID

The data ID is a 17-character data word consisting of information relating to the date and time of measurement, target number, reflectance correction factor, and whether the measurement was SCI or SCE. The format of data ID is as follows:

YYMMDDhhmmsTTTRCS <CR>

YY: Last two digits of year

MM: Month; if month is a single digit, digit will be preceded by "0".

DD: Day; if day is a single digit, digit will be preceded by "0".

hh: Hour (in 24-hour format); if hour is a single digit, digit will be preceded by "0".

mm: Minute; if minute is a single digit, digit will be preceded by "0".

ss: Second; if second is a single digit, digit will be preceded by "0".

TT: Target number; if target number is a single digit, digit will be preceded by "0".

RC: Reflectance correction factor (multiplied by 10).

S: Whether measurement was SCI or SCE: "I" indicates SCI measurements; "E" indicates SCE measurements.

- The data ID will always be 17 characters long. If any of the numerical values are single digits, they will be preceded by "0".
- TT will be a value from 01 to 50.
- RR will be the actual reflectance correction factor multiplied by 10. For example, if the actual reflectance correction factor is 4.8, "48" will be used. RR will be a value from 00 to 99.

### Comment

Output format for comment is as follows:

Comment <CR>

- For measurement data, the comment is an 11-character data word; it cannot be viewed in the CM-2002's display, but it will be saved to the memory card along with the specimen data.
- For target color data, the comment is an 8-character data word; it can be viewed in the CM-2002's display and can also be set directly on the CM-2002.

## Data for Enabled Color Modes

Data will be output for each enabled color mode data display when the command "MSC" is used or when the measuring button (and Accessory Switch) have been enabled using the command "SEC". If all color mode data displays (including ABS and when available) are enabled, data would be output in the following format:

```
"XYZ"<CR>X value<CR>Y value<CR>Z value<CR>
"dXYZ"<CR> $\Delta$ X value<CR> $\Delta$ Y value<CR> $\Delta$ Z value<CR> $\Delta E^*_{ab}$  value<CR>
"Yxy"<CR>Y value<CR>x value<CR>y value<CR>
"dYxy"<CR> $\Delta$ Y value<CR> $\Delta$ x value<CR> $\Delta$ y value<CR> $\Delta E^*_{ab}$  value<CR>
"L*a*b*"<CR>L* value<CR>a* value<CR>b* value<CR>
"dL*a*b*"<CR> $\Delta$ L* value<CR> $\Delta$ a* value<CR> $\Delta$ b* value<CR> $\Delta E^*_{ab}$  value<CR>
"LCH"<CR>L* value<CR>C* value<CR>H° value<CR>
"dLCH"<CR> $\Delta$ L* value<CR> $\Delta$ C* value<CR> $\Delta$ H° value<CR> $\Delta E^*_{ab}$  value<CR>
"Lab"<CR>L value<CR>a value<CR>b value<CR>
"dLab"<CR> $\Delta$ L value<CR> $\Delta$ a value<CR> $\Delta$ b value<CR> $\Delta E$  value<CR>
"L*u*v*"<CR>L* value<CR>u* value<CR>v* value<CR>
"dL*u*v*"<CR> $\Delta$ L* value<CR> $\Delta$ u* value<CR> $\Delta$ v* value<CR> $\Delta E^*_{uv}$  value<CR>
"CMC(2:1)"<CR> $\Delta$ L* value<CR> $\Delta$ C* value<CR> $\Delta$ H° value<CR>CMC(2:1) value<CR>
"CMC(1:1)"<CR> $\Delta$ L* value<CR> $\Delta$ C* value<CR> $\Delta$ H° value<CR>CMC(1:1) value<CR>
"FMC2"<CR> $\Delta$ L (FMC-2) value<CR> $\Delta$ RG value<CR> $\Delta$ YB value<CR>FMC-2 value<CR>
"MI (rrr:ttt)"<CR>MI value<CR>
"HVC"<CR>Munsell notation (hue value/chroma)<CR>
"WI_E313"<CR>WI (E 313) value<CR> $\Delta$ WI (E 313) value<CR>
"WI_CIE"<CR>WI (CIE) value<CR> $\Delta$ WI (CIE) value<CR>
"YI_E313"<CR>YI (E 313) value<CR> $\Delta$ YI (E 313) value<CR>
"YI_D1925"<CR>YI (D 1925) value<CR> $\Delta$ YI (D 1925) value<CR>
```

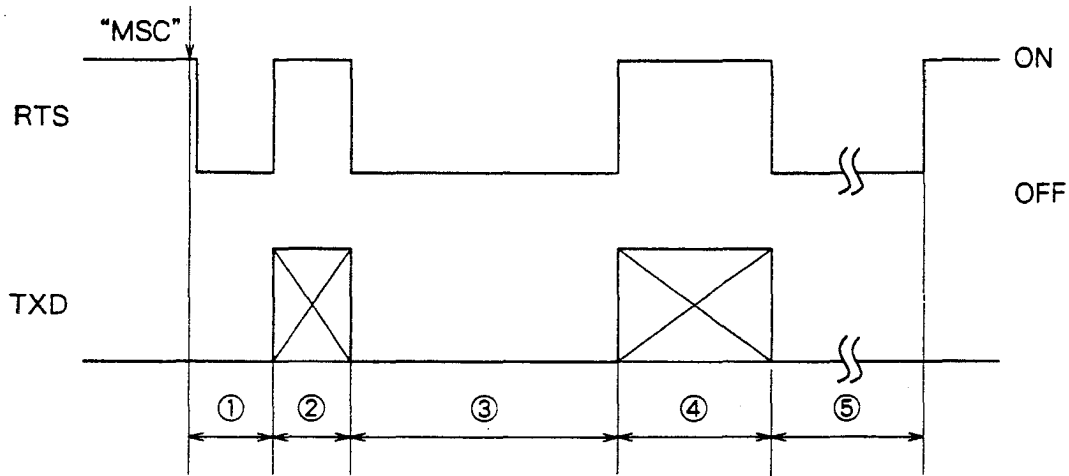
- The characters in quotes (" ") indicate the color mode data display for which data will be output.
- For MI (rrr:ttt), indicates a space, rrr (length may be 1 to 3 characters) indicates the reference illuminant and ttt (length may be 1 to 3 characters) indicates the test illuminant.
- " \_ " is output as ASCII code 5F<sub>H</sub>.

## Data Output Timing Charts

### Conditions:

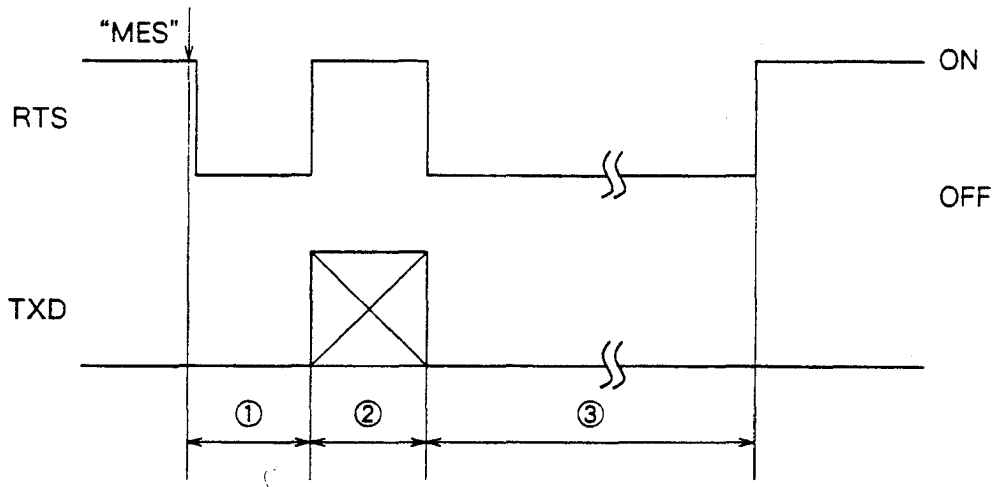
- Communication parameters:
  - Baud rate: 9600bps
  - Parity: None
  - Character length: 8
  - Stop bits: 1
- All color mode data displays are enabled.
- Computer is ready to receive data (CTS signal is ON).

### USING "MSC" COMMAND



- |   |                           |
|---|---------------------------|
| ① Measurement and calculations                              | Approximately 0.5 seconds |
| ② Output of spectral reflectance data, data ID, and comment | Approximately 0.4 seconds |
| ③ Calculations for color mode data displays                 | Approximately 3.3 seconds |
| ④ Output of calculated values for color mode data displays  | Approximately 0.9 seconds |
| ⑤ Charging of lamp circuit                                  |                           |

### USING "MES" COMMAND



- |   |                           |
|---|---------------------------|
| ① Measurement and calculations                              | Approximately 0.3 seconds |
| ② Output of spectral reflectance data, data ID, and comment | Approximately 0.4 seconds |
| ③ Charging of lamp circuit                                  |                           |

## Sample Programs

### PROGRAM 1

The following program performs white calibration and specimen measurement. The measured data is then output to the computer by the CM-2002 and displayed on the computer monitor.

100	'*****'	
110	'* CM-2002 Sample Program 1: Calibration, measurement, data display, and file save	
120	'*****'	
130	'	
140	'Initialize	
150	DIM D\$(31)	Creates array for storing measured data
160	CLS	
170	PRINT "IS CM-2002 SET TO REMOTE MODE?"	
180	PRINT "AFTER PREPARATIONS ARE COMPLETE, PRESS SPACE BAR TO CONTINUE."	
190	SS=INKEY\$:IF SS<>" " THEN 190	Waits for space bar
200	OPEN "COM1:4800,E,7,1,CS,DS,CD" AS #1	Opens RS-232C port <sup>1</sup>
210	PRINT #1,CHRS(3)	Prints break code
220	GOSUB 1300	To error-check code subroutine
230	'***** WHITE CALIBRATION	Start of white calibration section
240	PRINT #1,"CAL"	Sets CM-2002 to calibration mode
250	GOSUB 1300	To error-check code subroutine
260	CLS	
270	LOCATE 4,2	
280	PRINT "WHITE CALIBRATION WILL BE PERFORMED."	
290	LOCATE 5,2	
300	PRINT "ATTACH WHITE CALIBRATION CAP,"	
310	PRINT "THEN PRESS SPACE BAR TO PERFORM WHITE CALIBRATION."	
320	SS=INKEY\$:IF SS<>" " THEN 320	Waits for space bar
330	PRINT #1,"MES"	Takes measurements for calibration.
340	GOSUB 1300	To error-check code subroutine
350	CLS	
360	LOCATE 4,2	
370	PRINT "WHITE CALIBRATION HAS BEEN COMPLETED."	
380	LOCATE 6,2	
390	PRINT "READY FOR SPECIMEN MEASUREMENTS"	
400	'***** SETTING MEASUREMENT CONDITIONS	Start of measurement- conditions setting section
410	LOCATE 8,2	
420	PRINT "FIRST, MEASUREMENT CONDITIONS WILL BE SET."	
430	GOSUB 1300	To wait subroutine
440	CLS	
450	PRINT #1,"ATD"	Sets target color auto select function off
460	GOSUB 1300	To error-check code subroutine
470	PRINT "AUTO TARGET COLOR SELECT FUNCTION IS OFF.":PRINT	
480	PRINT #1,"OIS"	Sets observer/illuminant conditions: 2° observer/ Standard Illuminant C
490	PRINT #1,"001"	To error-check code subroutine
500	GOSUB 1300	
510	PRINT "2" CHRS(248) " OBSERVER AND STANDARD ILLUMINANT C SELECTED.":PRINT	
520	PRINT #1,"AVE"	Sets number of measurements to be automatically taken and averaged to 3
530	PRINT #1,"3"	To error-check code subroutine
540	GOSUB 1300	
550	PRINT "NUMBER OF MEASUREMENTS FOR AUTOMATIC AVERAGING SET TO 3.":PRINT	
560	PRINT #1,"PDS"	Enables L*a*b* (ABS) and SPECTRAL data displays
570	PRINT #1,"001000100000000000"	To error-check code subroutine
580	GOSUB 1300	



<pre> 590 PRINT "L*A*B* AND SPECTRAL DATA DISPLAYS ENABLED.":PRINT 600 PRINT #1,"RCS" 610 PRINT #1,"0" 620 GOSUB 1300 630 PRINT "REFLECTANCE CORRECTION FACTOR SET TO 0.0%" 640 GOSUB 1380 650 '***** MEASUREMENT 660 CLS 670 INPUT "WILL YOU USE MEASURING BUTTON OF CM-2002? (Y OR N)",ANS\$ 680 IF ANS\$ &lt;&gt;"Y" AND ANS\$ &lt;&gt;"N" THEN 670 690 IF ANS\$="Y" THEN 750  700 CLS 710 PRINT "POSITION CM-2002 ON SPECIMEN AND PRESS ENTER TO TAKE MEASUREMENT" 720 SS=INKEY\$:IF SS&lt;&gt;CHR\$(8) THEN 720 730 PRINT #1,"MSC" 740 GOTO 810 750 'ENABLE MEASURING BUTTON  760 PRINT #1,"SEC" 770 GOSUB 1300 780 PRINT "CM-2002 MEASURING BUTTON ENABLED":PRINT 790 PRINT "POSITION CM-2002 ON SPECIMEN," 800 PRINT "THEN PRESS MEASURING BUTTON TO TAKE MEASUREMENT" 810 '***** RECEIVE DATA  820 PRINT:PRINT 830 PRINT "WAITING FOR DATA FROM CM-2002" 840 GOSUB 1300 850 FOR I=1 TO 31 860 INPUT #1,DS(I) 870 NEXT I 880 INPUT #1,IDS:INPUT #1,COMTS 890 INPUT #1,STRS 900 INPUT #1,LLS 910 INPUT #1,AAS 920 INPUT #1,BBS 930 PRINT #1,"SWD" 940 GOSUB 1300 950 '***** DISPLAY DATA  960 CLS 970 FOR I=1 TO 31 980 PRINT DS(I), 990 NEXT I 1000 PRINT 1010 PRINT "ID: ";IDS 1020 PRINT "L*=";LLS 1030 PRINT "a*=";AAS 1040 PRINT "b*=";BBS 1050 '***** SAVE FILE  1060 GOSUB 1380 1070 CLS 1080 INPUT "SAVE DATA AS FILE? (Y OR N)",ANS\$ 1090 IF ANS\$ &lt;&gt;"Y" AND ANS\$ &lt;&gt;"N" THEN 1080  1100 IF ANS\$="N" THEN 1210  1110 INPUT "INPUT FILE NAME. (FILE WILL BE SAVED TO DRIVE A.)",FFS 1120 OPEN "A:"+FFS FOR APPEND AS #2 1130 FOR I=1 TO 31 1140 PRINT #2,DS(I) 1150 NEXT I 1160 PRINT #2,IDS:PRINT #2,COMTS 1170 PRINT #2,LLS 1180 PRINT #2,AAS </pre>	<pre> Sets reflectance correction factor to 0.0% To error-check code subroutine  To wait subroutine Start of measurement section  Requests whether or not measuring button will be used and waits for reply To measuring button enable subsection if answer is "Y" (yes)  Takes measurement when Enter is pressed To section for receiving data Start of measuring button enable subsection Enables measuring button To error-check code subroutine  Start of section for receiving data  To error-check code subroutine Inputs spectral data output by CM-2002  Inputs ID and comment Inputs color mode Inputs L* data Inputs a* data Inputs b* data Disables measuring button To error-check code subroutine Start of section for displaying data  Displays spectral data  Displays ID Displays L* data Displays a* data Displays b* data Start of section for saving data to disk To wait subroutine  Requests whether data should be saved to disk and waits for answer Skips to end of section if answer is "N" (no) Requests file name and receives answer Opens disk file  Saves spectral data to disk  Saves ID and comment to disk Saves L* data to disk Saves a* data to disk </pre>
--	--

1190 PRINT #2,BBS	Saves b* data to disk
1200 CLOSE #2	Closes disk file
1210 GOSUB 1380	To wait subroutine
1220 '***** CONTINUE OR END?	Start of section for continuing or ending
1230 CLS	
1240 INPUT "TAKE ANOTHER MEASUREMENT? (Y/N)",ANS2\$	Requests whether or not to continue and receives answer
1250 IF ANS2\$<>"Y" AND ANS2\$<>"N" THEN 1240	Skips next line if answer is "N" (no)
1260 IF ANS2\$="N" THEN 1280	To measurement section
1270 GOTO 660	Closes all ports and files
1280 CLOSE	Ends program
1290 END	Start of error-check code subroutine
1300 '***** ERROR-CHECK CODE HANDLING	Inputs error-check code
1310 INPUT #1,ERS	Returns from subroutine if no error
1320 IF LEFT\$(ERS,2)="OK" THEN RETURN	Skips next line if error
1330 IF LEFT\$(ERS,1)="E" THEN 1350	Prints error-check code;
1340 PRINT ERS:RETURN	returns from subroutine
1350 PRINT ERS	Prints error-check code
1360 PRINT "ERROR HAS OCCURRED. PROGRAM WILL END."	Closes all ports and files and ends program
1370 CLOSE:END	Start of wait subroutine
1380 '***** WAIT	
1390 LOCATE 17,8:PRINT "PRESS SPACE BAR TO CONTINUE"	
1400 SS=INKEYS:IF SS<>" " THEN 1400	Waits until space bar is pressed before continuing
1410 RETURN	Returns to program

1 Baud rate: 4800; parity: even; character length: 7; stop bits: 1

## PROGRAM 2

The following program consists of a series of subroutines for performing different CM-2002 commands. The subroutines are accessed by setting the appropriate line number in place of #### in line 300 of the program. Before running the program, be sure to set the appropriate line number in line 300.

```

100 '*****
110 '* CM-2002 SAMPLE PROGRAM 2: Command modules
120 '*****
130 '* NOTE: BEFORE RUNNING THIS PROGRAM,
CHANGE "####" IN LINE 300
140 '* TO THE FIRST LINE NUMBER OF THE
DESIRED MODULE.
150 '*****
160 '
170 '***** INITIALIZE
180 DIM D$(31),D(31)
190 CLS
200 PRINT "CHECK CM-2002 SET UP:"
210 PRINT "Baud Rate: 4800; Parity: EVEN;
Character: 7; Stop Bit: 1"
220 PRINT "IS CM-2002 SET TO REMOTE MODE?"
230 PRINT "AFTER PREPARATIONS ARE COMPLETE, PRESS
SPACE BAR TO CONTINUE."
240 $$=INKEY$:IF $$<>" " THEN 240
250 OPEN "COM1:4800,E,7,1,CS,DS,CD" AS #1
260 PRINT #1,CHR$(3)
270 GOSUB 4650
280 '***** CALL REQUIRED SUBROUTINE
290 CLS
300 GOSUB ####
310 CLOSE
320 END
330 '***** ATE: Target color auto select enable
340 PRINT #1,"ATE"
350 GOSUB 4650
360 RETURN
370 '***** AVG: Manual measurement averaging
380 CLS
390 PRINT #1,"AVE"
400 PRINT #1,"1"
410 GOSUB 4650
420 PRINT #1,"PDS"
430 PRINT #1,"000000100000000000"
440 GOSUB 4650
450 PRINT #1,"AVG"
460 GOSUB 4650
470 MEASF=0
480 PRINT "POSITION CM-2002 ON SPECIMEN,"
490 PRINT "THEN PRESS ENTER TO TAKE
MEASUREMENT.":PRINT
500 PRINT "PRESS ESC TO END MEASUREMENT SERIES."
510 $$=INKEY$:IF $$<>CHR$(27) AND $$<>CHR$(13)
THEN 510
520 IF $$=CHR$(27) THEN 640
530 PRINT #1,"MSC":MEASF=1
540 CLS
550 LOCATE 5,5:PRINT "TAKING MEASUREMENT."
560 TT$=RIGHT$(TIMES,1)
570 TT=VAL(TT$)
580 TT2=TT+4
590 IF TT2>9 THEN TT2=TT2-10
600 TT$=RIGHT$(TIMES,1)
610 TT=VAL(TT$)
620 IF TT<>TT2 THEN 600
630 CLS:GOTO 480
640 PRINT #1,"AVG"
650 GOSUB 4650

```

Creates arrays D\$ and D

Waits for space bar  
Opens RS-232C port  
Prints break code  
To error-check code subroutine

To subroutine specified by  
line number replacing ####  
Closes all ports and files  
Ends program  
Start of ATE subroutine  
Enables target color auto  
select function  
To error-check code subroutine  
Returns from subroutine  
Start of AVG subroutine

Sets number of measurements to  
be taken and averaged to 1  
To error-check code subroutine  
Enables SPECTRAL data display

