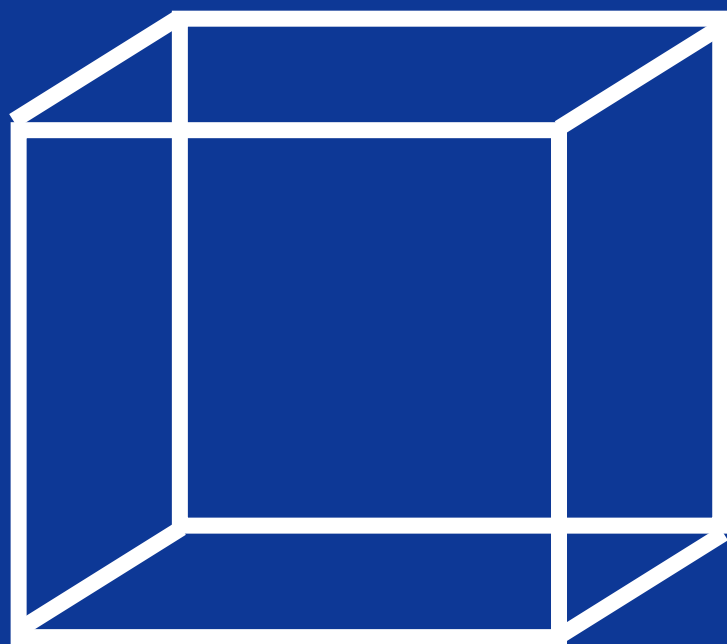


INSTRUCTION MANUAL

C-BOX V1.6

Smart Processing Interface
For MS-90

C-Box Modbus 485



EKO

1.	Index	1
2.	Important User Information	2
	2-1. Contact Information	2
	2-2. Warranty and Liability	3
	2-3. About Instruction Manual	3
	2-4. Environment	3
	2-5. CE Declaration	4
3.	Safety Information	5
	3-1. WARNING/CAUTION	5
4.	Introduction	6
	4-1. Package Contents	6
5.	Getting Started	7
	5-1. Parts Name	7
	5-2. System Overview	7
	5-3. Installation	8
	5-4. Settings	8
	5-5. Operating	11
	5-6. Irradiance measurements	12
6.	Modbus communication	13
	6-1. Communication	13
	6-2. Registers	14
	6-3. Software	15
7.	Specification	18
	7-1. Main Unit	18
	7-2. Dimensions	19
Appendix	20	
	Appendix -A. Wiring table C-Box	20

2. Important User Information

Thank you for using EKO Products

Make sure to read this instruction manual thoroughly and to understand the contents before starting to operate the instrument. Keep this manual at safe and handy place for whenever it is needed.

For any questions, please contact us at one of the EKO offices given below:

2-1. Contact Information

EKO INSTRUMENTS CO., LTD.

Asia, Oceania Region

www.eko-asia.com	EKO INSTRUMENTS Co., Ltd.	Tel: +81 (3) 3469-6713
info@eko.co.jp	1-21-8 Hatagaya, Shibuya-ku	Fax: +81 (3) 3469-6719
	Tokyo, 151-0072 Japan	

Europe, Middle East, Africa, South America Region

www.eko-eu.com	EKO INSTRUMENTS Europe B.V.	Tel: +31 (0)70 3050117
info@eko-eu.com	Lulofsstraat 55, Unit 28,	Fax: +31 (0)70 3840607
	2521 AL, Den Haag, The	
	Netherlands	

North America Region

www.eko-usa.com	EKO INSTRUMENTS USA Inc.	Tel: +1 408-977-7751
info@eko-usa.com	95 South Market Street, Suite 300	Fax: +1 408-977-7741
	San Jose, CA 95113 USA	

2-2. Warranty and Liability

For warranty terms and conditions, contact EKO or your distributor for further details.

EKO guarantees that the product delivered to customer has been verified, checked and tested to ensure that the product meets the appropriate specifications. The product warranty is valid only if the product has been installed and used according to the directives provided in this instruction manual.

In case of any manufacturing defect, the product will be repaired or replaced under warranty. However, the warranty does not apply if:

- Any modification or repair was done by any person or organization other than EKO service personnel.
- The damage or defect is caused by not respecting the instructions of use as given on the product brochure or the instruction manual.

2-3. About Instruction Manual

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This manual was issued: 2021/12/8
Version Number: 1.6.6

2-4. Environment

1. WEEE Directive 2002/96/EC

This product is subjected to WEEE Directive 2002/96/EC and should not be mixed with general household waste. For proper treatment, recovery and recycling, please take this product(s) to a designated recycle collection point.

