

App. Note Code: 2RA-J

# APPLICATION NOTE



**EKO MS-700**  
**Spectroradiometer Interfaced**  
**with a CR3000 Datalogger**

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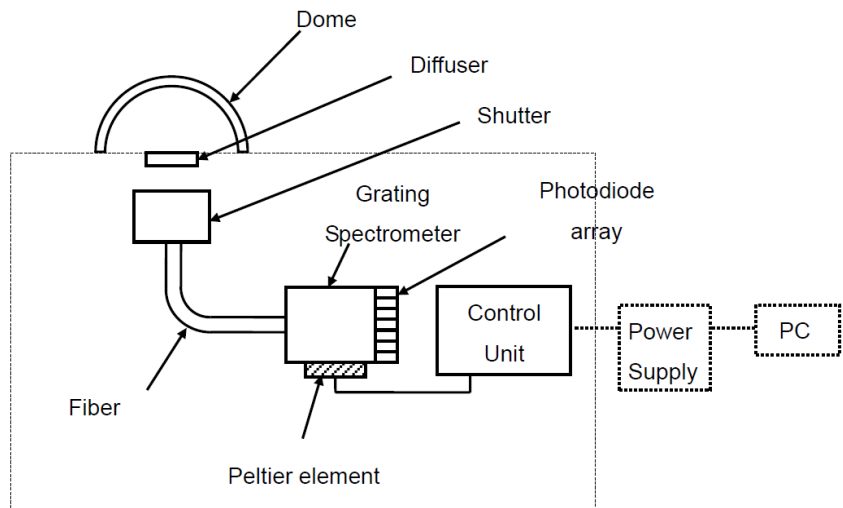


# ***EKO MS-700 Spectroradiometer with CR3000 Datalogger***

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## **1. Introduction**

The EKO Instruments MS-700 spectroradiometer represents one of the few all weather and permanently deployable spectroradiometers on the market. The sensor consists of a high quality hermetically sealed dome and diffuser which couple incident light into a fiber before emitting the light through a diffraction grating which projects the photons of varying wavelength across a charge-coupled device (CCD) detector array. The magnitude of the signal on each array pixel is converted to spectral irradiance values. The optics are kept at stable temperatures using a peltier element. A drawing of the sensor head configuration is provided in FIGURE 1-1.



*FIGURE 1-1. MS-700 sensor head and configuration with external power supply and PC (courtesy EKO)*

The EKO MS-700 Spectroradiometer measures spectral-flux density values of natural and artificial light. Common applications include providing data for solar radiation studies to renewable energy companies or atmospheric science researchers as well as materials testing for various industries.

While EKO Instruments supplies the sensor with a standard software package for operating the sensor with a PC, several researchers and organizations want an alternative method of sensor control and data management. Benefits of using a Campbell Scientific package include LoggerNet's data handling, robust electronics, and excellent customer support.

## 2. Specifications

EKO MS-700 Specifications (Typical)		
Sensor head	MS-700	MS-700 DNI
Wavelength range	350 to 1050 nm	
Wavelength interval	3.3 nm	
Spectral resolution FWHM	10 nm	
Wavelength accuracy	<0.3 nm	
Exposure time	10 ms to 5 s	
Temp. dependency (-20° to 50°C)	< ± 1 %	
Temperature control	25 ± 5°C	
Cosine response (0° to 80°)	<7%	–
Aperture	180°	5°
Slope angle	–	1°
Stray light	0.15%	
Window material	Optical glass	Quartz glass
Communication	RS-422 (Between head and power supply)	
Cable length	10 m (Optional max. 30 m)	
Power requirements	12 Vdc, 50 VA (power supply)	
Operating temperature range (°C)	-20 to +50	
Dimensions (sensor)	200(φ)×175(H) mm (With sun screen: 240(φ)×175(H) mm)	200(φ)×300(H) mm
Weight (sensor)	4 kg	4.5 kg
<b>Power supply</b>		
AC supply voltage	AC100-240V, 50/60 Hz, 50 VA	
DC supply voltage	DC 12 V	
Operating environment	Temperature: 0° to 40°C, Relative Humidity: 0 to 90%, non-condensing	
Dimensions	200 (W) x 140 (D) x 80 (H) mm	
Weight	1 kg	

### 3. Overview

The MS-700 outputs an RS-422 serial signal to the EKO power supply box. The power supply converts the RS-422 to RS-232. From EKO, the MS-700 is intended to be connected to a PC and operated using the software package provided by EKO. Data provided by this method will be provided in a .CSV format and stored on the PC hard drive.

When using a Campbell Scientific system, data are provided in comma delimited TOB3 ASCII files. Each sensor requires a baud rate of 38400 bps with a bit structure of 8 data bits, 1 stop bit and no parity. With only 4 MB of memory, the system will quickly begin to overwrite older data stored exclusively on the CR3000 datalogger. The solution is to redundantly store data to a CompactFlash (CF) card using a Campbell Scientific CFM100 or NL115 CF card storage module. The storage module easily attaches to and automatically integrates with the CR3000.