To error-check code subroutine  
Starts manual averaging  
To error-check code subroutine  
Sets measurement flag to 0

Waits for Enter or Esc to be  
pressed  
Skips to line 640 if Esc was  
pressed  
Takes measurement and sets  
measurement flag to 1

Waits 4 seconds

To measurement section  
Ends manual averaging  
To error-check code subroutine

<pre> 660 IF MEASF=0 THEN RETURN 670 FOR I=1 TO 31 680   INPUT #1,DS(I) 690 NEXT I 700 INPUT #1,IDS:INPUT #1,COMTS 710 FOR I=1 TO 31 720   PRINT DS(I), 730 NEXT I 740 PRINT IDS:PRINT COMTS 750 GOSUB 4730 760 CLS 770 RETURN 780 '***** BZD: Buzzer disable 790 PRINT #1,"BZD" 800 GOSUB 4650 810 RETURN 820 '***** BZE: Buzzer enable 830 PRINT #1,"BZE" 840 GOSUB 4650 850 RETURN 860 '***** CDR: Calibration data request 870 PRINT #1,"CDR"  880 GOSUB 4650 890 FOR I=1 TO 31 900   INPUT #1,DS(I) 910 NEXT I 920 FOR I=1 TO 31 930   PRINT DS(I), 940 NEXT I 950 GOSUB 4730 960 CLS 970 RETURN 980 '***** CDS: Calibration data set 990 DATA 100.00,100.00,100.00,100.00,100.00 1000 DATA 100.00,100.00,100.00,100.00,100.00 1010 DATA 100.00,100.00,100.00,100.00,100.00 1020 DATA 100.00,100.00,100.00,100.00,100.00 1030 DATA 100.00,100.00,100.00,100.00,100.00 1040 DATA 100.00,100.00,100.00,100.00,100.00,100.00 1050 RESTORE 990  1060 FOR I=1 TO 31 1070   READ D(I) 1080 NEXT I 1090 PRINT #1,"CDS"  1100 FOR I=1 TO 31 1110   PRINT #1,D(I) 1120 NEXT I 1130 GOSUB 4650 1140 RETURN 1150 '***** CMS: Memory card data save 1160 CLS 1170 PRINT "ALL DATA IN DISK FILE WILL BE READ 1180 PRINT "AND SAVED TO MEMORY CARD.":PRINT 1190 INPUT "INPUT FILE NAME. (FILE WILL BE READ FROM DRIVE C.)",FFS 1200 OPEN "C:"+FFS FOR INPUT AS #2 1210 PRINT:PRINT "PROCESS WILL BEGIN WHEN SPACE BAR IS PRESSED." 1220 GOSUB 4730 1230 CLS 1240 PRINT "READING/STORING DATA" 1250 PRINT #1,"CMS" 1260 PRINT #1,"S" 1270 FOR I=1 TO 8192 1280   FOR J=1 TO 16 1290     INPUT #2,DS 1300     PRINT #1,DS 1310   NEXT J 1320   INPUT #1,ACKS 1330 NEXT I </pre>	<pre> Returns from subroutine if no measurements were taken Inputs spectral data output by CM-2002  Inputs ID and comment  Displays spectral data  Displays ID and comment To wait subroutine  Returns from subroutine Start of BZD subroutine Disables buzzer To error-check code subroutine Returns from subroutine Start of BZE subroutine Enables buzzer To error-check code subroutine Returns from subroutine Start of CDR subroutine Requests output of white calibration data To error-check code subroutine Inputs white calibration data output by CM-2002  Displays white calibration data  To wait subroutine  Returns from subroutine Start of CDS subroutine  ] White calibration data  Ensures READ statement will start from line 990  Reads white calibration data  Prepares CM-2002 to receive white calibration data Sends white calibration data to CM-2002  To error-check code subroutine Returns from subroutine Start of CMS subroutine  Requests file name and receives answer Opens disk file  To wait subroutine  Prepares CM-2002 to receive measurement data Start of data output  Inputs data from disk file Outputs data to CM-2002  Inputs "A" from CM-2002 </pre>
--	--

1340	CLOSE #2	Closes disk file
1350	PRINT #1,"E"	End of data output
1360	GOSUB 4650	To error-check code subroutine
1370	GOSUB 4730	To wait subroutine
1380	CLS	
1390	RETURN	Returns from subroutine
1400	'***** DQR: Measurement data quantity request	Start of DQR subroutine
1410	PRINT #1,"DQR"	Requests output of data quantity
1420	GOSUB 4650	To error-check code subroutine
1430	INPUT #1,DQS	Inputs data quantity output by CM-2002
1440	PRINT DQS;" SPECIMEN DATA HAVE BEEN MEASURED."	Displays data quantity
1450	GOSUB 4730	To wait subroutine
1460	CLS	
1470	RETURN	Returns from subroutine
1480	'***** IDR: CM-2002 serial number request	Start of IDR subroutine
1490	PRINT #1,"IDR"	Requests output of CM-2002 serial number
1500	GOSUB 4650	To error-check code subroutine
1510	INPUT #1,IDS	Inputs serial number output by CM-2002
1520	PRINT "THE CM-2002'S SERIAL NUMBER IS ";IDS	Displays serial number
1530	GOSUB 4730	To wait subroutine
1540	CLS	
1550	RETURN	Returns from subroutine
1560	'***** LDR: Tolerance data request	Start of LDR subroutine
1570	PRINT #1,"PDS"	Enables Yxy (ABS) data display
1580	PRINT #1,"010000000000000000"	
1590	GOSUB 4650	To error-check code subroutine
1600	PRINT #1,"LDR"	Requests output of tolerance data
1610	GOSUB 4650	To error-check code subroutine
1620	INPUT #1,DSPS	Inputs color mode
1630	FOR I=1 TO 4	Inputs $\Delta Y$ , $\Delta x$ , $\Delta y$ , and $\Delta E^*_{ab}$
1640	INPUT #1,DS(I)	tolerance data
1650	NEXT I	
1660	PRINT "TOLERANCE OF ";DSPS	Displays color mode
1670	FOR I=1 TO 4	Displays $\Delta Y$ , $\Delta x$ , $\Delta y$ , and $\Delta E^*_{ab}$
1680	PRINT DS(I),	tolerance data
1690	NEXT I	
1700	PRINT	
1710	PRINT "MINUS VALUES INDICATE NO TOLERANCE HAS BEEN SET."	
1720	GOSUB 4730	To wait subroutine
1730	CLS	
1740	RETURN	Returns from subroutine
1750	'***** LDS: Tolerance data set	Start of LDS subroutine
1760	CLS	
1770	PRINT "TOLERANCE VALUES FOR Yxy AND WI(CIE) WILL BE SET."	
1780	PRINT #1,"LDS"	
1790	PRINT #1,"Yxy"	Prepares CM-2002 to receive tolerance data
1800	PRINT #1,"-1"	Indicates tolerance data will be for Yxy color mode
1810	PRINT #1,"0.05"	Outputs $\Delta Y$ data: No tolerance values
1820	PRINT #1,"0.06"	Outputs $\Delta x$ data: 0.05
1830	PRINT #1,"-1"	Outputs $\Delta y$ data: 0.06
1840	GOSUB 4650	Outputs $\Delta E^*_{ab}$ data: No tolerance values
1850	PRINT #1,"LDS"	To error-check code subroutine
1860	PRINT #1,"WI"+CHR\$(95)+"CIE"	Prepares CM-2002 to receive tolerance data
1870	PRINT #1,"2.0"	Indicates tolerance data will be for WI(CIE) color mode
1880	PRINT #1,CHR\$(13)	Outputs $\Delta WI$ data: 2.0
1890	PRINT #1,CHR\$(13)	Outputs carriage return
1900	PRINT #1,CHR\$(13)	Outputs carriage return
1910	GOSUB 4650	Outputs carriage return
1920	GOSUB 4730	To error-check code subroutine
1930	CLS	To wait subroutine
1940	RETURN	Returns from subroutine

1950	'***** MDR: Single memory card specimen data request	Start of MDR subroutine
1960	PRINT #1, "PDS"	Enables XYZ (ABS) and SPECTRAL data displays
1970	PRINT #1, "100000100000000000"	To error-check code subroutine
1980	GOSUB 4650	Requests output of measurement data
1990	PRINT #1, "MDR"	To error-check code subroutine
2000	GOSUB 4650	Inputs spectral data output by CM-2002
2010	FOR I=1 TO 31	
2020	INPUT #1, DS(I)	
2030	NEXT I	
2040	INPUT #1, IDS: INPUT #1, COMTS	Inputs ID and comment
2050	INPUT #1, DSPS	Inputs color mode
2060	INPUT #1, XXS	Inputs X data
2070	INPUT #1, YYS	Inputs Y data
2080	INPUT #1, ZZS	Inputs Z data
2090	FOR I=1 TO 31	
2100	PRINT DS(I),	Displays spectral data
2110	NEXT I: PRINT	
2120	PRINT IDS: PRINT COMTS	Displays ID and comment
2130	PRINT DSPS	Displays color mode
2140	PRINT XXS	Displays X data
2150	PRINT YYS	Displays Y data
2160	PRINT ZZS	Displays Z data
2170	GOSUB 4730	To wait subroutine
2180	CLS	
2190	RETURN	Returns from subroutine
2200	'***** MDS: Single memory card measurement data set	Start of MDS subroutine
2210	DATA 100.00, 100.00, 100.00, 100.00, 100.00	] Measurement data
2220	DATA 100.00, 100.00, 100.00, 100.00, 100.00	
2230	DATA 100.00, 100.00, 100.00, 100.00, 100.00	
2240	DATA 100.00, 100.00, 100.00, 100.00, 100.00	
2250	DATA 100.00, 100.00, 100.00, 100.00, 100.00	
2260	DATA 100.00, 100.00, 100.00, 100.00, 100.00, 100.00	
2270	DATA "9106152030400100I", "SAMPLE"	
2280	RESTORE 2210	ID and comment
2290	FOR I=1 TO 31	Ensures READ statement will start from line 2210
2300	READ DS(I)	Reads measurement data
2310	NEXT I	
2320	READ IDS: READ COMTS	Reads ID and comment
2330	PRINT #1, "MDS"	Prepares CM-2002 to receive measurement data
2340	FOR I=1 TO 31	Outputs measurement data to CM-2002 and displays measurement data
2350	PRINT #1, DS(I): PRINT DS(I),	Outputs ID and comment
2360	NEXT I: PRINT	Displays ID and comment
2370	PRINT #1, IDS: PRINT #1, COMTS	To error-check code subroutine
2380	PRINT IDS: PRINT COMTS	To wait subroutine
2390	GOSUB 4650	
2400	GOSUB 4730	Returns from subroutine
2410	CLS	Start of MES subroutine
2420	RETURN	
2430	'***** MES: Measurement and output of spectral data	
2440	PRINT "A MEASUREMENT WILL BE TAKEN WHEN THE SPACE BAR IS PRESSED."	To wait subroutine
2450	GOSUB 4730	Takes measurement
2460	PRINT #1, "MES"	
2470	CLS	
2480	LOCATE 5, 5: PRINT "TAKING MEASUREMENT"	To error-check code subroutine
2490	GOSUB 4650	Inputs spectral data output by CM-2002
2500	FOR I=1 TO 31	
2510	INPUT #1, DS(I)	
2520	NEXT I	
2530	INPUT #1, IDS: INPUT #1, COMTS	Inputs ID and comment
2540	FOR I=1 TO 31	
2550	PRINT DS(I),	Displays spectral data
2560	NEXT I: PRINT	
2570	PRINT IDS: PRINT COMTS	Displays ID and comment
2580	GOSUB 4730	To wait subroutine
2590	CLS	
2600	RETURN	Returns from subroutine

2610	'***** MIR: MI illuminant request	Start of MIR subroutine
2620	PRINT #1,"MIR"	Requests output of illuminant settings
2630	GOSUB 4650	To error-check code subroutine
2640	INPUT #1,XXYYS	Inputs illuminant settings
2650	PRINT "REFERENCE ILLUMINANT: ";LEFT\$(XXYYS,2)	Displays reference illuminant
2660	PRINT "TEST ILLUMINANT: ";RIGHT\$(XXYYS,2)	Displays test illuminant
2670	PRINT:PRINT "ILLUMINANT CODES:"	
2680	PRINT "00:A 01:C 02:D50 03:D65 04:F2 05:F6"	Displays illuminant codes
2690	PRINT "06:F7 07:F8 08:F10 09:F11 10:F12"	
2700	GOSUB 4730	To wait subroutine
2710	CLS	
2720	RETURN	Return from subroutine
2730	'***** MIS: MI illuminant set	Start of MIS subroutine
2740	PRINT #1,"MIS"	Sets D <sub>65</sub> as reference illuminant and F2 as test illuminant
2750	PRINT #1,"0304"	
2760	GOSUB 4650	To error-check code subroutine
2770	RETURN	Returns from subroutine
2780	'***** PDR: Data display parameter request	Start of PDR subroutine
2790	PRINT #1,"PDR"	Requests output of display parameters
2800	GOSUB 4650	To error-check code subroutine
2810	INPUT #1,PDS	Inputs display parameters
2820	PRINT PDS	Displays display parameters
2830	GOSUB 4730	To wait subroutine
2840	CLS	
2850	RETURN	Returns from subroutine
2860	'***** RCR: Reflectance correction factor request	Start of RCR subroutine
2870	PRINT #1,"RCR"	Requests output of reflectance correction factor
2880	GOSUB 4650	To error-check code subroutine
2890	INPUT #1,RCS	Inputs reflectance correction factor
2900	PRINT "REFLECTANCE CORRECTION FACTOR: ";VAL(RCS)/10;"%"	Displays reflectance correction factor
2910	GOSUB 4730	To wait subroutine
2920	CLS	
2930	RETURN	Returns from subroutine
2940	'***** SAV: Save measurement conditions, etc. to memory card	Start of SAV subroutine
2950	PRINT #1,"SAV"	Saves measurement conditions, etc. to memory card
2960	GOSUB 4650	To error-check code subroutine
2970	PRINT "MEASUREMENT CONDITIONS, ETC. SAVED TO MEMORY CARD."	
2980	GOSUB 4730	To wait subroutine
2990	CLS	
3000	RETURN	Returns from subroutine
3010	'***** SDS: Specimen data series set	Start of SDS subroutine
3020	DATA 88.10,89.20,90.20,91.10,91.90,92.70	] Specimen data 1
3030	DATA 93.40,94.00,94.50,95.00,95.40,95.70	
3040	DATA 96.00,96.20,96.30,96.35,96.39,96.42	] Specimen data 2
3050	DATA 96.44,96.45,96.45,96.45,96.46,96.46	
3060	DATA 96.46,96.47,96.47,96.47,96.47,96.48,96.48	
3070	DATA "9106152030400100I","TEST1"	ID and comment 1
3080	'	
3090	DATA 84.10,85.20,86.20,87.10,87.90,88.70	] Specimen data 2
3100	DATA 89.40,90.00,90.50,91.00,91.40,91.70	
3110	DATA 92.00,92.20,92.30,92.35,92.39,92.42	] Specimen data 2
3120	DATA 92.44,92.45,92.45,92.45,92.46,92.46	
3130	DATA 92.46,92.47,92.47,92.47,92.47,92.48,92.48	
3140	DATA "9106152035450100E","TEST2"	ID and comment 2
3150	RESTORE 3020	Ensures READ statement will start from line 3020
3160	PRINT #1,"SDS"	Prepares CM-2002 to receive specimen data
3170	PRINT #1,"2"	Number of specimen data sets: 2

```

3180 FOR J=1 TO 2
3190   FOR I=1 TO 31
3200     READ D(I):PRINT #1,D(I)
3210     NEXT I
3220     READ IDS:READ COMTS
3230     PRINT #1,IDS:PRINT #1,COMTS

3240   GOSUB 4650
3250 NEXT J
3260 RETURN
3270 '***** SNR: Specimen number request
3280 PRINT #1,"SNR"

3290 GOSUB 4650
3300 INPUT #1,SN$
3310 PRINT "PRESENT SPECIMEN NUMBER: ";SN$
3320 GOSUB 4730
3330 CLS
3340 RETURN
3350 '***** SNS: Specimen number set
3360 PRINT #1,"SNS"
3370 PRINT #1,"20"
3380 GOSUB 4650
3390 RETURN
3400 '***** STR: Status request
3410 PRINT #1,"STR"
3420 GOSUB 4650
3430 INPUT #1,STR$:PRINT STR$

3440 GOSUB 4730
3450 CLS
3460 RETURN
3470 '***** SES: Switch enable--spectral
3480 PRINT #1,"SES"
3490 GOSUB 4650
3500 PRINT "CM-2002 MEASURING BUTTON
ENABLED.":PRINT
3510 PRINT "POSITION CM-2002 ON SPECIMEN,"
3520 PRINT "THEN PRESS MEASURING BUTTON TO TAKE
MEASUREMENT."
3530 PRINT:PRINT
3540 PRINT "WAITING FOR DATA FROM CM-2002."
3550 GOSUB 4650
3560 FOR I=1 TO 31
3570   INPUT #1,DS(I)
3580 NEXT I
3590 INPUT #1,IDS:INPUT #1,COMTS
3600 FOR I=1 TO 31
3610   PRINT DS(I),
3620 NEXT I:PRINT
3630 PRINT IDS:PRINT COMTS
3640 PRINT #1,"SWD"
3650 GOSUB 4650
3660 GOSUB 4730
3670 CLS
3680 RETURN
3690 '***** TDR: Target data request
3700 PRINT #1,"PDS"
3710 PRINT #1,"00100010000000000"
3720 GOSUB 4650
3730 PRINT #1,"TDR"
3740 GOSUB 4650
3750 FOR I=1 TO 31
3760   INPUT #1,DS(I)
3770 NEXT I
3780 INPUT #1,IDS:INPUT #1,COMTS
3790 INPUT #1,DSPS
3800 INPUT #1,LLS
3810 INPUT #1,AA$
3820 INPUT #1,BB$
3830 FOR I=1 TO 31
3840   PRINT DS(I),
3850 NEXT I:PRINT
3860 PRINT IDS:PRINT COMTS:PRINT

```

```

Reads specimen data and
outputs specimen data to CM-
2002
Reads ID and comment
Outputs ID and comment to CM-
2002
To error-check code subroutine

Returns from subroutine
Start of SNR subroutine
Requests output of specimen
number
To error-check code subroutine
Inputs specimen number
Displays specimen number
To wait subroutine

Returns from subroutine
Start of SNS subroutine
Sets specimen number of CM-
2002 to 20
To error-check code subroutine
Returns from subroutine
Start of STR subroutine
Requests output of status word
To error-check code subroutine
Inputs and displays status
word
To wait subroutine

Returns from subroutine
Start of SES subroutine
Enables measuring button
To error-check code subroutine

To error-check code subroutine
Inputs spectral data from CM-
2002

Inputs ID and comment

Displays spectral data

Displays ID and comment
Disables measuring button
To error-check code subroutine
To wait subroutine

Returns from subroutine
Start of TDR subroutine
Enables L*a*b* and SPECTRAL
data displays
To error-check code subroutine
Requests output of target data
To error-check code subroutine
Inputs spectral target data
from CM-2002

Inputs ID and comment
Inputs color mode
Inputs L* target data
Inputs a* target data
Inputs b* target data

Displays spectral target data

Displays ID and comment