Disposing of this product correctly will help save valuable resources and prevent any potential negative effects on human health and the environment, which could otherwise arise from inappropriate waste handling.

2. RoHS Directive 2002/95/EC

EKO Instruments has completed a comprehensive evaluation of its product range to ensure compliance with RoHS Directive 2002/95/EC regarding maximum concentration values for substances. As a result all products are manufactured using raw materials that do not contain any of the restricted substances referred to in the RoHS Directive 2002/95/EC at concentration levels in excess of those permitted under the RoHS Directive 2002/95/EC, or up to levels allowed in excess of these concentrations by the Annex to the RoHS Directive 2002/95/EC.



DECLARATION OF CONFORMITY

We: EKO Instruments Europe B.V.
Lulofsstraat 55, U 28, Den Haag
2521 AL Den Haag

The Netherlands

Declare under our sole responsibility that the product:

Product Name : Control box for the MS-90 DNI sensor
Model No. : C-BOX

To which this declaration relates is in conformity with the following
harmonized standards of other normative documents:

Harmonized standards:

EN 61326-1:2006 Class A (Emission)
EN 61326-1:2006 (Immunity)

Following the provisions of the directive:

EMC-directive : 89/336/EEC
Amendment to the above directive : 93/68/EEC

Date : 01-02-2020

Position of Authorized Signatory : Technical Director

Name of Authorized Signatory : C.H. Hoogendijk

3. Safety Information

EKO Products are designed and manufactured with consideration for safety; however, please make sure to read and understand this instruction manual thoroughly to be able to operate the instrument safely in the correct manner.



WARNING
CAUTION

Attention to user; pay attention to the instructions given on the instruction manual with this sign.



3-1. WARNING/CAUTION

1. Installation

- Do not install C-BOX in a place, which it may get under water.
- Make sure the instruments are installed in a location where they are easily accessible for maintenance, or it may lead to unexpected accidents and injury.
- Although this product is designed to meet EMC Directive compliance requirements, it may not fully satisfy its primary specification/performance when using this product near following locations where strong electromagnetic wave is generated. Please pay attention to the installation environment.

Outdoor: High voltage power line, power receiver/distribution facility, etc.

Indoor: Large-size chiller, large rotation device, microwave, etc.

2. Power Supply

- Always make sure to check the power supply voltage and type (AC/DC) before connecting and powering ON the instruments.
- Use with fuse 0.5A connected in series on the power supply cable. Depending on the power supply connected, large current may flow when the internal malfunction occur, and may lead to generating heat and fire.

3. Instruction Manual

- In this instruction manual contains basic and important operation information for the use of the C-BOX for the MS-90 DNI sensor and MS-90 plus+ system.
- Read this instruction manual and understand the contents well before operating C-BOX.
- Also, keep this instruction manual in handy location in case you need it.

4. Introduction

The C-BOX smart processing interface provides different functions for sensor control and data processing of different EKO sensors. In combination with the MS-90 DNI sensor, the pulsed output can be converted into a Modbus 485 RTU signal.

The **C-Box Modbus 485** has a built in GPS receiver and is used as part of the MS-90 Plus+ sensor system. By using this device, the MS-90 analogue output pulse is converted to digital. With an additional MS-80S or MS-80M Smart pyranometer a turnkey system can be configured to measure DNI, GHI and DHI over Modbus.

With Modbus 485 communication, it is possible to connect with PV monitoring devices or datalogger, which have a RS-485 serial interface and provide MODBUS serial communication.

The signal converter is integrated in an IP65 enclosure for outdoor installation. The settings for the measurements and communication can be changed by using the EKO C-Box setup software.

4-1. Package Contents

Check the package contents first; if any missing item or damage is noticed, please contact EKO immediately.

Table 4-1 Package Contents

Standard Items	Qty.	Remarks
C-BOX Main Unit	1	C-BOX-Modbus 485 with GPS
Cable	1	10m for communication and power supply Optional item (Part of MS-90 Plus+)
Factory settings report	1	
MS-90 DNI Sensor, 1.5m cable	1	Optional item (Part of MS-90 Plus+)
MS-80S GHI Sensor, 1.5m cable	1	Optional item (Part of MS-90 Plus+)

5. Getting Started

5-1. Parts Name

Each part name and its main functions are described below.