Sensor data are measurements of spectral power-density values in units of  $Wm^{-2} \mu m^{-1}$  at approximately 3 nm bandwidth with an accuracy of <0.3 nm. The total measurement bandwidth spans from 350 to 1050 nm providing 256 irradiance values per measurement. There is a limitation in the sampling frequency when using the Campbell Scientific system. First, the detector requires 10 to 5000 ms of exposure for a signal to be measured. Second, to output a measurement after having a checksum calculated and verified takes some processing time. This limits the system to measurement scans of approximately 60 s.

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#### NOTE

A PC system could make faster measurements but would need a user to manually make the measurements or specific code written to automate the measurements on the PC.

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## 4. Installation and Operation

### 4.1 Wiring

The MS-700 requires the EKO power supply for powering the device and for conversion between RS-422 to RS-232. Wiring the MS-700 to the power supply is provided in the EKO MS-700 manual. The RS-232 cable can be connected to a PC, but for this application it will be connected to the CR3000's COM ports.

An SC110 (RS-232-to-Datalogger Cable) is used to connect the straight through serial cable from the MS-700 to the CR3000 COM ports as shown in TABLE 4-1.

TABLE 4-1. SC110 Wiring Table for CR800 Series <sup>1</sup> , CR1000, and CR3000 Dataloggers		
Datalogger	SC110	CR3000
Comm 1	Brown	Tx (COM 1*, 2*, 3, 4)
Comm 2	White	Rx (COM 1*, 2*, 3, 4)
G	Yellow	Ground
<sup>1</sup> CR800/850 dataloggers have only two COM ports		

If grounding issues are likely to occur, an SC105 9-pin-to-RS-232-DCE Interface device can be used instead of the SC110. This provides an additional buffer for the data to reside in before being read by the datalogger, which often eliminates grounding issues in field deployed systems.

To use the SC105, first configure it to one of the Synchronous Device Communication (SDC) addresses using our Device Configuration Utility (see the SC105 manual for more information). The SC105 connects to the CR3000 using the SC12 cable included with the SC105. One end of the SC12 cable connects to the datalogger's CS I/O port. The other end of the cable connects to the SC105 connector labeled Datalogger. The straight through serial cable from the MS-700 power supply connects to the SC105 connector labeled DCE.

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**NOTE** Please contact Campbell Scientific if grounding errors still occur.

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## 4.2 Data Analysis

Campbell Scientific's *Real Time Monitoring and Control (RTMC and RTMC Pro)* software can create displays of the results. However, for displays of time series of irradiance values, *RTMC* is limited to 15 data series values. Newer versions of *RTMC Pro* are not limited and could display all 256 irradiance values. *Matlab*® or another statistical analysis software or environment, such as *R*, may be better suited for analyzing very large data sets and producing visualizations. The center wavelengths of each measurement are calculated using the following equation as provided in the EKO MS-700 Command Codes document.

