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Erasmus+ - Key Action 2

Capacity Building within the Field of Higher Education

eACCESS Project

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EU-Asia Collaboration for aCcessible Education in Smart Power Systems

WP 4	PREPARATION
TASK	T4.1.3 Preparation of the detailed technical specifications for the physical laboratories (ATM)
LEAD PARTNER	TUL (Lodz University of Technology, Poland)
PARTICIPATING PARTNERS	ATM (Atma Jaya Catholic University of Indonesia)

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EXECUTIVE SUMMARY

Developing the laboratory is one of the eACCESS project's pillars, which is pillar 3. As a member of the Erasmus+-funded eACCESS project, Atma Jaya Catholic University of Indonesia (ATM) offers a laboratory dedicated to photovoltaic technology, complete with software for the computation of short circuits and coordination of protective systems for the PV power system. This PV laboratory is proposed in order to act in accordance with the current technological advancements, particularly in the field of Renewable Energy (RE). In addition to that, the Indonesian government is currently pushing the usage of RE due to the depletion of fossil fuels. The Indonesian government promotes the use of renewable energy which is considered as green energy with sources such as photovoltaic, wind, and bioenergy.

The PV Lab that will be installed in this eACCESS Project is a PV Lab that combines several solar modules into one array which can be regulated by the solar controller/solar inverter. The development of the proposed PV lab will give more chances in deepening knowledge and experience of Renewable Energy related issues. The system can be utilized as an off-grid system, using the battery as energy storage, or as an on-the-grid system, by incorporating it with the grid, or a hybrid system. The PV System can also be connected to a diesel-generating plant. The system is equipped with an anti-islanding system. If there is no voltage from the grid, the PV System will be automatically disconnected from the grid and can only be operated in an off-grid mode. At present, the parameter can only be monitored and controlled locally, with the possibility of being remotely controlled using Modbus.

1. INTRODUCTION

Solar Power Plant (PLTS) is one of the alternatives to the power generation system that is suitable for remote places which is distant from the generator resulting in a relatively high cost of generation, The Solar Power Plant work system uses photovoltaic (PV) modules, also known as Solar Modules, to convert solar energy into electrical energy so that it can function as an efficient and effective generator. Solar Power Plant is an eco-friendly generator since their working system uses solar energy to provide electricity to the load. also recently, the utilization of photovoltaics as a source of electricity on a rooftop become familiar.

Currently, the need for electrical energy consumption around the world is increasing rapidly, especially in industry and research. However, the existing energy resource still uses a lot of fossil energy which decreases from time to time. Hence a power plant using resources with Renewable Energy (RE) is needed. Specifically, in Indonesia, Renewable Energy utilization until 2025 is targeted to reach 25%. For this reason, Atma Jaya Catholic University of Indonesia (ATM), one of the universities that also took part in the development of the research, supports the government program for the development of technology and introducing the use of Renewable Energy. For the realization of this program, ATM plans to build a PV lab located in the ATM third campus in Bumi Serpong Damai (BSD) so that ATM can support the implementation of the engineering education and research point in the Photovoltaic area.

A PV system converts sunlight into electricity. A PV system contains different components including cells, electrical connections, mechanical mounting, and a way to convert the electrical output. The electricity generated can be kept in a standalone system, stored in batteries, or can feed a greater electricity power grid. It is interesting to include electrical conditioning equipment. This one ensures the PV system operates under optimum conditions. In this case, we use special equipment to follow the maximum power of the array.

1.1 PURPOSE AND OBJECTIVES

a. Construct a PV lab Solar Power Plant that can be used to develop Photovoltaic technology hence the PV lab can be used to conduct the training for the student and the training center for industries in the area near the ATM campus

b. Implement the transfer of PLTS system technology in the operation and maintenance of the generating system to ensure its continued functioning.

1.2 TECHNICAL SPECIFICATIONS

The PV mini-grid that will be installed in this work is a PV mini-grid system that combines several solar modules into one array which is regulated automatically by the solar controller/inverter. This generating system is centralized with the generated energy distributed through a 220V low-voltage AC power distribution network. The inverter used must also be able to be paired (hybrid) with a diesel generator, in anticipation of a lack of solar energy during cloudy or rainy weather.

2. PROPOSED LABORATORY

2.1 2.1 INTRODUCTION

To follow up the vision and mission of the Faculty of Engineering, particularly in the fields of Teaching and research development, as well as with the collaboration with Erasmus, especially with pillar 3 (Infrastructure Development), ATM hereby uses this opportunity to carry out the construction of the infrastructure of laboratory namely the PV Lab. This PV laboratory is proposed in order to act in accordance with the current technological advancements, particularly in the field of Renewable Energy (RE).