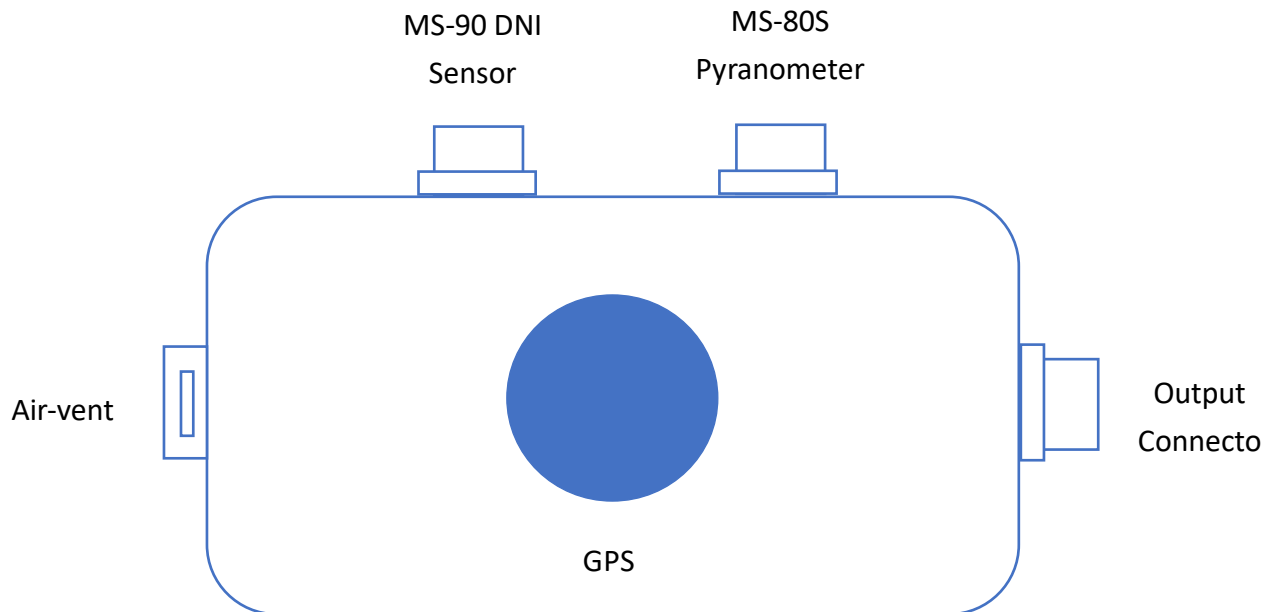


Figure 5-2-1. C-BOX

5-2. System Overview

The C-BOX Smart Processing Interface is used to build a sensor system to measure multiple irradiance components. Below figure describes the system overview of C-BOX.

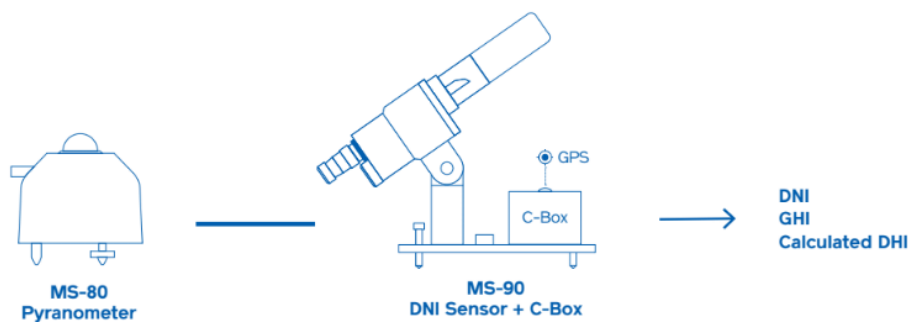


Figure 5-2-2. C-BOX system (sensors MS-90 and 80S are optional)

5-3. Installation

The ideal mounting position is a place without any obstructions such as buildings, trees, and mountains, however it might be difficult to find such location. As a general rule the sensors should have a clear horizon above 5°. The setup location should be easily accessible for periodic maintenance of glass dome cleaning, desiccant replacement, etc. Avoid surrounding towers, poles, walls or billboards with bright colors that can reflect solar radiation onto the sensors.

For is installation of the sensors MS-90 DNI sensor and MS-80S pyranometer check out the sensor specific online manuals at EKO-EU.com.

5-4. Settings

1. Wiring

Connect all cables to the sensors and data acquisition system.

