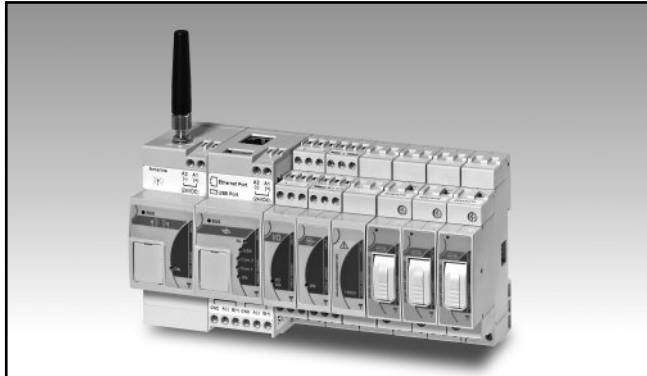


# Energy Management

## Integrated WEB based monitoring solution for Solar PV applications

### Type Eos-Web



- Integrated modular local monitoring system for PV plants based on WEB access
- Up to 20 DIN modules configuration equivalent to 360mm width
- Eos-Web can manage on local bus up to 18 VMU units and up to 10 Eos-Array on RS485 bus.
- Eos-Web can manage in addition to VMU-C, WEB communication access master unit up to:
  - max 1 VMU-W unit;
  - max 15 VMU-S units;
  - max 1 VMU-P unit;
  - max 3 VMU-O units;
  - max 1 VMU-O.AT unit;
  - max 1 VMU-1.

## Product Description

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Eos-Web is a combination of modules which performs the monitoring of a roof-top photovoltaic installation or a ground small to medium size plant. The core unit is VMU-C which in addition to the data-logging, web server functionality performs also the local bus management of VMU-S, VMU-P both "Measuring units", VMU-O "I/O unit" and VMU-W "Modem unit". VMU-C assigns the proper local unit address automatically (up to 15 units). VMU-C can provide by means

of a VMU-O module relay outputs alarm contacts and digital input status (e.g. to sense the tripping of the switch disconnecter and the exhausting of the surge protection device). The VMU-W unit has the task to transmit, with wireless modem technology, all the data when a wired LAN or Internet access is not available. Housing for DIN-rail mounting, IP40 (front) protection degree.



## VMU-C, WEB-based master unit



- One Ethernet port
- Two multi purpose USB 2.0 ports
- 12 to 28 VDC power supply
- Dimensions: 2-DIN modules
- Protection degree (front): IP40

- Micro PC with Web-server capability
- Linux embedded operating system
- DC managed measurements: V, A, kW, kWh
- Environment variables: sun-irradiation, cell-temperature, air-temperature and wind speed
- Inverters: VAC (VDC without VMU-S), AAC (ADC without VMU-S), kWAC (kWDC without VMU-S) and alarm and error messages
- Energy meter: AC managed measurements: V, A, kW, kWh
- Efficiency calculation and control on different levels: string, BOS and Performance ratio and Yield indices
- Variables shown as graphs and numbers in formatted tables
- Alarms control with automatic e-mailing and SMS management (with VMU-W only)
- All data exports on HTML format compatible with Excel or other spreadsheets
- Internal data storage up to 30 years in a 4GB memory
- Optional automatic data back-up on micro SD or micro SDHC memories (not supplied)
- Two RS485 communication ports (Modbus)

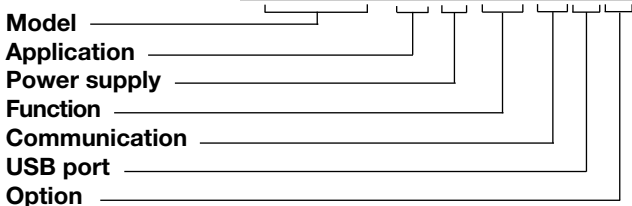
### Product Description

VMU-C is a micro PC with Web communication access capability suitable to gather photovoltaic plant information from up to 1+10 Eos-Array, up to 11 energy meters and up to 11 inverters (with a max. total power of approx. 1000kW). VMU-C provides information in a quick and automatic fashion via the internet using a standard browser, so the data is available wherever you are. VMU-C shows information on the DC part of the PV plant such as: V, A, kW, kWh, sun-irradiation, cell-temperature, air-tempera-

ture and wind speed while from energy meter it provides the following AC variables: V, A, kW, kWh. VMU-C can be used in two different main ways:

- The PV plant is formed by Eos-Array (VMU-S, VMU-P and VMU-O), up to 11 Energy Meters and up to 11 inverters which provide in this case AC variables;
  - The PV plant is formed by up to one VMU-P and up to 11 inverters which provide in this case AC and DC variables.
- All data are available as graphs and numbers in for-

### How to order **VMU-C PV A WS S U X**



matted tables. VMU-C performs alarms control, managing also automatic e-mailing and SMS when combined with VMU-W. All available data can be exported in an HTML format so to be imported in standard spreadsheets for fur-

ther analysis. VMU-C communicates data in a M2M (machine to machine) scenario by using CVS format and FTP protocol and/or HTTP protocol.

### Type Selection

Application	Power supply	Function	Communication
<b>PV:</b> Photovoltaic application in combination with Eos-Array (*)	<b>A:</b> From 12 to 28VDC (*)	<b>WS:</b> Web-Server	<b>S:</b> two RS485 Modbus (*)
<b>USB port</b>	<b>Option</b>		(*) as standard.
<b>U:</b> two USB 2.0 (*)	<b>X:</b> none		

## VMU-W, universal mobile modem for data communication



- Internet access point when regular wired network is not available
- Compatibility with quad-band GSM-GPRS-EDGE standards
- Compatibility with dual-band UMTS-HSPA standards
- SIM (25 x 15mm) for data communication (M2M SIM type only)
- Three available versions: one for Europe (EU27), one for USA and Canada and one for Australia
- 12 to 28 VDC power supply
- Dimensions: 2-DIN module
- Protection degree (front): IP40

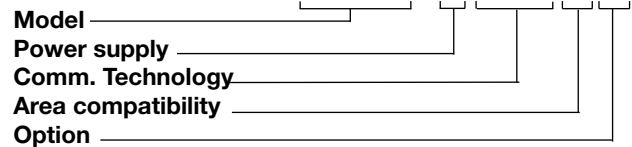
### Product Description

Modem based on “UMM” (Universal Mobile Modem) communication technology for data communication when wired Internet is not available. This unit is suitable to be used in combination with VMU-C only. Eos-Web (VMU-W + VMU-C) can manage a plant control based on SMS alert received

by maintenance personnel on mobile phones, who might decide, based on the relevant message to go straight on site or to access to the proper plant domain for further details. Housing for DIN-rail mounting, IP40 (front) protection degree.

### How to order

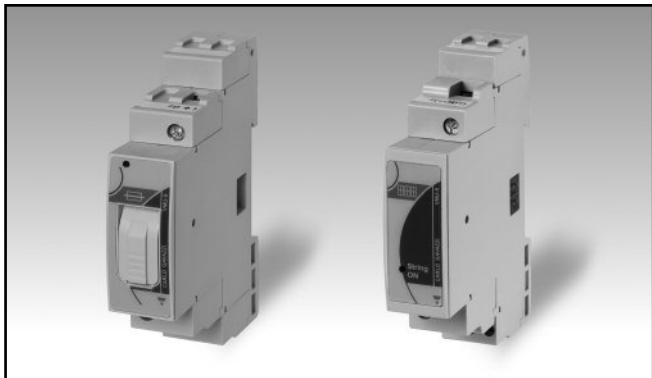
**VMU-W A UMM 1 X**



### Type Selection

Power supply	Comm. Technology	Area compatibility	Option
<b>A:</b> from 12 to 28VDC	<b>UMM:</b> universal mobile modem compatible with quad-band GSM-GPRS-EDGE standards; dual-band UMTS-HSPA. The supply includes already a stub antenna to be screwed on the RP-SMA connector	<b>1:</b> Europe (EU27) <b>2:</b> USA, Canada <b>3:</b> Australia	<b>X:</b> none

## VMU-S, string measuring unit



- Instantaneous variables: V, A, W.
- Instantaneous variables data format: 4 DGTs
- Energy measurements: kWh
- Energies data format: 6 DGT
- Accuracy: Class 1 (kWh)  $\pm 0.5$  RDG (current/voltage)
- Direct DC current measurement up to 16A or up to 30A without fuse
- Direct DC voltage measurement up to 1000V
- Auxiliary communication bus to VMU-C unit or VMU-M unit depending on which bus it belongs to
- Auxiliary power supply from VMU-C or VMU-M unit depending on which bus it belongs to
- String alarm management by means of VMU-C unit only
- Fuse blow detection by means of VMU-C unit only
- PV module connection control by means of VMU-C unit only
- Integrated 10.3x38mm fuse holder for string protection
- Dimensions: 1-DIN module
- Protection degree (front): IP40

### Product Description

String measuring unit with built-in protection fuse-holder (only up to 16A model, the fuse is not provided). VMU-S is specifically designed for DC current, voltage, power and energy metering in PV solar applications. The current inputs/outputs and also the voltage inputs are made so to simplify the string common connections. Direct connection up to 16A or 30A

depending on the model. Moreover the unit is provided with an auxiliary serial communication bus. Alarms, fuse blow detection, PV module connection and serial communication are managed by means of VMU-C or VMU-M module. Housing for DIN-rail mounting, IP40 (front) protection degree.

### How to order **VMU-S AV10 X S FX**

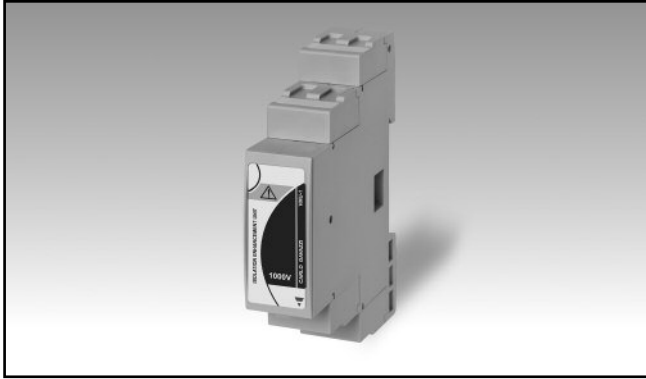
Model \_\_\_\_\_  
 Range \_\_\_\_\_  
 Power supply \_\_\_\_\_  
 Communication \_\_\_\_\_  
 Option \_\_\_\_\_

### Type Selection

Range	Power supply	Communication	Option
<b>AV10:</b> 1000V DC, 16A (Direct connection) (*)	<b>X:</b> self-power supply from VMU-C or VMU-M unit	<b>S:</b> auxiliary communication bus, compatible only to VMU-C or VMU-M unit (*)	<b>XX:</b> none (no fuse holder, only in case of AV30 type)
<b>AV30:</b> 1000V DC, 30A (Direct connection) (*). In this case the "Option" is "XX" only.			<b>FX:</b> with fuse holder, only in case of AV10 type

(\*) as standard.

## VMU-1, isolation enhancement unit



- Enhancement of isolation of voltage measuring inputs to earth of VMU-S: from 800VDC (without VMU-1) to 1000VDC max.
- Dimensions: 1-DIN module
- Protection degree (front): IP40

### Product Description

Isolation enhancement unit suitable to be used in combination with VMU modules. VMU-1 allows to enhance the isolation of the voltage measuring input to earth from 800VDC to 1000VDC.

The module is to be mounted between VMU-C or VMU-M + VMU-O (if needed) + VMU-P (if needed) and all VMU-S. Housing for DIN-rail mounting, IP40 (front) protection degree.

### How to order

**VMU-1 1000**

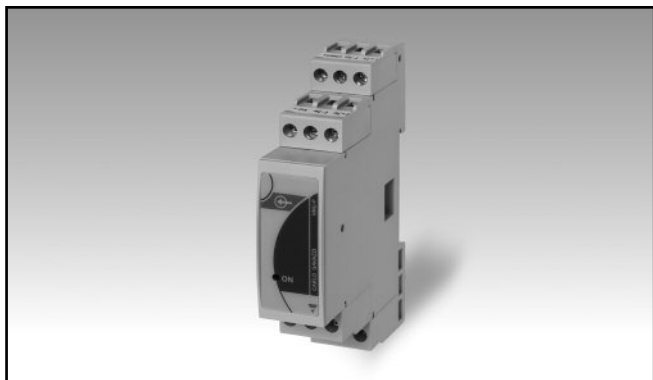
Standard model

### Type Selection

#### Standard model

**Isolation voltage 1000V:** isolation enhancement on VMU-S voltage measuring input to earth from 800VDC (without module) to 1000VDC.  
 Note: only one VMU-1 is needed per Eos-Array

## VMU-P, environment variable unit



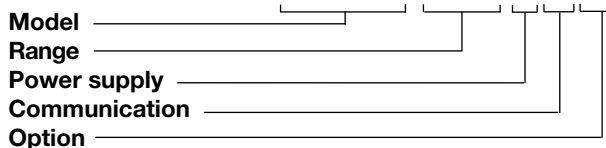
- **Measurements:** PV module temperature, air temperature, sun irradiation, wind speed
- **Two temperature inputs:** Pt100-Pt1000 type
- **One 120mV or 20mA DC input** with scaling capability for irradiation measurement
- **One pulse input** for wind speed measurement
- **Auxiliary communication bus** to VMU-C unit or VMU-M unit depending on which bus it belongs to
- **Auxiliary power supply** from VMU-C or VMU-M unit depending on which bus it belongs to
- **Dimensions:** 1-DIN module
- **Protection degree (front):** IP40

### Product Description

Environment variable measurement unit particularly indicated for PV module temperature, air temperature, sun irradiation, wind speed metering in PV solar applications. Moreover the unit is provided with a spe-

cific serial communication bus which is managed by means of the additional VMU-C or VMU-M module. Housing for DIN-rail mounting, IP40 (front) protection degree.

### How to order **VMU-P 2TIW X S X**

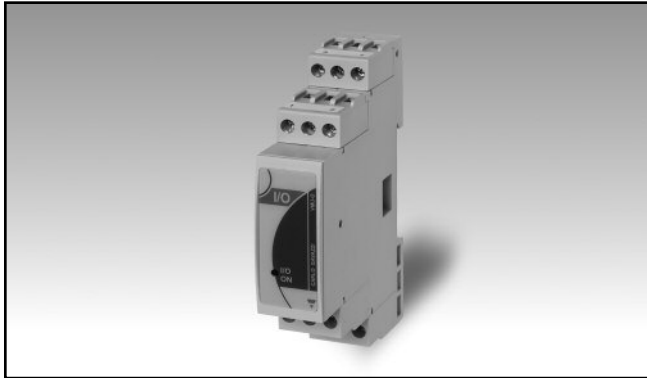


### Type Selection

Range	Power supply	Communication	Option
<b>2TIW:</b> Two "Pt" temperature type probes, mV sun irradiation and wind speed measuring inputs (*)	<b>X:</b> self-power supply from VMU-C or VMU-M unit	<b>S:</b> auxiliary communication bus, compatible only to VMU-C or VMU-M unit	<b>X:</b> none
<b>2TCW:</b> Two "Pt" temperature type probes, mA sun irradiation and wind speed measuring inputs (*)			

(\*) as standard.