$$\text{Lambda}(n) = (C_4 * n^4) + (C_3 * n^3) + (C_2 * n^2) + (C_1 * n) + C_0$$

## 4.3 Programming Example

```
'CR3000 Series Datalogger
'Sample code for integrating an EKO MS-700 Spectroradiometer with a Campbell Scientific
'CR3000 Datalogger

PreserveVariables
Const pixels_count = 256
Const input_buffer_len = pixels_count * 15 + 100
Const wavelength_coefs_count = 5
Const serial_port = COM1
Const Standard = 0
Const Deluxe = 1

Public serial_no As Long
Public package As Long
Public progsig
Public Result(2)
Public GetData(20)

Public wavelength_coefs(wavelength_coefs_count)
Public irradiance(pixels_count)
Units irradiance = "W/m^2/um"
Public last_error As String * 128
Public exposure_time
Units exposure_time = "ms"
Public BattVolt
Units BattVolt=Volts
```



```

Public panelTemp1
Units panelTemp1=Deg C
Public DeviceTemp
Units DeviceTemp=Deg C

DataTable(MS700, true, -1)
  DataInterval(0, 1, min, 10)
  CardOut(0,-1)
  Sample(wavelength_coefs_count, wavelength_coefs, IEEE4)
  FieldNames("c0,c1,c2,c3,c4")
  average (1,irradiance(),IEEE4,False)
  Sample(pixels_count, irradiance, IEEE4)
EndTable

DataTable(ms700_debug, true, 1000)
  Sample(1, last_error, String)
EndTable

BeginProg
  'The MS-700 requires 38400 baud, 8 data bits, no parity and 1 stop bit
  SerialOpen(serial_port, 38400, 3, 0, input_buffer_len) 'Comm 3
  Scan (3,Sec,3,0)
    PanelTemp (DeviceTemp,_60Hz)
    Battery (BattVolt)
  'Additional measurements could be placed here as well as a call to additional data tables
NextScan

Const xsum_buffer_len = 25
Dim input_buffer As String * input_buffer_len
Dim xsum_buffer As String * xsum_buffer_len
Dim ms700_vals_ok As Boolean
Dim ms700_retry_count As Long
Dim i As Long
Dim calc_xsum As Long
Dim sent_xsum As Long

SlowSequence
Scan (1,Min,0,0)
  'Before a measurement is made all values will be initialized with NaNs
  For i = 1 To pixels_count
    irradiance(i) = NaN
  Next
  For i = 1 To wavelength_coefs_count
    wavelength_coefs(i) = NaN
  Next
  last_error = ""
  ms700_retry_count = 0

  'Read the wavelength Coefficients from the sensor
  For i = 1 To wavelength_coefs_count
    SerialFlush(serial_port)
    SerialOut(serial_port, "C" + (i - 1) + CHR(13), "", 0, 0)
    SerialIn(input_buffer, serial_port, 2 / 0.01, 13, input_buffer_len)
    If InStr(1, input_buffer, ",OK", 2) > 0 Then
      wavelength_coefs(i) = input_buffer
    Else
      last_error = "read C" + (i - 1) + " failed: " + input_buffer + ""
      CallTable(ms700_debug)
      ExitFor
    EndIf
  Next

  If Len(last_error) = 0 Then
    'Initiate an "auto" measurement
    SerialFlush(serial_port)
    SerialOut(serial_port, "AM,0" + CHR(13), "", 0, 0)
    SerialIn(input_buffer, serial_port, 15 / 0.01, 13, input_buffer_len)
    If InStr(1, input_buffer, ",OK", 2) > 0 Then

```

```

'The exposure time is returned along with the OK signal
exposure_time = input_buffer

'Attempt to read the measured values from the sensor
ms700_vals_ok = false
ms700_retry_count = 0
Do While NOT ms700_vals_ok AND ms700_retry_count < 3
  'Issue the command to send the values and read these into the input buffer
  SerialFlush(serial_port)
  SerialOut(serial_port, "DT,0" + CHR(13), "", 0, 0)
  SerialIn(input_buffer, serial_port, 2 / 0.01, 13, input_buffer_len)
  If InStr(1, input_buffer, "OK", 2) > 0 Then
    'Calculate the check sum of the data buffer. This will need to include
    'the CR that was stripped off by SerialIn()
    calc_xsum = 0
    For i = 1 To Len(input_buffer)
      calc_xsum = (calc_xsum XOR Ascii(input_buffer(1, 1, i))) AND &hFF
    Next i
    calc_xsum = (calc_xsum XOR 13) AND &hff

    'Verify the check sum for the data values
    SerialFlush(serial_port)
    SerialOut(serial_port, "CS" + CHR(13), "", 0, 0)
    SerialIn(xsum_buffer, serial_port, 2 / 0.01, 13, xsum_buffer_len)
    If InStr(1, xsum_buffer, "OK", 2) > 0 Then
      'Compare the checksum calculated above with that returned
      'by the CS command. These should be equal. If not, retry the
      'command to collect data
      sent_xsum = HexToDec(xsum_buffer)
      If sent_xsum = calc_xsum Then
        ms700_vals_ok = true
        SplitStr(irradiance, input_buffer, ",", pixels_count, 0)
        'Verify the values that were read
        For i = 1 To pixels_count
          If irradiance(i) < 0.0 Then
            irradiance(i) = 0.0
          ElseIf irradiance(i) >= 2000 OR irradiance(i) = NaN Then
            last_error = "invalid irradiance(" + i + "): " + irradiance(i)
            CallTable(ms700_debug)
            ms700_vals_ok = false
            ms700_retry_count = ms700_retry_count + 1
            irradiance(i) = NaN
          EndIf
        Next
      Else
        last_error = "checksums don't match: calc=" + calc_xsum + " sent=" + sent_xsum
        CallTable(ms700_debug)
        ms700_retry_count = ms700_retry_count + 1
      EndIf
    Else
      last_error = "invalid CS ack: " + xsum_buffer
      CallTable(ms700_debug)
      ms700_retry_count = 3
    EndIf
  Else
    last_error = "invalid DT,0 ack"
    CallTable(ms700_debug)
    ms700_retry_count = ms700_retry_count + 1
  EndIf
Wend
Else
  last_error = "measure failed: '" + input_buffer + "'"
  CallTable(ms700_debug)
EndIf
EndIf
CallTable(Ms700)
NextScan
EndProg

```

## **5. Attributions**

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*R* is a product of [r-project.org](http://r-project.org)





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