2.2 2.2 DESCRIPTION OF THE PROPOSED LABORATORY:

PV laboratory will be located in an area at the 3rd Campus of Atma Jaya, at Bumi Serpong Damai. The surrounding is free from high building, so the solar radiation can be fully utilized by the PV. Based on the data from ”Solar resource maps of Indonesia” the solar radiation in the area of the campus is 4 kWh/m2 per day, as shown the Figure 1.

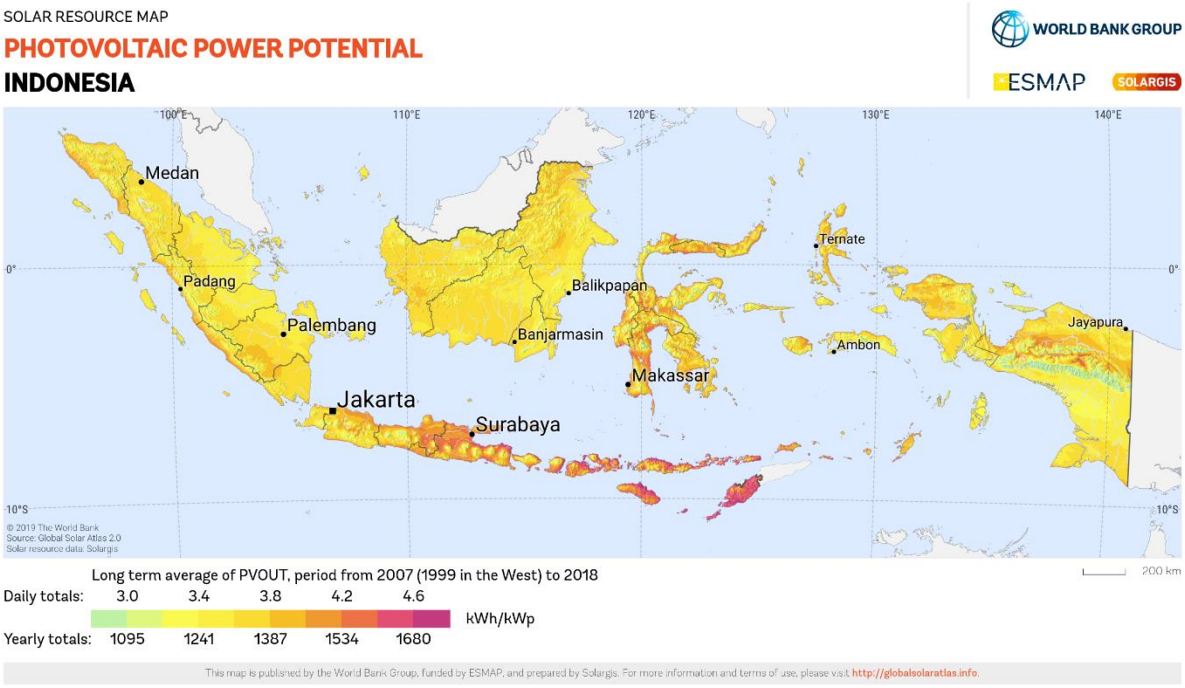

FIGURE 1. SOLAR IRRADIANCE IN INDONESIA

The PV installed has a capacity of 5.25 kWp, and it occupies an area of 30 sq meters. The proposed location is free from obstacles such as tall trees and buildings, and it is intended as an open space. The total solar energy that can be available is 120 kWh per day. With the efficiency of the PV array of 18 %, the harvested energy will be around 21 kWh per day. The electric energy can be utilized or it can be stored in a LiFePO4 battery with a total storage of 10.2 kWh. The PV is intended to supply several pieces of equipment such as air conditioning, water pump, lighting, and PC. Currently, the electrical load system is supplied by the Low voltage grid, and it is independent of the main supply of the campus. For the time being, the PV is controlled in a way not to supply energy to the grid. The grid is used as a reference for voltage and frequency only.

A hybrid system can be operated as an on-grid PV system, an off-grid PV system, or both. As an on-grid PV, the system can be connected to the grid via a bidirectional inverter. It can also be operated in parallel with another PV system using a solar inverter.