## VMU-O, inputs/outputs unit



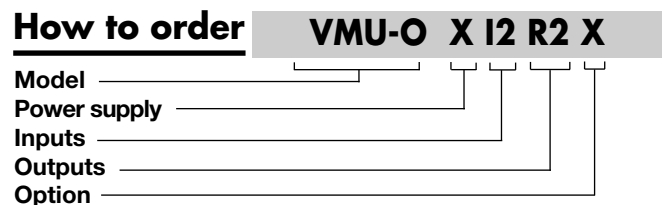
- Expansion I/O module (digital inputs and outputs)
- VMU-O: two digital inputs and two relay outputs managed by the VMU-C or VMU-M unit
- VMU-O.AT: three digital inputs and one relay output managed by the VMU-C or VMU-M unit
- Auxiliary communication bus to VMU-C unit or VMU-M unit depending on which bus it belongs to
- Auxiliary power supply from VMU-C or VMU-M unit depending on which bus it belongs to
- Dimensions: 1-DIN module
- Protection degree (front): IP40

### Product Description

I/O unit suitable to be used in combination with a VMU-C or a VMU-M module. VMU-O allows to add, depending on the unit, two digital inputs and two relay outputs for a standard appli-

cation or three digital inputs and one relay output when an antitheft system is needed. Housing for DIN-rail mounting, IP40 (front) protection degree.

### How to order



### Type Selection (Standard model)

Power supply	Inputs	Outputs	Option
<b>X:</b> self-power supply from VMU-C or VMU-M unit	<b>I2:</b> two digital inputs	<b>R2:</b> two relay outputs	<b>X:</b> none

### Type Selection (Antitheft model)

Power supply	Inputs	Outputs	Option
<b>X:</b> self-power supply from VMU-C or VMU-M unit	<b>I3:</b> three digital inputs	<b>R1:</b> one relay output	<b>AT:</b> antitheft compatibility



## VMU-AT, Antitheft sensor for VMU-O with "AT" option



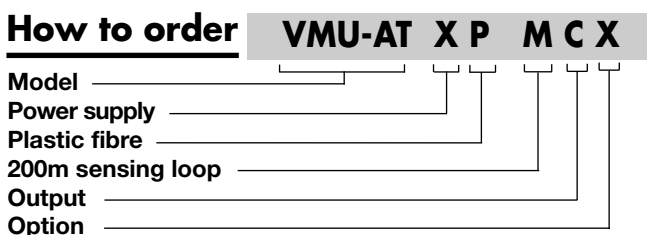
- Plastic fibre optic sensor
- Sensing distance up to 200m
- Static output compatible with VMU-O "AT" option
- Auxiliary power supply from VMU-O "AT" option
- Dimensions: 14 x 31 x 73 mm housing
- Protection degree (front): IP50

### Product Description

Antitheft plastic fibre optic sensor to be used in combination with VMU-O "AT" I/O unit, suitable to carry out an antitheft control on PV modules which are passed by 2.2 mm plastic fibre optic.

The maximum loop distance which can be covered by the sensor is 200m. Housing for DIN-rail mounting, IP50 (front) protection degree.

### How to order



### Type Selection

#### Power supply

**X:** self-power supply from VMU-O "AT" option unit

#### Fibre optic

**P:** plastic

#### Sensing loop

**M:** 200m

#### Output

**C:** open collector

#### Option

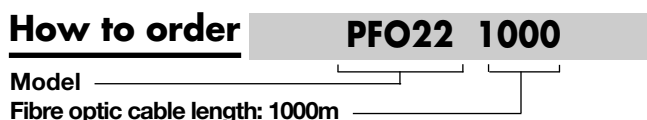
**X:** none

### Product Description

PFO22-1000 is a specific plastic fibre optic cable which is made for VMU-AT sensor and is supplied in a

quantity of 1000m. The working temperature is -55 to 70°C.

### How to order





## Eos-Web module combinations with Eos-Array units

Eos-Array: units compatibility		VMU-C Main Master unit		Total
Module	Description	On local bus	(1) Eos-Array modules combination connected to the RS485 port	VMU units
<b>VMU-W</b>	Mobile communication unit	max 1	None	1
<b>VMU-M</b>	Local master unit	None	1	10
<b>VMU-S</b>	String measuring unit	Max 15	Max 15	165
<b>VMU-O</b>	I/O unit	Max 3	Max 3	33
<b>VMU-O.AT</b>	I/O unit for antitheft sensors	Max 1	Max 1	11
<b>VMU-AT</b>	Antitheft sensor	Max 3	Max 3	33
<b>VMU-P</b>	Environment variables measuring unit	Max 1	MAx 1	11
Max number of total units (VMU: S, O, P type)		15	15	165
<b>VMU-1</b>	Isolation enhancement unit	Max 1	Max 1	11
Max. additional units in the whole network		One VMU-W and one VMU-1	One VMU-1	12
Max units configuration (all modules type, VMU-AT excluded)		18	17	188

**Note:** the Eos-Web solution can manage up to 10 external Eos-Array formed by the single VMU units like the point (1) in the table above.

If not specifically mentioned in this document, for detailed information relevant to: **VMU-M, VMU-S, VMU-O, VMU-O.AT, VMU-AT, VMU-P and VMU-1** please refer to the Eos-Array datasheet and instruction manuals.

## VMU-C Main hardware characteristics

<b>Memory</b> Flash (data) RAM Back-up Memory  File system	4 GB 128 MB (internal) Up to 2 GB in case of micro SD type and from 4 to 16 GB in case of micro SDHC type (removable, not supplied), industrial type (-25°C to 85°C) suggested External micro SD or USB memory stick only: FAT32 (VFAT)	<b>Other ports</b> Mini USB  USB	1, “D” device function only for firmware upgrade purpose 1, “H” host function (not available when VMU-W is connected)
<b>Communication ports</b> RS485 Ethernet	2 ports 1 port, for internet/LAN connection		
<b>Auxiliary bus</b> Right side  Left side	Compatible with Eos-Array units Compatible with VMU-W (modem Unit)		



## VMU-C RS485 communications ports

Number of ports	2	Data format	Selectable: 1 start bit, 7/8 data bit, no/odd/even/parity, 1/2 stop bit
Purpose	COM1: for external Eos-Array management. COM2: for Inverter (CG and others), and energy meters (EM21-72D, EM24-DIN, EM26-96, EM33-DIN and WM30-96)	Baud-rate	Selectable: 9600, 19200, 38400, 115200, bits/s
Type	Multidrop, bidirectional (static and dynamic variables)	Driver input capability	1/8 unit load. Up to 256 nodes on a network.
Connections	2-wire. Max. distance 1000m	Insulation	See the table "Insulation between inputs and outputs"
Addresses	247		
Protocol	MODBUS/JBUS (RTU)		
Data (bidirectional)	All data		

## VMU-C USB ports

Type	High speed 2.0	Device function (mini USB)	Available on the "D" USB port only, can be connected to a PC to perform the following functions: - service port for firmware upgrading
Connections	"A" type as "Host" function on the top of the housing "Mini A" type as "Device" function on the front of the housing protected by front cover		<b>Note:</b> both USB and mini USB ports are working in parallel, so relevant port functions can work simultaneously. The Mini USB is a virtual Ethernet port and works as a real Ethernet port performing all the functions of the main Ethernet port.
Host function (USB)	Available on the "H" USB port only, can be used to perform the following functions: - downloading and uploading PV plant file based on measurement data and events on a memory stick; <b>Note:</b> this port cannot be used when VMU-W is already connected.	Working type Communication speed	Hot swap 60MB/s (480Mbits/s)

## Memory management

Function	Micro-SD (SDHC)	USB (H)	USB (D)
Download (from VMU-C to micro-SD/USB)			
Plant configuration	YES	YES	YES
Database and events export	YES (*)	YES (*)	YES (*)
Upload (from micro-SD/USB to VMU-C)			
XML driver (energy meters and inverters)	NO (*)	YES	YES
Plant configuration	YES	YES	YES
Firmware upgrade	NO (*)	NO	YES
Database and events export	YES (*)	YES (*)	NO

Note: both USB (D and H) and micro-SD storing are equivalent, if both are available than the priority is on the micro-SD.

(\*) The data base export is based on HTML format compatible with Excel or other equivalent spreadsheet of the last full month.

## VMU-C Ethernet port

<b>Protocol</b>	HTTP	Client connections	Max 20 simultaneously (one administrator by time) RJ45 10/100 BaseTX Max. distance: 100m See "Insulation between inputs and outputs" table.
IP configuration	Static IP / Netmask / Default gateway	Connections	
DNS	Primary and secondary DNS as a static or dynamic management (using DHCP server if configured)	Insulation	
Port	Fixed		

## VMU-W "Modem" Main hardware characteristics

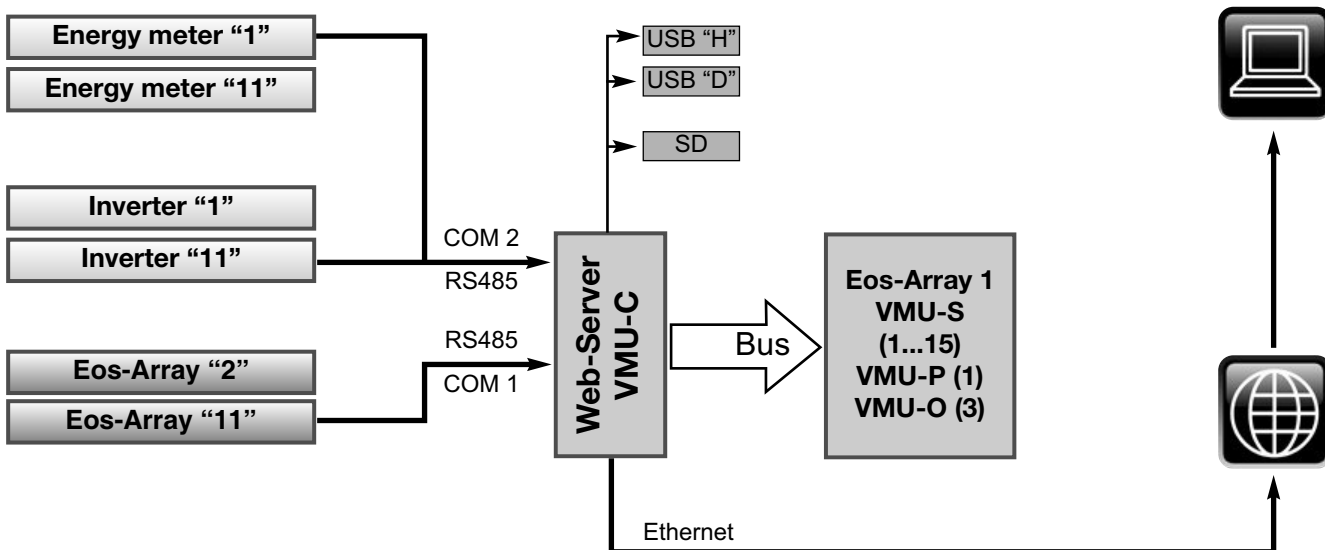
<b>Radio modem</b>	GSM, GPRS, EDGE standards Quad band: 850MHz, 900MHz, 1800MHz, 1900MHz. UMTS and HSPA standards Dual band: Europa (EU27): 900MHz, 2100MHz; USA and Canada: 850MHz, 1900MHz; Australia: 850MHz, 2100MHz. Class 4 (2W, 33dBm) @ GSM 850/900MHz Class 1 (1W, 30dBm) @ GSM 1800/1900MHz Class E2 (0.5W, 27dBm) @ EDGE 850/900MHz Class E2 (0.4W, 26dBm) @ EDGE 1800/1900MHz Class 3 (0.25W, 24dBm) @ UMTS	<b>SIM</b>	SIM (25 x 15mm) for data communication (M2M SIM type only) On the front with protection cover
Communication technology		Type	
Output power		Holder	
		<b>GPRS-EDGE connectivity</b>	12 class B class GPRS: up to 107 kb/s EDGE: up to 296 kb/s GPRS: up to 85.6 kb/s EDGE: up to 236.8 kb/s Downlink/Uplink: up to 14.4 kb/s
		Multi-slot Mobile-station Downlink speed	
		Uplink speed	
		CSD (Circuit Switch Data)	
		<b>UMTS-HSPA connectivity</b>	HSDPA 7.2 Mb/s (Category 8) HSUPA 5.76 Mb/s (Category 6)
		Downlink speed Uplink speed	
		W-CDMA (Wideband Code Division Multiple Access)	Downlink/Uplink: up to 384 kb/s
<b>Modem Configuration</b>	By means of the PC browser: - access point name (APN); - connection number	<b>Auxiliary port</b>	Compatible with VMU-C unit only
<b>Communication Purpose</b>	- Access to the Web-Server (VMU-C) and all its functionalities if the wired network is not available; - To send SMS	Type and connections	



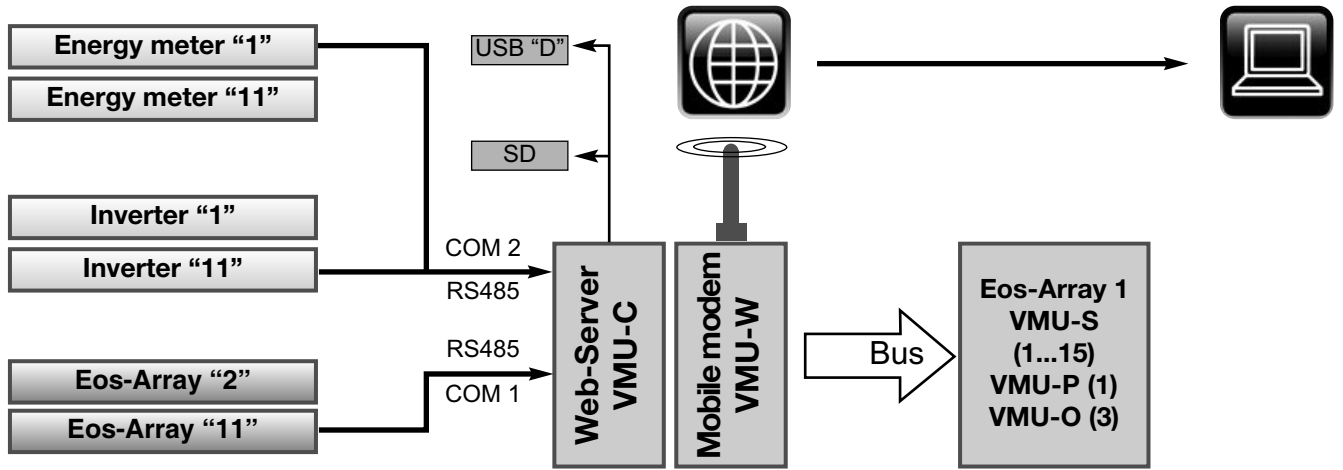
## VMU-W "Modem" Main functions

<b>SMS Configuration</b> Phone book	Set of phone number Managed as groups and phone numbers belonging to each group. Every group can manage alarm SMS	<b>SMS commands</b>	VMU-W accepts and executes commands sent by SMS: -System Reboot -Data communication ON/OFF
<b>Alarm management and messaging</b> Actions	Alarms as working status of the PV plant. Anomalies as working status of the monitoring system. Events as working status of inverters and low priority status change of monitoring system. Commands status change of monitoring system.	<b>Watchdog</b>	
<b>Data download</b> Features and working mode	It is the same of VMU-C being VMU-W only an alternative access point to the regular wired network.		