1. Connect the C-BOX to data logger via Modbus 485 RTU
2. Connect the Main Unit power supply (12VDC)
3. Connect the MS-90 DNI sensor signal cable to the sensor and C-Box
4. Connect the MS-80S Pyranometer signal cable to the sensor and C-Box

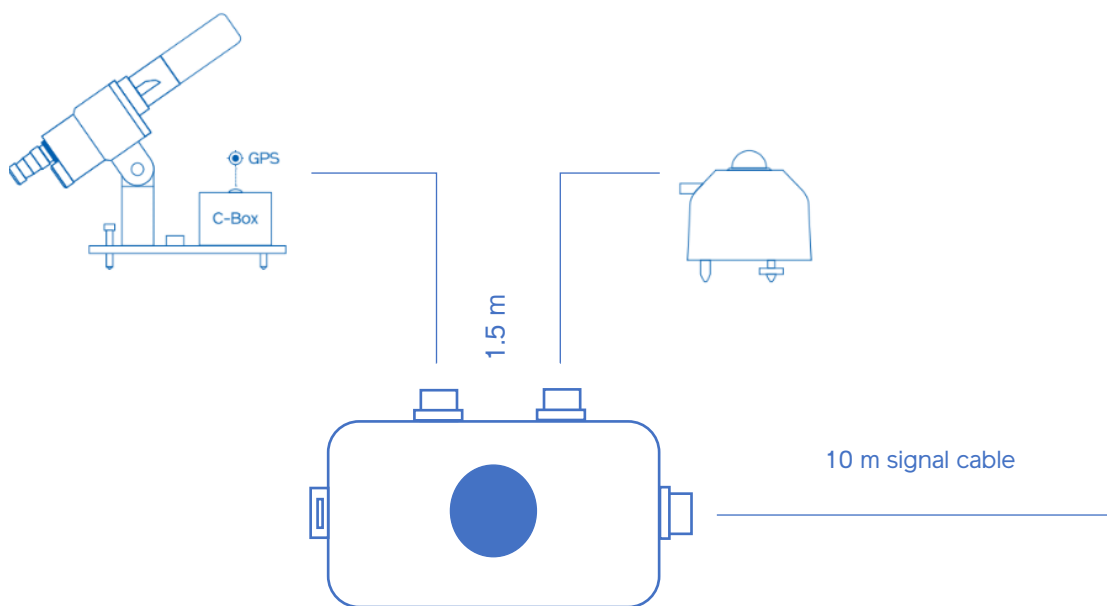


Figure 5-4-1. C-BOX system configuration and cables

2. Connections

To extend the cable lifetime, prevent that the cables are not directly exposed to direct sun light or rain/wind. Cables can be placed in a cable conduit. Cable vibrations will potentially cause noise in the output signal. Fasten the cable so that the cable does not swing or move by wind blowing. Exposure of the signal cable to excessive electromagnetic emissions can cause noise in the output signal as well. Therefore the cable should be lined at a safe distance from a potential source generating EMC noise, such as an AC power supply, high voltage lines or telecom antenna.

Input MS-80S and MS-90

Table 5-4-1. Internal connections MS-80S / 90 to C-BOX

Terminals	Function
1. Shield	Not used
2. Shield	Not used
3. 0V	MS-80S (White)
4. 12 VDC Out	MS-80S (Brown)
5. Modbus B	MS-80S (Black)
6. Modbus A	MS-80S (Blue)
7. Modbus GND	MS-80S (Grey)
8. Reserved	Not used
9. MS-80 (+) Analog	Disabled
10 MS-80 (-) Analog	Disabled
11. MS-90 DNI (-)	MS-90 (Black) Cable V2
12. MS-90 DNI (+)	MS-90 (Blue) Cable V2
13. 0V	Not used
14. 0V	Not used
15. 12VDC Out MS-90	MS-90 (Brown) Cable V2
16. 0VDC Out MS-90	MS-90 (White) Cable V2

Output Modbus 485 mode

Table 5-4-2. Connections C-BOX-Modbus 485 (Output)

5 Pin connector / wire Color	Function
1. Brown	12V Supply voltage
2. White	Supply voltage ground
3. Blue	Modbus (+) / A
4. Black	Modbus (-) / B
5. Grey	NC

C-BOX can connect to a system that communicates with Modbus 485 RTU.

Connection of C-BOX to the RS-485 communication network is shown below. The Master represents the data-logging device [such as PC], and the slaves represent devices such as the C-BOX. Connect the + and - for the master to [A] and [B]. Also at the end of the network, connect a 120Ω termination resistor.

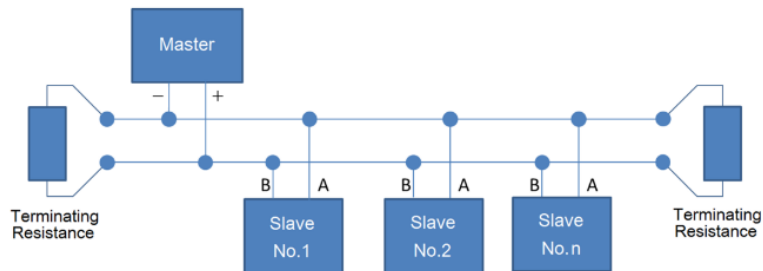


Figure 5-4-2. Connections of C-BOX in a Modbus 485 network

5-5. Operating

The Modbus operating mode is factory preset and can only be changed when operated in Modbus mode and connected to a PC. When powering the C-BOX it will always start up in Modbus mode.