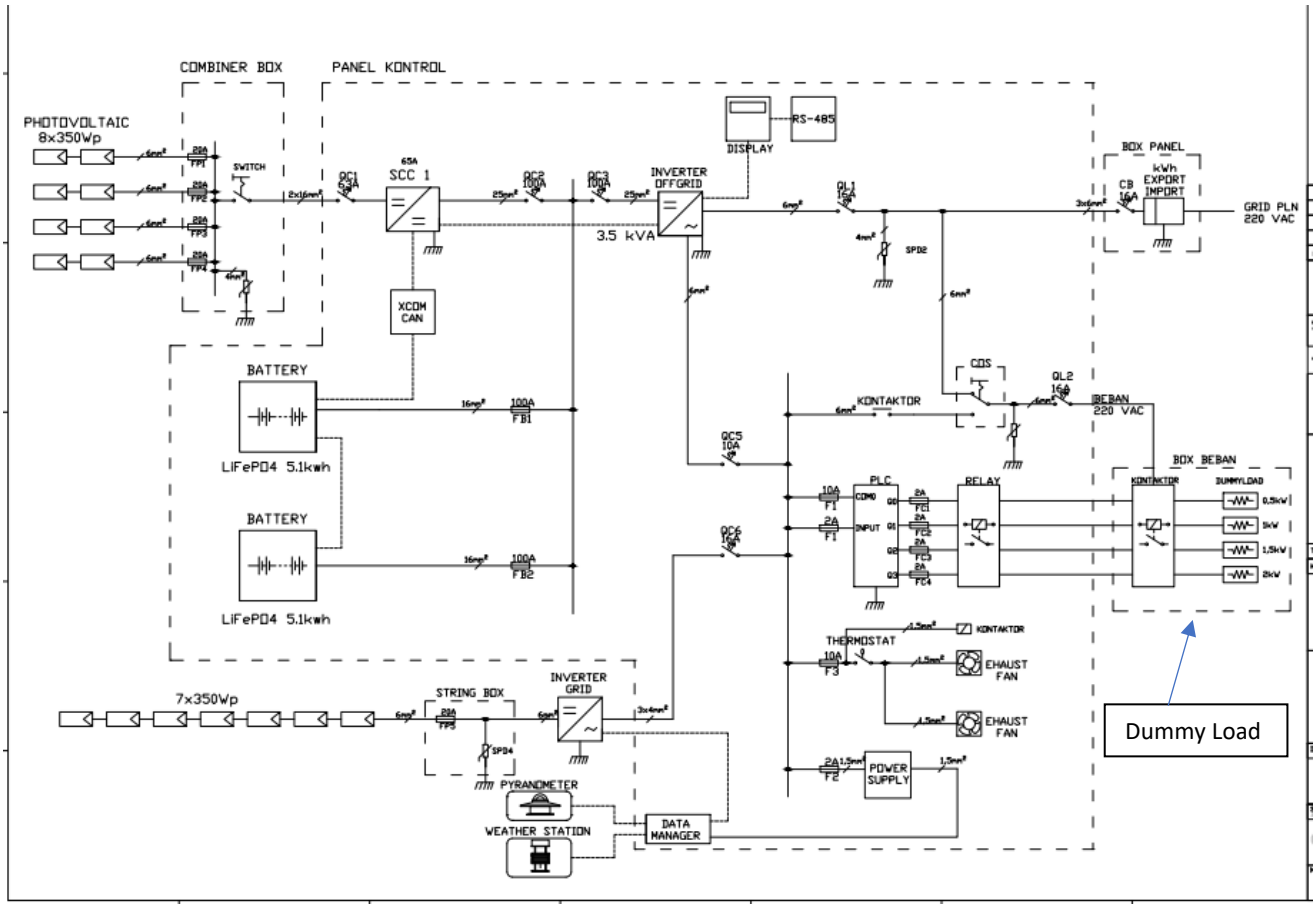

FIGURE 2. ONE LINE DIAGRAM PV LAB.

Figure 2 shows the One-Line Diagram of the PV lab, here it shows that the PV lab System uses two pieces inverter for the purpose of the experiment to analyze the DC and AC coupling.