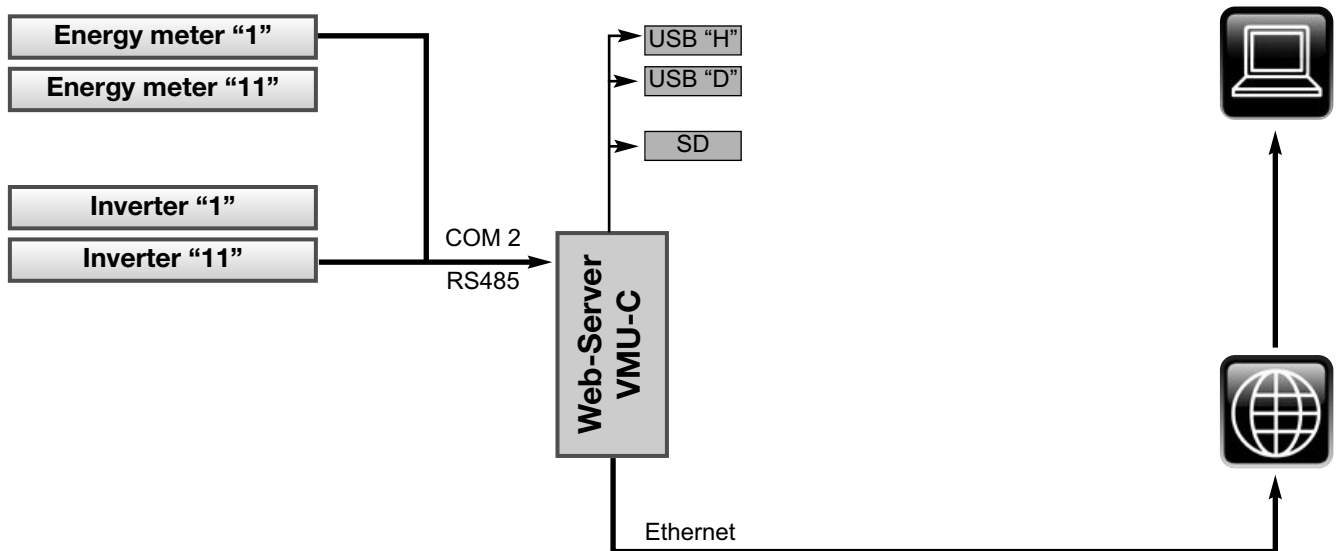
## Example of communication architecture with wired Internet access



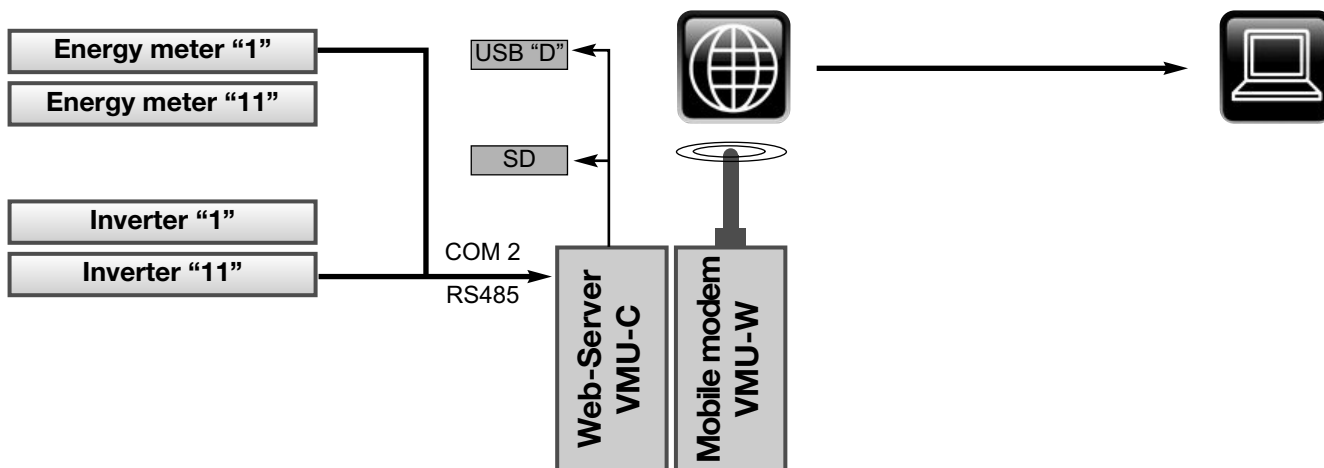
### Example of communication architecture with wireless Internet access



### Example of communication architecture with wired Internet access and Inverter and energy meter management only



## Example of communication architecture with wireless Internet access and Inverter and energy meter management only



## VMU-C TCP/IP networking

Inbound TCP/IP communication		
TCP/IP port number	TCP/IP port description	Purpose
80	HTTP	Access to the internal web-server
22	SSH	Remote service (reserved to support personnel)

Outbound TCP/IP communication		
TCP/IP port number	TCP/IP port description	Purpose
53	DNS	Domain name resolution
37	NTP	Network time services access
21	FTP	Data upload to FTP server
25	SMTP	Email message dispatching

Automated remote TCP/IP data exchange				
Feature	Information	Protocol	Data Format	Description
Schedule FTP push	Alarms, Measured variables	FTP upload at fixed intervals (from 10 minutes to 24 hours)	CVS file (fixed format)	Data are uploaded from VMU-C the remote FTP server
On request FTP push	Alarms, Measured variables, device list	FTP upload at fixed intervals (from 10 minutes to 24 hours)	CVS file (fixed format)	Data are uploaded from VMU-C the remote FTP server following an HTTP query
On request HTTP pull	Alarms, measured variables, device list	HTTP response to HTTP query	CVS formatted response (fixed format)	An HTTP query is sent from the remote server to the VMU-C; an immediate response is expected

**Note:** the communication protocol, the data formats in use and the parameters needed by the HTTP query are detailed in the relevant VMU-C instruction manual for developers.

## Max. number of external Eos-Array systems which can be managed by one VMU-C

Every Eos-Array is equipped with 15 VMU-S			Total number of VMU-S which can be connected to one port at the given communication speed			
Data logger time interval (minutes)	Total number of Eos-Array	Total number of VMU-S	@9600bits/s	@19200bits/s	@38400bits/s	@115200bits/s
5	10 + 1 (*)	165	165	165	165	165
10	10 + 1 (*)	165	165	165	165	165
15	10 + 1 (*)	165	165	165	165	165
30	10 + 1 (*)	165	165	165	165	165
60	10 + 1 (*)	165	165	165	165	165

RS485 communication port: COM1

(\*) Including one Eos-Array connected to the auxiliary bus of VMU-C

- All the details of the daily logged data will be available, independently from the selected time interval, for the last 6 months, after that they will be available with daily resolution.
- The monthly data are available with daily resolution
- The yearly data are available with monthly resolution

## VMU-C memory format and data occupancy

Description	Used memory	Information format and time resolution		
		Data resolution	Graph resolution	Graph format
Total available memory for database and events	3.5 GB			
6 months database at the minimum 5 minutes time interval (*)	1.0 GB	From 5 to 60 minutes	Minutes, days, month	Minutes, month, year
Yearly grouped data	6.0 MB	24 hours	Day, month	Month, year
Single event	350 bytes	Text	NO	NO

### Notes:

(\*) From current instant the data are available with the selected time interval for 6 months back. Afterwards keeping the 6 months rolling time period all old data are compressed to a 1 day resolution.

- All the used memory is relevant to the worst case which means using 11 Eos-Array, 11 energy meters, 11 inverters and all enabled external measuring probes.
  - The memory format above allows VMU-C to store data and events for more than 30 years.
  - The memory used data are relevant to the internal VMU-C memory only.
- The external (removable) back-up memory saves data in "HTML" format compatible with Excel or other spread sheets therefore memory occupancy is more demanding than the internal database.

## Max. number of Inverters and energy meters which can be managed by one VMU-C

Max. number of inverters	Maximum number of energy meters
Up to 11	Up to 11
<ul style="list-style-type: none"> <li>• All inverters have to be connected on "COM2". The refresh time of the data depends on the inverter's communication speed.</li> <li>• The data (power, energy, and other AC and DC variables) are stored with the selected time interval.</li> <li>• Those data will be available for graph displaying for more than 30 years.</li> </ul>	<p><b>RS485 communication port:</b></p> <ul style="list-style-type: none"> <li>• The information acquired from every single energy meter complies to the "Stored set of variables coming from every energy meter" table.</li> <li>• During the set-up of VMU-C only one energy meter can be selected as main yield energy meter.</li> <li>• All the details of the daily logged data will be available and therefore displayable as graphs for 6 months back at the selected resolution (from 5 to 60 minutes), if there is the need to move back for data analysis beyond 6 months than data will be available according to the selected graph with a minimum time interval of one day. The single day data will be available and displayable as graphs for more than 30 years (either "Month" or "Year" selection).</li> </ul>

Inverter and Energy meters use the same RS485 communication port 2



## Max. number of sensors which can be managed by one VMU-C

### Max. number of temperature, irradiation and wind speed sensors

Up to 11 VMU-P units available in the network

- Every single VMU-P can manage up to:
  - two temperature measurements;
  - one irradiation measurement;
  - one wind speed measurement.
- Every single VMU-P can be linked to a zone and therefore to a proper efficiency calculation, for more information see “Zone efficiency calculation and management”.
- All the details of the daily logged data will be available and therefore displayable as graphs for 6 months back at the selected resolution (from 5 to 60 minutes), if there is the need to move back for data analysis beyond 6 months than data will be available according to the selected graph with a minimum time interval of one day. The single day data will be available and displayable as graphs for more than 30 years (either “Month” or “Year” selection).

## VMU-C LED specifications

Type	Single colour		
Status	Changing according to the function		
Controlled functions	Internal communication bus, communication port COM1 and COM2, USB ports, alarms, power supply	USB	Modbus request (time-out); Fast Blinking: regular communication.
Colour code and working mode			- Bleu. Steady ON: acknowledged device, no writing in progress, device can be removed; Steady OFF: neither acknowledged device nor connected device; Blinking: acknowledged device and writing cycle in progress, device cannot be removed.
Power on	- Green. Steady ON: power supply is on; Blinking: writing cycle on micro SD card.		
Bus (internal)	- Yellow. Steady OFF: no communication; Blinking: regular communication; Steady ON: error on communication.	Alarm	- Red. Steady ON: alarm in progress Steady OFF: no alarms Note: the LED is ON either for one alarm or for more alarms.
COM1	- Yellow. Steady OFF: no communication; Slow Blinking: no answer to Modbus request (time-out); Fast Blinking: regular communication.		
COM2	- Yellow. Steady OFF: no communication. Slow Blinking: no answer to		

## VMU-W LED specifications

<b>Type</b> Status	Single colour Changing according to the function	<ul style="list-style-type: none"> <li>- Fast blinking: net search / not registered / turning off.</li> <li>- Slow blinking: registered full service.</li> <li>- Steady ON: a call is active.</li> </ul>
<b>Colour and status</b> Power supply Communication	Green: steady ON Blue: - Steady OFF: the unit is OFF.	

## VMU-C Main Functions

<b>Configuration</b>	The configuration and the programming of all parameter of VMU-C and all other VMU modules connected to either the same local bus or to the managed RS485 ports can be carried out using the Web-Server capability of VMU-C (Ethernet port or by means of wireless communication see also VMU-W). No specific configuration software is needed.	Hysteresis On-time delay Output status	From 0 to full scale 0 to 3600s Selectable; normally de-energized or normally energized ≤ 700ms, set-point on-time delay: "0 s"
<b>Clock</b> Functions  Daylight-saving enabling Time format  Date format  Battery life	Universal clock and calendar with automatic synchronisation enabling through internet connection Activation: automatic Hour:minutes with automatic 24 hours or AM/PM selection Month-Day, where the month is displayed in a three letter format (e.g.: JAN-FEB-MAR) and the date as a number. Year is displayed in a two digit format. 10 years	Min. response time  <b>Alarm management and messaging</b> E-mails Configuration   Actions       Planning	Set of recipient addresses and relevant subject, sender address, sender name, SMTP server, username of SMTP server and password of SMTP server. Mail sent in case of: - alarms as working status of the PV plant; - anomalies as working status of the monitoring system; - events as working status of inverters and low priority status change of monitoring system; commands status change of monitoring system. Enabling of automatic e-mailing based on daily, weekly and monthly shipments with pre-set time, the list of the e-mail addresses and the relevant attachments.
<b>Alarms (virtual or real)</b> Number of alarms  Alarm types Alarm modes  Set-point adjustment	One, for every single available variable (see the table "List of the variables that can be displayed and connected to ...") Virtual alarm or real alarm Up alarm, down alarm (see the table "List of the variables that can be connected to ...") From 0 to 100% of the display scale	SMS (with VMU-W only) Configuration Actions	Set of phone number - alarms as working status of the PV plant; - anomalies as working status of the monitoring system; - events as working status of inverters and low priority

## VMU-C Main Function (cont.)

	status change of monitoring system; commands status change of monitoring system.		soon as they occur. For more information about the type and stored data, see “List of the variables that can be displayed and connected to ....”
<b>Data logging</b>			Till memory is full
Data	The data are accessible and downloadable using either Ethernet communication port or configuration USB “H” port, see “Memory Management” table	Number of events Data reset	The reset can be carried out through the proper command in the Web-Server screen.
Function enabling Function description	Activation: NO/YES All the variables gathered from both VMU-S and VMU-P modules are stored individually into the internal memory.	Data format Memory type	Event, date (dd:mm:yy) and time (hh:mm:ss) Flash and Micro SD (Industrial type suggested, not supplied)
Stored data type	Variables: V, A, W, Wh, PV module temperature, air temperature, irradiation, wind speed, string efficiency and BOS efficiency.	Memory retention time	10 years
Storage interval	Selectable: 5-10-15-30-60 minutes.	<b>String control</b>	
Sampling management	The sample stored within the selected time interval results from the continuous average calculation of the measured values. The average is calculated with an interval within two following measurements of approx. 2s.	Function enabling Function selection	Activation: NO/YES Match max. control or median control
Data format	Variables, date (dd:mm:yy) and time (hh:mm:ss)	Function description	Match max. control: this function is helpful only if there are at least two string controls (VMU-S units). The highest value of the measured string power among those available is used as a reference value. The alarm set-point is a value which can be set by the user as a percentage of the reference value below, which there is the alarm condition. Median control: the measurement of the string power is performed by the local VMU-S module individually. Within the VMU-C network all values coming at the same instant from every VMU-S module are used to calculate the “median” value which becomes the reference value to which the dynamic window set-point (in percentage set by the user) is linked. The abnormal condition is detected when the measured instantaneous string power is out of the set window alarm. The alarm activates, with reference to the failed string, either a relay output (only in case of “VMU-O” connection) or/and a message which is transmitted by means of the RS485 communication port to an
Storage method Memory type	Circular FIFO Flash and Micro SD (Industrial type suggested, not supplied)		
Memory size Memory retention time	4 GB 10 years		
<b>Events logging</b>			
Events	The data are accessible and downloadable using either Ethernet communication port or Micro SD, see “Memory Management” table		
Function enabling Function description	Activation: NO/YES All the events gathered from both VMU-S, VMU-P and VMU-O modules are stored individually into the internal memory.		
Type of stored events	VMU-O digital input/output status change (real and virtual alarms), string alarms (see “String control”) and theft alarm, VMU-M 1st digital input status change. The events are recorded as		



