Designation: E 2222 – 02 (Reapproved 2007)

Standard Practice for Host Computer Communication with Spectrometers for Color Measurements[1]

This standard is issued under the fixed designation E 2222; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice provides a standard communications protocol for a serial communication between a host computer and a spectrometer designed for colorimetry. The adoption of the standard communication protocol on the part of instrument manufacturers will allow instrument users the option to employ third-party software, or to replace one instrument with another while retaining the same software. This standard is not intended to replace existing standards, such as SCPI-1999 written by the SCPI Consortium[2] as a set of Standard Commands for Programmable Instruments for bench-top instruments that utilize the IEEE-488 or IEEE-488.2 interface. This standard has been adopted by many analytical instrument makers and is used by them as the interface standard for spectroscopy even when the instrument interface is RS-232c.

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:* [3]

E 284 Terminology of Appearance

3. Terminology

3.1 Terms and definitions in Terminology E 284 are applicable to this practice.

4. Summary of Practice

4.1 The practice provides a minimal set of commands to be issued to the instrument by the host computer and the arguments of these commands. It standardizes the instrument's acknowledgement, the data format, and the error messages the instrument will return from such command. The commands are complete enough to allow the users to set the instrument's mode of measurement to transmission or reflectance measurements, and the wavelength interval to 10 or 20 nm. Users may perform zero and 100 % photometric calibration, and they may both upload and download standard white-tile calibration data to the instrument. Provision is made for obtaining a status string, and obtaining information about the particular instrument such as its serial number and geometry.

5. Significance and Use

5.1 The practice should be adopted by spectrometer manufacturers and developers of software to be used on host computers to communicate with such instruments.

6. Procedure

6.1 *RS232C Communications Parameters*—The following serial communications parameters are supported:

Baud rates	1200 bps
	2400 bps
	4800 bps
	9600 bps
	19200 bps
Character length	8 bits
Stop bits	1 bit
Parity	None
X parameter	Not used

6.2 *Universal Serial Buss (USB) Communications Parameters*—USB 1.1 Specification, or higher, at a transfer rate not less than 1.5 Mb/s is supported for USB compatible devices.

6.3 *Delimiter Codes*—Any of the following three ASCII codes may terminate any command to the instrument:

<CR>	Carriage return
<LF>	Line feed
<CR><LF>	Carriage return and line feed

[1] This practice is under the jurisdiction of ASTM Committee E12 on Color and Appearance and is the direct responsibility of Subcommittee E12.04 on Color and Appearance Analysis.

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[2] Standard Commands for Programmable Instruments is an industrial consensus standard and is under the control of the SCPI Consortium, 8380 Hercules Drive, Suite P3, La Mesa, CA 91942, www.scpiconsortium.org.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

6.3.1 The instrument will automatically terminate its replies with the user-selected delimiter. The symbol <DE>, implying that any of the three may be used, will denote further occurrences of the delimiter in this practice.

6.4 *Error Codes*—All of the following error codes are supported by the practice:

OK00	Command performed successfully
OK02	Low lamp light
OK99	Calibration coefficients out-of-limit
ER00	Command not understood
ER02	Illumination circuit still charging
ER07	Instrument not calibrated

For codes beginning with OK, the command has been completed. For codes beginning with ER, the command has not been performed. Instrument manufacturers may assign any meaning desired to unused codes, but such codes may not be interpreted by third-party software.

6.5 *Commands and Replies*—The following commands and their replies are supported by the practice:

6.5.1 *Set Measurement Mode*—The host computer's command to the instrument is:

CPS,aa,b,c,d,<DE>

aa = number of measurements to be averaged as a 2 digit number 01 to 99
b = SCI/SCE setting;
0 = SCI,
1 = SCE
2 = 0 : 45
c = Measurement area setting;
0 = > 18 mm (LA),
1 = 10-18 mm (MA),
2 = 6-9 mm (SA),
3 = ≤5 mm (UA)
d = Reflectance or transmittance mode;
0 = 10 nm reflectance,
1 = 10 nm transmittance,
2 = 20 nm reflectance,
3 = 20 nm transmittance