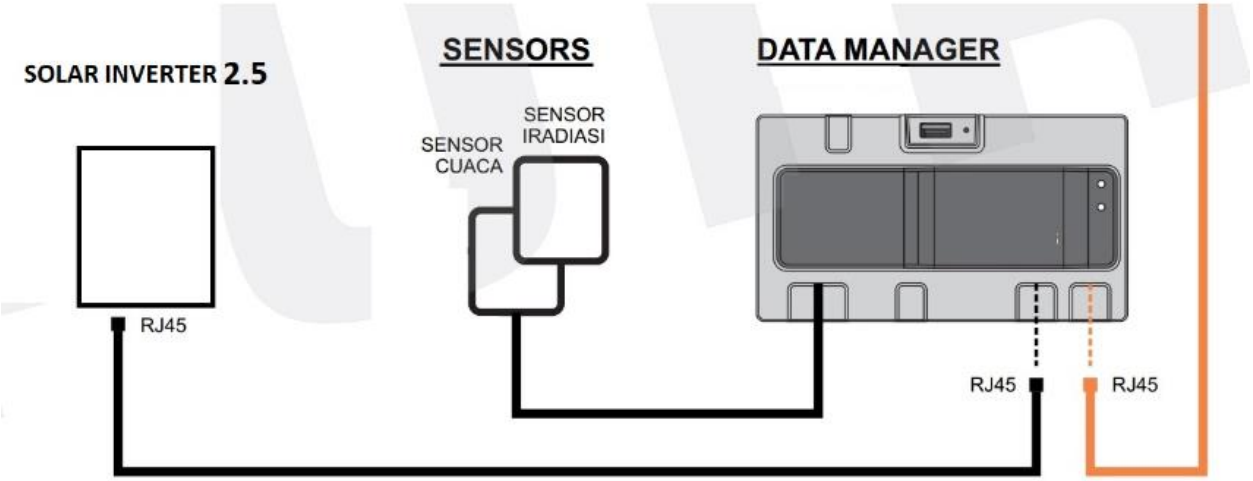

FIGURE 3. BOCK- DIAGRAM SOLAR INVERTER AND DATA MANAGER

Figure 3 shows how the monitoring system block diagram for the Diagram Solar Inverter and Data Manager, the One-line Diagram Communication of AC Coupling is illustrated in Figure 4.