```



```

3870 PRINT DSP$
3880 PRINT LLS$
3890 PRINT AAS$
3900 PRINT BBS$
3910 GOSUB 4730
3920 CLS
3930 RETURN
3940 '***** TDS: Target data set
3950 DATA 88.10,89.20,90.20,91.10,91.90,92.70
3960 DATA 93.40,94.00,94.50,95.00,95.40,95.70
3970 DATA 96.00,96.20,96.30,96.35,96.39,96.42
3980 DATA 96.44,96.45,96.45,96.45,96.46,96.46
3990 DATA 96.46,96.47,96.47,96.47,96.47,96.48,96.48
4000 DATA "9106150000000100I", "TARGET"
4010 RESTORE 3950

4020 PRINT #1, "TDS"

4030 FOR I=1 TO 31
4040   READ D(I):PRINT #1,D(I)
4050 NEXT I
4060 READ IDS:READ COMTS$
4070 PRINT #1,IDS:PRINT #1,COMTS$
4080 GOSUB 4650
4090 RETURN
4100 '***** TGD: Target data delete
4110 PRINT #1, "TGD"
4120 PRINT #1, "1"
4130 GOSUB 4650
4140 RETURN
4150 '***** TGR: Target data recover
4160 PRINT #1, "TGR"
4170 PRINT #1, "1"
4180 GOSUB 4650
4190 RETURN
4200 '***** TNR: Target number request
4210 PRINT #1, "TNR"

4220 GOSUB 4650
4230 INPUT #1,TNS$

4240 PRINT TNS
4250 GOSUB 4730
4260 CLS
4270 RETURN
4280 '***** TNS: Target number set
4290 PRINT #1, "TNS"
4300 PRINT #1, "50"
4310 GOSUB 4650
4320 RETURN
4330 '***** UZC: User zero calibration
4340 PRINT "ZERO CALIBRATION WILL BE
PERFORMED.":PRINT
4350 PRINT #1, "SEC"
4360 GOSUB 4650
4370 PRINT #1, "UZC"

4380 GOSUB 4650
4390 PRINT "AFTER PREPARATIONS FOR ZERO CALIBRATION
HAVE BEEN COMPLETED,"
4400 PRINT "PRESS MEASURING BUTTON."
4410 GOSUB 4650
4420 PRINT #1, "SWD"
4430 GOSUB 4650
4440 PRINT #1,CHRS(3)
4450 GOSUB 4650
4460 CLS
4470 RETURN
4480 '***** To display messages in CM-2002's LCD

4490 CLS
4500 PRINT "MESSAGE WILL BE DISPLAYED IN CM-2002'S
LCD."
4510 PRINT #1,CHRS(&H13)

```

```

Displays color mode
Displays L* target data
Displays a* target data
Displays b* target data
To wait subroutine

Returns from subroutine
Start of TDS subroutine

] Target data

ID and comment
Ensures READ statement will
start from line 3950
Prepares CM-2002 to receive
target data
Reads target data and outputs
target data to CM-2002

Reads ID and comment
Outputs ID and comment
To error-check code subroutine
Returns from subroutine
Start of TGD subroutine
Temporarily deletes CM-2002
data for target number 1
To error-check code subroutine
Returns from subroutine
Start of TGR subroutine
Recovers CM-2002 data for
target number 1
To error-check code subroutine
Returns from subroutine
Start of TNR subroutine
Requests output of target
number
To error-check code subroutine
Inputs target number output by
CM-2002
Displays target number
To wait subroutine

Returns from subroutine
Start of TNS subroutine
Sets CM-2002 target number to
50
To error-check code subroutine
Returns from subroutine
Start of UZC subroutine

Enables measuring button
To error-check code subroutine
Prepares CM-2002 to perform
zero calibration
To error-check code subroutine

To error-check code subroutine
Disables measuring button
To error-check code subroutine
Outputs break code to CM-2002
To error-check code subroutine

Returns from subroutine
Start of terminal mode
subroutine

Sets CM-2002 to terminal mode

```

4520 GOSUB 4650	To error-check code subroutine
4530 LOCATE 3,2	
4540 PRINT "INPUT MESSAGE TO BE DISPLAYED."	Requests message
4550 LOCATE 5,2	
4560 PRINT "INPUT '\$SEND' TO END MODE."	
4570 INPUT ANSS	Receives message
4580 IF ANSS="\$SEND" THEN 4610	Skips to line 4610 to end terminal mode
4590 PRINT #1,ANSS	Outputs message to CM-2002
4600 GOTO 4530	Repeats message input/display sequence
4610 PRINT #1,CHRS(3)	Outputs break code to CM-2002
4620 CLS	
4630 RETURN	Returns from subroutine
4640 '	
4650 '***** ERROR-CHECK CODE HANDLING	Start of error-check code subroutine
4660 INPUT #1,ERS	Inputs error-check code
4670 IF LEFT\$(ERS,2)="OK" THEN RETURN	Returns from subroutine if no error
4680 IF LEFT\$(ERS,1)="E" THEN 4700	Skips next line if error
4690 PRINT ERS:RETURN	Prints error-check code; returns from subroutine
4700 PRINT ERS	Prints error-check code
4710 PRINT "ERROR HAS OCCURRED. PROGRAM WILL END."	
4720 CLOSE:END	Closes all ports and files and ends program
4730 '***** WAIT	Start of wait subroutine
4740 LOCATE 20,20:PRINT "PRESS SPACE BAR TO CONTINUE."	
4750 SS=INKEY\$:IF SS<>" " THEN 4750.	Waits for space bar
4760 RETURN	Returns from subroutine

1 Baud rate: 4800; parity: even; character length: 7; stop bits: 1

## Detailed Descriptions of Commands

### ATD (Auto Target Disable)

**Function:**

Sets target color auto select function (p. 54) to off.

Required input to CM-2002:

"ATD" <CR>

Response from CM-2002:

Error-check code <CR> (See p. 91.)

### ATE (Auto Target Enable)

**Function:**

Sets target color auto select function (p. 54) to on.

Required input to CM-2002:

"ATE" <CR>

Response from CM-2002:

Error-check code <CR> (See p. 91.)

### AVE (Set Automatic Averaging Number)

**Function:**

Sets number of measurements to be automatically taken and averaged.

Required input to CM-2002:

"AVE" <CR>

Number of measurements to be taken and averaged <CR>

Response from CM-2002:

Error-check code <CR> (See p. 91.)

- Number of measurements can be set to 1, 3, 5, or 8. If a value other than 1, 3, 5, or 8 is input, the value will be automatically set to 1.
- Measurements will be automatically taken and averaged only if the command "MSC" is used to take measurements or if the measuring button is pressed after being enabled using the command "SEC". If the command "MES" is used to take measurements or the measuring button is pressed after being enabled using the command "SES", only one measurement will be taken regardless of the previously set number of measurements to be automatically taken and averaged.

## AVG (Manual Average Control)

### Function:

When input the first time, indicates start of series of measurements to be taken manually and averaged.  
When input the second time, indicates the end of the series of measurements to be averaged. The average of the measurements taken between the first time "AVG" is input and the second time "AVG" is input is then calculated and the results (both spectral data and data for all enabled color mode data displays) are output to the computer.

### Required input to CM-2002:

(To start series of measurements)

"AVG" < CR >

[Take measurements using command "MSC" or "MES" or pressing measuring button]

(To end series of measurements)

"AVG" < CR >

### Response from CM-2002:

Error-check code < CR > (See p. 91.)

Error-check code < CR > (See p. 91.)

Averaged spectral reflectance data (See p. 93.)

Data ID < CR > (See p. 93.)

Comment < CR > (See p. 93.)

Averaged data for each enabled color mode data display (See p. 94.)

- Because there is no comment, only the delimiter code will be output.
- After inputting "AVG" the first time, measurements can be taken by inputting the command "MES" or "MSC", or by pressing the CM-2002's measuring button (if it has been enabled). Commands other than "MES" or "MSC" will not be accepted and the error-check code will not be output even if such unacceptable commands are input.
- Even if measurements are taken by inputting the command "MES" or by pressing the measuring button (after it has been enabled using the command "SES"), averaged data will be output according to the above output format (with output of both spectral data and data for each enabled color mode data display).
- Up to 100 measurements can be taken for averaging. When the 100th measurement is taken, the measurements will be automatically averaged (even though "AVG" has not been input a second time), the average measurement data will be output, and manual averaging mode will be canceled.
- To interrupt the series of measurements and cancel manual averaging mode, input the break code (p. 87) or press **BREAK/DELETE** on the CM-2002.
- The time required for data output depends on the number of color mode data displays which have been enabled.

## BZD (Buzzer Disable)

### Function:

Disables CM-2002's internal buzzer.

### Required input to CM-2002:

"BZD" < CR >

### Response from CM-2002:

Error-check code < CR > (See p. 91.)

## BZE (Buzzer Enable)

### Function:

Enables CM-2002's internal buzzer.

### Required input to CM-2002:

"BZE" < CR >

### Response from CM-2002:

Error-check code < CR > (See p. 91.)

### CAL (White Calibration)

**Function:**

Causes CM-2002 to enter white calibration mode.

Required input to CM-2002:

"CAL" <CR>

Response from CM-2002:

Error-check code <CR> (See p. 91.)

- After inputting this command, inputting the command "MES" or "MSC" or pressing the measuring button (if measuring button is enabled) will cause the CM-2002 to perform white calibration.
- In white calibration mode, any command (with the exception of "AVG") will be accepted by the CM-2002. If any such command is input and then the break code is input to cancel the command, white calibration mode will also be canceled.

### CDR (White Calibration Data Request)

**Function:**

Requests output of white calibration data presently stored in the memory of the CM-2002.

Required input to CM-2002:

"CDR" <CR>

Response from CM-2002:

Error-check code <CR> (See p. 91.)  
Spectral reflectance data (See p. 93.)

- The output spectral reflectance data is the presently stored spectral reflectance data for the white calibration surface.
- The output spectral reflectance data will be either SCI data or SCE data, depending on the present setting of the CM-2002.

### CDS (White Calibration Data Set)

**Function:**

Prepares CM-2002 to receive white calibration data.

Required input to CM-2002:

"CDS" <CR>  
Spectral reflectance data (See p. 90.)

Response from CM-2002:

Error-check code <CR> (See p. 91.)

- The input spectral reflectance data should be white calibration data for SCI or SCE measurements, depending on the present setting of the CM-2002. To input white calibration data for both SCI and SCE measurements, follow the steps below:
  1. Set CM-2002 to SCI.
  2. Input the command "CDS".
  3. Input the white calibration data for SCI measurements.
  4. Set CM-2002 to SCE.
  5. Input the command "CDS".
  6. Input the white calibration data for SCE measurements.

## CMR (Memory Card Data Request)

### Function:

Requests output of all 128KB of data stored on the memory card.

### Required input to CM-2002:

"CMR" <CR>

### Response from CM-2002:

Error-check code <CR> (See p. 91.)

"S" <CR>

First byte of data stored on memory card <CR>

Second byte of data stored on memory card <CR>

.

.

Last byte of data stored on memory card <CR>

"E" <CR>

- All 128KB of data stored on the memory card will be output byte by byte in ASCII code. For example, if four bytes of data stored on the memory card were "FF<sub>H</sub>", "FF<sub>H</sub>", "12<sub>H</sub>", and "01<sub>H</sub>", the output data would be "255", "255", "18" and "1".
- While data is being output, "/OUTPUT/" will appear in the CM-2002's display.
- Do not open the memory card chamber cover while data is being output.
- To interrupt data output, input the break code (p. 87) or press **BREAK/DELETE** on the CM-2002. When data output is interrupted, "E" will be output at the point of interruption.
- The error-check code "E19Y" or "E19N" will be output in the following cases:
  1. No memory card is installed.
  2. The memory card chamber cover is open.
  3. The battery of the memory card is low in power.

## CMS (Memory Card Data Set)

### Function:

Prepares CM-2002 to receive 128KB of data to be saved to the memory card.

### Required input to CM-2002:

"CMS" <CR>

"S" <CR>

One byte of data <CR>

One byte of data <CR>

.

.

.

One byte of data <CR>

Repeat of (A)

Repeat of (A)

.

.

Final repeat of (A)

"E" <CR>

### Response from CM-2002:

"A" <CR>

"A" <CR>

"A" <CR>

.

.

"A" <CR>

Error-check code <CR> (See p. 91.)

- Data should be input byte by byte in ASCII code; it is stored on the memory card as hexadecimal notation. For example, if four bytes of input data are "0", "1", "255", and "53", the data will be stored on the memory card as "00<sub>H</sub>", "01<sub>H</sub>", "FF<sub>H</sub>", and "35<sub>H</sub>".
- "A" will be output by the CM-2002 after each 16 bytes of data. This character should be accepted by the computer before the next 16 bytes of data are input.
- While data is being input to the CM-2002, "/INPUT/" will be shown in the CM-2002's display.
- Do not open the memory card chamber cover while data is being input.
- After (A) above (input of 16 bytes of data) has been repeated 8192 times, "E" will be input to the CM-2002 to indicate the end of data input.
- To interrupt data input, input the break code (p. 87) or "E". Data input up to that point will be stored on the memory card.
- In the following cases, the error-check code "E19Y" or "E19N" will be output by the CM-2002 immediately after the command "CMS" has been input to the CM-2002:
  1. No memory card is installed.
  2. The memory card chamber cover is open.
  3. The battery of the memory card is low in power.
  4. The write-protect switch of the memory card is set to ON.

## DQR (Measurement Data Quantity Request)

### Function:

Requests output of the number of specimen numbers for which measurement data is stored on the memory card.

### Required input to CM-2002:

"DQR" <CR>

### Response from CM-2002:

Error-check code <CR> (See p. 91.)

Number of specimen numbers for which  
measurement data is stored <CR>

- "0" will be output if the memory card contains no measurement data or if no memory card is installed.

IDR (ID Request)

Function:

Requests output of the serial number of the CM-2002.

• Required input to CM-2002:

"IDR" <CR>

Response from CM-2002:

Error-check code <CR> (See p. 91.)  
Serial number of CM-2002 <CR>

- The serial number of the CM-2002 consists of 8 digits.



LDR (Limit Data Request)

Function:

Requests output of the tolerance values for the presently set target number.

Required input to CM-2002:

"LDR" <CR>

Response from CM-2002:

Error-check code <CR> (See p. 91.)  
 Color-mode ID <CR>  
 Tolerance value <CR>  
 Tolerance value <CR> (A)  
 Tolerance value <CR>  
 Tolerance value <CR>

- "- 0.01" will be output for any variable (except  $\Delta x$  or  $\Delta y$ ) for which no tolerance value has been set; "- 0.0001" will be output for  $\Delta x$  or  $\Delta y$  if no tolerance value has been set.
- (A) above is repeated for each enabled color mode data display.
- For 10 to 14 in the table below, only one tolerance value will be output. For example, if WI(E313) is enabled and the tolerance value is 10, output from the CM-2002 would be:  
 "WI \_ E313" <CR> (Color mode ID)  
 "10.0" <CR> (Tolerance value)

	Color mode ID	Color mode	Tolerance variables
1	"XYZ"	XYZ	$\Delta X, \Delta Y, \Delta Z, \Delta E^*_{ab}$
2	"Yxy"	Yxy	$\Delta Y, \Delta x, \Delta y, \Delta E^*_{ab}$
3	"L*a*b*"	L*a*b*	$\Delta L^*, \Delta a^*, \Delta b^*, \Delta E^*_{ab}$
4	"LCH"	L*C*H°	$\Delta L^*, \Delta C^*, \Delta H^*, \Delta E^*_{ab}$
5	"Lab"	Hunter Lab	$\Delta L, \Delta a, \Delta b, \Delta E$
6	"Luv"	L*u*v*	$\Delta L^*, \Delta u^*, \Delta v^*, \Delta E^*_{uv}$
7	"CMC(2:1)"	CMC(2:1)	$\Delta L^*, \Delta C^*, \Delta H^*, \text{CMC (2:1)}$
8	"CMC(1:1)"	CMC(1:1)	$\Delta L^*, \Delta C^*, \Delta H^*, \text{CMC (1:1)}$
9	"FMC2"	FMC-2	$\Delta L, \Delta RG, \Delta YB, \text{FMC-2}$
10	"MI"	MI (Metamerism index)	MI
11	"WI _ E313"	WI (Whiteness index) ASTM E 313	$\Delta WI$ (ASTM E 313)
12	"WI _ CIE"	WI (Whiteness index) CIE	$\Delta WI$ (CIE)
13	"YI _ E313"	YI (Yellowness index) ASTM E 313	$\Delta YI$ (ASTM E 313)
14	"YI _ D1925"	YI (Yellowness index) ASTM D 1925	$\Delta YI$ (ASTM D 1925)

LDS (Limit Data Set)

Function:

Prepares CM-2002 to receive tolerance values in one color mode for the presently set target number.

Required input to CM-2002:

"LDS" < CR >  
Color-mode ID < CR >  
Tolerance value < CR >  
Tolerance value < CR >  
Tolerance value < CR >  
Tolerance value < CR >

Response from CM-2002:

Error-check code < CR > (See p. 91.)

- Refer to the table on p. 113 for a listing of color mode IDs and tolerance variables for which values can be set.
- If correct characters are not output for color mode ID, the error-check code "E00Y" or "E00N" will be output.
- For all tolerance variables except  $\Delta x$  and  $\Delta y$ , values from 0.0 to 99.9 can be set; only values down to the first decimal place will be accepted and values for lower decimal places will be ignored. If a value greater than 99.9 is input, the value will automatically be set to 99.9.
- For  $\Delta x$  and  $\Delta y$ , values from 0.000 to 0.999 can be set; only values down to the third decimal place will be accepted and values for lower decimal places will be ignored. If a value greater than 0.999 is input, the value will automatically be set to 0.999.
- If no tolerance value will be set for a variable, input a negative value.
- For WI(E313), WI(CIE), YI(E313), and YI(D1925) color modes, only one tolerance value should be input; input only the delimiter code for the remaining three tolerance values. For example, to input a tolerance value of  $\Delta WI$  (ASTM E 313)=10, the following would be input for (A) above:  
    "WI \_ E313" < CR >  
    "10.0" < CR >  
    < CR >  
    < CR >  
    < CR >

MDR (One Memory Data Request)

Function:

Requests the output of measurement data (spectral data and data for each enabled color mode data display), data ID, and comment for the presently set specimen number.

Required input to CM-2002:

"MDR" < CR >

Response from CM-2002:

Error-check code < CR > (See p. 91.)  
Spectral reflectance data (See p. 93.)  
Data ID < CR > (See p. 93.)  
Comment < CR > (See p. 93.)  
Data for each enabled color mode data display  
(See p. 94.)

- The error-check code "E10Y" or "E10N" will be output if the memory card contains no measurement data.
- The error-check code "E19Y" or "E19N" will be output in the following cases:
  1. No memory card is installed.
  2. The memory card chamber cover is open.
  3. The battery of the memory card is low in power.
- The time required for data output depends on the number of color mode data displays which have been enabled.
- If the comment consists of the single letter "E", there is a chance that it will be mistaken for the "E" which indicates the end of data output. The program for the computer to receive data should be written to avoid this problem.

MDS (One Memory Data Set)

Function:

Prepares the CM-2002 to receive measurement data to be stored in the presently set specimen number.

Required input to CM-2002:

"MDS" <CR >

Spectral reflectance data (See p. 90.)

Data ID (See p. 90.)

Comment (See p. 91.)

Response from CM-2002:

Error-check code <CR > (See p. 91.)

- In the following cases, the error-check code "E19Y" or "E19N" will be output by the CM-2002 immediately after the command "MDS" has been input to the CM-2002:
  1. No memory card is installed.
  2. The memory card chamber cover is open.
  3. The battery of the memory card is low in power.
  4. The write-protect switch of the memory card is set to ON.
  5. The memory card contains no measurement data (there is no presently selected specimen number).

## MES (Measurement: Spectral)

### Function:

- Causes the CM-2002 to take a measurement. Only measured spectral reflectance data are output by the CM-2002 after the measurement has been completed; measurement data are not stored on the memory card.
  - In manual averaging mode (after the command "AVG" has been input once), causes the CM-2002 to take measurement but no response is output by CM-2002.
  - If input after the command "CAL" has been input, causes the CM-2002 to perform white calibration.
  - If input after the command "UZC" has been input, causes the CM-2002 to perform zero calibration.
- See p. 118 for information on the command "MSC", which can also be used to take measurements.

### Required input to CM-2002:

- To take measurement:  
"MES" < CR >

### Response from CM-2002:

(After measurement calculations have been completed)  
Error-check code < CR > (See p. 91.)  
Spectral reflectance data (See p. 93.)  
Data ID < CR > (See p. 93.)  
Comment < CR > (See p. 93.)

- In manual averaging mode (after "AVG" has been input once):

"MES" < CR >

(No output)

- In white calibration mode (after "CAL" has been input):

"MES" < CR >

(After white calibration has been completed)  
Error-check code < CR > (See p. 91.)

- In zero calibration mode (after "UZC" has been input):

"MES" < CR >

(After zero calibration has been completed)  
Error-check code < CR > (See p. 91.)

- When taking measurements, only one measurement will be taken, regardless of the setting of the number of measurements to be automatically taken and averaged.
- In manual averaging mode, no data are output until the command "AVG" is input a second time to end the series of measurements to be averaged.
- In white calibration mode, three measurements will be automatically taken. After the three measurements have been taken, white calibration is complete and white calibration mode is canceled.
- In zero calibration mode, three measurements will be automatically taken. After the three measurements have been taken, zero calibration is complete, zero calibration mode is canceled, and the CM-2002 will change to white calibration mode.
- To interrupt the series of measurements for white calibration or zero calibration, press **BREAK/DELETE** on the CM-2002.
- After a measurement has been taken, the CM-2002's RTS signal will be set to OFF while the lighting circuit charges. During this time, no command will be accepted.