The instrument replies:

Error-code<DE>

6.5.2 *Zero Calibration*—The host computer's command to the instrument is:

UZC<DE>

The instrument makes the zero measurement and replies:

Error-Code<DE>

6.5.3 *White Calibration*—The host computer's command to the instrument is:

UWC<DE>

The instrument makes the reference white measurement and replies:

Error-Code<DE>

6.5.4 *Measure*—The host computer's command to the instrument is:

MES<DE>

The instrument makes the measurement and replies:

Error-Code,***.***,***.***,***.***,……..,***.***,***.***,<DE>

. is a corrected reflectance or transmittance value expressed in percent. In 10 nm interval, 43 values between 360 and 780 nm are returned. Unmeasured values are zero padded. In 20 nm interval, 16 values are returned.

6.5.5 *Upload Status String*—The host computer's command to the instrument is:

STR<DE>

The instrument replies:

Error-code,a,b,c,d,<DE>

a = battery status; 0 = charged, 1 = battery low warning
b = area of view during last calibration; codes same as CPS command
c = white cal status, 0 = yes, 1 = not yet
d = zero cal status; 0 = yes, 1 = not yet

Benchtop instruments to which the battery status is inapplicable reply with a = 0.

6.5.6 *Upload Measurement Status*—The host computer's command to the instrument is:

CPR<DE>

The instrument replies:

Error-Code,aa,b,c,d<DE>

aa = number of measurements to be averaged as a 2 digit number 01 to 99
b = SCI/SCE setting;
0 = SCI,
1 = SCE
2 = 0 : 45
c = Measurement area setting;
0 = >18 mm (LA),
1 = 10-18 mm (SA),
2 = 6-9 mm (UA),
3 = ≤5 mm (NA)
d = Reflectance or transmittance mode;
0 = 10 nm reflectance,
1 = 10 nm transmittance,
2 = 20 nm reflectance,
3 = 20 nm transmittance

6.5.7 *Upload Instrument Serial*—The host computer's command to the instrument is:

IDR<DE>

The instrument replies:

Error-code,aa,bbb,cccccccc,d,eee,fff,gg,<DE>

aa = model number code per instrument manufacturer's choice
bbb = Firmware Version number; a three digit integer which is to be interpreted as being divided by 100 to generate the version number
cccccccc = eight digit instrument serial number
d = geometry of the instrument; 0 = d : 8, 1 = 0 : 45
eee = lowest measured wavelength in nm
fff = highest measured wavelength in nm
gg = measurement interval

6.5.8 *Download White Calibration Data*—The host computer's command to the instrument is:

CDS,a,b,c,***.***,***.***,***.***,……..,***.***,***.***,<DE>

where the reflectances (or transmittances) are the transfer standard values for the white tile (or the standard blank reference for transmittance), and

a = SCI / SCE setting for which data are applicable; 0 and 1 codes same as for CPS command
b = measurement area setting for which data is applicable; 0, 1, 2 and 3 codes same as CPS command
c = Reflectance or transmittance mode;

0 = 10 nm reflectance,
1 = 10 nm transmittance,
2 = 20 nm reflectance,
3 = 20 nm transmittance

The instrument replies:

Error-code<DE>

6.5.9 *Upload White Calibration Data*—The host computer's command to the instrument is:

CDR,a,b,c,<DE>

a = SCI / SCE setting for which data are applicable; 0 and 1 codes same as for CPS command
b = measurement area setting for which data is applicable; 0, 1, 2 and 3 codes same as CPS command
c = Reflectance or transmittance mode;
0 = 10 nm reflectance,
1 = 10 nm transmittance,
2 = 20 nm reflectance,
3 = 20 nm transmittance

The instrument returns:

Error-code,***.***,***.***,***.***,……..,***.***,***.***,<DE>

where the reflectances (or transmittances) are the transfer standard values for the white tile (or the standard blank reference for transmittance) for the measurement mode conditions sent in the command string.

7. Keywords

7.1 communications protocol; serial communications; software; spectrometer