After powering the C-BOX all connected sensors automatically start measuring. While connected to the MS-90 DNI sensor, the mirror will start to rotate. Upon startup of the C-BOX, the detector voltage output will build up due to internal charging of a capacitor from the MS-90 sensor circuit, this voltage will slowly decay to 0 if the irradiance conditions are 0 W/m² after approximately **1 minute**.

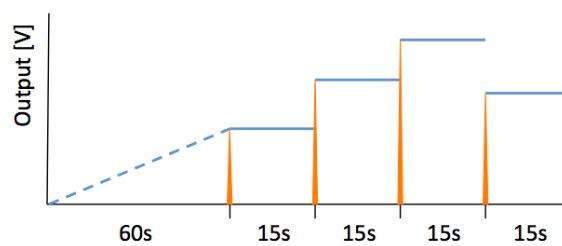


Figure 5-5-1. C-BOX analog output signal

5-6. Irradiance measurements

The DNI measurements are taken every 15 seconds based on the rotation speed of the mirror. Global Irradiance (GHI) measurements are measured every 1 second.

For a system configured with MS-90 DNI and MS-80S pyranometer and operated in Modbus mode the three irradiance components (DNI, GHI, DHI) will be measured.

The pyranometer (GHI) signal is converted into irradiance based on the sensitivity figure which is factory preset. Hence the diffuse irradiance (DHI) is calculated based on the DNI and GHI.

$$\text{Irr}_{\text{DHI}} = \text{Irr}_{\text{GHI}} - (\text{Irr}_{\text{DNI}} \cdot \text{Cos } \theta)$$

Irr_{DHI} = Calculated diffuse horizontal irradiance [W/m^2]

Irr_{GHI} = Global Horizontal Irradiance [W/m^2]

Irr_{DNI} = Direct Normal Irradiance [W/m^2]

$\text{Cos } \theta$ = Zenith angle ($^\circ$)

6. Modbus communication

6-1. Communication

Table 6-1. C-BOX communication settings (Between C-Box and DAQ system or PC)

C-Box	Function
Communication standard	RS-485
Protocol	Modbus Slave RTU
Communication speed	9600 Default
Data length	8bits
Node address	1 Default / can be changed with EKO software
Stop bit	1
Parity bit	None

Table 6-2. MS-80S communication settings (Between C-Box and sensor)

MS-80S	Function
Communication standard	RS-485
Protocol	Modbus Slave RTU
Communication speed	19200
Data length	8bits
Node address	Last 2 digits of serial number (100 in case ending at 00)
Parity bit	Even 1

Table 6-3. MS-80M communication settings (Between C-Box and sensor)

MS-80M	Function
Communication standard	RS-485
Protocol	Modbus Slave RTU
Communication speed	9600
Data length	8bits
Node address	1 Default
Parity bit	None