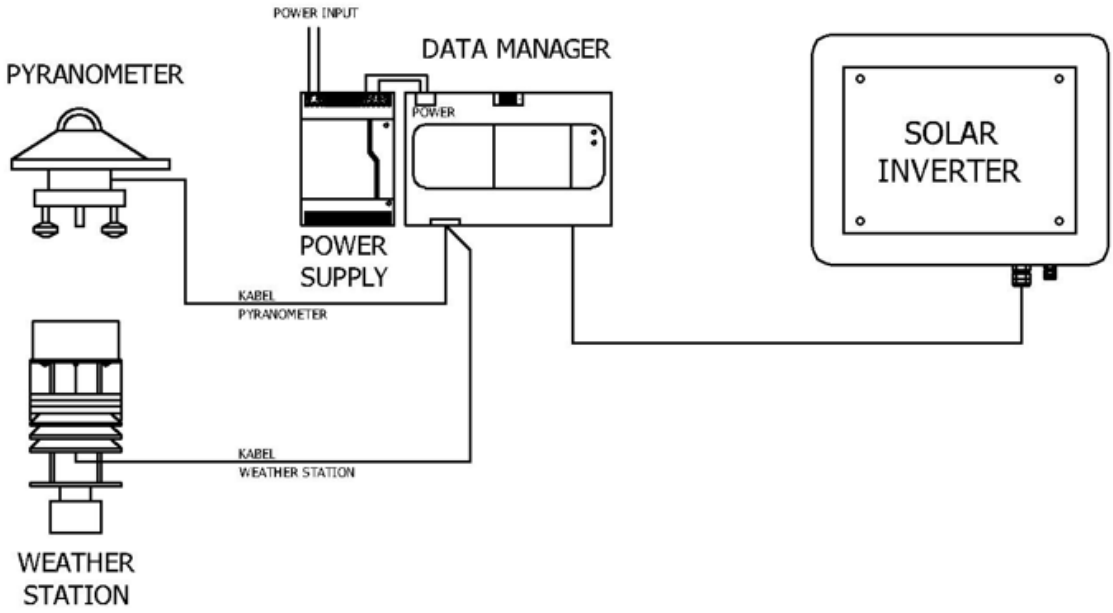

FIGURE 4. ONE-LINE DIAGRAM COMMUNICATION OF AC COUPLING

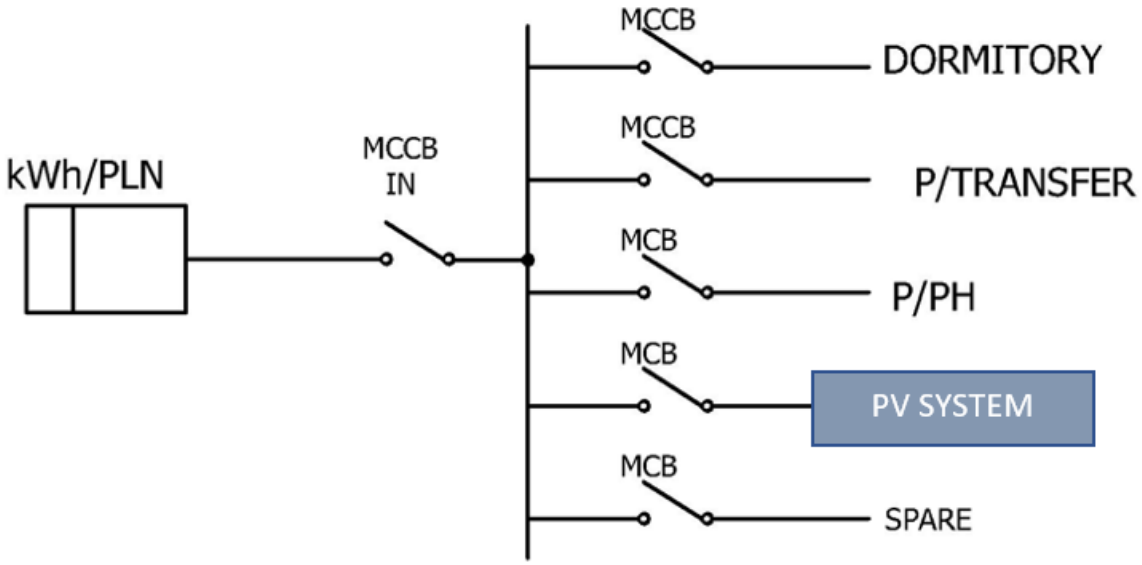

FIGURE 5. SCHEMA HOW THE CONNECTION TO GRID AND DORMITORY OF ATM.

Figure 5 shows how the schema connection to the electrical grid for internal use for the dormitory of the BSD campus of ATM, while the One-line diagram electrical of the Dormitory of ATM as shown in Figure 6.