MIR (Metamerism Illuminant Request)

Function:

Requests output of the reference and test illuminants selected for calculation of MI (metamerism index).

Required input to CM-2002:

"MIR" < CR >

Response from CM-2002:

Error-check code < CR > (See p. 91.)  
Reference illuminant code  
Test illuminant code < CR >

- A four-digit data word (two digits each for the reference illuminant code and the test illuminant code) will be output.
- Illuminant codes are two-digit codes from the table listed under "MIS" below.

MIS (Metamerism Illuminant Set)

Function:

Prepares CM-2002 to receive settings of reference and test illuminants for MI data display.

Required input to CM-2002:

"MIS" < CR >  
Reference illuminant code  
Test illuminant code < CR >

Response from CM-2002:

Error-check code < CR > (See p. 91.)

- Illuminant codes are two-digit codes listed in the table below:

Illuminant	Code	Illuminant	Code	Illuminant	Code
A	"00"	F2	"04"	F10	"08"
C	"01"	F6	"05"	F11	"09"
D <sub>50</sub>	"02"	F7	"06"	F12	"10"
D65	"03"	F8	"07"		

- A four-digit data word (two digits each for reference illuminant and test illuminant) should be input. For example, to set reference illuminant to D<sub>65</sub> and test illuminant to A, input "0300" as the data word.
- If either code (reference illuminant code or test illuminant code) is set to a value other than those listed in the table above, the illuminant corresponding to the unacceptable code will be set as if the corresponding illuminant code was "00". For example, if the input data word was "0A05" (reference illuminant code is unacceptable), the reference illuminant would be set as if the input data word was "0005" (reference illuminant code changed to "00").

## MSC (Measurement: Spectral and Colorimetric)

### Function:

- Causes the CM-2002 to take a measurement. Both spectral reflectance data and data for each enabled color mode data display are output by the CM-2002 after the measurement has been completed; measurement data are also stored on the memory card.
  - In manual averaging mode (after the command "AVG" has been input once), causes the CM-2002 to take measurement but no response is output by CM-2002.
  - If input after the command "CAL" has been input, causes the CM-2002 to perform white calibration.
  - If input after the command "UZC" has been input, causes the CM-2002 to perform zero calibration.
- See p. 118 for information on the command "MES", which can also be used to take measurements.

### Required input to CM-2002:

- To take measurement:  
"MSC" < CR >

### Response from CM-2002:

(After measurement calculations have been completed)  
Error-check code < CR > (See p. 91.)  
Spectral reflectance data (See p. 93.)  
Data ID < CR > (See p. 93.)  
Comment < CR > (See p. 93.)  
Data for each enabled color mode data display  
(See p. 94.)

- In manual averaging mode (after "AVG" has been input once):  
"MSC" < CR >

(No output)

- In white calibration mode (after "CAL" has been input):  
"MSC" < CR >

(After white calibration has been completed)  
Error-check code < CR > (See p. 91.)

- In zero calibration mode (after "UZC" has been input):  
"MSC" < CR >

(After zero calibration has been completed)  
Error-check code < CR > (See p. 91.)

- When taking measurements, the number of measurements taken will correspond to the setting of the number of measurements to be automatically taken and averaged (see p. 107).
- In manual averaging mode, no data is output until the command "AVG" is input a second time to end the series of measurements to be averaged.
- In white calibration mode, three measurements will be automatically taken. After the three measurements have been taken, white calibration is complete and white calibration mode is canceled.
- In zero calibration mode, three measurements will be automatically taken. After the three measurements have been taken, zero calibration is complete, zero calibration mode is canceled, and the CM-2002 will change to white calibration mode.
- To interrupt the series of measurements for white calibration or zero calibration, press **BREAK/DELETE** on the CM-2002.
- After a measurement has been taken, the CM-2002's RTS signal will be set to OFF while the lighting circuit charges. During this time, no command will be accepted.
- Even if no memory card is installed or the write-protect switch of the installed memory card is set to ON, data will be output.
- The time required for data output depends on the number of color mode data displays which have been enabled.

### OIR (Observer, Illuminant Request)

**Function:**

Requests output of the presently set observer and illuminant conditions.

**Required input to CM-2002:**

"OIR" < CR >

**Response from CM-2002:**

Error-check code < CR > (See p. 91.)  
Observer code  
Illuminant code < CR >

- A three-digit data word (one digit for observer code and two digits for illuminant code) will be output.
- Observer and illuminant codes are listed under "OIS" below.

### OIS (Observer, Illuminant Set)

**Function:**

Prepares CM-2002 to receive settings for observer and illuminant conditions.

**Required input to CM-2002:**

"OIS" < CR >  
Observer code  
Illuminant code < CR >

**Response from CM-2002:**

Error-check code < CR > (See p. 91.)

- The observer code is a one-digit code which can be set according to the table below:

Observer condition	Value
2° Standard Observer	"0"
10° Standard Observer	"1"

- The illuminant code is a two-digit code from the table below.

Illuminant	Code	Illuminant	Code	Illuminant	Code
A	"00"	F2	"04"	F10	"08"
C	"01"	F6	"05"	F11	"09"
D <sub>50</sub>	"02"	F7	"06"	F12	"10"
D65	"03"	F8	"07"		

- A three-digit data word (one digit for observer code and two digits for illuminant code) should be input. For example, to set 2° Standard Observer and Illuminant C conditions, input "001" as the data word.
- If values other than those listed above ("0" or "1" for the observer code, "00" through "10" for the illuminant code) are input, the CM-2002 will set the observer and illuminant as if the unacceptable code (observer code or illuminant code) was all zeros. For example, if the input data word is "502" (observer code is unacceptable), the CM-2002 will set the observer and illuminant as if the input data word was "002" (observer code changed to 0); likewise, if the input data word is "1A2" (illuminant code is unacceptable), the CM-2002 will set the observer and illuminant as if the input data word was "100" (illuminant code changed to 00).

PDR (Display Parameter Data Request)

Function:

Requests output of presently set data display parameters.

Required input to CM-2002:

"PDR" <CR>

Response from CM-2002:

Error-check code<CR> (See p. 91.)  
Display parameter data word<CR>

- The display parameter data word is a 17-digit data word. The meaning of the data word is described under "PDS" on the following page.



PDS (Display Parameter Data Set)

**Function:**

Prepares CM-2002 to receive data display parameters.

Required input to CM-2002:

"PDR" <CR>

Display parameter data word <CR>

Response from CM-2002:

Error-check code <CR> (See p. 91.)

- The display parameter data word is a 17-digit data word. Each digit should be set according to the desired setting of the corresponding data display as listed in the table below:

Data display	Digit position	Data display	Digit position	Data display	Digit position
XYZ	1	SPECTRAL	7	MUNSELL	13
Yxy	2	COLOR GR.	8	WI(E313)	14
L*a*b*	3	CMC(2:1)	9	WI(CIE)	15
L*C*H°	4	CMC(1:1)	10	YI(E313)	16
Lab	5	FMC2	11	YI(D1925)	17
L*u*v*	6	MI	12		

- For digit positions 1 to 6, the digit value can be set as follows to disable the corresponding data display or enable only ABS, only Δ, or both ABS and Δ for the corresponding data display.

Data display condition	Value of digit
Disabled	"0"
ABS only enabled	"1"
Δ only enabled	"2"
Both ABS and Δ enabled	"3"

- If a digit for digit positions 1 through 6 is set to a value of 4 or greater, the value will automatically be set to 3.
- For digit positions 7 through 17, the digit value can be set as follows to disable or enable the corresponding data display.

Data display condition	Value of digit
Disabled	"0"
Enabled	"1"

- If a digit for digit positions 7 through 17 is set to a value of 2 or greater, the digit will automatically be set to 1.
- If any digit position is set to other than a numerical value, the digit position will automatically be set to 0.
- If the input display parameter data word is not a 17-digit data word, the error-check code "E00Y" or "E00N" will be output.

### RCR (Reflectance Correction Factor Request)

**Function:**

Requests output of the presently set reflectance correction factor.

Required input to CM-2002:

"RCR" < CR >

Response from CM-2002:

Error-check code < CR > (See p. 91.)  
Reflectance correction factor < CR >

- The output value of the reflectance correction factor is ten times the actual reflectance correction factor. For example, if the output value is "99", the actual value of the reflectance correction factor is 9.9.

### RCS (Reflectance Correction Factor Set)

**Function:**

Prepares CM-2002 to receive reflectance correction factor.

Required input to CM-2002:

"RCS" < CR >

Reflectance correction factor < CR >

Response from CM-2002:

Error-check code < CR > (See p. 91.)

- The input value of the reflectance correction factor should be ten times the actual desired reflectance correction factor. For example, to set a reflectance correction factor of 9.9, input "99".
- If the input value is set to a negative number, the value will automatically be set to 0; if the input value is 100 or more, the value will automatically be set to 99.
- If the input characters are not numbers or ".", the character will be ignored. For example, if the input value is "0.5", the value will be set as if "05" was input.

### SAV (DATA SAVE)

**Function:**

Causes CM-2002 to perform DATA SAVE (see p. 40); measurement conditions, target color data, and communication parameters are saved to the memory card.

Required input to CM-2002:

"SAV" < CR >

Response from CM-2002:

Error-check code < CR > (See p. 91.)

- In the following cases, the error-check code "E19Y" or "E19N" will be output by the CM-2002:
  1. No memory card is installed.
  2. The memory card chamber cover is open.
  3. The battery of the memory card is low in power.
  4. The write-protect switch of the memory card is set to ON.
- If the memory card is faulty, the error-check code "E21Y" or "E21N" will be output by the CM-2002.



## SDS (Specimen Data Set)

### Function:

Prepares CM-2002 to receive measurement data for a series of specimen numbers and store the data on the memory card.

### Required input to CM-2002:

"SDS" < CR >

Quantity of specimen numbers for which data will be set < CR >

Spectral reflectance data

(See p. 90.) (A)

Data ID (See p. 90.)

Comment (See p. 91.)

### Response from CM-2002:

Error-check code < CR > (See p. 91.)

- Data for the input quantity of specimen numbers are received by the CM-2002 and stored on the memory card. All measurement data which was previously stored on the memory card are erased.
- If a character other than a number is included in the input quantity of specimen numbers for which data will be set, the unacceptable character will be ignored. For example, if the input value is "1A5", the value would be set to 15.
- The input quantity of specimen numbers for which data will be set can be set from 0 to 1000. If it is set to a value outside this range, the error-check code "E00Y" or "E00N" will be output by the CM-2002. If the value is set to 0, the error-check code will be output and all measurement data previously stored on the memory card will be erased.
- Data is stored starting with specimen number 1.
- (A) above is repeated until data for the input quantity of specimen numbers have been input to the CM-2002 and stored on the memory card. After each set of measurement data (A) has been input to the CM-2002, the error-check code will be output by the CM-2002. Be sure to receive the error-check code after input of each set of measurement data (A) to the CM-2002 has been completed.
- While data is being input, "/INPUT/" will be shown in the CM-2002's display.
- Do not open the memory card chamber cover while data is being input.
- If the break code (p. 87) is input or **BREAK/DELETE** is pressed to interrupt data input, only the completed sets of measurement data will be stored on the memory card. For example, if the break code was input while data for specimen number 50 was being input, only data for specimen numbers 1 through 49 would be stored on the memory card.
- After data input has been completed, the specimen number will be set to the last specimen number for which data was input.
- In the following cases, the error-check code "E19Y" or "E19N" will be output by the CM-2002 immediately after the command "SDS" has been input to the CM-2002:
  1. No memory card is installed.
  2. The memory card chamber cover is open.
  3. The battery of the memory card is low in power.
  4. The write-protect switch of the memory card is set to ON.
  5. The memory card contains no measurement data (there is no presently selected specimen number).

## SEC (Switch Enable: Color)

### Function:

Enables CM-2002's measuring button (and Accessory Switch). After measuring button has been enabled with this command, taking a measurement with the measuring button causes the CM-2002 to function in the same way as inputting the command "MSC" (p. 118).

### Required input to CM-2002:

"SEC" < CR >

### Response from CM-2002:

Error-check code < CR > (See p. 91.)

### SES (Switch Enable: Spectral)

**Function:**

Enables CM-2002's measuring button (and Accessory Switch). After measuring button has been enabled with this command, taking a measurement with the measuring button causes the CM-2002 to function in the same way as inputting the command "MES" (p. 116).

Required input to CM-2002:

"SES" <CR>

Response from CM-2002:

Error-check code <CR> (See p. 91.)

### SNR (Specimen Number Request)

**Function:**

Requests output of the presently set specimen number.

Required input to CM-2002:

"SNR" <CR>

Response from CM-2002:

Error-check code <CR> (See p. 91.)

Presently set specimen number <CR>

- In the following cases, the error-check code "E19Y" or "E19N" will be output by the CM-2002:
  1. No memory card is installed.
  2. The memory card chamber cover is open.
  3. The battery of the memory card is low in power.
  4. The memory card contains no measurement data (there is no presently selected specimen number).

### SNS (Specimen Number Set)

**Function:**

Prepares the CM-2002 to receive a specimen number and set itself to the received specimen number.

Required input to CM-2002:

"SNS" <CR>

Specimen number <CR>

Response from CM-2002:

Error-check code <CR> (See p. 91.)

- The input specimen number should be less than or equal to the highest specimen number for which data has been stored on the memory card. If the input specimen number is greater than the highest specimen number for which data has been stored on the memory card, the specimen number will automatically be set to the highest specimen number for which data has been stored on the memory card.
- If the input specimen number is 0 or less, the specimen number will automatically be set to 1.
- In the following cases, the error-check code "E19Y" or "E19N" will be output by the CM-2002 immediately after the command "SNS" has been input to the CM-2002:
  1. No memory card is installed.
  2. The memory card chamber cover is open.
  3. The battery of the memory card is low in power.
  4. The memory card contains no measurement data.

STR (Status Request)

Function:

Requests information related to the status of the CM-2002.

Required input to CM-2002:

"STR"<CR>

Response from CM-2002:

Error-check code<CR> (See p. 91.)

16-character status data word<CR>

- The status data word can be requested and checked to determine the present status of the CM-2002. It is especially recommended that it be checked before performing a measurement or any operation which accesses the memory card.
- The 16-character status data word contains the following information:

Character position	Item	Character	Meaning
1	CHARGE lamp	"Y"	CHARGE lamp is lit.
		"N"	CHARGE lamp is not lit.
2	White calibration	"Y"	White calibration has been performed.
		"N"	White calibration has not been performed.
3	Not used	":	
4	Battery condition	"Y"	Battery power is sufficient.
		"N"	Battery power is low.
5	Measuring button	"Y"	Measuring button is enabled.
		"N"	Measuring button is disabled.
6	White calibration mode	"Y"	Presently in white calibration mode.
		"N"	Presently not in white calibration mode.
7	Zero calibration mode	"Y"	Presently in zero calibration mode.
		"N"	Presently not in zero calibration mode.
8	Zero calibration data	"U"	Compensation for stray light is performed according to the zero calibration obtained by performing zero calibration after POWER switch was set to I (on).
		"P"	Compensation for stray light is performed according to the zero calibration data obtained the last time zero calibration was performed.
		"S"	Compensation for stray light is performed according to the zero calibration data stored at the time of shipment from the factory.
9	Monitored illumination quantity	"Y"	Monitored illumination quantity is normal.
		"N"	Monitored illumination quantity is low. Contact the nearest Minolta authorized service facility.
10	Not used	"0"	
11	Number of measurements for automatic averaging	"1", "3", "5", or "8"	Value output is presently set number of measurements for automatic averaging.

Character position	Item	Character	Meaning
12	Internal buzzer	"Y"	Internal buzzer is on.
		"N"	Internal buzzer is off.
13	State of CM-2002's communication buffer	"Y"	State of CM-2002's communication buffer is normal.
		"N"	CM-2002's communication buffer is in an overflow state.
14	SCI/SCE setting	"I"	CM-2002 is presently set to SCI.
		"E"	CM-2002 is presently set to SCE.
15	Memory card condition	"0"	Memory card condition is normal.
		"1"	Memory card chamber cover is open.
		"2"	No memory card is installed.
		"3"	Power of memory card battery is low.
		"4"	Memory card's write-protect switch is set to ON.
16	Target color auto select function	"Y"	Target color auto select function is on.
		"N"	Target color auto select function is off.

#### SWD (Switch Disable)

##### Function:

Disables CM-2002's measuring button (and Accessory Switch).

##### Required input to CM-2002:

"SWD" <CR>

##### Response from CM-2002:

Error-check code <CR> (See p. 91.)

- Disabling the measuring button prevents a measurement from being accidentally taken by pressing the measuring button.
- The measuring button is disabled when the CM-2002 is first set to REMOTE mode.

## TDR (Target Data Request)

### Function:

Requests output of target color data of presently selected target number.

### Required input to CM-2002:

"TDR" < CR >

### Response from CM-2002:

Error-check code < CR > (See p. 91.)  
Spectral reflectance data (See p. 93.)  
Data ID < CR > (See p. 93.)  
Comment < CR > (See p. 93.)  
Data for each enabled color mode  
data display (See p. 94.)

- The output target data is the target data loaded into the CM-2002's memory from the memory card.
- The time required for data output depends on the number of color mode data displays which have been enabled.

## TDS (Target Data Set)

### Function:

Prepares CM-2002 to receive target color data for the presently set target number.

### Required input to CM-2002:

"TDS" < CR >

Spectral reflectance data (See p. 90.)

Data ID (See p. 90.)

Comment (See p. 91.)

### Response from CM-2002:

Error-check code < CR > (See p. 91.)

- The input target data are stored only in the CM-2002's internal memory; they are not stored in the memory card. To save the input target data to the memory card, use the command "SAV" (p. 122).

## TGD (Target Delete)

### Function:

Prepares CM-2002 to receive target number for which target color data will be temporarily deleted.

### Required input to CM-2002:

"TGD" < CR >

Target number for which target color data will be  
deleted < CR >

### Response from CM-2002:

Error-check code < CR > (See p. 91.)

- Target number can be set from 1 to 50. If the input target number is 0 or less, the target number will automatically be set to 1; if the input target number is 51 or more, the target number will automatically be set to 50.
- If a character other than a number or "." is included in the target number, the unacceptable character will be ignored; for example, if the input target number is "0.5", the target number would be set to 5.
- If the presently set target number is input, the error-check code "E00Y" or "E00N" will be output by the CM-2002. To temporarily delete the target color data of the presently set target number, use the command "TNS" (p. 129) to set another target number, then use the command "TGD" again to temporarily delete the target color data.
- If the target number input is the target number for which the target color data is the only target color data not yet temporarily deleted, the error-check code "E00Y" or "E00N" will be output by the CM-2002. It is not possible to temporarily delete the target color data for all 50 target numbers.



### TGR (Target Recover)

Function:

Prepares CM-2002 to receive the target number for which temporarily deleted target color data will be recovered.

Required input to CM-2002:

"TGR"<CR>

Target number for which target color data will be recovered<CR>

Response from CM-2002:

Error-check code<CR> (See p. 91.)

- Target number can be set from 1 to 50. If the input target number is 0 or less, the target number will automatically be set to 1; if the input target number is 51 or more, the target number will automatically be set to 50.
- If a character other than a number or "." is included in the target number, the unacceptable character will be ignored; for example, if the input target number is "0.5", the target number would be set to 5.

### TNR (Target Number Request)

Function:

Requests output of the presently set target number.

Required input to CM-2002:

"TNR"<CR>

Response from CM-2002:

Error-check code<CR> (See p. 91.)

Presently set target number<CR>

### TNS (Target Number Set)

Function:

Prepares CM-2002 to receive target number to be set.

Required input to CM-2002:

"TNS"<CR>

Target number to be set<CR>

Response from CM-2002:

Error-check code<CR> (See p. 91.)

- Target number can be set from 1 to 50. If the input target number is 0 or less, the target number will automatically be set to 1; if the input target number is 51 or more, the target number will automatically be set to 50.
- If a character other than a number or "." is included in the target number, the unacceptable character will be ignored; for example, if the input target number is "0.5", the target number would be set to 5.
- If the target color data for the input target number is presently temporarily deleted, the error-check code "E00Y" or "E00N" will be output by the CM-2002.

UZC (User Zero Calibration)

Function:

Prepares CM-2002 for zero calibration.

Required input to CM-2002:

"UZC" <CR>

Response from CM-2002:

Error-check code <CR> (See p. 91.)