## VMU-C Main Function (cont.)

String window alarm	acquisition system. A window alarm can be set as a string power control, the value is programmable in percentage (of the measured string value) from 0.1 to 99.9.	<p>table “Hardware combinations for BOS efficiency calculation”):</p> <ul style="list-style-type: none"> <li>- A) a yield energy meter and an inverter is available and connected to the RS485 communication port COM2 on the VMU-C;</li> <li>- B/C) a yield energy meter is available and connected to the RS485 communication port COM2 on the VMU-C and VMU units are connected to the local bus and/or Eos-Array are connected to the RS485 communication port COM1 on the VMU-C. Note: either the Inverters are able to provide DC or AC energy data, those will not considered for BOS efficiency calculation.;</li> <li>- D) only one inverter is connected to the RS485 communication port COM2 on VMU-C and is capable to provide the BOS efficiency directly because it is calculated by the inverter itself, this means no Eos-Array are being part of the system. Note: if there are more than one inverter or no Eos-Array the calculation cannot be carried out and therefore the information is “Not Available”. In any case if both yield energy meter and inverter is available, the yield energy meter is predominant.</li> </ul>
Other variable alarms	The alarms can be connected also to the string current and voltage.	
<b>“PV string” efficiency calculation</b>		
Function enabling	Activation: NO/YES Three type of controls are available	
Control type “0”	The VMU-P unit is not available therefore the single value strings are used to calculate the reference value for the efficiency calculation.	
Control type “1”	The VMU-P module is present and both PV module temperature and irradiation are measured and used to calculate the reference value for the efficiency calculation.	
Control type “2”	The VMU-P module is present and both air temperature and irradiation are measured to calculate the reference value for the efficiency calculation.	
<b>BOS efficiency calculation</b>	The BOS efficiency calculation is based on the comparison between the generated DC energy and the exported AC energy supplied to the grid. The grid supplied energy measurement is transmitted by means of its energy meter connected to the Com2 RS485 port of VMU-C. Note: the BOS efficiency is calculated only in the following conditions (see also	

## Hardware combinations for BOS efficiency calculation

VMU-C is always available	Hardware combinations for BOS calculation DC/AC kWh			
	A	B	C	D
Yield energy meter	Yes	Yes	Yes	(*)
Inverter (DC + AC)	Yes	No	(*)	YES
Inverter (AC)	(*)	No	(*)	NO
Eos-Array	(*)	Yes	Yes	(*)

Yes: Data source for BOS calculation

No: Data source available but not used for BOS calculation

(\*): the devices is neither available or not connected to RS485 port

## VMU-C Main Function (cont.)

<p><b>Total efficiency calculation</b></p>	<p>The total efficiency calculation is based on the combined calculation of Yield energy (data coming from AC energy meter), solar irradiation and cell or ambient temperature (by means of a VMU-P module and only in case of calculation mode 1 or 2 of PV string efficiency). Missing of one these three sources will not allow to calculate the Total efficiency. Notes:</p> <ul style="list-style-type: none"> <li>- The sample time interval is 60 min.</li> <li>- If in the system there is more than one yield energy meter, then the calculation is based on the virtual yield energy meter (which is the sum of all AC yield energy meters).</li> <li>- If in the system there is more than one VMU-P, the efficiency calculation is based on an internal algorithm. Note: if the plant is split in different ZONEs, to be able to carry out the calculation, it is mandatory that every zone has to have it's own VMU-P; if not, the calculation result is not available.</li> </ul>	<p><b>Yield indices</b></p>	<p>The yield indices is calculated on daily base and complies the IEC 61724 standard.</p>
<p><b>Performance Ratio indices</b></p>	<p>The performance ratio indices is calculated on daily base and complies the IEC 61724 standard</p>	<p><b>Antitheft control</b></p>	<p>Antitheft control on PV modules sensed by means of both VMU-O.AT and VMU-AT units. Warning message transmission through both local bus (local VMU units) and RS485 (in case of remote connected Eos-Array system) port to the VMU-C unit.</p>
		<p><b>Fuse blow detection and missing PV module connection (only AV10 range code)</b></p>	<p>Warning message transmission through both local bus (local VMU units) and RS485 (in case of remote connected Eos-Array system) port to the VMU-C unit.</p>
		<p><b>Wrong PV module connection</b></p>	<p>Warning message transmission through both local bus (local VMU units) and RS485 (in case of remote connected Eos-Array system) port to the VMU-C unit.</p>

## Zone efficiency calculation and management

Example of efficiency parameters set

Zone (1)	Type of efficiency calculation (2)			Reference (3)	Graph (4)
	0	1	2		
Label "a"	x			VMU-P "a"	Label "a"
Label "a"	x			VMU-P "a"	Label "a"
Label "b"		x		VMU-P "b"	Label "b"
Label "b"		x		VMU-P "b"	Label "b"
Label "b"		x		VMU-P "b"	Label "b"
Label "c"			x	VMU-P "c"	Label "c"
Label "c"			x	VMU-P "c"	Label "c"
Label "a"	x			VMU-P "a"	Label "a"
Label "b"		x		VMU-P "b"	Label "b"
Label "a"	x			VMU-P "a"	Label "a"
Label "a"	x			VMU-P "a"	Label "a"

### ZONE

A "zone" is a part of the PV plant where there is the use of an homogeneous PV technology and same sun exposure. A PV plant based on its size and position can be one "zone" type or "multi zone" type, this latter point means the PV plant might be split in different zones with different PV modules technologies and/or different positions (rooftop, façade, ground type with different sun exposures etc.)

(1) Zone of the installation to which the VMU-M belongs to, it is to say the zone in the plant which is using the same efficiency calculation formula and therefore the same VMU-P reference. Every single zone has a description label which will also appear as soon as the graph will be displayed. The max. number of zones is limited to the max. number of VMU-M + one VMU-C.

(2) The type of efficiency calculation is according to the "PV string" efficiency calculation in the "VMU-C Main functions" description.

(3) The reference is the VMU-P unit which is considered for the zone (Total/partial) efficiency calculation.

(4) The graph is represented by the combination of VMU-M units and therefore the relevant VMU-S belonging to the same zone.

#### Note

The kind of efficiency graphs which can be represented are connected to the number of available zones (Zone efficiency graphs). If, as in the example above, there are labels like "a", "b" and "c", the total number of efficiency graphs are three. This combination allows to combine the zones according to the different PV technologies or/and position of the PV modules which require for accuracy reasons also a different and relevant environment measurement.

In addition to the zone efficiency graphs above there is also one BOS efficiency graph.

**Note:** the "String control", the "PV string efficiency calculation", the "BOS efficiency calculation" and the "Total efficiency calculation" can be carried out only in case a minimum system is available like VMU-C + VMU-S + VMU-P + VMU-O + an energy meter connected to the RS485 communication port.

## VMU-C based insulation between inputs and outputs

Type of input/output	DC Power supply	RS485 - COM 1	RS485 - COM 2	Ethernet	USB port "H"	USB port "D"	VMU-W
DC Power supply	-	2kV	2kV	0.5kV	0kV	0kV	0kV
RS485 - COM 1 (Eos-Array)	2kV	-	0.5kV	2kV	2kV	2kV	2kV
RS485 - COM 2 (Inverters, energy meter)	2kV	0.5kV	-	2kV	2kV	2kV	2kV
Ethernet (LAN/Internet)	0.5kV	2kV	2kV	-	0.5kV	0.5kV	0.5kV
USB port "H" (Host)	0kV	2kV	2kV	0.5kV	-	0kV	0kV
USB port "D" (Service)	0kV	2kV	2kV	0.5kV	0kV	-	0kV
VMU-W	0kV	2kV	2kV	0.5kV	0kV	0kV	-

0kV	Inputs / outputs are not insulated
2kVrms	EN61010-1, IEC60664-1 - Over-voltage category III, Pollution degree 2, double insulation on systems with max. 300Vrms to ground
0.5kVrms	The insulation is functional type

## Insulation between inputs and outputs

Module	Type of input/output	Any	VMU-M			VMU-P			VMU-O		VMU-S		
		Local bus	DC Power supply	Temperature or digital inputs: Ch1, Ch2	RS485	Temperature: Ch1, Ch2	Solar irradiation	Wind speed	Digital inputs: Ch1, Ch2, Ch3	Relay outputs: Ch1, Ch2	Input string (V-)	Input string (A+)	Output string (A+)
Any	Local bus	-	0kV	0kV	0kV	0kV	0kV	0kV	0kV	4kV	4kV	4kV	4kV
VMU-M	DC Power supply	0kV	-	0kV	0kV	0kV	0kV	0kV	0kV	4kV	4kV	4kV	4kV
	Temperature or digital inputs: Ch1, Ch2	0kV	0kV	-	0kV	0kV	0kV	0kV	0kV	4kV	4kV	4kV	4kV
	RS485	0kV	0kV	0kV	-	0kV	0kV	0kV	0kV	4kV	4kV	4kV	4kV
VMU-P	Temperature: Ch1, Ch2	0kV	0kV	0kV	0kV	-	0kV	0kV	0kV	4kV	4kV	4kV	4kV
	Solar irradiation	0kV	0kV	0kV	0kV	0kV	-	0kV	0kV	4kV	4kV	4kV	4kV
	Wind speed	0kV	0kV	0kV	0kV	0kV	0kV	-	0kV	4kV	4kV	4kV	4kV
VMU-O	Digital inputs: Ch1, Ch2, Ch3	0kV	0kV	0kV	0kV	0kV	0kV	0kV	-	4kV	4kV	4kV	4kV
	Relay outputs: Ch1, Ch2	4kV	4kV	4kV	4kV	4kV	4kV	4kV	4kV	-	4kV	4kV	4kV
VMU-S	Input string (V-)	4kV	4kV	4kV	4kV	4kV	4kV	4kV	4kV	4kV	-	5MΩ	5MΩ
	Input string (A+)	4kV	4kV	4kV	4kV	4kV	4kV	4kV	4kV	4kV	5MΩ	-	4kV
	Output string (A+)	4kV	4kV	4kV	4kV	4kV	4kV	4kV	4kV	4kV	5MΩ	4kV	-

**Note:** The isolation between the two relay outputs is 4kV.

0kV	Inputs / outputs are not insulated. Use insulated probes and free of voltage contacts inputs.
4kVrms	EN61010-1, IEC60664-1 - Over-voltage category III, Pollution degree 2, double insulation on systems with max. 300Vrms to ground
4kVrms	IEC60664-1 - Using protection device with clamping voltage $\leq 4kV$ (surge suppressor) the system insulation can be considered as reinforced for string output voltage up to 1000V (800V to earth). IEC60664-1, IEC61730-2 application class B: impulse withstand voltage 1,2/50μsec: 6000V.
4kV	Only if the fuse is not present. Remove the fuse only when the disconnecting breaker is switched off. The fuse is only for over-current protection (it has not to be considered as a disconnecting device).

## VMU-C, VMU-M, VMU-W, VMU-S, VMU-P and VMU-O General specifications

<b>Operating temperature</b>	See table "String current vs. operating temperature".	<b>EMC (Emission)</b> Radio frequency suppression	According to EN61000-6-3 According to CISPR 22, class B
<b>Storage temperature</b>	-30 to +70°C (-22°F to 158°F) (R.H. < 90% non-condensing @ 40°C)	<b>Standard compliance (all units)</b> Safety	IEC60664, IEC61010-1 EN60664, EN61010-1
<b>Over voltage category</b>	Cat. III (IEC 60664, EN60664) For inputs from string: equivalent to Cat. I, reinforced insulation.	<b>Standard compliance (VMU-W only)</b> Health and Safety EMC RF spectrum efficiency	EN60950 EN301489-1, EN301 489-1-7 EN301511
<b>Insulation (for 1 minute)</b>	See table "Insulation between inputs and outputs"	<b>Approvals</b>	All units: CE, cULus Listed VMU-W only: R&TTE 99/5/CE
<b>Dielectric strength</b>	4000 VAC RMS for 1 minute	<b>Housing</b> Dimensions (WxHxD)	VMU-S, VMU-P, VMU-O modules: 17.5 x 90 x 67 mm VMU-C, VMU-W modules: 35.5 x 90 x 67 mm
<b>Noise rejection</b> CMRR	65 dB, 45 to 65 Hz	Material	Noryl, self-extinguishing: UL 94 V-0
<b>EMC (Immunity)</b> Electrostatic discharges	According to EN61000-6-2 EN61000-4-2: 8kV air discharge, 4kV contact;	<b>Mounting</b>	DIN-rail
Immunity to irradiated Electromagnetic fields	EN61000-4-3 : 10V/m from 80 to 3000MHz;	<b>Protection degree</b> Front Screw terminals	IP40 IP20
Immunity to Burst	EN61000-4-4: 4kV on power lines, 2kV on single lines;		
Immunity to conducted disturbances	EN61000-4-6: 10V from 150KHz to 80MHz;		
Surge	EN61000-4-5: 500V on power supply; 4kV on string inputs.		

## Connections

<b>VMU-C</b> Ethernet	RJ-45 connector (10/100Base-T)	<b>VMU-W</b> Antenna	RP-SMA female
USB	High speed USB 2.0	Power supply	2 screw terminals
RS485	3 screw terminals per port		1.5 mm <sup>2</sup> max
Cable cross-section area	1.5 mm <sup>2</sup> max		Min./Max. screws tightening torque: 0.4Nm / 0.8Nm
	Min./Max. screws tightening torque: 0.4 Nm / 0.8 Nm	Weight	Approx. 100 g (packing included)
Power supply	2 screw terminals		
	1.5 mm <sup>2</sup> max		
	Min./Max. screws tightening torque: 0.4 Nm / 0.8 Nm		
Weight	Approx. 150 g (packing included)		

## Power supply specifications

<b>VMU-C</b> Power supply	12 to 28 VDC	<b>VMU-W</b> Power supply	12 to 28 VDC
Power consumption	≤5W	Power consumption	≤5W



## Sizing of Carlo Gavazzi DC power supply with one VMU-C, up to one VMU-W and without antitheft functionality

VMU-S units	VMU-O units	VMU-P unit	VMU-W unit	Consumption	Start up current	Power supply part number
From 1 to 3	None	None	None	PS <sub>w</sub> : 6.5W <sub>typ</sub>	4.5A for 1s	SPM3 24 1 (30W) or SPD 24 18 1B (18W)
From 1 to 3	Up to 1	Up to 1	None	PS <sub>w</sub> : 9W <sub>typ</sub>	6A for 1s	SPM3 24 1 (30W) or SPD 24 18 1B (18W)
From 4 to 10	From 2 to 3	Up to 1	Up to 1	PS <sub>w</sub> : 18.9W <sub>typ</sub>	13A for 1s	SPM4 24 1 (60W) or SPD 24 60 1B (60W)
From 11 to 13	Up to 1	Up to 1	Up to 1	PS <sub>w</sub> : 19W <sub>typ</sub>	14A for 1s	SPM4 24 1 (60W) or SPD 24 60 1B (60W)
Max. 15	Max. 3	Max. 1	Max. 1			Note: VMU-P as 1.8W includes also the CG (part number DWS-V) wind sensor consumption.