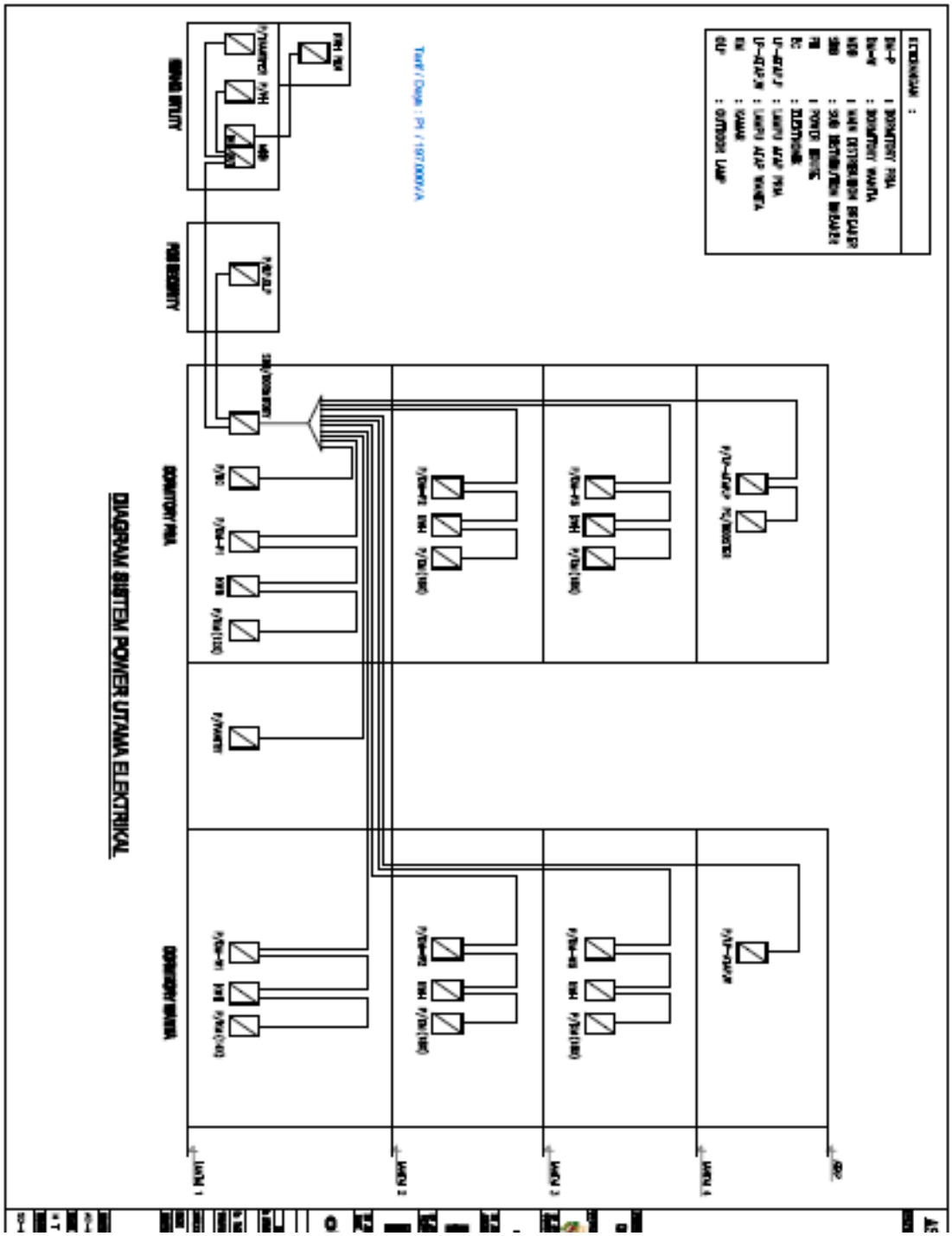

FIGURE 6. SINGLE LINE DIAGRAM ELECTRICAL FOR THE DORMITORY OF ATM

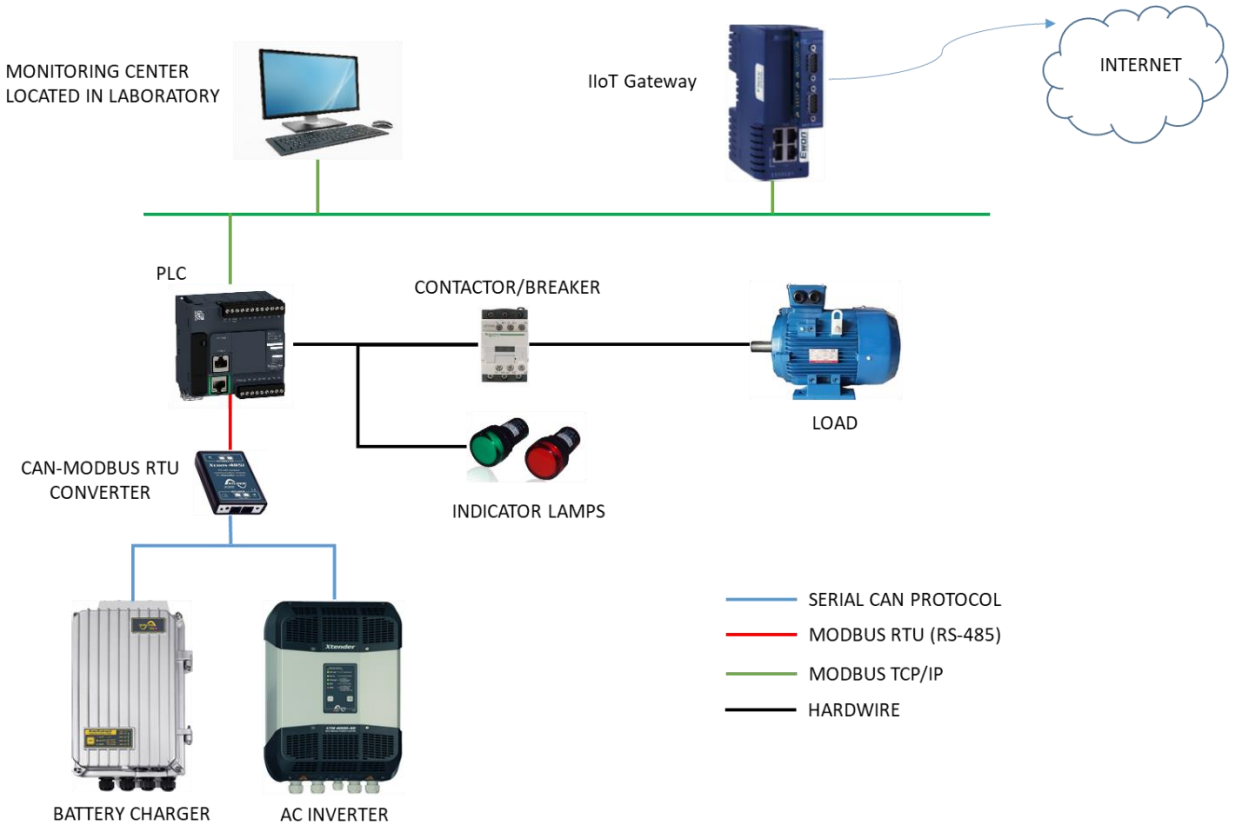

FIGURE 7. SCHEME ARCHITECTURE COMMUNICATION SYSTEM.

Figure 7 shows the architecture of the communication system as follows:

1. In the PV system, there are two components that can be accessed and monitored: Battery charger and AC Inverter. These two devices can handle external communication using Serial Can Protocol.
2. To make the PV system available for Modbus protocol connection, the CAN protocol is converted to Modbus Serial/RTU using CAN-Modbus RTU Converter.
3. PLC will communicate with the PV devices using this Modbus RTU protocol.
4. Using the parameters that can be collected from the PV system, PLC can be programmed to run a designated control strategy according to our needs.
   One example of the control strategy that we can design is: PLC will open the load breaker if the PV system is overload.
5. Parameters that are available in the PLC, then can be monitored and collected in the Monitoring Center/Server using SCADA software.
   With this SCADA software, the parameters can be Controlled, Monitored, Historically stored and analyzed.
6. The installed system is also equipped with Industrial IoT gateway. With this gateway, the overall PV system can be monitored remotely via internet connections. The connections can be established using Virtual Private Network (VPN) or commonly used IoT protocol such as MQTT.