- After this command has been input, inputting the command "MES" or "MSC" or pressing the measuring button (if measuring button is enabled) will cause the CM-2002 to perform zero calibration.
- After this command has been input but before zero calibration has been performed, any command (with the exception of "AVG") will be accepted by the CM-2002. If any such command is input and then the break code is input to cancel the command, the preparations for zero calibration will also be canceled.

## Terminal Mode

Messages input via the CM-2002's RS-232C terminal can be shown on the CM-2002's display by using terminal mode. For example, by connecting the CM-2002 to a modem, messages from a computer at a distant location can be made to appear on the CM-2002's display.

- Terminal mode operates only when CM-2002 is set to REMOTE mode. (For details on entering REMOTE mode, see p. 84.)
- Commands for terminal mode are listed in the table below.

### TERMINAL MODE COMMANDS

Input command	Hexadecimal notation	Function	Response from CM-2002
S	13 <sub>H</sub> < CR >	Causes CM-2002 to enter terminal mode.	Error-check code (See p. 91.)
C Q	03 <sub>H</sub> 11 <sub>H</sub>	Causes CM-2002 to exit terminal mode.	Error-check code (See p. 91.)
M	0D <sub>H</sub>	Moves cursor to beginning of same line (carriage return).	
J	0A <sub>H</sub>	Moves cursor to beginning of next line.	
R	12 <sub>H</sub>	Moves cursor to beginning of display.	

- <sub>H</sub> indicates that the CTRL key of the computer should be pressed at the same time as the letter key.
- <sub>H</sub> indicates hexadecimal notation.
- Only the command S requires a delimiter code.
- If the measuring button (after being enabled before entering terminal mode) is pressed while CM-2002 is in terminal mode, a measurement will be taken and the measurement data will be output. The output data and whether or not data is saved to the memory card depends on whether the command "SEC" (p. 124) or "SES" (p. 125) was used to enable the measuring button.
- In terminal mode, the CM-2002 will not respond to commands other than those listed above or the pressing of the measuring button (if measuring button has been enabled). Necessary settings should be performed before entering terminal mode or by exiting terminal mode, performing the necessary operation, and then returning to terminal mode.
- Characters which may be displayed in terminal mode are characters from 20<sub>H</sub> through 7E<sub>H</sub> as shown in the table on the following page.
  - <sub>H</sub> indicates hexadecimal notation.

CHARACTERS DISPLAYED IN TERMINAL MODE

First digit

	0	1	2	3	4	5	6	7
0				0	°	P		p
1		D1	!	1	A	Q	a	q
2		D2	"	2	B	R	b	r
3	EX	D3	#	3	C	S	c	s
4			*	4	D	T	d	t
5			%	5	E	U	e	u
6			&	6	F	V	f	v
7			'	7	G	W	g	w
8			(	8	H	X	h	x
9			)	9	I	Y	i	y
A	LF		*	:	J	Z	j	z
B			+	;	K	[	k	†
C			,	<	L	\	l	
D	CR		-	=	M	]	m	↓
E			.	>	N		n	→
F			/	?	○	-	o	

Second digit

## ERROR MESSAGES

- If any of the following messages continue to appear and normal operation cannot be resumed, contact the nearest Minolta authorized service facility.

Message	Problem	
NO W. CAL	White calibration was not performed after POWER switch was set to   (on) or after switching between SCI and SCE measurements.	Perform white calibration with present settings of CM-2002.
CALB ERR	When white calibration or zero calibration was performed, the procedure was not performed correctly.	Perform white calibration or zero calibration correctly. If this message reappears, contact the nearest Minolta authorized service facility.
NO ZERO CAL.	Zero calibration in CM-2002's memory has been lost.	Perform zero calibration.
LOW BAT	Battery power is low.	Replace batteries with new ones or use AC adapter.
CHRG ERR	Lamp circuit has not finished charging.	Wait until CHARGE lamp is lit before pressing the measuring button.
FLSH ERR	Pulsed xenon arc lamp did not flash.	Perform measurement or calibration again. If this message reappears, contact the nearest Minolta authorized service facility.
A/D ERR	Error in internal A/D converters.	Set power switch to ○ (off) for a moment, then set it back to   (on). If this message reappears, contact the nearest Minolta authorized service facility.
MC COVER	Memory card chamber cover is open when memory card access is attempted.	Close memory card chamber cover.
NO CARD	No memory card is installed when memory card access is attempted.	Install memory card and close memory card chamber cover.
CARD ERR	Memory card cannot be accessed.	Check that memory card is installed correctly.
		Check that memory card chamber cover is closed.
		Set write-protect switch of memory card to OFF or try another memory card.
NO DATA	Memory card contains no measurement data.	Take measurements.
CARD FULL	Memory card presently contains 1000 sets of measurement data. Further measurements will overwrite the data for specimen number 1000.	Install a new memory card and close memory card chamber cover.
CARD BAT	Power of memory card battery is low.	Replace memory card battery with new one.

Message	Problem	Solution
NO TARG	Target color data of presently selected target number was temporarily erased.	Recover temporarily deleted target color data for present target number or select a target number which has target color data.
TIME OUT	Data could not be output because CTS input of CM-2002 was OFF.	Check that RS-232C cable is correctly connected.
		Check CTS input.
		Check state of receiving device.
LOW ILL.	Monitored illumination inside integrating sphere is low.	Contact the nearest Minolta authorized service facility.
EEPROM ERR	Error in CM-2002's internal EEPROM.	
SRAM ERR	Error in CM-2002's internal SRAM.	
BUS ERROR	Internal program is running wild due to excessive electrical noise (power fluctuations, etc.) or instrument malfunction.	Set power switch to ○ (off) for a moment, then set it back to   (on). If this message reappears, contact the nearest Minolta authorized service facility.
ADDRESS ERROR		
ILLEGAL ERROR		
ZDIV ERROR		
E1010 ERROR		
E1111 ERROR		
FP ERROR DIVZERO		
FP ERROR UNDERFLOW		
FP ERROR OVERFLOW		
FP ERROR OPERROR		
COMMUN. ERR.	Communication parameters of CM-2002 do not match those of computer.	Press <b>BREAK/DELETE</b> to exit REMOTE mode. Set communication parameters of both units to the same values, reenter REMOTE mode, and input the break code to the CM-2002

## TROUBLESHOOTING GUIDE

If a problem occurs with the CM-2002, check the following points before requesting service. If the problem continues to occur even after the suggested corrective actions have been taken, contact the nearest Minolta authorized service facility.

Condition	Checkpoint	Corrective action
Nothing is shown in the display.	Are batteries installed correctly or is AC adapter connected correctly to both CM-2002 and an AC wall outlet?	Install batteries correctly or connect AC adapter correctly.
	Is battery power exhausted?	Replace batteries with new ones.
	Is display contrast adjusted correctly?	Move contrast-adjustment slide for easiest viewing.
CHARGE lamp does not light.	Are batteries installed correctly or is AC adapter connected correctly to both CM-2002 and an AC wall outlet?	Install batteries correctly or connect AC adapter correctly.
	Is battery power exhausted?	Replace batteries with new ones.
Nothing happens when a key is pressed.	Does the key have a function in the present mode?	Press a key which has a function in the present mode.
Nothing happens when the measuring button is pressed.	Is the CM-2002 in the middle of processing the previous measurement?	After a measurement has been taken, wait until the CHARGE lamp is lit before pressing the measuring button to take the next measurement.
	Is the CM-2002 in MEASURE mode?	Set CM-2002 to MEASURE mode before pressing measuring button.
	Is the measuring-button selector set to <b>NORM.</b> ?	Set measuring-button selector to <b>NORM.</b>
	If in REMOTE mode, has measuring button been enabled using the command "SEC" or "SES"?	Input the command "SEC" or "SES" to the CM-2002 to enable the measuring button.
Buzzer does not sound when a key is pressed.	Is BUZZER in CLOCK, BUZZER mode set to ON?	Set BUZZER in CLOCK, BUZZER mode to ON.
	Was buzzer enabled in REMOTE mode by using the command "BZE"?	Use the command "BZE" in REMOTE mode to enable the buzzer.
	If presently in REMOTE mode, since keys other than <b>BREAK/DELETE</b> and the measuring button (if enabled) do not function, no buzzer will sound if such keys are pressed.	
Measurement was taken correctly (pulsed xenon arc lamp flashed) but measurement results are not shown on graph.	Is graph range set correctly?	Set graph range correctly.

Condition	Checkpoint	Corrective action
Measurement results seem strange.	Was CM-2002 held correctly against specimen surface, with measurement aperture flat against the surface and the CM-2002 perpendicular to the surface?	Hold CM-2002 correctly against the specimen surface.
	Is white calibration cap still attached to CM-2002?	Remove white calibration cap.
	Is an error message related to the memory card displayed?	Memory card malfunction.
	Was white calibration performed correctly?	Attach white calibration cap and perform white calibration correctly.
	Was zero calibration performed correctly?	Remove white calibration cap and aim measurement aperture into the air (or use the optional Zero Calibration Box) and perform zero calibration correctly.
	Is calibration data correct? (Calibration data can be checked and set only in REMOTE mode.)	Set calibration data correctly in REMOTE mode and then perform calibration again.
Measurement values vary widely.	Was the CM-2002 moved during the measurement?	Do not move the CM-2002 until the measurement has been completed.
The target number changes when a measurement is taken.	Is target color auto select function set to on?	Set target color auto select function to off and manually select the desired target number.
"-FAIL-" appears in the display even though tolerance values are not set.	Is target color auto select function set to on?	Set target color auto select function to off and manually select a target number for which tolerance values have not been set.
The date and time which are displayed after the POWER switch is set to   (on) are incorrect.	Were incorrect date and time set in CLOCK, BUZZER mode?	Set correct date and time in CLOCK, BUZZER mode.
After switching between SCI and SCE measurements, the previous setting is shown in the display. (Present setting is shown in calibration mode; setting is shown after a measurement is taken in MEASURE mode.)		Switch back to previous setting for a moment, then switch to desired setting again.



Condition	Checkpoint	Corrective action
a) Specimen number is not displayed or does not increase even after a measurement is taken. b) Measurement conditions, etc. are not loaded into the CM-2002's memory. c) Measurement mode, etc. cannot be saved to the memory card. d) Unusual data is output when DUMP is performed. e) In REMOTE mode, data cannot be saved to the memory card.	Is a memory card installed?	Install a memory card.
	Is the memory card chamber cover closed?	Close the memory card chamber cover.
	Is a battery with sufficient power installed in the memory card?	Install a battery with sufficient power in the memory card.
	Is the write-protect switch of the memory card set to OFF? (For conditions a, c, and e)	Set the write-protect switch of the memory card to OFF.
	Are the communication parameters set correctly? (For condition d)	Set communication parameters correctly.
		Memory card malfunction
Spectral reflectance data shown in the display is different from the spectral reflectance data output automatically, when DUMP is performed, or when data output is requested in REMOTE mode.	Is the reflectance correction factor set to a value other than 0.0?	Set the reflectance correction factor to 0.0.
Data input/output between the CM-2002 and a computer cannot be performed. Commands cannot be input to the CM-2002 from a computer.	Is the RS-232C cable connected correctly to both the CM-2002 and the computer?	Connect the RS-232C cable correctly to both the CM-2002 and the computer.
	Are the internal connections of the RS-232C cable correct?	The internal connections of the RS-232C cable should be the same as those shown on p. 74.
	Are the communication parameters (baud rate, character length, parity, and stop bit) of both the CM-2002 and the computer set to the same values?	Set the communication parameters of the CM-2002 and the computer to the same values.
	Is the program correct?	Check operation using the sample program starting on p. 96.
	Is a command being input when the CM-2002's RTS output is OFF?	Do not input a command when the CM-2002's RTS output (the computer's CTS input) is OFF.
The input command is not received correctly.	Are lower-case letters being input the command?	Commands should be input using only upper-case letters.
	Was the error-check code output after the previous command received by the computer?	Input the break code to the CM-2002 and then input the desired command again.
<b>BREAK/DELETE</b> does not function in REMOTE mode.	Was the wrong quantity of data input to the CM-2002?	Input the break code to the CM-2002.
		Set the POWER switch to ○ (off) for a moment and then set it back to   (on).

Condition	Checkpoint	Corrective action
While DUMP or data output in REMOTE mode is being performed, data output is interrupted.	Is the program for the computer to receive the data mistaking the character "E" or "W" in a comment as the end mark or error-check code?	Do not check the comment for the characters "E" or "W" when checking for the end of data output or an error condition.
In REMOTE mode, the specimen number does not increase even after a measurement is taken.	Is a memory card installed?	Install a memory card.
	Is the memory card chamber cover closed?	Close the memory card chamber cover.
	Is the write-protect switch of the memory card set to OFF?	Set the write-protect switch of the memory card to OFF.
	Is a battery with sufficient power installed in the memory card? (The power of the memory card battery can be checked by inputting the command "STR". If the value of character position 15 is "3", the memory card battery power is low.)	Install a battery with sufficient power in the memory card.
	Was the measurement taken using the command "MES"?	If the measurement was taken using the command "MES", measurement data is not stored on the memory card and thus the specimen number does not increase. If data storage to the memory card is required, use the command "MSC" instead of "MES" for taking measurements.
In REMOTE mode, even though the number of measurements for automatic averaging was set to a value other than "1", only one measurement was taken.	Was the number of measurements for automatic averaging set correctly?	Set the number of measurements for automatic averaging correctly.
	Was the measurement taken using the command "MES"?	Automatic averaging is not performed if the command "MES" is used to take measurements. Use the command "MSC" instead of "MES" to take measurements.
	Was the measuring button enabled using the command "SES"?	Automatic averaging is not performed if the measuring button was enabled by using the command "SES". Use the command "SEC" instead of "SES" to enable the measuring button.

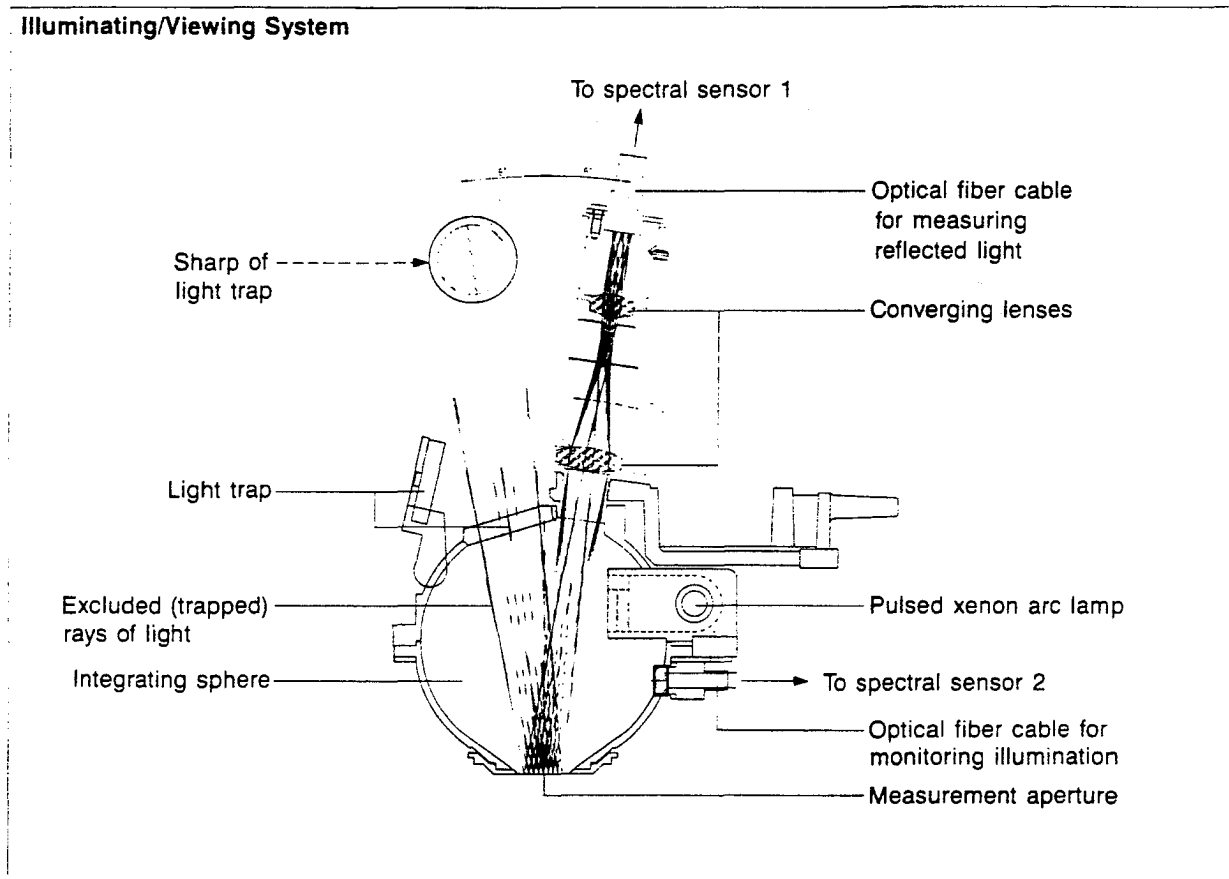
## MEASURING PRINCIPLE

### ILLUMINATION/VIEWING SYSTEM

The illuminating/viewing system of the CM-2002 is shown in the diagram below. In this system, the specimen is illuminated diffusely and viewed at an  $8^\circ$  angle to the normal to the specimen surface; the width of the viewing beam is  $7.4^\circ$ . This geometry meets the specifications for  $d/0$  (diffuse illumination/ $0^\circ$  viewing angle) geometry in CIE Publication 15.2<sup>1</sup> as well as the specifications for  $d/8$  (diffuse illumination/ $8^\circ$  viewing angle) geometry described in ISO 7724/1<sup>2</sup> and DIN 5033 teil 7<sup>2</sup>. In addition, the geometry can be switched between SCI (specular component included) and SCE (specular component excluded) measurements.

1. CIE standards state that for  $d/0$  geometry, the angle between the viewing beam and the normal to the specimen surface should not exceed  $10^\circ$ ; in addition, the angle between the axis of the viewing beam and any ray within that beam should not exceed  $5^\circ$ . The CM-2002's viewing beam is at an angle of  $8^\circ$  to the normal of the specimen with a width of  $7.4^\circ$  and thus meets this specification.
2. ISO 7724/1 and DIN 5033 Teil 7 state that for  $d/8$  geometry, the angle between the viewing beam and the normal to the specimen should be  $8^\circ \pm 2^\circ$ ; in addition, the angle between the axis of the viewing beam and any ray within that beam should not exceed  $5^\circ$ . The CM-2002's viewing angle is at an angle of  $8^\circ$  to the normal of the specimen with a width of  $7.4^\circ$  and thus meets this specification.

### Illuminating/Viewing System



The basic flow of operations in the illuminating/viewing system during a measurement is as follows:

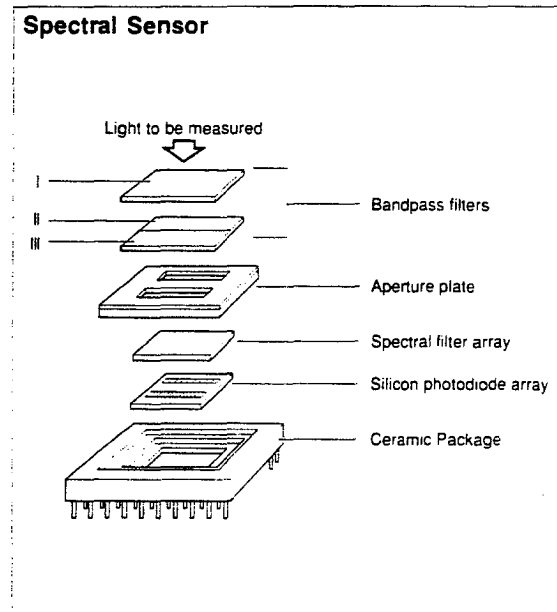
1. Light from the pulsed xenon arc lamp is thoroughly diffused inside the integrating sphere and provides even illumination over the area of the specimen surface to be measured.
  - For SCE (specular component excluded) measurements, the light trap is opened as shown in the diagram. The light which would have been reflected by the surface of the integrating sphere at the light trap position (the light which would have illuminated the specimen surface at an angle which would result in specular reflection) enters the light trap and is absorbed.