**Note:** the consumption above includes already one VMU-C unit without any antitheft management. For different units combinations not mentioned above the consumption calculation is the following:  $PS_w \geq 5W + n_{VMU-S} \cdot 0.5W + n_{VMU-O} \cdot 0.7W + n_{VMU-P} \cdot 1.8W + n_{VMU-W} \cdot 5W$ . Where "n" is the number of power supplied units.

## Sizing of Carlo Gavazzi DC power supply with one VMU-M and without antitheft functionality

VMU-S units	VMU-O units	VMU-P unit	Consumption	Start up current	Power supply part number
From 1 to 3	None	None	PS <sub>w</sub> : 2.5W <sub>typ</sub>	1.5A for 1s	SPM3 24 1 (30W) or SPD 24 18 1B (18W)
From 1 to 3	Up to 1	Up to 1	PS <sub>w</sub> : 5W <sub>typ</sub>	1.5A for 1s	SPM3 24 1 (30W) or SPD 24 18 1B (18W)
From 4 to 10	From 2 to 4	Up to 1	PS <sub>w</sub> : 10.6W <sub>typ</sub>	1.5A for 1s	SPM3 24 1 (30W) or SPD 24 30 1B (30W)
From 11 to 13	Up to 1	Up to 1	PS <sub>w</sub> : 10W <sub>typ</sub>	1.5A for 1s	SPM3 24 1 (30W) or SPD 24 30 1B (30W)
Max. 15	Max. 3	Max. 1			Note: VMU-P as 1.8W includes also the CG (part number DWS-V) wind sensor consumption.

**Note:** the consumption above includes already one VMU-M unit without any antitheft management. For different units combinations not mentioned above the consumption calculation is the following:  $PS_w \geq 1W + n_{VMU-S} \cdot 0.5W + n_{VMU-O} \cdot 0.7W + n_{VMU-P} \cdot 1.8W$ . Where "n" is the number of power supplied units.

## Sizing of Carlo Gavazzi DC power supply with one VMU-C, up to one VMU-W and with antitheft functionality

VMU-S units	VMU-O.X units	VMU-O.AT unit	VMU-AT unit	VMU-P unit	VMU-W unit	Consumption	Start up current	Power supply part number
From 10 to 14	None	Up to 1	Up to 3	None	None	PS <sub>w</sub> : 16W	12A for 1s	SPM3 24 1 (30W) or SPD 24 30 1B (30W)
From 10 to 12	Up to 1	Up to 1	Up to 3	Up to 1	Up to 1	PS <sub>w</sub> : 22.5W	16A for 1s	SPM4 24 1 (60W) or SPD 24 60 1B (60W)
From 10 to 11	Up to 2	Up to 1	Up to 3	Up to 1	Up to 1	PS <sub>w</sub> : 22.7W	16A for 1s	SPM4 24 1 (60W) or SPD 24 60 1B (60W)
10	Up to 3	Up to 1	Up to 3	Up to 1	Up to 1	PS <sub>w</sub> : 22.9W	15A for 1s	SPM4 24 1 (60W) or SPD 24 60 1B (60W)
Max. 14	Max. 3	Max. 1	Max. 3	Max. 1	Max. 1			Note: VMU-P as 1.8W includes also the CG (part number DWS-V) wind sensor consumption.

**Note:** in order to carry out, in the Eos-Web, the proper antitheft functionality, one VMU-O.X.I3.R1.AT unit and up to three VMU-AT.X.P.M.C.X sensors have to be added, in this case the maximum equivalent added consumed power is 4W. For different units combination not mentioned above the consumption calculation is the following:  $PS_w \geq 5W + n_{VMU-S} \cdot 0.5W + n_{VMU-O.X} \cdot 0.7W + n_{VMU-O.AT} \cdot 0.7W + n_{VMU-AT} \cdot 1.1W + n_{VMU-P} \cdot 1.8W + n_{VMU-W} \cdot 5W$ . Where "n" is the number of power supplied units.

## Sizing of Carlo Gavazzi DC power supply with one VMU-M and with antitheft functionality

VMU-S units	VMU-O.X units	VMU-O AT units	VMU-AT units	VMU-P units	Consumption	Start up current	Power supply part number
10 to 14	None	Up to 1	Up to 3	None	PS <sub>w</sub> : 12W	1.5A for 1s	SPM3 24 1 (30W) or SPD 24 18 1B (18W)
10 to 12	Up to 1	Up to 1	Up to 3	Up to 1	PS <sub>w</sub> : 13.5W	1.5A for 1s	SPM3 24 1 (30W) or SPD 24 30 1B (30W)
10 to 11	Up to 2	Up to 1	Up to 3	Up to 1	PS <sub>w</sub> :13.7W	1.5A for 1s	SPM3 24 1 (30W) or SPD 24 30 1B (30W)
10	Up to 3	Up to 1	Up to 3	Up to 1	PS <sub>w</sub> :13.9W	1.5A for 1s	SPM3 24 1 (30W) or SPD 24 30 1B (30W)
Max. 14	Max. 3	Max. 1	Max. 3	Max. 1			Note: VMU-P as 1.8W includes also the CG (part number DWS-V) wind sensor consumption.

**Note:** in order to carry out, in the Eos-Array, the proper antitheft functionality, one VMU-O.X.I3.R1.AT unit and up to three VMU-AT.X.P.M.C.X sensors have to be added, in this case the maximum equivalent added consumed power is 4W. For different units combination not mentioned above the consumption calculation is the following:  $PS_w: \geq 1W + n_{VMU-S} * 0.5W + n_{VMU-O.X} * 0.7W + n_{VMU-O.AT} * 0.7W + n_{VMU-AT} * 1.1W + n_{VMU-P} * 1.8W$ .

## Stored set of variables in the VMU-C module

No.	Variable	Data format	Notes
1	BOS efficiency	0.0 to 99.9	“Total BOS efficiency” result in percentage as a calculation out of all modules being part of the network.
2	Total yield AC energy value	0.0 to 99999999.9	The value is in kWh and is the result of the totalized yield energy measurement coming from the reference energy meter being part of the system. This total calculation based on the working selection can be also the virtual reference yield energy meter being the sum of many real energy meters.
3	Total consumed AC energy value	0.0 to 99999999.9	The value is in kWh and is the result of the totalized consumed energy measurement coming from the reference energy meter being part of the system. This total calculation based on the working selection can be also the virtual reference consumed energy meter being the sum of many real energy meters.
4	Zone string efficiency	0.0 to 99.9	The zone “PV string” efficiency is the result of efficiency calculation based on selected “0-1-2” method and single string efficiency calculation extended to a certain area within the PV plant. The same area refers to selected environment parameters such as air or PV module temperature and sun irradiation coming from the relevant VMU-P unit. Note: the string efficiency calculation is calculated for every single available zone.
5	Total efficiency	0.0 to 99.9	“Total efficiency” result in percentage as a calculation out of all enabled VMU-S modules being part of the network.

## Stored set of variables coming from every single VMU-S module

No.	Variable	Data format	Sub-address	Notes
1	V	0.0 to 1250.0	From 1 to 15	
2	A	0.0 to 50.00	From 1 to 15	
3	kW	0.0 to 99.99	From 1 to 15	
4	kWh	0.0 to 99999.9	From 1 to 15	
5	String efficiency	0.0 to 199.9		"PV string" efficiency result in percentage. Every string in the network has its own data.

## Stored set of variables coming from every single VMU-P module

No.	Variable	Data format	Sub-address	Notes
1	Temperature 1 (PV module)	-60.0 to 400.0	From 1 to 15	PV module temperature (°C/°F). The range is extended to cover both °C and °F indication
2	Temperature 2 (Air)	-60.0 to 400.0	From 1 to 15	Air temperature (°C/°F). The range is extended so to cover both °C and °F indication
3	Solar irradiation (IRR)	0.0 to 9999	From 1 to 15	Irradiation W/m <sup>2</sup> (W/feet <sup>2</sup> ). (e.g. in: 0 to 1000W/m <sup>2</sup> (1000W/feet <sup>2</sup> , out: 0 to 100mV)
4	Wind speed (SPEED)	0.0 to 299.9	From 1 to 15	Wind speed (m/s) or feet/s

## VMU-C Alarm and diagnostics messages

No.	Message	Notes
1	Connection continuity (only AV10 range code)	Fuse blow detection. The status of each fuse is indicated by the colour change of the relevant LED on the VMU-S module.
2	String anomaly	String anomaly warning: the "String control" function has detected a anomaly. The STRING information is given in combination with the LED alarm on VMU-C and the LED colour code on every single string.
3	Connection polarity	The string is wrongly connected (reverse polarity)
4	System error	Power-up self-test error
5	Bus error	Auxiliary bus communication error
6	Alarm	Variables alarm (any)
7	Theft	Theft warning: removal of the PV modules in the fibre optic loop controlled by the relevant VMU-AT sensor. The THEFT information is given in combination with the LED alarm on VMU-C and the LED colour code on the relevant VMU-O.AT unit.
8	Missing communication on COM1	In case of missing of communication on COM1 for more than 30 seconds a proper alarm will be managed
9	Missing communication on COM2	In case of missing of communication on COM2 for more than 30 seconds a proper alarm will be managed

## Stored set of variables coming from every external AC energy meter

No.	Variable	Data format	Notes
1a	VLN sys AC	0.0 to 1250.0	Three-phase type or one-phase type
2a	VL1N AC	0.0 to 1250.0	Three-phase type, if available
3a	VL2N AC	0.0 to 1250.0	Three-phase type, if available
4a	VL3N AC	0.0 to 1250.0	Three-phase type, if available
1b	VLL sys AC	0.0 to 1250.0	Three-phase type or one-phase type
2b	VL1L2 AC	0.0 to 1250.0	Three-phase type, if available
3b	VL2L3 AC	0.0 to 1250.0	Three-phase type, if available
4b	VL3L1 AC	0.0 to 1250.0	Three-phase type, if available
5	AL1 AC	0.0 to 1250.0	Three-phase type or one-phase type
6	AL2 AC	0.0 to 1250.0	Three-phase type, if available
7	AL3 AC	0.0 to 1250.0	Three-phase type, if available
8	kW sys AC	0.0 to 1000,0	Three-phase type or one-phase type
9	kWL1 AC	0.0 to 1000,0	Three-phase type, if available
10	kWL2 AC	0.0 to 1000,0	Three-phase type, if available
11	kWL3 AC	0.0 to 1000,0	Three-phase type, if available
12	kWh AC (yield)	0.0 to 99999999.9	Three-phase type or one-phase type
13	kWh AC (consumed)	0.0 to 99999999.9	Three-phase type or one-phase type

**Note:** for any calculation which is involving the yield energy metering, the metering is available as a real partial metering and a virtual total metering, if only one energy meter is available in the system this can be only a total yield energy meter. VMU-C can gather data from one or more inverters only if no yield energy meters are available, the selection is automatic. Also in this case the information can be managed like a yield energy meter as a partial or a total metering (virtual energy meter).

## Working mode of all AC energy meters

Working mode	Source	Metered energy	Use	Type	Function	Max. number of meters managed by VMU-C
1a	Meter	Yield	Total kWh AC	Virtual, Real	R, T	1
	Meter	Yield	Partial kWh AC	Real	Y, N	Up to 11
1b	Meter	Consumed	Total kWh AC	Virtual, Real	T	1
	Meter	Consumed	Partial kWh AC	Real	Y, N	Up to 11
2	Inverter	Yield	Total kWh AC	Virtual, Real	R, T	1
	Inverter	Yield	Partial kWh AC	Real	Y, N	Up to 11

**R:** Reference energy meter in the system (used to calculate the BOS and the Total efficiency), there can be only one in the system.

**T:** Totalizer function, there can be only one in the system.

**Y:** Yes, contribution to total energy calculation.

**N:** No contribution to total energy metering.

**Note:** working mode “1a” and “1b” can be allowed together

## Stored set of variables coming from every single inverter

No.	Variable	Data format	VMU-C working mode	Notes
1	V DC	0.0 to 1250.0	I (1)	Inverter input measurement, in case of multi-string inverter, the value is related to every single string.
2	A DC	0.0 to 1250.0	I (1)	Inverter input measurement, in case of multi-string inverter, the value is related to every single string.
3	kW DC	0.0 to 1000.0	I (1)	Inverter input measurement, in case of multi-string inverter, the value is related to every single string.
4	kWh DC	0.0 to 99999999.9	I (1)	Inverter input measurement, in case of multi-string inverter, the value is related to every single string.
5	kWh AC	0.0 to 99999999.9	I, S+I (1)	Inverter output measurement. Three-phase type or one-phase type
6	Efficiency	0.0 to 99.9	I, S+I (1)	
7	VLN sys AC	0.0 to 1250.0	I, S+I (1)	Inverter output measurement. Three-phase type or one-phase type
8	VL1N AC	0.0 to 1250.0	I, S+I (1)	Inverter output measurement. Three-phase type, if available
9	VL2N AC	0.0 to 1250.0	I, S+I (1)	
10	VL3N AC	0.0 to 1250.0	I, S+I (1)	
11	VLL sys AC	0.0 to 1250.0	I, S+I (1)	Inverter output measurement. Three-phase type, if available
12	VL1L2 AC	0.0 to 1250.0	I, S+I (1)	Inverter output measurement. Three-phase type, if available
13	VL2L3 AC	0.0 to 1250.0	I, S+I (1)	
14	VL3L1 AC	0.0 to 1250.0	I, S+I (1)	
15	AL1 AC	0.0 to 1250.0	I, S+I (1)	Inverter output measurement. Three-phase type or one-phase type
16	AL2 AC	0.0 to 1250.0	I, S+I (1)	
17	AL3 AC	0.0 to 1250.0	I, S+I (1)	
18	kW sys AC	0.0 to 1000.0	I, S+I (1)	Inverter output measurement. Three-phase type or one-phase type
19	kWL1 AC	0.0 to 1000.0	I, S+I (1)	Inverter output measurement. Three-phase type, if available
20	kWL2 AC	0.0 to 1000.0	I, S+I (1)	
21	kWL3 AC	0.0 to 1000.0	I, S+I (1)	
22	Warning messages	Text: 10 characters format	I, S+I, EM+S+I (1)	The number and kind of managed message is depending on the inverter's protocol

**Note:** the variable availability, see list above, is depending on the inverter's manufacturer and model.

**(1)** In case of more inverters connected at the same grid (in parallel), the system voltage output is the average of all inverter system voltages and the single phase voltages (L1, L2, L3 individually) are the average of every inverter single voltage while current and power, are according to the type, the sum of the single phase variables. The efficiency is available only as a single inverter information.

**I:** is intended as a PV installation with data gathering from inverter only (neither Eos-Array, VMU units or yield energy meters are available).