6-2. Registers

Table 6-2. C-BOX communication registers

C-BOX Firmware V2.01 MODBUS registers

Address	Label	Format	Function	Description
0	FW_VERSION	16 bit WORD	Read only	Firmware version
1	SERIAL	16 bit WORD	Read only	Serial number
2	SENSOR_MODEL	16 bit WORD	Read only	Sensor model
3	BOARD_TEMPERATURE	16 bit WORD	Read only	Board temperature
4	GHI	32 bit FLOAT	Read only	MS80S Global horizontal irradiance
6	DNI	32 bit FLOAT	Read only	MS90 Direct normal irradiance
8	AO	32 bit FLOAT	Read only	
10	RESET_ALL	32 bit FLOAT	Read and Write	RESET CBOX
12	DHI	32 bit FLOAT	Read only	Calculated DHI
14	TIMESTAMP	32 bit FLOAT	Read only	GPS Time
16	UPDATE	32 bit FLOAT	Read and Write	Update CBOX
18	GPS_SATS	32 bit FLOAT	Read only	
19	ANALOGMODE	16 bit WORD	Read and Write	
21	MODE	16 bit WORD	Read and Write	
22	MS80_HUMIDITY	32 bit FLOAT	Read only	GHI sensor humidity
24	MS80_TILT_X	32 bit FLOAT	Read only	GHI sensor tilt X
26	MS80_TILT_Y	32 bit FLOAT	Read only	GHI sensor tilt Y
28	MS80_SENSOR_TEMP	32 bit FLOAT	Read only	MS80 Temperature
32	CF_MS90	32 bit FLOAT	Read and Write	MS90 Sensitivity
34	LAT	32 bit FLOAT	Read only	
36	LON	32 bit FLOAT	Read only	
40	ELEVATION	32 bit FLOAT	Read only	
42	AZIMUTH	32 bit FLOAT	Read only	
44	DHI_NO_COR	32 bit FLOAT	Read only	
46	BAUDRATE	32 bit FLOAT	Read and Write	C-BOX output Baud
47	PARITY_STOPBITS	16 bit WORD	Read and Write	C-BOX output parity
48	BAUDRATE_MASTER	16 bit WORD	Read and Write	GHI sensor baud
49	PARITY_STOPBITS_MASTER	16 bit WORD	Read and Write	GHI sensor parity
50	NODE_ID	16 bit WORD	Read and Write	C-BOX node
51	EXT_SENSOR	16 bit WORD	Read only	
52	EXT_NODE_ADDRESS	16 bit WORD	Read and Write	2 nd pyranometer node, Default 2
53	GHI_SENSOR	16 bit WORD	Read only	
54	GHI_NODE_ADDRESS	16 bit WORD	Read and Write	GHI sensor node, Default 1
56	MS80_2_HUMIDITY	32 bit FLOAT	Read only	
58	MS80_2_TILT_X	32 bit FLOAT	Read only	
60	MS80_2_TILT_Y	32 bit FLOAT	Read only	
62	MS80_2_SENSOR_TEMP	32 bit FLOAT	Read only	
64	MS80_2_IRRADIANCE	32 bit FLOAT	Read only	

6-3. Software

The C-Box configuration software can be downloaded from the EKO-EU website (MS-90+ plus product page). Different measurement parameters can be displayed to verify the output parameters of the system. Sensor and communication settings can be made to setup the system. For connection to a PC an optional USB to 485-communication cable is required.

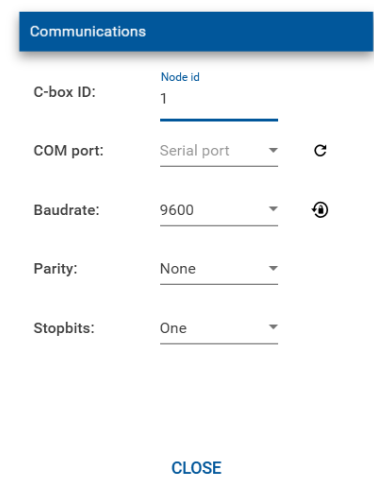
Communication

The C-box communication with PC or DAQ system is through Modbus 485 RTU.

C-Box communication settings (Default)

Settings between C-Box and DAQ system or PC

RS-485	: Modbus RTU
Baud-rate	: 9600
Node address	: 1
Parity	: None
Stop bit	: 1



Communications	
C-box ID:	Node id 1
COM port:	Serial port
Baudrate:	9600
Parity:	None
Stopbits:	One
CLOSE	

Table 6-3.1 Communications



Important Note: Any commercial USB / RS-485 communication can be used. USB communication settings should correspond to C-BOX communication settings.

Sensor Settings

1) MS-90 Sensitivity

The setting menu can be used to change the sensitivity figure of the MS-90 DNI sensor. When the MS-90+ plus system is provided as a turn-key system, all sensor setting (MS-90, MS-80S) are made.

2) MS-80S node address

PYR1 is the primary MS-80S used for DHI calculations. PYR2 is an optional secondary pyranometer (MS-80S) which can be used in a Tilted or Albedo setup to acquire collocated irradiance data.

(MS-80S node address is last 2 digits of MS-80S serial number)

Note: MS-80S pyranometer communication settings should be default (19200, 8E1). C-Box can't accept any other settings.

C-Box Communication setting

3) Communications

C-Box communication settings can be changed according to the communication setting of the DAQ system or PC.

Note: C-Box default communication settings are (9600, 8N1)

The screenshot displays the EKO Settings application interface. On the left is a blue sidebar with the EKO logo and 'Beyond Accuracy.' text, and navigation options for 'Data' and 'Settings'. The main area is titled 'Settings' and contains two panels. The first panel, labeled '1', is a table with 'SETTING' and 'VALUE' columns. The second panel, labeled '3', is titled 'COMMUNICATIONS' and contains fields for 'Node Address', 'Baudrate', 'Parity', and 'Stopbits', each with a dropdown menu. A 'Write Settings to C-Box' button is located at the bottom of the communications panel. A gear icon is visible in the top right corner of the settings area.