The monitoring center will be located in the Laboratory Room inside the campus building. This Monitoring center is in a different location than the PV installation site. This can be done because the PV system (Inverter, PLC, etc) and the monitoring center will be connected using Ethernet/Wi-Fi network.

The communication protocol between the PV system and the monitoring center is Modbus TCP/IP Protocol.

The installed system can also be monitored from a different location using internet connections. This can be done using a VPN (Virtual Private Network) Connection or commonly used IIoT (Industrial Internet of Things) protocols such as MQTT.

3. Architecture Design of PV lab

The Architecture Design of the PV lab design can be seen in Figure 8. It shows "The PV lab of the Side view and Front View".

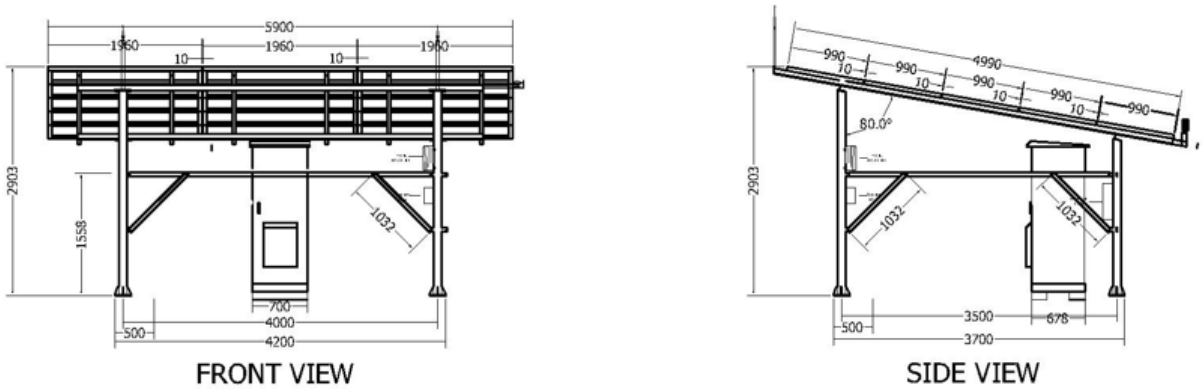

FIGURE 8. DESIGN VIEW.

4. PV LABORATORY Location

Considering the area of the ATM campus, the PV lab location can be seen in Figure 9 as the aerial view, while the Location of the monitoring Center are shown in Figure 10. And the using google Maps the PV lab area shown in Figure 11.

FIGURE 9. PROPOSED LOCATION OF THE PV LAB AERIAL VIEW

FIGURE 10. THE LOCATION OF MONITORING CENTER (MC)

FIGURE 11. LOCATION OF THE PV LAB BY USING GOOGLE MAP

5. LABORATORY CAPABILITY

5.1 The features of PV lab has several features such as

* Can be operated as an on-grid, off-grid, or Hybrid PV Power plant

* Equipped with anti-islanding protection

- With inverter in parallel operation. Load sharing can be done between the two inverters
- Automatic load shedding
- The battery can be charged via the PV panel or from the grid (if necessary).
- The system can be operated as an on-grid system even with the absence of a real power grid. In this case, the battery and the bi-directional inverter can function as a voltage and frequency reference. If preferred to export the PV energy to a real grid, the kWh meter must be replaced with an import-export type.

5.2 The Laboratory can be used for the following

The proposed experiment that will be executed on the PV lab ATM can be as the following:

1. Design and Installation
   - On-Grid design Installation
   - Off-Grid design Installation
2. Trouble Shooting.
   - Trouble Shooting on the On-Grid System
   - Trouble Shooting on the Off-Grid System
3. Training and Workshop for Industrial.

The course that can be implemented using this PV Lab as follows;

- Design principle of the photovoltaic system
- Type of the photovoltaic: Monocrystalline, Polycrystalline, Thin Film
- Voltage-Current Characteristic: Open circuit and Short Circuit
- Maximum Power Point Tracking (MPPT)
- Battery Management System (BMS)
- On-grid PV system, Off-Grid PV system, and Hybrid PV system
- Anti-Islanding
- Bi-directional inverter
- Lightning protection in PV Installation
- Protection in PV Installation

5.2.1 Laboratory Experiment Name;

5.2.1.1 TITLE: Understanding How to Measure the Actual output of Solar Module.

OBJECTIVE: After completing this experiment, the users are expected to be able to calculate the solar modul efficiency.

5.2.1.2 TITLE: Configuration of Solar Cell from DC output to 220 VAC of Solar Module.

OBJECTIVE: After completing the experiment, the users are expected to be able to understand the function of the inverter of the solar cell and measure the output current of the solar cell with typical any load.

5.2.1.3 TITLE: Measuring the light Intensity of Solar radiation and ambient temperature.

OBJECTIVE: After completing this experiment, the user are expected to be able to calculate and comparing to the output power of solar module at various light intensity as well as the ambient temperature.