**S+I:** is intended as a PV installation with Eos-Array solution (string control), and data gathering from inverter where yield energy metering is gathered from the inverter since a real yield energy meter is not available.

**EM+S+I:** is intended as a PV installation with Eos-Array solution (string control), data gathering from inverter and energy metering gathered from real yield energy meters.

## List of the variables that can be displayed and connected to ...

- Ethernet communication port
- Real and virtual alarms and events
- Data-logging

No	Variable	Event-logging	Data-logging	Alarm output	Module	Notes
1	% BOS efficiency	Yes	Yes	Yes	VMU-C	BOS efficiency calculation of the PV plant
2	Zone % string efficiency	Yes	Yes	Yes	VMU-C	Zone string efficiency calculation of the PV plant
3	Total % efficiency	Yes	Yes	Yes	VMU-C	Total efficiency calculation of the PV plant
4a	Total yield kWh AC	No	Yes	No	EM/inverter	Total yield energy calculation as sum of "A" + "B" + "n" (see further lines below)
4b	Partial yield kWh "A"	No	Yes	No	EM	AC partial yield energy meter connected in the network
4c	Partial yield kWh "B"	No	Yes	No	EM	AC partial yield energy meter connected in the network
4d	Partial yield kWh "n"	No	Yes	No	EM	AC partial yield energy meter connected in the network
5a	Total consumed kWh AC	No	Yes	No	EM	Total consumed energy calculation as sum of "A" + "B" + "n"
5b	Partial consumed kWh "A"	No	Yes	No	EM	AC partial consumed energy meter connected in the network
5c	Partial consumed kWh "B"	No	Yes	No	EM	AC partial consumed energy meter connected in the network
5d	Partial consumed kWh "n"	No	Yes	No	EM	AC partial consumed energy meter connected in the network
6	COM1 alarm	Yes	No	Yes (a)	VMU-C	Missing communication for more than 30s
7	COM2 alarm	Yes	No	Yes (a)	VMU-C	Missing communication for more than 30s
8	Error: 1	Yes	No	Yes (a)	VMU-C/M	Local bus communication problems
9	Error: 2	Yes	No	Yes (a)	VMU-C/M	Changed system modules configuration
10	Error: 3	Yes	No	Yes (a)	VMU-C/M	Incoherent programming parameters
11	Error: 4	Yes	No	Yes (a)	VMU-C/M	More than one VMU-P unit connected to the AUX bus
12	Status: 1	Yes	No	No	VMU-C/M	Local programming access
13	Status: 2	Yes	No	No	VMU-C/M	Power OFF/ON
14a	°C (°F) (input 1)	Yes	Yes	Yes	VMU-M	As alternative of status detection No15
14b	°C (°F) (input 2)	Yes	Yes	Yes	VMU-M	Other temperature
15	ON/OFF status (input 1)	Yes	Yes	No	VMU-M	As alternative of variable No14a
16	V	Yes	Yes	Yes	VMU-S	Available from every string
17	A	Yes	Yes	Yes	VMU-S	Available from every string
18	kW	Yes	Yes	Yes	VMU-S	Available from every string
19	kWh	Yes	Yes	No	VMU-S	Available from every string
20	Reset string kWh	No	No	No	VMU-S	Resetting DC string energy meter
21	Reset all strings kWh	No	No	No	VMU-S	Resetting all DC string energy meters
22	% string efficiency	Yes	Yes	Yes	VMU-S	String efficiency
23	Status: 1	Yes	No	Yes (b)	VMU-S	Incoherent programming parameters
24	Status:2	Yes	No	Yes (b)	VMU-S	Not connected solar string
25	Status: 3	Yes	No	Yes (b)	VMU-S	Reverse string current or voltage
26	Status: 4	Yes	No	Yes (b)	VMU-S	High temperature inside VMU-S unit
27	String control	Yes	Yes	Yes	VMU-S	
28	°C (°F) (input 1)	Yes	Yes	Yes	VMU-P	PV module temperature

## List of the variables that can be displayed and connected to ... (cont.)

- Ethernet communication port
- Real and virtual alarms and events
- Data-logging

No	Variable	Event-logging	Data-logging	Alarm output	Module (from)	Notes
29	°C (°F) (input 2)	Yes	Yes	Yes	VMU-P	Air temperature
30	W/m <sup>2</sup> (W/ft <sup>2</sup> )	Yes	Yes	Yes	VMU-P	Solar irradiation
31	m/s (ft/s)	Yes	Yes	Yes	VMU-P	Wind speed
32	Error: 1	Yes	No	Yes (c)	VMU-P	Incoherent programming parameters
33	Error: 2	Yes	No	Yes (c)	VMU-P	Short circuit on probe input 1
34	Error: 3	Yes	No	Yes (c)	VMU-P	Open circuit on probe input 1
35	Error: 4	Yes	No	Yes (c)	VMU-P	Short circuit on probe input 2
36	Error: 5	Yes	No	Yes (c)	VMU-P	Open circuit on probe input 2
37	Status: input 1	Yes	No	No	VMU-O	ON/OFF status detection
38	Status: input 2	Yes	No	No	VMU-O	ON/OFF status detection
39	Status: input 3	Yes	No	No	VMU-O	ON/OFF status detection
40	Status: output 1	Yes	No	No	VMU-O	ON/OFF status detection
41	Status: output 2	Yes	No	No	VMU-O	ON/OFF status detection
42	Error: 1	Yes	No	Yes	VMU-O	Incoherent programming parameters
43	V DC	No	Yes	No	Inverter	For every inverter in the network
44	A DC	No	Yes	No	Inverter	For every inverter in the network, in case of multi-string inverter, the values is related to every single string.
45	Yield kW DC	No	Yes	No	Inverter	For every inverter in the network, in case of multi-string inverter, the values is related to every single string.
46	Yield kWh DC	No	Yes	No	Inverter	For every inverter in the network, in case of multi-string inverter, the values is related to every single string.
47	kW AC	No	Yes	No	Inverter	For every inverter in the network
48	kWh AC	No	Yes	No	Inverter	For every inverter in the network
49	Efficiency	No	Yes	No	Inverter	For every inverter in the network
50	VLN sys AC	No	Yes	No	Inverter/EM	As an average of all inverters in the network
51	VL1N, VL2N, VL3N AC	No	Yes	No	Inverter/EM	As an average of all inverters in the network
52	VLL sys AC	No	Yes	No	Inverter/EM	As an average of all inverters in the network
53	VL12, VL23, VL31 AC	No	Yes	No	Inverter/EM	As an average of all inverters in the network
54	AL1, AL2, AL3 AC	No	Yes	No	Inverter/EM	As a sum of every single phase of all inverters
55	kW sys AC	No	Yes	No	Inverter/EM	As a sum of every single phase of all inverters
56	kWL1, kWL2, kWL3 AC	No	Yes	No	Inverter/EM	As a sum of every single phase of all inverters
57	Error xx	Yes	No	Yes	Inverter	Inverter message

**Note about "Alarm output":** YES (a), YES (b) and YES (c) are according to the relevant letter "OR" logic alarms.

**EM:** energy meter

## Alarms Management and VMU-O outputs link

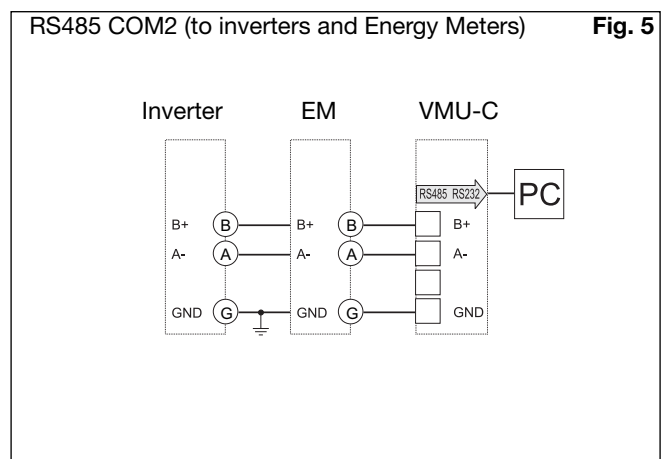
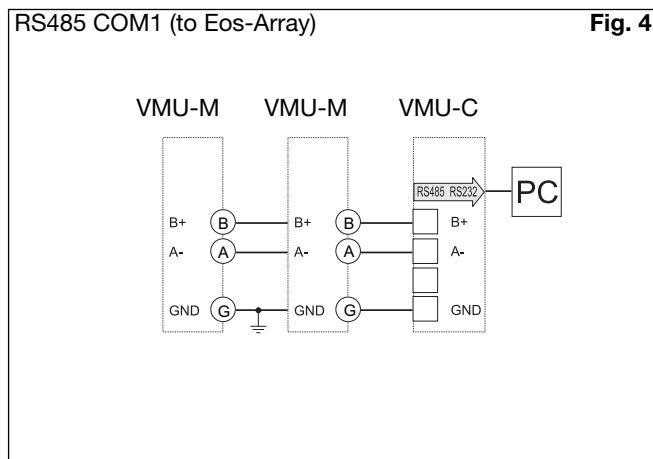
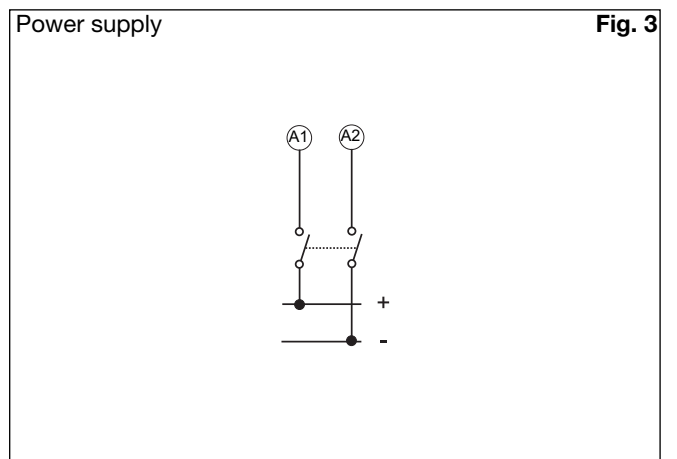
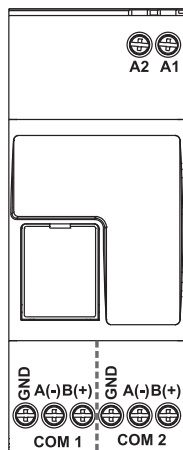
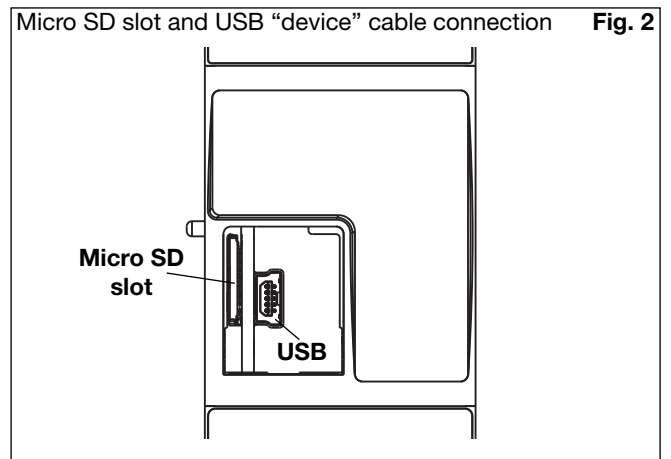
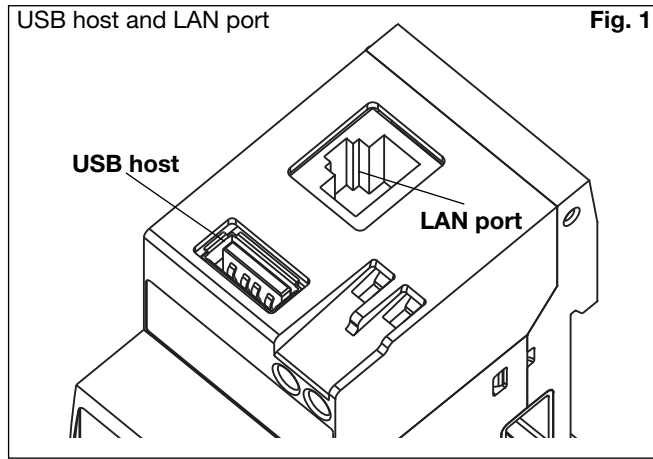
Variable or function	Alarm origin device	Local alarm	Global alarm	Type of alarm
Total efficiency	VMU-C	NO	YES	Single
BOS efficiency	VMU-C	NO	YES	Single
Zone String efficiency	VMU-C	NO	YES	Single
Antitheft	VMU-M (VMU-C)	YES	NO	Single
Temperature input 1	VMU-M	YES	NO	Single
Temperature input 2	VMU-M	YES	NO	Single
Missing communication on COM1 and COM2	VMU-M (VMU-C)	YES	NO	OR (a)
Local bus communication problems	VMU-M	YES	NO	OR (a)
Changed system modules configuration	VMU-M	YES	NO	OR (a)
Incoherent programming parameters	VMU-M	YES	NO	OR (a)
More than one VMU-P unit connected to the bus	VMU-M	YES	NO	OR (a)
Voltage	VMU-S	YES	NO	Single
Current	VMU-S	YES	NO	Single
Power	VMU-S	YES	NO	Single
String efficiency	VMU-S	YES	NO	Single
String control	VMU-S	YES	NO	Single
Incoherent programming parameters	VMU-S	YES	NO	OR (b)
Not connected solar string	VMU-S	YES	NO	OR (b)
Reverse string current or voltage	VMU-S	YES	NO	OR (b)
High temperature inside VMU-S unit	VMU-S	YES	NO	OR (b)
Temperature input 1	VMU-P	YES	NO	Single
Temperature input 2	VMU-P	YES	NO	Single
Solar irradiation	VMU-P	YES	NO	Single
Wind Speed	VMU-P	YES	NO	Single
Incoherent programming parameters	VMU-P	YES	NO	OR (c)
Short circuit on probe input 1	VMU-P	YES	NO	OR (c)
Open circuit on probe input 1	VMU-P	YES	NO	OR (c)
Short circuit on probe input 2	VMU-P	YES	NO	OR (c)
Open circuit on probe input 2	VMU-P	YES	NO	OR (c)
Incoherent programming parameters	VMU-O	YES	NO	OR (d)
Inverter XX error message	Inverter	NO	YES	OR (e)

### Type of alarms:

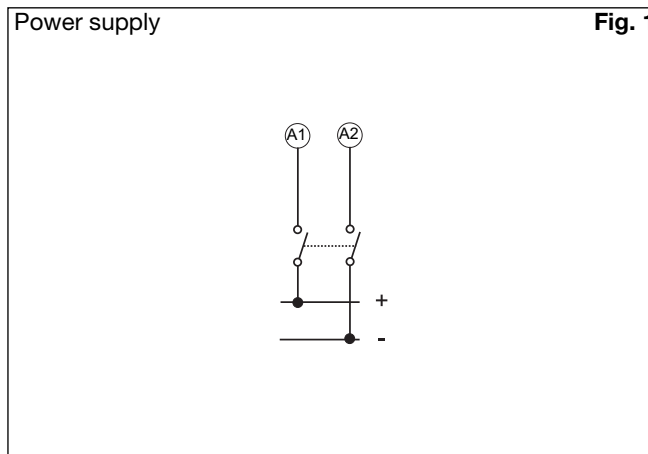
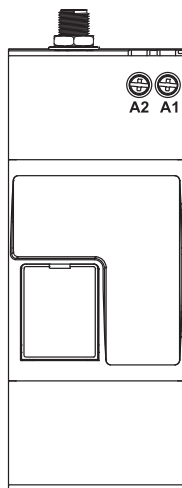
- Single type of alarm means an alarm condition which is managed individually and independently from the other alarms but could drive a same contact output.
- OR (a) , OR (b), OR (c), OR (d) and OR (e) type of alarms are meant to be grouped alarms managed independently according to the proper letter.