SETTING	VALUE
MS90	Sensitivity $\mu\text{V}/\text{W}/\text{m}^2$ 0.000
Pyranometer model	
PYR1(GHI) Address	Pyr1 node address 0
PYR2 Node Address	Pyr2 node address 0
Analog mode	<input type="checkbox"/>

COMMUNICATIONS	
Node Address:	Modbus node address 0
Baudrate:	Baudrate
Parity:	Parity
Stopbits:	Stopbits

Write Settings to C-Box

Table 6-3.2 Settings

Data

When the GPS signal is available the latitude, Longitude and time information will be displayed. The solar Elevation and Azimuth position are calculated based on the GPS data. When the DNI sensor and MS-80S pyranometer is connected the GHI, DHI and sensor diagnostic parameters (T, RH, Tilt angle) will be shown.

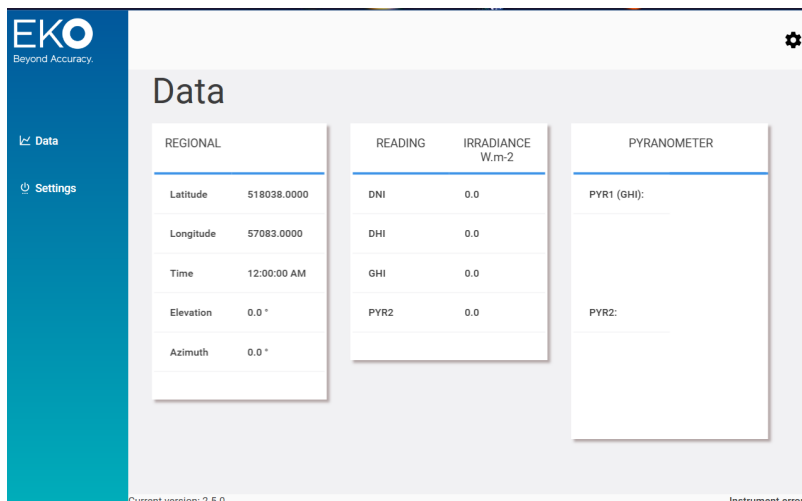


Table 6-3.3 Data

USB Communication settings

Change USB communication settings.

Note: USB communication settings should correspond to C-BOX communication settings.