2. Light reflected from the specimen surface at an angle of  $8^\circ$  to the normal enters the optical fiber cable for taking measurements and is transmitted to spectral sensor 1. At the same time, the light inside the integrating sphere (the light which illuminates the specimen surface) enters the optical fiber cable for monitoring illumination and is transmitted to spectral sensor 2.
3. The light from each optical fiber cable is divided by wavelength (from 400 to 700nm) at a 10nm pitch before striking the segments of the silicon photodiode array of the spectral sensor. The segments of the spectral sensor convert the received light into electrical currents proportional to the intensity of the light. These electrical currents are then passed to the analog control circuits.
  - By using two spectral sensors and measuring the both the light which illuminated the specimen surface and the light reflected by the specimen surface, the effects of variations in the spectral characteristics or intensity of the illumination can be eliminated. (Double-beam feedback system)

## SPECTRAL SENSOR

An exploded view of the spectral sensor developed by Minolta for use in Minolta's Spectrophotometers is shown at right. The sensor is composed of a 40-segment silicon photodiode array. The segments are arranged in two rows: one for shorter wavelengths (400 to 500nm) and the other for longer wavelengths (500 to 700nm).

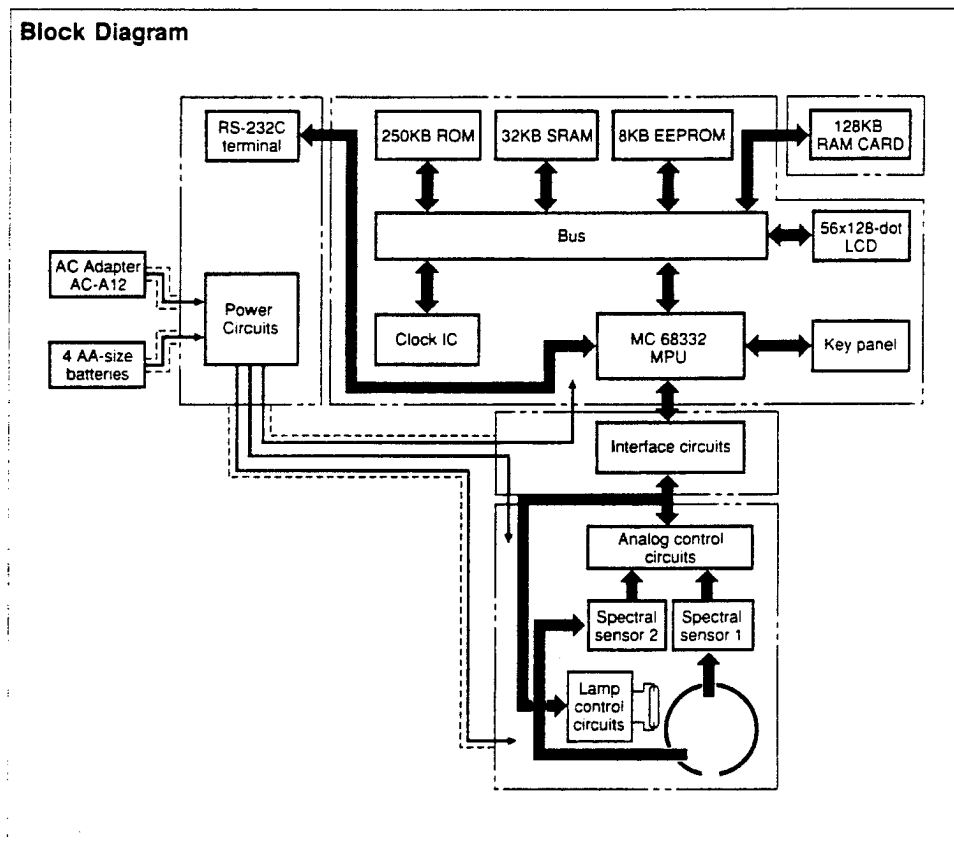
The light to be measured enters the sensor from the top. Light with wavelengths from 400 to 500nm are passed by bandpass filters I and II; light with wavelengths from 500 to 700nm are passed by bandpass filters I and III. The light then passes through the spaces in the aperture plate and strikes the spectral filter array. The spectral filter array separates the light by wavelength at a 10nm pitch. The separated light then strikes the corresponding segments of the silicon photodiode array, which converts the received light into electrical currents which are proportional to the intensity of the light.



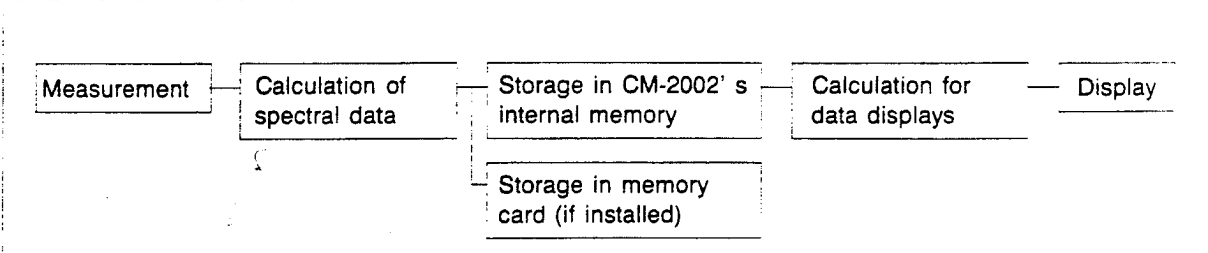
## PROCESSING BLOCK DIAGRAM

A block diagram of the processing circuits of the CM-2002 is shown below. To provide high reliability and allow miniaturization, the analog circuits use hybrid ICs. Further, all processing is controlled by the single-chip 32-bit 68332 microcomputer, allowing all control circuitry to be built into the CM-2002's compact body.

The analog circuits convert the currents output by each segment of the spectral sensors into a proportional voltage, and then into a digital signal. These digital signals are input to the MPU, which performs the various calculations to determine the spectral reflectance, which is then stored in the CM-2002's internal RAM (and the memory card, if installed). The MPU then performs further calculations according to the settings of the CM-2002 and displays the results in the LCD (liquid crystal display).



### Data Flow at Time of Measurement



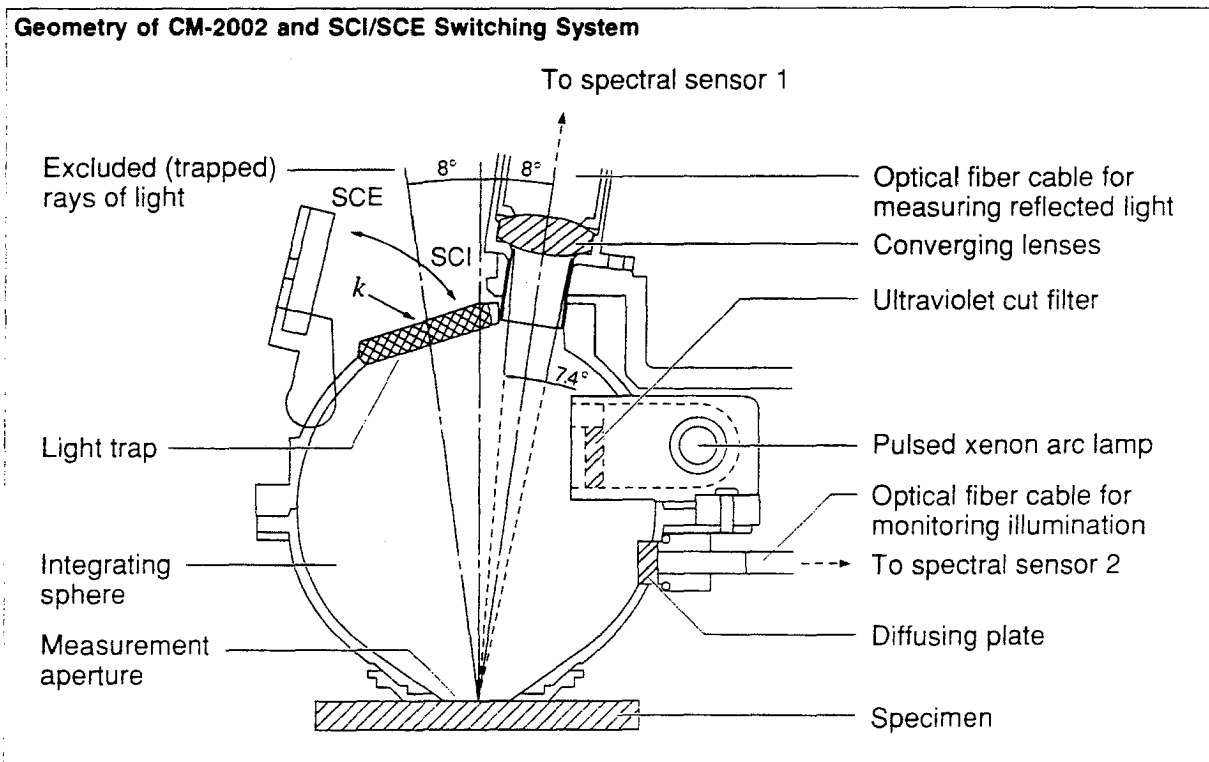
## SPECULAR COMPONENT INCLUDED/SPECULAR COMPONENT EXCLUDED

The CM-2002's geometry allows the user to switch between SCI (specular component included) and SCE (specular component excluded) measurements.

For SCI measurements, the light reflected from the specimen surface, including both diffusely reflected light and specularly reflected light, is received for measurements. For SCE measurements, only light reflected diffusely from the specimen surface is received for measurements.

In the CM-2002, specularly reflected light would be due to light illuminating the specimen surface after being reflected by the portion of the inner surface of the integrating sphere located opposite the measuring optical system (with respect to the normal of the specimen surface) at an angle of  $8^\circ$  to the normal of the specimen surface. (This portion of the inner surface of the mixing chamber is labeled  $k$  in the diagram below.) By replacing  $x$  with a small door which opens into a light trap, SCI or SCE measurements can be easily selected: when the door is closed, measurements will be SCI; when the door is open, measurements will be SCE.

- The CM-2002 can also calculate SCE data from SCI data using a reflectance correction factor set by the user.



## MATHEMATICAL FORMULAS

XYZ

ABS

FOR 2° STANDARD OBSERVER (CIE 1931)

$$\begin{aligned} X &= K \sum_{400}^{700} S(\lambda) \bar{x}(\lambda) R(\lambda) \\ Y &= K \sum_{400}^{700} S(\lambda) \bar{y}(\lambda) R(\lambda) \\ Z &= K \sum_{400}^{700} S(\lambda) \bar{z}(\lambda) R(\lambda) \\ K &= \frac{100}{\sum_{400}^{700} S(\lambda) \bar{y}(\lambda)} \end{aligned}$$

where

- $\underline{S}(\lambda)$  : Relative spectral power distribution of the illuminant (A, C, D<sub>50</sub>, D<sub>65</sub>, F2, F6, F7, F8, F10, F11, or F12)
- $\underline{x}(\lambda)$  :
- $\underline{y}(\lambda)$  : Color-matching functions for CIE 2° Standard Observer (1931)
- $\underline{z}(\lambda)$  :
- $R(\lambda)$  : Spectral reflectance of specimen
- $\lambda$  : Wavelength (10nm pitch)

By performing tertiary extrapolation using the spectral reflectance values measured at a 10nm pitch, values from 380nm to 720nm at a 5nm pitch can be calculated and the tristimulus values are calculated based on the spectral reflectance values calculated at 5nm pitch.

- Observer and illuminant used for calculations will be those selected in OBS.,ILL. mode (p. 39).
- The  $\Delta E^*$  value shown in the display in this mode is the  $\Delta E^*_{ab}$  value from the L\*a\*b\* system (p. 151).

This method is based on the specifications in:

CIE COLORIMETRY Second edition, Publication 15.2 (1986)

Related references:

- ISO 7724/1-1984 Paints and varnishes - Colorimetry - Part 1:Principles
- ASTM E 308-1985 Standard Method for COMPUTING THE COLORS OF OBJECTS BY USING THE CIE SYSTEM
- DIN 5033 Teil 3-1980 Farbmessung; Farbmaßzahlen

FOR 10° STANDARD OBSERVER (CIE 1964)

$$\begin{aligned} X_{10} &= K \sum_{400}^{700} S(\lambda) \bar{x}_{10}(\lambda) R(\lambda) \\ Y_{10} &= K \sum_{400}^{700} S(\lambda) \bar{y}_{10}(\lambda) R(\lambda) \\ Z_{10} &= K \sum_{400}^{700} S(\lambda) \bar{z}_{10}(\lambda) R(\lambda) \\ K &= \frac{100}{\sum_{400}^{700} S(\lambda) \bar{y}_{10}(\lambda)} \end{aligned}$$

where

- $S(\lambda)$  : Relative spectral power distribution of the illuminant (A, C, D<sub>50</sub>, D<sub>65</sub>, F2, F6, F7, F8, F10, F11, or F12)
- $\bar{x}_{10}(\lambda)$  : Color-matching functions for CIE 2° Standard Observer (1931)
- $\bar{y}_{10}(\lambda)$  : Color-matching functions for CIE 2° Standard Observer (1931)
- $\bar{z}_{10}(\lambda)$  : Color-matching functions for CIE 2° Standard Observer (1931)
- $R(\lambda)$  : Spectral reflectance of specimen
- $\lambda$  : Wavelength (10nm pitch)

- Observer and illuminant used for calculations will be those selected in OBS.,ILL. mode (p. 39).
- The  $\Delta E^*$  value shown in the display in this mode is the  $\Delta E^*_{ab}$  value from the L\*a\*b\* system (p. 151).

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- DIN 5033 Teil 3-1980 Farbmessung; Farbmaßzahlen



Δ

FOR 2° STANDARD OBSERVER (CIE 1931)

$$\begin{aligned}\Delta X &= X - X_t \\ \Delta Y &= Y - Y_t \\ \Delta Z &= Z - Z_t\end{aligned}$$

where

$X_t, Y_t, Z_t$ : Tristimulus values of target color  
 $X, Y, Z$ : Tristimulus values of specimen

- Observer and illuminant used for calculations will be those selected in OBS.,ILL. mode (p. 39).
- The  $\Delta E^*$  value shown in the display in this mode is the  $\Delta E^*_{ab}$  value from the  $L^*a^*b^*$  system (p. 151).

This method is based on the specifications in:

CIE COLORIMETRY Second edition, Publication 15.2 (1986)

Related references:

ISO 7724/1-1984 Paints and varnishes - Colorimetry - Part 1:Principles  
ASTM E 308-1985 Standard Method for COMPUTING THE COLORS OF OBJECTS BY USING THE CIE SYSTEM  
DIN 5033 Teil 3-1980 Farbmessung; Farbmaßzahlen

FOR 10° STANDARD OBSERVER (CIE 1964)

$$\begin{aligned}\Delta X_{10} &= X_{10} - X_{10,t} \\ \Delta Y_{10} &= Y_{10} - Y_{10,t} \\ \Delta Z_{10} &= Z_{10} - Z_{10,t}\end{aligned}$$

where

$X_{10,t}, Y_{10,t}, Z_{10,t}$ : Tristimulus values of target color  
 $X_{10}, Y_{10}, Z_{10}$ : Tristimulus values of specimen

- Observer and illuminant used for calculations will be those selected in OBS.,ILL. mode (p. 39).
- The  $\Delta E^*$  value shown in the display in this mode is the  $\Delta E^*_{ab}$  value from the  $L^*a^*b^*$  system (p. 151).

This method is based on the specifications in:

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Related references:

ISO 7724/1-1984 Paints and varnishes - Colorimetry - Part 1:Principles  
ASTM E 308-1985 Standard Method for COMPUTING THE COLORS OF OBJECTS BY USING THE CIE SYSTEM  
DIN 5033 Teil 3-1980 Farbmessung; Farbmaßzahlen

Yxy

ABS

FOR 2° STANDARD OBSERVER (CIE 1931)

Lightness Variable Y

Y in the Yxy system is the tristimulus value Y (p. 143).

Chromaticity Coordinates x and y

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

where

X, Y, Z: Tristimulus values (p. 143)

x, y: Chromaticity coordinates

- Observer and illuminant used for calculations will be those selected in OBS.,ILL. mode (p. 39).
- The  $\Delta E^*$  value shown in the display in this mode is the  $\Delta E^*_{ab}$  value from the  $L^*a^*b^*$  system (p. 151).

This method is based on the specifications in:

CIE COLORIMETRY Second edition, Publication 15.2 (1986)

Related references:

- |                      |   |
|----------------------|---|
| ISO 7724/1-1984      | Paints and varnishes - Colorimetry - Part 1:Principles  |
| ASTM D 2244-1985     | Standard Method for CALCULATION OF COLOR DIFFERENCES FROM INSTRUMENTALLY MEASURED COLOR COORDINATES |
| DIN 5033 Teil 3-1980 | Farbmessung; Farbmaßzahlen  |

FOR 10° STANDARD OBSERVER (CIE 1964)

Lightness Variable Y

When the CM-2002 is set to 10° Standard Observer, Y in the Yxy system is the tristimulus value  $Y_{10}$  (p. 144).

Chromaticity Coordinates  $x_{10}$  and  $y_{10}$

$$x_{10} = \frac{X_{10}}{X_{10} + Y_{10} + Z_{10}}$$
$$y_{10} = \frac{Y_{10}}{X_{10} + Y_{10} + Z_{10}}$$

where

$X_{10}, Y_{10}, Z_{10}$  : Tristimulus values  
 $x_{10}, y_{10}$  : Chromaticity coordinates

- Observer and illuminant used for calculations will be those selected in OBS.,ILL. mode (p. 39).
- The  $\Delta E^*$  value shown in the display in this mode is the  $\Delta E^*_{ab}$  value from the  $L^*a^*b^*$  system (p. 151).

This method is based on the specifications in:

CIE COLORIMETRY Second edition, Publication 15.2 (1986)

Related references:

ISO 7724/1-1984 Paints and varnishes - Colorimetry - Part 1:Principles  
ASTM D 2244-1985 Standard Method for CALCULATION OF COLOR DIFFERENCES FROM INSTRUMENTALLY MEASURED COLOR COORDINATES  
DIN 5033 Teil 3-1980 Farbmessung; Farbmaßzahlen

Δ

FOR 2° STANDARD OBSERVER (CIE 1931)

$$\begin{aligned}\Delta Y &= Y - Y_t \\ \Delta X &= X - X_t \\ \Delta y &= y - y_t\end{aligned}$$

where

$Y_t, X_t, y_t$  : Target color data  
 $Y, X, y$  : Specimen data

- Observer and illuminant used for calculations will be those selected in OBS.,ILL. mode (p. 39).
- The  $\Delta E^*$  value shown in the display in this mode is the  $\Delta E^*_{ab}$  value from the  $L^*a^*b^*$  system (p. 151).

This method is based on the specifications in:

CIE COLORIMETRY Second edition, Publication 15.2 (1986)

Related references:

ISO 7724/1-1984      Paints and varnishes - Colorimetry - Part 1:Principles  
ASTM D 2244-1985      Standard Method for CALCULATION OF COLOR DIFFERENCES FROM INSTRUMENTALLY MEASURED COLOR COORDINATES  
DIN 5033 Teil 3-1980      Farbmessung; Farbmaßzahlen

FOR 10° STANDARD OBSERVER (CIE 1964)

$$\begin{aligned}\Delta Y_{10} &= Y_{10} - Y_{10,t} \\ \Delta X_{10} &= X_{10} - X_{10,t} \\ \Delta y_{10} &= y_{10} - y_{10,t}\end{aligned}$$

where

$Y_t, X_t, y_t$  : Target color data  
 $Y, X, y$  : Specimen data

- Observer and illuminant used for calculations will be those selected in OBS.,ILL. mode (p. 39).
- The  $\Delta E^*$  value shown in the display in this mode is the  $\Delta E^*_{ab}$  value from the  $L^*a^*b^*$  system (p. 151).

This method is based on the specifications in:

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Related references:

ISO 7724/1-1984      Paints and varnishes - Colorimetry - Part 1:Principles  
ASTM D 2244-1985      Standard Method for CALCULATION OF COLOR DIFFERENCES FROM INSTRUMENTALLY MEASURED COLOR COORDINATES  
DIN 5033 Teil 3-1980      Farbmessung; Farbmaßzahlen

## L\*a\*b\*

- The L\*a\*b\* system is also referred to as the CIELAB system.