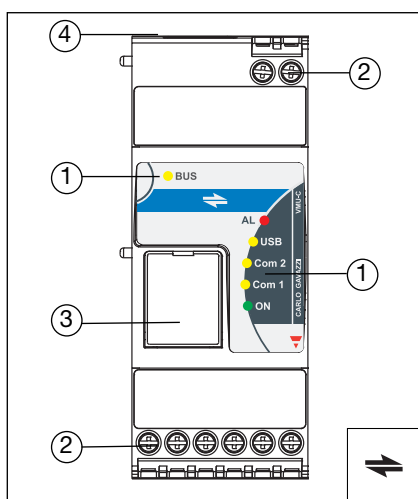
## VMU-C connections



## VMU-W connections



## VMU-C Front panel description



### 1. LED.

- Power ON (Green)  
Steady ON: power supply is on;  
Blinking: writing cycle on micro SD card
- Bus (internal) (Yellow)  
Steady OFF: no communication; blinking: regular communication  
Steady ON: error on communication.
- COM1 (Yellow)  
Steady OFF: no communication;  
Slow blinking: no answer to Modbus request (time-out);  
Blinking: regular communication.
- COM2 (Yellow)  
Steady OFF: no communication;  
Slow blinking: no answer to Modbus request (time-out);  
Blinking: regular communication.
- USB (Blue)  
Steady ON: acknowledged device, no writing in progress;  
Steady OFF: neither acknowledged device nor connected device;  
Blinking: acknowledged device and writing cycle in progress.
- Alarm (Red)  
Steady on: alarm in progress;  
Steady OFF: no alarms.

### 2. Screw terminals.

For power supply, bus and digital inputs/output connections

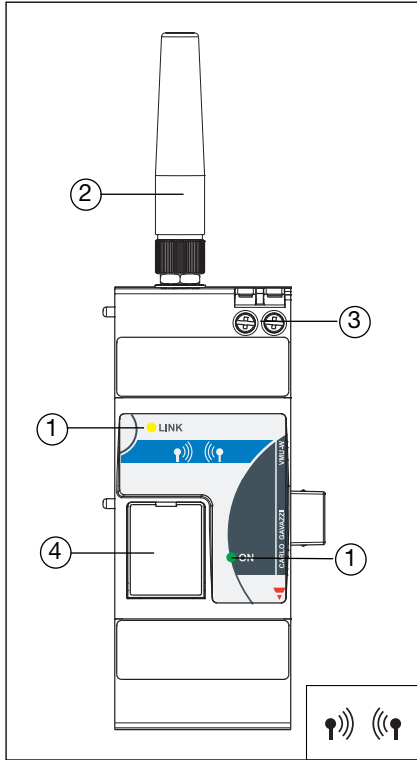
### 3. Micro SD holder.

Slot to plug-in the proper micro SD or micro SDHC memory and mini USB connector

### 4. USB and RJ connector.

USB "A" type connector and RJ45 10/100 BaseTX connector for Ethernet communication.

## VMU-W Front panel description



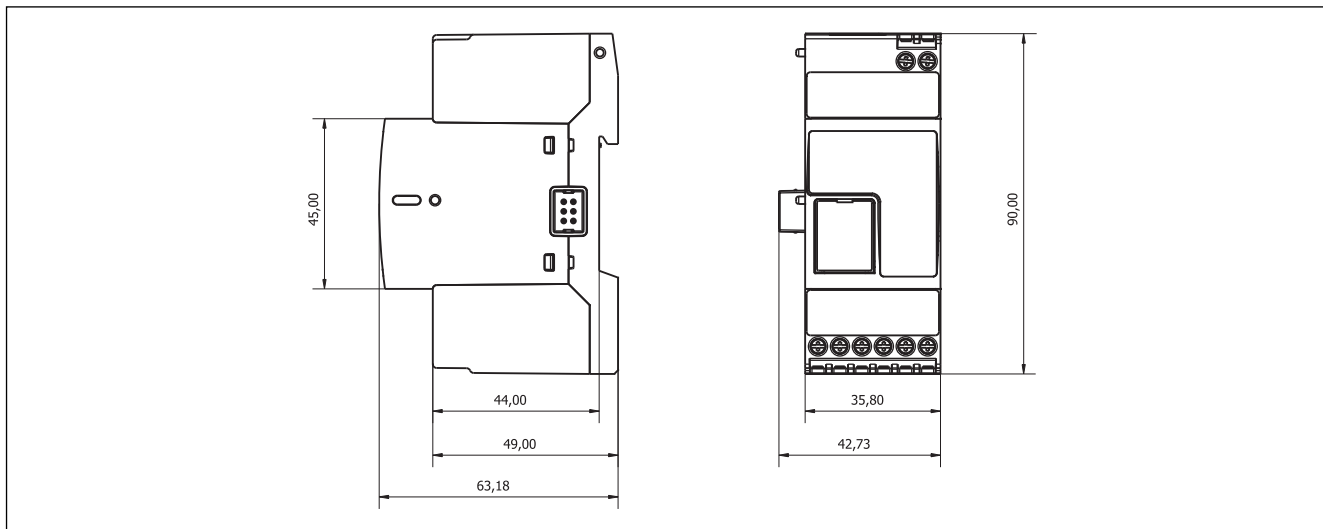
1. **LED.**
  - Power supply (Green):  
Steady ON
  - Link (Blue):  
Steady OFF: the unit is OFF.  
Fast blinking: net search / not registered / turning off.  
Slow blinking: registered full service.  
Steady ON: a call is active.
2. **Antenna.**
3. **Power supply.**  
For power supply connections
4. **Sim card holder.**  
Proper slot for SIM card with protection cover

## Mean time to failure (MTTF)

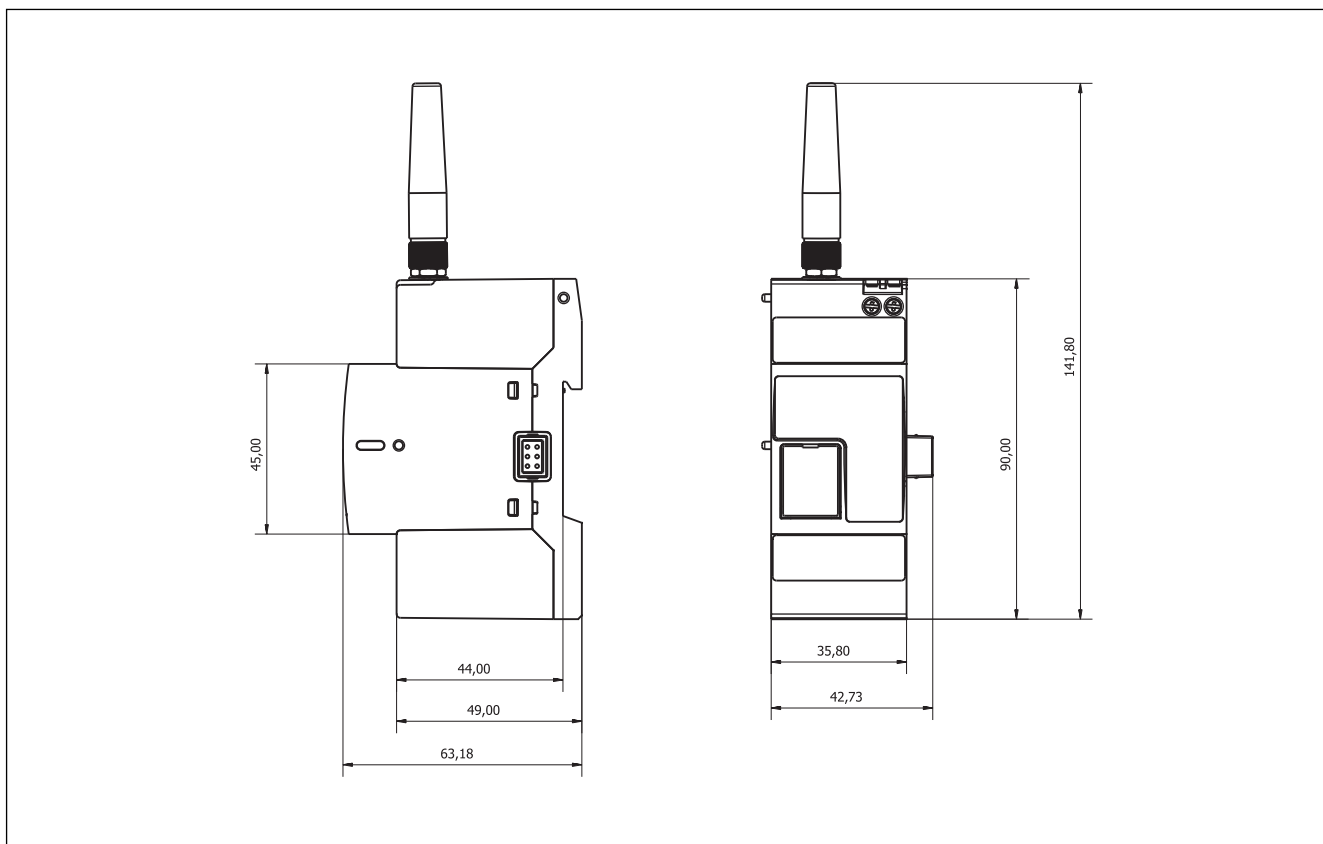
Model	MTTF/MTBF - Years	Test conditions	Standard
VMU-C	12.0	gf, 50° C	MIL-HDBK-217F
VMU-W	26.0	gf, 50° C	MIL-HDBK-217F
VMU-M	24.2	gf, 50° C	MIL-HDBK-217F
VMU-S	35.4	gf, 50° C	MIL-HDBK-217F
VMU-P	31.7	gf, 50° C	MIL-HDBK-217F
VMU-O	65.4	gf, 50° C	MIL-HDBK-217F
VMU-AT	28.0	gf, 50° C	MIL-HDBK-217F

gf: ground, fixed.

### VMU-C Dimensions (mm)



### VMU-W Dimensions (mm)



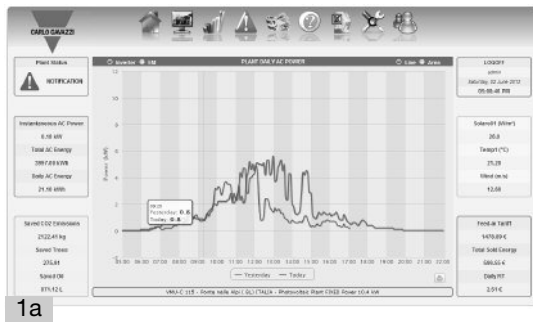
## WEB-server "Access and Home page"



### Access page of VMU-C

This page has a double access:

- **"Free access"**: there is access at the home page, see fig. 1a without the top icons and the blue outlined box.
- **"Registered users"**: the access is with "User name" and "Password" and has different privileges according to the type of user:
  - **As "User"**: in this case the user has access to the "Home" page and all the other charts and tables pages.
  - **As an "Administrator"**: in this case the user has access to all pages as per "User" above but in addition also to all "Settings" and to the "Account" management.

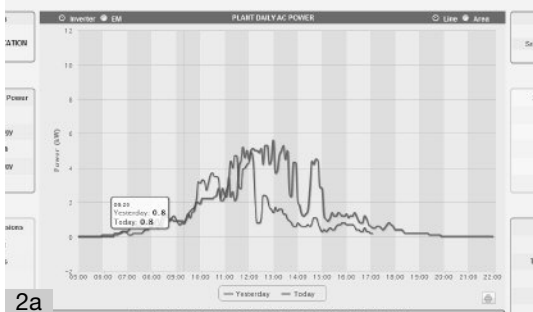


1a

### "Home" page

The page is divided in four areas:

1. **On the top. 9 icons are available to have direct access to different functionalities like (Fig.1a):**
  - Home page: Plant today/yesterday AC power;
  - Plant page: Detailed graphs of all available variables;
  - Monitor page: combination of main charts for accurate plant analysis;
  - Alarms page: alarms, anomalies, events, commands list;
  - Economy page: economical parameters of the installation;
  - Information page: plant description with relevant technical data, financial highlights;
  - Export page: data base export in Excel spreadsheet;
  - Setting page: access to the configuration of Modbus and communication all parameters of VMU-C and Eos-Array;
  - Account page: access to account configuration.
2. **On the middle (Fig.2a).** The plant daily power graph which allows to compare the actual AC power vs. the day before AC power. The graph is available as either a line or an area graph. The showed power may come directly either from the inverters or from the energy meters (selectable).
3. **In the left hands (Fig.3a).** Power and Savings information such as:
  - Instantaneous AC power (kW);
  - Total AC energy (kWh);
  - Daily AC energy (kWh);
  - Saved CO2 emissions (kg/lb);
  - Saved trees (qty.);
  - Saved oil (l/gallons).
4. **On the right hands (Fig.4a).** Environment and Economic information such as:
  - Solar irradiation (W/m<sup>2</sup>, W/ft<sup>2</sup>);
  - Module temperature (°C/°F);
  - Wind speed (m/s, ft/s);
  - Total incentive (currency/kWh);
  - Total savings on bills (currency);
  - Daily incentive (currency).