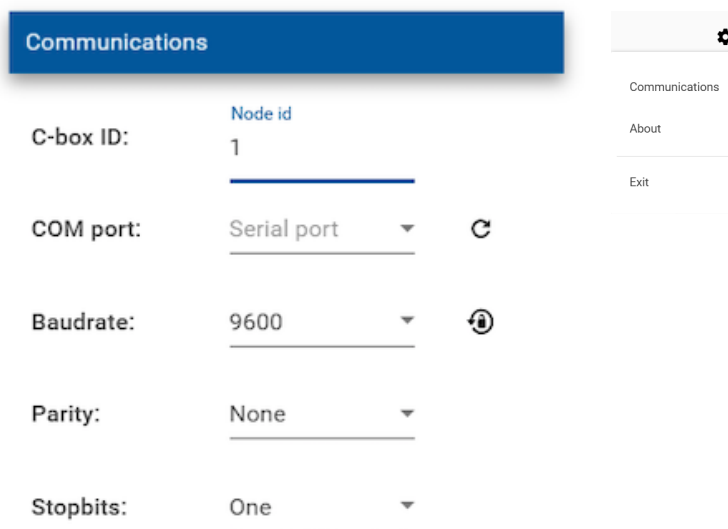


Table 6-3.4 USB communication settings

7. Specification

7-1. Main Unit

Table 7-1. C-Box Specification

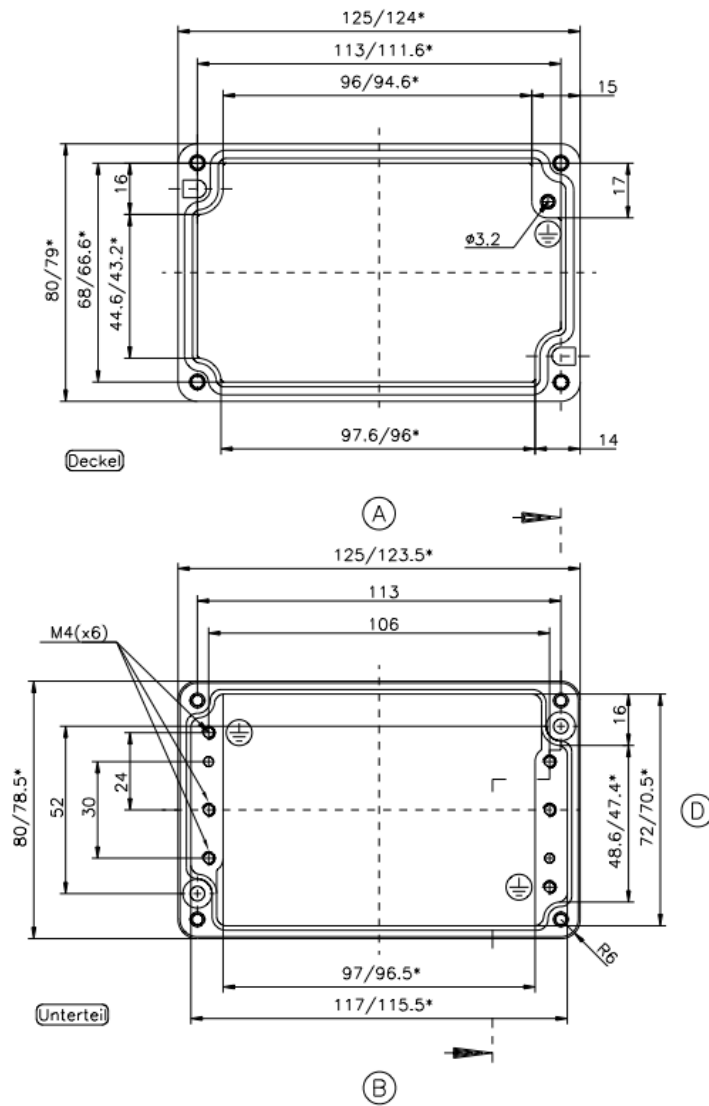
Characteristics	Details	
Input Signals	EKO MS-90 DNI sensor	Analog pulse 0 to 2V
	EKO MS-80S/M Pyranometer	Modbus 485 RTU
Communication Method	RS-485 (Modbus RTU)	
Operating Temperature Range	-40 to +80°C	
Power Supply	12VDC +/- 10% (Note: Supply voltage critical for MS-90)	
Average Power Consumption	0.5W	
Dimensions (L / W / H)	125 x 60 x 80 mm	
Weight (kg)	0.5	
Ingress protection	IP 65	

Table 7-2. C-Box system Specification

Characteristics	Details	
Input parameters	EKO MS-90 DNI sensor	DNI
	EKO MS-80S/M Pyranometer	GHI
Output parameters	DNI / GHI / DHI (Meta data T, RH, Tilt, Long / Lat position, Solar Position, Time)	
Sampling	1s (15s DNI)	
Irradiance range DNI (Measured)	120 – 1600 W/m ²	
Irradiance range GHI (Measured)	0 – 1600W/m ²	
Irradiance range DHI (Calculated)	0 – 500 W/m ² (DHI = GHI when DNI < 120 W/m ²)	

7-2. Dimensions

<https://www.rose-systemtechnik.com/pim/assets/M01081306.pdf>



Appendix -A. Wiring table C-Box

Table appendix Wiring table

Terminals	Function
1. Shield	No used
2. Shield	No used
3. 0V	MS-80S (White)
4. 12 VDC Out	MS-80S (Brown)
5. Modbus B	MS-80S (Black)
6. Modbus A	MS-80S (Blue)
7. Modbus GND	MS-80S (Grey)
8. Reserved	No used
9. MS-80 (+) Analog	Disabled
10 MS-80 (-) Analog	Disabled
11. MS-90 DNI (-)	MS-90 (Black) Cable V2
12. MS-90 DNI (+)	MS-90 (Blue) Cable V2
13. 0V	No used
14. 0V	No used
15. 12VDC Out MS-90	MS-90 (Brown) Cable V2
16. 0VDC Out MS-90	MS-90 (White) Cable V2



EKO Asia, Oceania

1-21-8 Hatagaya,
Shibuya-ku, Tokyo
151-0072 Japan
P. +81.3.3469.6711
F. +81.3.3469.6719
info@eko-asia.com
www.eko.co.jp

EKO North America

95 South Market Street,
Suite 300, San Jose,
CA 95113, USA
P. +1-408-977-7751
F. +1-408-977-7741
info@eko-usa.com
www.eko-usa.com

**EKO Europe,
Middle East, Africa,
South America**

Lulofsstraat 55, Unit 28,
2521 AL, Den Haag,
The Netherlands
P. +31 (0)70 3050117
F. +31 (0)70 3840607
info@eko-eu.com
www.eko-eu.com