### ABS

#### Lightness Variable L\*

$$L^* = 116 \left( \frac{Y}{Y_n} \right)^{\frac{1}{3}} - 16 \quad \text{when} \quad \left( \frac{Y}{Y_n} \right) > 0.008856$$
$$L^* = 903.29 \left( \frac{Y}{Y_n} \right) \quad \text{when} \quad \left( \frac{Y}{Y_n} \right) \leq 0.008856$$

where

- Y: Tristimulus value Y (for 2° Standard Observer) or Y10 (for 10° Standard Observer) of the specimen
- Y<sub>n</sub>: Tristimulus value Y (for 2° Standard Observer) or Y10 (for 10° Standard Observer) of a perfect reflecting diffuser

#### Chromaticity Coordinates a\* and b\*

$$a^* = 500 \left[ \left( \frac{X}{X_n} \right)^{\frac{1}{3}} - \left( \frac{Y}{Y_n} \right)^{\frac{1}{3}} \right] \quad b^* = 200 \left[ \left( \frac{Y}{Y_n} \right)^{\frac{1}{3}} - \left( \frac{Z}{Z_n} \right)^{\frac{1}{3}} \right]$$

when

$$\frac{X}{X_n} > 0.008856 \quad \frac{Y}{Y_n} > 0.008856 \quad \frac{Z}{Z_n} > 0.008856$$

where

- X, Y, Z: Tristimulus values XYZ (for 2° Standard Observer) or X<sub>10</sub>Y<sub>10</sub>Z<sub>10</sub> (for 10° Standard Observer) of the specimen
- X<sub>n</sub>, Y<sub>n</sub>, Z<sub>n</sub>: Tristimulus values XYZ (for 2° Standard Observer) or X<sub>10</sub>Y<sub>10</sub>Z<sub>10</sub> (for 10° Standard Observer) of a perfect reflecting diffuser

If X/X<sub>n</sub>, Y/Y<sub>n</sub>, or Z/Z<sub>n</sub> is less than 0.008856, the above equations are changed as described below:

$$\left( \frac{X}{X_n} \right)^{\frac{1}{3}} \text{ is replaced by } 7.787 \left( \frac{X}{X_n} \right) + \frac{16}{116}$$
$$\left( \frac{Y}{Y_n} \right)^{\frac{1}{3}} \text{ is replaced by } 7.787 \left( \frac{Y}{Y_n} \right) + \frac{16}{116}$$
$$\left( \frac{Z}{Z_n} \right)^{\frac{1}{3}} \text{ is replaced by } 7.787 \left( \frac{Z}{Z_n} \right) + \frac{16}{116}$$

- Observer and illuminant used for calculations will be those selected in OBS.,ILL. mode (p. 39).

This method is based on the specifications in:

CIE COLORIMETRY Second edition, Publication 15.2 (1986)

Related references:

ISO 7724/1-1984	Paints and varnishes - Colorimetry - Part 1:Principles
ASTM E 308-1985	Standard Method for COMPUTING THE COLORS OF OBJECTS BY USING THE CIE SYSTEM
ASTM D 2244-1985	Standard Method for CALCULATION OF COLOR DIFFERENCES FROM INSTRUMENTALLY MEASURED COLOR COORDINATES
DIN 5033 Teil 3-1980	Farbmessung; Farbmaßzahlen

Δ

$$\begin{aligned}\Delta L^* &= L^* - L_t^* \\ \Delta a^* &= a^* - a_t^* \\ \Delta b^* &= b^* - b_t^*\end{aligned}$$

where

$L_t^*, a_t^*, b_t^*$  : Target color data  
 $L^*, a^*, b^*$  : Specimen data

The color difference  $\Delta E^*_{ab}$  between two points is calculated according to the following formula:

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

- Observer and illuminant used for calculations will be those selected in OBS.,ILL. mode (p. 39).

This method is based on the specifications in:

CIE COLORIMETRY Second edition, Publication 15.2 (1986)

Related references:

ISO 7724/1-1984	Paints and varnishes - Colorimetry - Part 1:Principles
ASTM E 308-1985	Standard Method for COMPUTING THE COLORS OF OBJECTS BY USING THE CIE SYSTEM
ASTM D 2244-1985	Standard Method for CALCULATION OF COLOR DIFFERENCES FROM INSTRUMENTALLY MEASURED COLOR COORDINATES
DIN 5033 Teil 3-1980	Farbmessung; Farbmaßzahlen
DIN 6174-1979	Farbmetrische Bestimmung von Farbabständen bei Körperfarben nach der CIELAB-Formel

**L \* C \* H°**

**ABS**

Lightness Variable L\*

The lightness variable L\* in the L\*C\*H° system is the same as the lightness variable L\* in the L\*a\*b\* system (p. 149).

Metric Chroma C\*

$$C^* = \sqrt{(a^*)^2 + (b^*)^2}$$

Metric Hue-Angle H°

$$H^\circ = \tan^{-1} \left( \frac{b^*}{a^*} \right) \text{ (degrees)} \quad 0^\circ \leq H^\circ < 360^\circ$$

where

a\*, b\* : Chromaticity coordinates of L\*a\*b\* system (p. 149)

- Observer and illuminant used for calculations will be those selected in OBS.,ILL. mode (p. 39).
- The  $\Delta E^*$  value shown in the display in this mode is the  $\Delta E^*_{ab}$  value from the L\*a\*b\* system (p. 151).

This method is based on the specifications in:

CIE COLORIMETRY Second edition, Publication 15.2 (1986)

Related references:

ISO 7724/1-1984	Paints and varnishes - Colorimetry - Part 1:Principles
ASTM D 2244-1985	Standard Method for CALCULATION OF COLOR DIFFERENCES FROM INSTRUMENTALLY MEASURED COLOR COORDINATES
DIN 5033 Teil 3-1980	Farbmessung; Farbmaßzahlen



Δ

$$\begin{aligned}\Delta L^* &= L^* - L_t^* \\ \Delta C^* &= C^* - C_t^* \\ &= \sqrt{(a^*)^2 + (b^*)^2} - \sqrt{(a_t^*)^2 + (b_t^*)^2}\end{aligned}$$

*Metric Hue-Difference  $\Delta H^*$ :*

$$\begin{aligned}\Delta H^* &= \sqrt{(\Delta E_{ab}^*)^2 - (\Delta L^*)^2 - (\Delta C^*)^2} \\ &= \sqrt{(\Delta a^*)^2 + (\Delta b^*)^2 - (\Delta C^*)^2}\end{aligned}$$

where

$L_t^*, a_t^*, b_t^*$  : Target data in L\*a\*b\* color system  
 $L^*, a^*, b^*$  : Specimen data in L\*a\*b\* color system  
 $\Delta E_{ab}^*$  : Color difference between two points

- The value of the metric hue-difference is positive if the hue angle of the specimen is greater than the hue angle of the target and negative if the hue angle of the specimen is less than the hue angle of the target.
- Observer and illuminant used for calculations will be those selected in OBS.,ILL. mode (p. 39).
- The  $\Delta E^*$  value shown in the display in this mode is the  $\Delta E_{ab}^*$  value from the L\*a\*b\* system (p. 151).

This method is based on the specifications in:

CIE COLORIMETRY Second edition, Publication 15.2 (1986)

Related references:

ISO 7724/1-1984	Paints and varnishes - Colorimetry - Part 1:Principles
ASTM D 2244-1985	Standard Method for CALCULATION OF COLOR DIFFERENCES FROM INSTRUMENTALLY MEASURED COLOR COORDINATES
DIN 5033 Teil 3-1980	Farbmessung; Farbmaßzahlen
DIN 6174-1979	Farbmetrische Bestimmung von Farbabständen bei Körperfarben nach der CIELAB-Formel

**Lab**

**ABS**

$$L = 100 \left( \frac{Y}{Y_n} \right)^{\frac{1}{2}}$$
$$a = 175 \left[ \frac{0.0102 X_n}{(Y/Y_n)} \right]^{\frac{1}{2}} \cdot \left[ \left( \frac{X}{X_n} \right) - \left( \frac{Y}{Y_n} \right) \right]$$
$$b = 70 \left[ \frac{0.00847 Z_n}{(Y/Y_n)} \right]^{\frac{1}{2}} \cdot \left[ \left( \frac{Y}{Y_n} \right) - \left( \frac{Z}{Z_n} \right) \right]$$

where

X, Y, Z : Tristimulus values X, Y, and Z (p. 143) or X<sub>10</sub>, Y<sub>10</sub>, and Z<sub>10</sub> (p. 144) of the specimen  
X<sub>n</sub>, Y<sub>n</sub>, Z<sub>n</sub> : Tristimulus values X, Y, and Z (p. 143) or X<sub>10</sub>, Y<sub>10</sub>, and Z<sub>10</sub> (p. 144) of a perfect reflecting diffuser

- Observer and illuminant used for calculations will be those selected in OBS.,ILL. mode (p. 39).

Related references:

ASTM D 2244-1985 Standard Method for CALCULATION OF COLOR DIFFERENCES FROM INSTRUMENTALLY MEASURED COLOR COORDINATES

Δ

$$\Delta L = L - L_t$$
$$\Delta a = a - a_t$$
$$\Delta b = b - b_t$$

Where

L, a, b: Specimen data in Lab system  
L<sub>t</sub>, a<sub>t</sub>, b<sub>t</sub>: Target data in Lab system

The color difference ΔE between two points in the Lab system is calculated according to the following formula:

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

- Observer and illuminant used for calculations will be those selected in OBS.,ILL. mode (p. 39).

Related references:

ASTM D 2244-1985 Standard Method for CALCULATION OF COLOR DIFFERENCES FROM INSTRUMENTALLY MEASURED COLOR COORDINATES

## L\*u\*v\*

- The L\*u\*v\* system is also referred to as the CIELUV system.

## ABS

$$L^* = 116 \left( \frac{Y}{Y_n} \right)^{\frac{1}{3}} - 16 \quad \text{when} \quad \left( \frac{Y}{Y_n} \right) > 0.008856$$
$$L^* = 903.29 \left( \frac{Y}{Y_n} \right) - 16 \quad \text{when} \quad \left( \frac{Y}{Y_n} \right) \leq 0.008856$$
$$u^* = 13L^* (u' - u'_n)$$
$$v^* = 13L^* (v' - v'_n)$$

where

- Y : Tristimulus value Y (p. 143) or  $Y_{10}$  (p. 144) of the specimen
- $Y_n$  : Tristimulus value Y (p. 143) or  $Y_{10}$  (p. 144) of a perfect reflecting diffuser
- $u', v'$  : Chromaticity coordinates  $u', v'$  from the CIE 1976 UCS of the specimen
- $u'_n, v'_n$  : Chromaticity coordinates  $u', v'$  from the CIE 1976 UCS of a perfect reflecting diffuser

$u'$  and  $v'$  are calculated from the tristimulus values XYZ (p. 143) or  $X_{10}Y_{10}Z_{10}$  (p. 144) according to the following formulas:

$$u' = \frac{4X}{X + 15Y + 3Z}$$
$$v' = \frac{9Y}{X + 15Y + 3Z}$$

- Observer and illuminant used for calculations will be those selected in OBS.,ILL. mode (p. 39).

This method is based on the specifications in:

CIE COLORIMETRY Second edition, Publication 15.2 (1986)

Δ

$$\begin{aligned}\Delta L^* &= L^* - L_t^* \\ \Delta u^* &= u^* - u_t^* \\ \Delta v^* &= v^* - v_t^*\end{aligned}$$

where

$L_t^*, u_t^*, v_t^*$  : Target color data  
 $L^*, u^*, v^*$  : Specimen data

The color difference  $\Delta E^*_{uv}$  between two points is calculated according to the following formula:

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

- Observer and illuminant used for calculations will be those selected in OBS., ILL. mode (p. 39).

This method is based on the specifications in:

CIE COLORIMETRY Second edition, Publication 15.2 (1986)

## MUNSELL

There is no international standard for converting tristimulus values to Munsell HVC notation. The CM-2002 uses a set of tables relating L\*C\*H° data to Munsell HVC data, which was created based on the tables in JIS Z 8721 relating Yxy data and Munsell HVC data. If the L\*C\*H° data of the specimen is not listed in the tables, the CM-2002 performs interpolation using four surrounding points to determine the Munsell HVC data.

- Munsell data are calculated based on the 2° Standard Observer and Standard Illuminant C, regardless of the observer and illuminant selected in OBS.,ILL. mode.

### Related references:

JIS Z 8721-1977	Specification of Colours According to their Three Attributes
ASTM D 1535-1980	Standard Method of SPECIFYING COLOR BY THE MUNSELL SYSTEM

## MI

Two colors with different spectral characteristics that appear the same under a specified light source are referred to as metameric colors. Even though such colors look the same under a reference light source, they look different under a different test light source; the degree of difference is the degree of metamerism. This degree of metamerism is usually expressed as a numerical metamerism index (MI).

The metamerism index is a numerical indication of the degree of color difference produced under a test illuminant for two colors which appear the same under a reference illuminant. If the two colors are not exactly the same under the reference illuminant, the tristimulus values for the colors are first adjusted to eliminate the difference under the reference illuminant, and then the color difference under the test illuminant is calculated to determine the metamerism index.

1. The tristimulus values ( $X_{r1}$ ,  $Y_{r1}$ ,  $Z_{r1}$  for specimen 1;  $X_{r2}$ ,  $Y_{r2}$ ,  $Z_{r2}$  for specimen 2) are determined based on the selected reference illuminant (r). (Tristimulus values will be determined according to the observer selected in OBS.,ILL. mode. See p. for details on tristimulus values XYZ for the 2° Standard Observer; see p. 144 for details on tristimulus values  $X_{10}Y_{10}Z_{10}$  for the 10° Standard Observer.)
2. The tristimulus values ( $X_{t1}$ ,  $Y_{t1}$ ,  $Z_{t1}$  for specimen 1;  $X_{t2}$ ,  $Y_{t2}$ ,  $Z_{t2}$  for specimen 2) are determined under the test illuminant (t).
3. The tristimulus values for specimen 2 under the test illuminant are adjusted to eliminate the difference in tristimulus values between specimen 1 and specimen 2 under the reference illuminant (r). The adjusted tristimulus values  $X'_{t2}$ ,  $Y'_{t2}$ ,  $Z'_{t2}$  are calculated according to the following formula:

$$X'_{t2} = X_{t2} \left( \frac{X_{r1}}{X_{r2}} \right) \quad Y'_{t2} = Y_{t2} \left( \frac{Y_{r1}}{Y_{r2}} \right) \quad Z'_{t2} = Z_{t2} \left( \frac{Z_{r1}}{Z_{r2}} \right)$$

4. The L\*a\*b\* values for specimen 1 ( $L^*_1$ ,  $a^*_1$ ,  $b^*_1$ ) are calculated from the tristimulus values ( $X_{t1}$ ,  $Y_{t1}$ ,  $Z_{t1}$ ) for specimen 1 under the test illuminant; the L\*a\*b\* values for specimen 2 ( $L^*_2$ ,  $a^*_2$ ,  $b^*_2$ ) are calculated from the adjusted tristimulus values ( $X'_{t2}$ ,  $Y'_{t2}$ ,  $Z'_{t2}$ ) for specimen 2 under the test illuminant. The metamerism index is then determined from these L\*a\*b\* values according to the following formula:

$$MI = \sqrt{(L^*_2 - L^*_1)^2 + (a^*_2 - a^*_1)^2 + (b^*_2 - b^*_1)^2}$$

- The reference illuminant and the test illuminant can be set to any of the CM-2002's illuminants: A, C, D50, D65, F2, F6, F7, F8, F10, F11, or F12.

This method is based on the specifications in:

CIE COLORIMETRY Second edition, Publication 15.2 (1986)

### Related references:

ISO 7724/1-1984	Paints and varnishes - Colorimetry - Part 1:Principles
DIN 6172-1973	Metamerie-Index von Probenpaaren bei Lichtartwechsel

## WI(E313)

When WI(E313) is selected as the data display, the CM-2002 shows the ASTM E 313 whiteness index. The whiteness index expresses the degree to which a specimen is white. A perfect reflecting diffuser (an ideal white surface) would have a whiteness index of 100. As the difference between this ideal white and the specimen surface increases, the whiteness index decreases.

The whiteness index can be used to check the product whiteness of paint, textiles, paper, plastics, and ceramics.

The ASTM E 313 whiteness index is calculated according to the following formula:

$$WI = 4B - 3G$$

where

*B* : Blue reflectance (equal to  $-0.847Z$ ) of the specimen surface

*G* : Green or luminous reflectance (equal to tristimulus value *Y*) of the specimen surface

The above equation can also be written in terms of the tristimulus values *Y* and *Z* as follows:

$$WI = 4(0.847 Z) - 3Y = 3.388Z - 3Y$$

where

*Y, Z* : Tristimulus values *Y* and *Z* (p. 143) of the specimen surface

- The ASTM E 313 whiteness index is intended for use in measuring near-white opaque, non-glossy specimens. "Near-white" is described in the standard as satisfying the following requirements:
  - Munsell Value  $V < 8.3$  (equivalent to a luminous reflectance of 65%)
  - Munsell Chroma  $C \leq 0.5$  (for B Hues)
  - Munsell Chroma  $C \leq 0.8$  (for Y Hues)
  - Munsell Chroma  $C \leq 0.3$  (for all other Hues)However, with the CM-2002, any specimen (including those which are not near-white) can be measured.
- WI(E313) is calculated based on the 2° Standard Observer and Standard Illuminant C, regardless of the observer and illuminant selected in OBS., ILL. mode. This conforms to ASTM E 313.
- The standard states that geometries in common use include 45° illumination/perpendicular viewing, perpendicular illumination/45° viewing, unidirectional illumination/diffuse viewing, and diffuse illumination/unidirectional viewing. The CM-2002 uses diffuse illumination/8° (unidirectional) viewing.
- The displayed value WI is the difference between the whiteness index of the specimen and the whiteness index of the target color.

This method is based on the specifications in:

ASTM E 313-73 (Reapproved 1979)

Standard Test Method for INDEXES OF WHITENESS AND YELLOWNESS OF NEAR-WHITE, OPAQUE MATERIALS

## WI(CIE)

When WI(CIE) is selected as the data display, the CM-2002 shows the CIE whiteness index. The whiteness index expresses the degree to which a specimen is white. A perfect reflecting diffuser (an ideal white surface) would have a whiteness index of 100. As the difference between this ideal white and the specimen surface increases, the whiteness index decreases.

The CIE whiteness index is calculated according to the following formulas:  
For 2° Standard Observer:

$$WI = Y + 800(x_n - x) + 1700(y_n - y)$$

where

- Y : XYZ tristimulus value Y (p. 143) of the specimen surface
- x, y : x, y chromaticity coordinates (p. 146) of the specimen surface
- x<sub>n</sub>, y<sub>n</sub> : x, y chromaticity coordinates of the perfect diffuser

For 10° Standard Observer:

$$WI_{10} = Y_{10} + 800(x_{n,10} - x_{10}) + 1700(y_{n,10} - y_{10})$$

where

- Y<sub>10</sub> : X<sub>10</sub>Y<sub>10</sub>Z<sub>10</sub> tristimulus value Y (p. 144) of the specimen surface
- x<sub>10</sub>, y<sub>10</sub> : x<sub>10</sub>, y<sub>10</sub> chromaticity coordinates of the specimen surface
- x<sub>n,10</sub>, y<sub>n,10</sub> : x<sub>10</sub>, y<sub>10</sub> chromaticity coordinates of the perfect diffuser

- The CIE whiteness index is intended for use in measuring near-white specimens which satisfy the following conditions:

$$40 < WI < 5Y - 280 \text{ or } 40 < WI < 5Y_{10} - 280$$

$$-3 < T_w < 3 \text{ or } -3 < T_{w,10} < 3$$

T<sub>w</sub> and T<sub>w,10</sub> are defined by the following formulas:

$$T_w = 1000(x_n - x) - 650(y_n - y)$$

$$T_{w,10} = 900(x_{n,10} - x_{10}) - 650(y_{n,10} - y_{10})$$

If the measured specimen does not satisfy these conditions, WI(CIE) will be displayed as '----'.

- WI(CIE) is calculated based on Standard Illuminant D<sub>65</sub>, regardless of the illuminant selected in OBS., ILL. mode.
- The displayed value ΔWI is the difference between the whiteness index of the specimen and the whiteness index of the target color.

This method is based on the specifications in:

CIE COLORIMETRY Second edition, Publication 15.2 (1986)

## YI(E313)

When YI(E313) is selected as the data display, the CM-2002 shows the ASTM E 313 yellowness index. The yellowness index is an indication of the degree to which a specimen surface is different from the ideal white in the yellow direction. As the difference from the ideal white increases, the numerical absolute value of the yellowness index increases. A positive yellowness index indicates a difference toward yellow; a negative yellowness index indicates a difference toward blue.

The yellowness index is often used to check the color degradation of materials due to light, temperature, or other factors in the environment. It is also used to check the yellowness and yellowing of paint, paper, plastic, or textiles.