2a

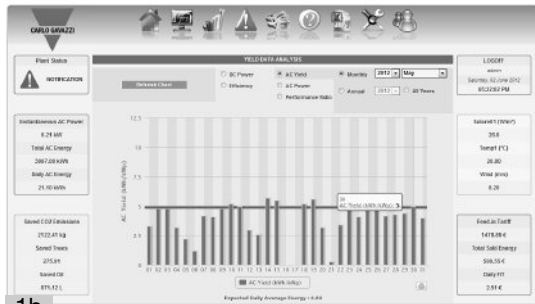
<b>Instantaneous AC Power</b>	0.18 kW
<b>Total AC Energy</b>	3997.00 kWh
<b>Daily AC Energy</b>	21.10 kWh
<b>Saved CO2 Emissions</b>	2122.41 kg
<b>Saved Trees</b>	275.91
<b>Saved Oil</b>	871.12 L

3a

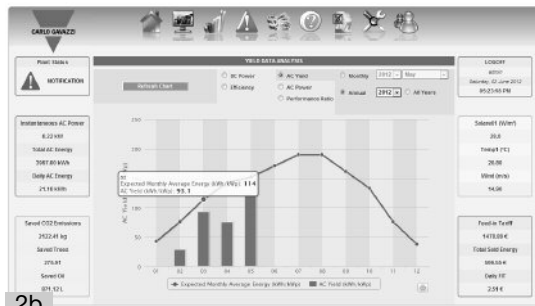
<b>Solare01 (W/m<sup>2</sup>)</b>	26.0
<b>Temp1 (°C)</b>	21.20
<b>Wind (m/s)</b>	12.60
<b>Feed-in Tariff</b>	1478.89 €
<b>Total Sold Energy</b>	599.55 €
<b>Daily FIT</b>	2.51 €

4a

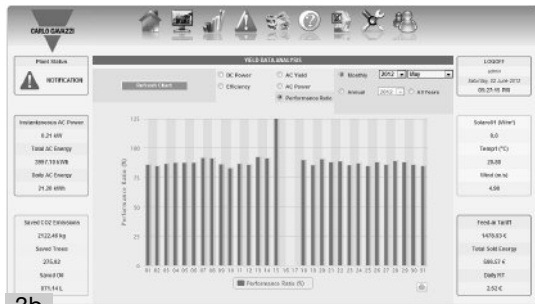
# WEB-server "Monitor Page"



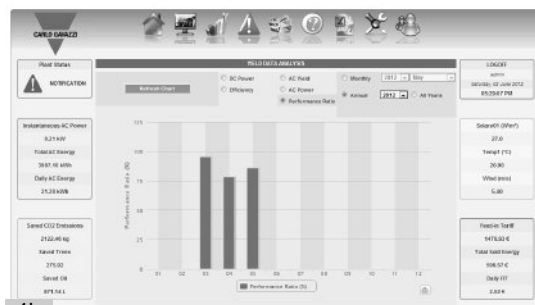
1b



2b



3b



4b

## Monitor page (Fig.1b-2b-3b-4b)

This page shows to the user the System Performance Indices as different combinations of variables which will let the user to understand how the photovoltaic installation behaves and if there are problems such low efficiencies.

There are two indices:

### The Yield index

- kWh/kWp AC (see fig. 1b) as a combination of daily yield vs. kWh/kWp project reference (see red line). This is the most important graph among all since it gives to the user immediate feedback on how the installation performs on a monthly base with daily resolution. In addition Fig. 2b shows how to display the available yield data on yearly base and last but not least on all years. Important: if Annual graph is displayed than clicking with the mouse on the desired day bar the relevant daily graph has to appear, like in the picture below. Note: the expected monthly average has to be changed showing a horizontal line for every monthly limit;

### The Performance Ratio index

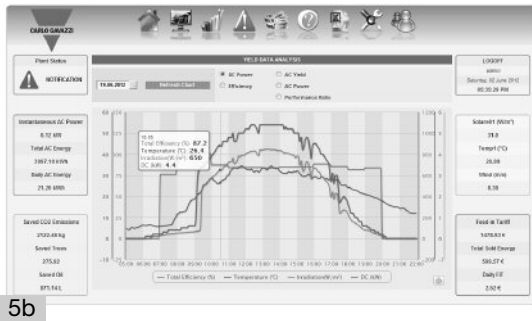
- **Performance Ratio** (see fig. 3b) as the overall effect of losses on the PV modules rated output due to PV module temperature, incomplete utilisation of the irradiation, and system component inefficiencies or failures. The Fig. 4b shows how to display the available yield data on yearly base and last but not least on all years (see the picture details for other information);
- **"DC Power"** as a combination of 4 graphs (fig. 5b): all strings efficiency, DC power, Solar irradiation, Cell or air temperature (depending on the selection made by the user). The time interval of the graphs is depending on settings of Eos-Array system;
- **"Efficiency"** as a combination of 2/3 graphs (fig. 6b): all strings efficiency, BOS efficiency and Total efficiency. The time interval of the graph is 60 minutes.
- **"AC Power"** as a combination of 4/5 graphs (fig. 7b): Total efficiency, AC power (three sources are selectable: inverter, energy meter, inverter + energy meter), Solar irradiation, Cell or air temperature (depending on the selection made by the user). The time interval of the graphs is 60 minutes for total efficiency while for the other variables it is depending on the programmed time interval (5 to 60 mins).

**Note:** if only "Inverters" are connected in the "Example of communication architecture with wired (or wireless) Internet access and Inverter and energy meter management ..." the only available pages will be:

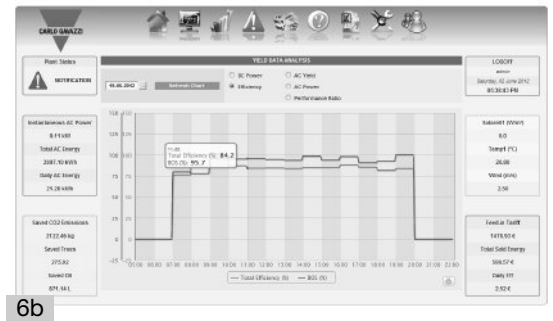
Fig. 5b without string efficiency and DC power coming from inverters themselves;

Fig. 7b. if external sensors (temperature and irradiation) are not enabled than this page will not be available at all.

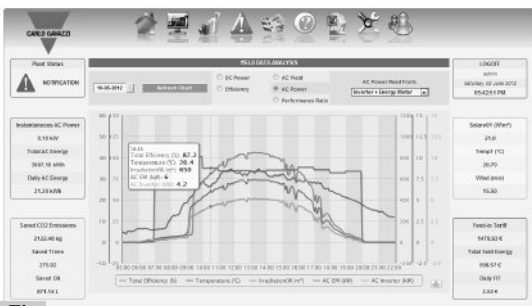
## WEB-server "Monitor Page" (cont.)



5b

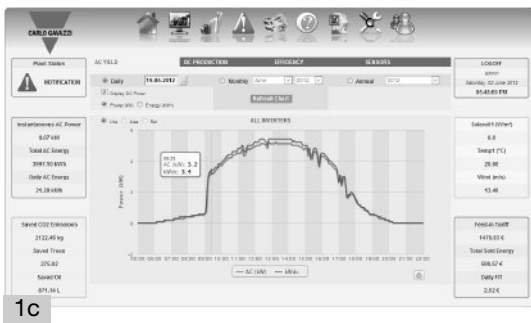


6b



7b

## WEB-server "Plant page"



1c



2c



3c

### Available only with "Password acces"

The page has access to 4 different and specialised menus like: **AC Yield and then the following selections:**

- **"All inverter"** with the possibility to "display DC kW", "AC Power (kW)" and "AC Energy (kWh)" (see Fig.1c). In the same page it is also possible to display the "Daily", "Monthly" an "Annual" charts.
- **"Single inverter"** with the possibility to "display DC kW", "AC Power (kW)" and "AC Energy (kWh)". In the same page it is also possible to display the "Daily", "Monthly" an "Annual" charts. An additional combo-box "Inverter name" is available to display the charts as "All" Inverters (see Fig.2c) so all charts of every single inverter will be displayed simultaneously so to carry out a comparison among all available inverters or "Inverter label" (see Fig.3c) where only the selected inverter name will be shown.
- **"Total EM"** (Energy Meters) with the possibility to display "AC Power (kW)" and "AC Energy (kWh)" (see Fig.4c). In the same page it is also possible to display the graphs "Daily", "Monthly" and "Annual" charts.
- **"Partial EM"** (Energy Meters) (see Fig.5c), with the possibility to display "AC Power (kW)" and "AC Energy (kWh)". In the same page it is also possible to display the "Daily", "Monthly" and "Annual" charts. The measurements are available, similar to "Single inverter" either as single graphs where, by group, they appear all at the same time with different colours so to allow an easy comparison of the different strings or as a sum of kW, A and kWh. The combo-box allows to select the requested energy meter for proper analysis.

Note: the graph (fig. 5c) shows a serial communication interruption on the energy meter.

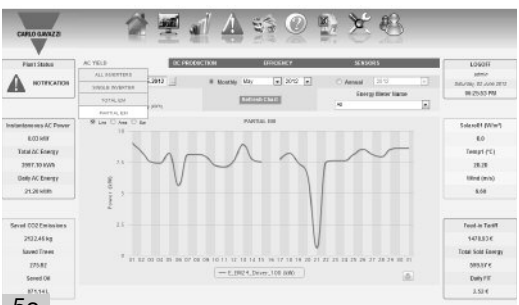
## WEB-server “Plant page” (cont.)



4c

The page has access to 2 different and specialised menus like: **DC production and then the following selections:**

- **“All strings”** with the possibility to display “DC Power (kW)”, “DC Energy (kWh)” and “DC Current (A)” and in addition also to select “Daily”, “Monthly” and “Annual” chart (see Fig. 6c).
- **“Single strings”** (see Fig.7c), with the possibility to display “DC Power (kW)”, “DC Energy (kWh)”, “DC Current (A)”, “DC Voltage (V)”. The measurements are available either as single charts where, by group using the “String unit” combo-box, they appear all at the same time with different colours so to allow an easy comparison of the different strings. In addition another tool is available, as a combined graph “DC Power (kW) + DC Current (A) + DC Voltage (V) + Irradiation” (see Fig.8c) but only when in the “String Unit” combo-box a single string is selected. To select the proper Eos-Array or String-box so to perform the needed string analysis, use the “Eos-Array” combo-box.



5c

The page has access to 4 different and specialised menus like: **Efficiency and then the following selections:**

- **“Total”** so to display the total efficiency which is based on the combined calculation of Yield energy (data coming from AC energy meter/s), DC energy coming from all strings, solar irradiation and cell or ambient temperature. This chart shows the efficiency contribution of all strings. The chart can be displayed on daily, monthly or Annual base.
- **“Eos-Array”/ “All strings” efficiency:** this chart shows the trend of efficiency based on the contribution of all string efficiencies. The chart can be displayed on daily, monthly or Annual base.
- **“Eos-Array”/ “Single string” efficiency:** this chart shows, simultaneously, the trend of efficiency of all available strings based on the “Eos-Array” and “Strings” combo-boxes selections.
- **“Inverter” / “Single Inverter” efficiency:** this chart shows, simultaneously, the trend of efficiency of all available inverters based on the “Inverter Name” combo-box selection. The combo-box allows to show one inverter efficiency by time or all efficiencies charts showed simultaneously.
- **“BOS”:** this chart shows the trend of “Balance of System” efficiency and is based on the calculation of the sum of all DC string energies and the total AC energy supplied to the grid. The chart can be displayed on daily, monthly or Annual base.



6c

**Sensors and then the following selections:**

- **“Solar Irradiation”:** this chart shows, simultaneously, the trend of solar irradiation of all available sensors based on the “Sensor label” combo-box selection. The combo-box allows to show one sensor by time or all irradiation sensors charts showed simultaneously. The latter function is available only if more than one “zone” has been set during the configuration procedure. As usual all available graphs can be displayed on daily, monthly or Annual base.
- **“Temperature”:** this chart shows, simultaneously, the trend of any available temperature probe based on the “Sensor label” combo-box selection. The combo-box allows to show one sensor by time or all temperature charts showed simultaneously. The latter function is available only if more than one “zone” has been set during the configuration procedure. As usual all available graphs can be displayed on daily, monthly or Annual base.
- **“Wind speed”:** this chart shows, simultaneously, the trend of any available wind speed sensor based on the “Sensor label” combo-box selection. The combo-box allows to show one sensor by time or all wind speed sensor charts showed simultaneously. The latter



7c



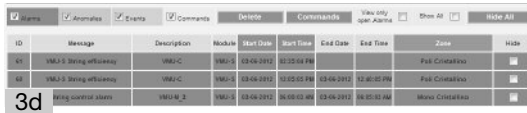
# WEB-server "Alarms page"



1d



2d



3d



4d

function is available only if more than one "zone" has been set during the configuration procedure. As usual all available graphs can be displayed on daily, monthly or Annual base.

## "Alarms" page

The page (Fig. 1d) has access to the list of all available anomalies not yet disappeared and not yet acknowledged such as:

- **Alarms:** the alarms are relevant to the working status of the PV plant and managed by the system as high priority;
- **Anomalies:** the anomalies are relevant to the working status of the monitoring and managed by the system as medium to high priority ;
- **Events:** the events are relevant to the working of both inverters and monitoring where this latter one is focused on changing of status with medium to low priority looking at its importance in the context;
- **Commands:** closing/opening contact detected by VMU-O units, the commands are relevant to the monitoring system and priorities are not managed.

The page is split in two main parts which are then sub-split in some columns:

- **Message, Description, Module, Start date, Start time, End date, End time and Zone:** these information are all details relevant to the recorded alarm. Every line is a new alarm.
- **Address, Group (VMU-C), Position, Channel:** these are the information of the same line above but relevant to the device which has generated the alarm.

All alarms according the privilege of the user can be hidden.

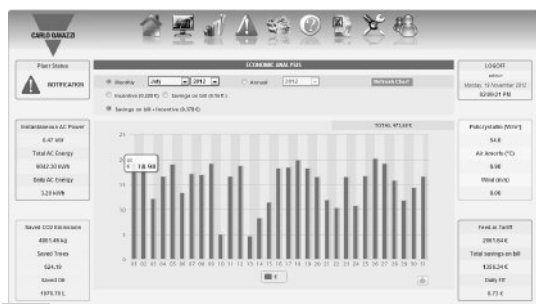
One box (Fig.2d) on the left hands upper corner shows at a glance the status of the photovoltaic park. Two type of messages may appear:

- **STATUS OK (green):** there are no alarms or low priority alarms;
- **ALARM with message (red):** there are high priority alarms.

Some additional command are available to cancel the alarms (see Fig. 3d) like:

- **Delete:** this command deletes only the closed alarms;
- **Commands:** see figure 4d;
- **View only open alarms;**
- **Show all:** it shows all the available and not yet deleted alarms;
- **Hide:** this command hides the selected single alarm.

## WEB-server “Economy page”



1e

### Economy page

This page shows to the user :

- the feed-in tariff look-out.

### Economy page (Fig. 1e)

This page shows to the user:

- the incentive trend according to the selection on monthly-yearly base.
- the savings on bill trend according to the selection on monthly-yearly base.
- the sum of savings on bill and incentive trend according to the selection on monthly-yearly base.

## WEB-server “Information page”



1f

### Information page

This page shows to the user :

- the feed-in tariff parameters.

### Information page (Fig. 1f)

This page shows to the user:

- the plant description such as: plant name, plant location, plant property, installer, PV module installation date and Eos-Web installation date;
- the technical data such as: plant type, total area of PV modules, number of inverters, number of strings, peak power of plant;
- the financial highlights such as: energy system, incentive paid per kWh, kWh purchasing price, % of sold energy vs. total produced energy, price per sold kWh;
- the energy production data source: inverter or energy meter which has been selected in settings.
- The monthly planned energy yield (kWh/kWp).

## WEB-server “Export page”



1g

### Export page (Fig. 1g)

The database of the whole photovoltaic park managed by the Eos-Web can be downloaded as an Excel spreadsheet and is available according to the following selection:

Monthly: max. 31 days with the selection of the needed “Month” and “Year”;

Annual: 12 months with the selection of the needed “Year”.

In order to help the user to focus on the desired information a further criteria is available:

- Alarms
- Eos-Array
- Temperature
- Solar irradiation
- Wind speed
- Inverters
- Energy meter