The ASTM E 313 yellowness index is calculated according to the following formula:

$$YI = 100 (1 - B/G)$$

where

*B* : Blue reflectance (equal to  $-0.847Z$ ) of the specimen surface

*G* : Green or luminous reflectance (equal to tristimulus value *Y*) of the specimen surface

The above equation can also be written in terms of the tristimulus values *Y* and *Z* as follows:

$$YI = 100 (1 - 0.847Z/Y)$$

where

*Y, Z* : Tristimulus values *Y* and *Z* (p. 143) of the specimen surface

- The ASTM E 313 yellowness index is intended for measuring specimens with dominant wavelengths of between 570 and 580nm (approximately equal to Munsell Hues between 2.5Y and 2.5GY). However, the CM-2002 can be used to measure any specimen, including those not meeting these standards.
- YI(E313) is calculated based on the 2° Standard Observer and Standard Illuminant C, regardless of the observer and illuminant selected in OBS.,ILL. mode. This conforms to ASTM E 313.
- The standard states that geometries in common use include 45° illumination/perpendicular viewing, perpendicular illumination/45° viewing, unidirectional illumination/diffuse viewing, and diffuse illumination/unidirectional viewing. The CM-2002 uses diffuse illumination/8° (unidirectional) viewing.
- If the XYZ tristimulus value *Y* of the measured specimen is 0, YI(E313) will be displayed as '----'.
- The displayed value  $\Delta YI$  is the difference between the yellowness index of the specimen and the yellowness index of the target color.

This method is based on the specifications in:

ASTM E 313-73 (Reapproved 1979)

Standard Test Method for INDEXES OF WHITENESS AND YELLOWNESS OF NEAR-WHITE, OPAQUE MATERIALS



## YI(D1925)

When YI(D1925) is selected as the data display, the CM-2002 shows the ASTM D 1925 yellowness index. The yellowness index is an indication of the degree to which a specimen surface is different from the ideal white in the yellow direction. As the difference from the ideal white increases, the numerical absolute value of the yellowness index increases. A positive yellowness index indicates a difference toward yellow; a negative yellowness index indicates a difference toward blue.

The ASTM D 1925 yellowness index is used to check the reflective color of plastics.

The ASTM D 1925 yellowness index YI and change in yellowness index  $\Delta YI$  are calculated according to the following formulas:

$$YI = [100 (1.28X - 106Z)] / Y$$
$$\Delta YI = YI - YI_0$$

where

- YI : Yellowness index of specimen surface
- X, Y, Z : XYZ tristimulus values (p. 143) of the specimen surface
- $\Delta YI$  : Change in yellowness index
- $YI_0$  : Yellowness index of initial specimen

- The ASTM D 1925 yellowness index is intended primarily for measuring homogeneous, non-fluorescent opaque plastic specimens with dominant wavelengths between 570 and 580. However, the CM-2002 can be used to measure any reflecting specimen, including those not meeting this standard.
- Although the ASTM D 1925 standard can also be applied to measuring the transmitted yellowness index of a specimen, the CM-2002 is limited to measuring the reflected yellowness index.
- YI(D1925) is calculated based on the 2° Standard Observer and Standard Illuminant C, regardless of the observer and illuminant selected in OBS., ILL. mode. This conforms to ASTM D 1925.
- ASTM D 1925 states that the measuring instrument should satisfy the conditions in ASTM E 308.
- If the XYZ tristimulus value Y of the measured specimen is 0, YI(D1925) will be displayed as '----'.

This method is based on the specifications in:

ASTM D 1925-70 (Reapproved 1977) Standard Test Method for YELLOWNESS INDEX OF PLASTICS

Related references:

ASTM E 308-85 Standard Method for COMPUTING THE COLORS OF OBJECTS BY USING THE CIE SYSTEM

**CMC(2:1) AND CMC(1:1)**

$$\Delta E = \left[ \left( \frac{\Delta L^*}{\ell \cdot S_L} \right)^2 + \left( \frac{\Delta C^*}{c \cdot S_c} \right)^2 + \left( \frac{\Delta H^*}{S_H} \right)^2 \right]^{1/2}$$

where

$$S_L = \frac{0.040975 L_t^*}{1 + 0.01765 L_t^*} \quad \text{If } L_t^* < 16, S_L = 0.511$$

$$S_c = \frac{0.0638 C_t^*}{1 + 0.0131 C_t^*} + 0.638$$

$$S_H = S_c(F T + 1 - F)$$

$$F = \left[ \frac{(C_t^*)^4}{(C_t^*)^4 + 1900} \right]^{1/2}$$

$$T = 0.36 + |0.4 \cos(H_t^° + 35)|$$

If  $H_t^°$  is between  $164^°$  and  $345^°$ ,

$$T = 0.56 + |0.2 \cos(H_t^° + 168^°)|$$

where

- $L_t^*$ : Metric lightness (in  $L^*C^*H^°$  color system, p. 152) of target color
- $C_t^*$ : Metric chroma (in  $L^*C^*H^°$  color system, p. 152) of target color
- $H_t^°$ : Metric hue-angle (in  $L^*C^*H^°$  color system, p. 152) of target color
- $\Delta L^*$ ,  $\Delta C^*$ ,  $\Delta H^*$ : Difference between specimen and target color in  $L^*C^*H^°$  color space (p. 153)
- $\ell$ ,  $c$ : Constants: for CMC(2:1),  $\ell=2$  and  $c=1$ ; for CMC(1:1),  $\ell=1$  and  $c=1$ . If perceptible color difference is required, 1:1 is usually used; for critical acceptability determination, 2:1 is usually used.

- Observer and illuminant used for calculations will be those selected in OBS., ILL. mode (p. 39).
- CMC(2:1) is often used in the textile industry.

At present, the  $L^*a^*b^*$  color system is often used for color control. However, the degree of color difference in the  $L^*a^*b^*$  color system do not always match the degree of color difference perceived by humans. For a color of low chromaticness, the color difference  $E^*_{ab}$  calculated in the  $L^*a^*b^*$  color system is usually smaller than the color difference perceived by humans. Also, there are often differences between the measured and perceived hue and lightness values. The CMC formula was developed to try and correct these problems.

This method is based on the specifications in:

BSI DRAFT FOR PUBLIC COMMENT (Document 86/43526): DRAFT BS METHOD FOR CALCULATION OF SMALL COLOUR DIFFERENCES

**FMC-2**

$$\Delta E = \left[ (\Delta L)^2 + (\Delta C_{r-g})^2 + (\Delta C_{y-b})^2 \right]^{1/2}$$

where

$$\Delta L = \frac{0.279 K_2}{a} \cdot \left[ \frac{P\Delta P + Q\Delta Q}{(P^2 + Q^2)^{1/2}} \right]$$

$$\Delta C_{r-g} = \frac{K_1}{a} \cdot \left[ \frac{Q\Delta P - P\Delta Q}{(P^2 + Q^2)^{1/2}} \right]$$

$$\Delta C_{y-b} = \frac{K_1}{b} \cdot \left[ \frac{S(P\Delta P - Q\Delta Q)}{(P^2 + Q^2)} - \Delta S \right]$$

$$P = 0.724X + 0.382Y - 0.098Z$$

$$Q = -0.480X + 1.370Y + 0.1276Z$$

$$S = 0.686Z$$

$$a^2 = \frac{\alpha^2(P^2 + Q^2)}{1 + \frac{NP^2Q^2}{P^4 + Q^4}}$$

$$b^2 = B^2[S^2 + (\rho Y)^2]$$

$$\alpha = 0.00416$$

$$B = 0.0176$$

$$N = 2.73$$

$$\rho = 0.4489$$

X, Y, Z : XYZ tristimulus values (p. 143)

- $\Delta C_{r-g}$  will be displayed as "ΔRG";  $\Delta C_{y-b}$  will be displayed as "ΔYB"; and  $\Delta E$  will be displayed as "FMC2".
- Observer and illuminant used for calculations will be those selected in OBS.,ILL. mode (p. 39).
- If the value of  $\Delta L$ ,  $\Delta C_{r-g}$ ,  $\Delta C_{y-b}$ , or  $\Delta E$  is greater than 10,000, "----" will be shown in the display.

This method was developed by Friele, MacAdam, Chickering, and others based on the MacAdam ellipses of minimum perceptible color difference. It was originally intended for measurements of specimens having approximately the same lightness under Standard Illuminant C and 2° Standard Observer conditions, but it has also been used under other conditions. The values of  $\Delta C_{r-g}$  and  $\Delta C_{y-b}$  indicate color difference in the red and yellow directions respectively, and correspond to  $\Delta a^*$  and  $\Delta b^*$  in the  $L^*a^*b^*$  color system (p. 149).

This method is based on the description in:

PRINCIPLES OF COLOR TECHNOLOGY, 2nd Edition

Fred W. Billmeyer, Jr. and Max Saltzman (John Wiley and Sons, New York, 1981)

Related references:

ASTM D 2244-85 Standard Method for CALCULATION OF COLOR DIFFERENCES FROM INSTRUMENTALLY MEASURED COLOR COORDINATES

**XYZ TRISTIMULUS VALUES OF THE PERFECT REFLECTING DIFFUSER**

	X	Y	Z
A	109.80	100.0	35.59
C	98.06	100.0	118.23
D <sub>50</sub>	96.40	100.0	82.51
D <sub>65</sub>	95.03	100.0	108.88
F2	99.19	100.0	67.39
F6	97.34	100.0	60.26
F7	95.04	100.0	108.75
F8	96.42	100.0	82.42
F10	96.38	100.0	82.36
F11	100.96	100.0	64.35
F12	108.11	100.0	39.28

**X<sub>10</sub>Y<sub>10</sub>Z<sub>10</sub> TRISTIMULUS VALUES OF THE PERFECT REFLECTING DIFFUSER**

	X	Y	Z
A	111.12	100.0	35.24
C	97.28	100.0	116.15
D <sub>50</sub>	96.71	100.0	81.43
D <sub>65</sub>	94.80	100.0	107.33
F2	103.28	100.0	69.03
F6	102.18	100.0	62.11
F7	95.79	100.0	107.69
F8	97.11	100.0	81.19
F10	98.96	100.0	83.29
F11	103.87	100.0	65.61
F12	111.49	100.0	40.37

## OPTIONAL ACCESSORIES

### Memory Card CM-A46

Memory Card CM-A46 is a blank memory card which can be used to store one set of measurement conditions, white calibration data, data for up to 1000 measurements, and data for up to 50 target colors. The card conforms to JEIDA (Japan Electronic Industry Development Association) standards.

### Granular-Materials Cover Set CM-A40

Granular-Materials Cover Set CM-A40 can be used for measuring powdered or paste-like substances. The set consists of a glass plate which prevents the specimen from entering the measurement aperture and a vinyl cover which protects the CM-2002 against dust.

### Sample Holder Set CM-A48 and CM-A49

These sets enable accurate measurements of thin, lightweight, flat specimens such as paper or cloth. Two different sets, one with an Ø8mm measuring area and the other with a Ø5mm measuring area, are available. Sample Holder Set CM-A48 (Ø8mm measuring area) consists of Sample Holder CM-A35, Stand CM-A34, and Grip CM-A42; Sample Holder Set CM-A49 (Ø5mm measuring area) consists of Sample Holder CM-A44, Stand CM-A34, Grip CM-A42, Zero Calibration Box CM-A32, and White Calibration Plate CM-A45 (with a memory card containing white calibration data for the Ø5mm measuring area).

### RS-232C Cable IF-A11 to IF-A15

These cables can be used to connect the CM-2002 to an external computer via the CM-2002's RS-232C terminal. All the cables have a male 9-pin D-subminiature connector for connection to the CM-2002's RS-232C terminal on one end and a connector appropriate to the specific computer on the other.

Cable	Length	Connector
RS-232C Cable IF-A10	2m	Male 25-pin D-subminiature
RS-232C Cable IF-A11	5m	
RS-232C Cable IF-A12	2m	Female 9-pin D-subminiature
RS-232C Cable IF-A13	5m	
RS-232C Cable IF-A14	2m	Female 25-pin D-subminiature
RS-232C Cable IF-A15	5m	

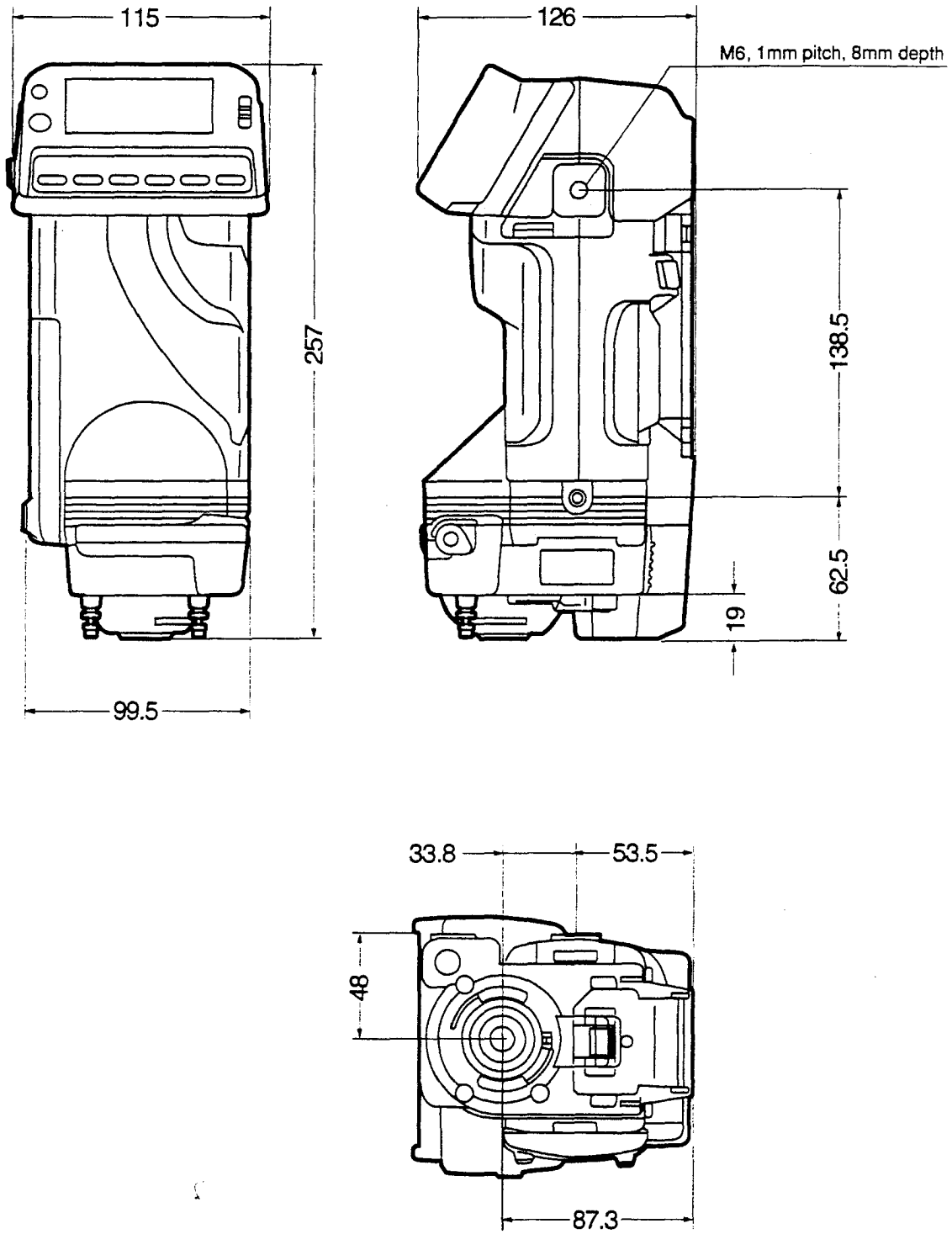
### Zero Calibration Box CM-A32

Zero Calibration Box CM-A32 allows zero calibration to be performed accurately and easily.

### Measuring Stand CM-A30

Measuring Stand CM-A30 enables accurate positioning and consistent measurement conditions.

# DIMENSION DIAGRAM



## SPECIFICATIONS

Model	CM-2002
Illuminating/viewing system	d/8 (diffuse illumination/8° viewing angle); switchable between specular component included and specular component excluded Meets ISO 7724/1 and DIN 5033 teil 7 for d/8 geometry; also meets CIE recommendations and ASTM E 1164 for d/0 geometry.
Detector	Silicon photodiode array with spectral filter array
Wavelength range	400 to 700nm
Wavelength pitch	10nm
Half bandwidth	15nm average
Photometric range	0 to 175% reflectance; resolution: 0.01%
Light source	Pulsed xenon arc lamp
Illumination/measurement area	Ø11mm illumination/Ø8mm measurement (Measurement aperture is Ø11mm)
Microprocessor	32-bit 68332 MPU (16MHz max.)
Measurement and calculation time	0.3 to 0.5 seconds to display of results (except Munsell)
Minimum interval between measurements	3 seconds
Measuring modes	Manual/REMOTE (using computer connected to RS-232C terminal); single measurement/automatic averaging of multiple measurements
Measurement conditions	Illuminant: CIE Standard Illuminants A, C, D <sub>50</sub> , and D <sub>65</sub> ; Fluorescent Illuminants F2, F6, F7, F8, F10, F11, and F12 Observer: CIE 2° and 10° Standard Observers Measurement conditions can be automatically loaded from installed memory card
Display	21-character x 7-line (128 x 56-dot) dot-matrix LCD with adjustable contrast
Displayed data	Spectral reflectance: Graph, numerical values; reflectance correction factor can also be set and used in calculating spectral reflectance Colorimetric values: Numerical absolute color and/or color difference values in the following notations: XYZ, Yxy, L*a*b*, L*C*H°, Hunter Lab, L*u*v*, MI (metamerism index), Munsell, CMC (2:1), CMC (1:1), FMC-2, WI (ASTM E 313), WI (CIE), YI (ASTM E 313), YI (ASTM D 1925) Color difference graph ( $\Delta L^*$ , $\Delta a^*$ , $\Delta b^*$ ) Data or messages transmitted from a computer connected to the RS-232C terminal can also be displayed in REMOTE mode.
Measurement-data memory	Internal: Single measurement Memory card: Space for up to 1000 sets of measurement data
Target-data memory	Space for up to 50 target colors; set by measurement or by data input using computer connected to RS-232C terminal; target data can be temporarily deleted and later recovered; automatic target color selection function determines which target color is closest to measured color.

Tolerance data	Upper and lower limits of absolute color or color difference values in the following color spaces: XYZ, Yxy, L*a*b*, L*C*H°, Hunter Lab, L*u*v*, MI (metamerism index), CMC (2:1), CMC (1:1), FMC-2, WI (ASTM E 313), WI (CIE), YI (ASTM E 313), YI (ASTM D 1925)
Interface	RS-232C standard, 9-pin D-subminiature connector Communication parameters: Baud rate:1200, 2400, 4800, 9600, 19200bps Character length: 7 or 8 bits Stop bits: 1 or 2 Parity: None, odd, even Manual mode: Measurement data can be output (for each measurement at time of measurement; for all measurements stored on memory card) REMOTE mode: Command input, data output, input of messages for display only (terminal function); automatic selection of delimiter code
Repeatability	Spectral reflectance: Standard deviation within 0.10% Colorimetric values: Standard deviation within $\Delta E^*_{ab}$ 0.03 (Measurement conditions: White calibration plate measured 30 times at 10-second intervals after white calibration was performed)
Temperature drift	Spectral reflectance: Within $\pm 0.20\%/^{\circ}\text{C}$ Color difference: Within $\Delta E^*_{ab}$ 0.05/ $^{\circ}\text{C}$ (When white calibration plate is measured)
Other	Displayed data can be inverted; built-in calendar/clock
Power source	Dedicated AC adapter (9V, 1.2A) or 4 AA-size batteries
Battery performance	Alkaline manganese: Up to 500 measurements at 10-second intervals
Temperature/humidity range	Operation: 0 to 40°C (32 to 104°F); less than 85% relative humidity at 35°C (95°F) with no condensation Storage: -20 to 55°C (-4 to 131°F); no condensation
Dimensions	W x H x D: 115 x 257 x 126mm (4-1/2 x 10-1/8 x 5 in.)
Weight	1.6kg (3-1/2 lb.) including batteries
Standard accessories	White Calibration Cap CM-A21 (with memory card and data sheet); Target Mask CM-A22; Accessory Switch CM-A23; Handstrap CM-A24; AC Adapter AC-A12; Hard Case CM-A62
Optional accessories	Measuring Stand CM-A30; Zero Calibration Box CM-A32; Granular-Materials Cover Set CM-A40; Memory Card CM-A46; Sample Holder Set ( $\varnothing$ 8mm) CM-A48; Sample Holder Set ( $\varnothing$ 5mm) CM-A49; RS-232C Cables IF-A11 through IF-A15; Color Data Software CM-1



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MEMO

MEMO



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