5.2.1.4 TITLE: Measuring the input and output of solar controller (SCC).

OBJECTIVE: After completing this experiment, the users are expected to understand the function and characteristic of the SCC, and finally able to analyze the relation of the input and output SCC.

5.2.1.5 TITLE: Measuring the input and output of solar inverter (On Grid Inverter).

OBJECTIVE: After completing this experiment, the user are expected to understand the function and characteristic of the Solar Inverter, and finally able to analyze the relation of the input and output Solar Inverter.

5.2.1.6 TITLE: Measuring the input and output of Battery

OBJECTIVE: After completing this experiment, the user are expected to understand the function and characteristic of the battery, as well as charging and discharging.

5.2.1.7 TITLE: Measuring the input and output of Battery Inverter (Bi-directional Inverter)

OBJECTIVE: After completing this experiment, the users are expected to understand the function and caracteristic of the battery inverter, as conversion energy from both of DC to AC or from AC to DC.

5.2.1.8 TITLE: Measuring the characteristic of the On-grid System.

OBJECTIVE: After completing this experiment, the users are expected to understand the principle of the On-Grid System.

5.2.1.9 TITLE: Measuring the characteristic of the Off-Grid System.

OBJECTIVE: After completing this experiment, the users are expected to understand the principle of the On-Grid and Off-Grid System.

5.2.1.10 TITLE: Trouble Shooting on the Off-Grid and On-Grid Systems.

OBJECTIVE: After completing this experiment, the users are expected to understand how to overcome the problems of the Off-Grid and On-Grid System.

5.2.1.11 TITLE: Design and Installation overview of an On-grid and an Off-Grid System.

OBJECTIVE: After completing this course the users are expected to understand the principle of works of PV power system, as well as how to operate and maintenace of the the PV System.

5.2.1.12 TITLE: Training, workshop, and maintenance of PV power systems.

OBJECTIVE: After completing this course the users are expected to understand the principle of works of PV power system, as well as how to operate and maintenance of the PV System.

5.2.2 Laboratory Ability, and Learning out of the Laboratory.

The existing Laboratory has the ability to serve the student for one practicum title are 15 people. The importance of this laboratory is for the development and implementation of Renewable Energy, especially in the electrical and electronic department so that it can provide knowledge to students and the general public. And this Laboratory can be used as a source of innovation for electrical energy knowledge.

The learning out of this Laboratory is by using the PV lab will give the users more chances in deepening knowledge and experience of Renewable Energy related issues. With the development and implementation of Renewable Energy, the system can be utilized as an off-grid system, using the battery as energy storage, or as an on-grid system, by incorporating it with the grid, or a hybrid system.

6. EXTENDED POSSIBILITY

The PV lab can be utilized as a learning platform in industrial training and research, and in the future, it will be expanded for three-phase applications with On-grid System, With the additional Battery Inverter 2 pcs, Solar Inverter 2 pcs, cabinet, Protection component and cabling should be replaced.

7. TECHNICAL SPECIFICATION

The PV Lab that will be installed in this eACCESS Project is a PV Lab that combines several solar modules into one array which can be regulated by the solar controller/solar inverter. The system can be utilized as an off-grid system, using the battery as energy storage, or as an on-the-grid system, by incorporating it with the grid, or a hybrid system. The PV System can also be connected to a diesel-generating plant. The system is equipped with an anti-islanding system, If there is no voltage from the grid, the PV System will be automatically disconnected from the grid and can only be operated in an off-grid mode. At present, the parameter can only be monitored and controlled locally, with the possibility of being remotely controlled using Modbus, for upgrading in the future.

In General, the Solar Power Plant equipment consists of Solar Module, Bidirectional Inverter, Solar Charge Regulator, Solar Inverter, and Battery Bank with detailed specifications as follows:

7.1 Technical specification of Solar Module:

- Module type: monocrystalline silicon
- Capacity of PV module: 350 Wp
- Solar module efficiency: 18 %
- Module frame thickness: 50 mm
- Colour of the module: Silver-Level of protection: IP65

7.2 Technical specification Bidirectional Inverter:

- Total output power: 3500 VA
- Inverter type: bidirectional
- Output voltage: 220 V AC, 50 Hz, single phase
- Output waveform: pure sine wave
- Input voltage: 48 V
- AC Input voltage: 160 V- 250 V, 45 Hz-60 Hz
- Equipped with LED/LCD display, battery management System, and power control

7.3 Technical specification of Solar Charge Regulator:

- Capacity: 4kWp

- Control algorithm: MPPT (Maximum Power Point Tracking)

- Nominal input voltage: 48 VDC

- Protection system: overload, reverse polarity, over and under battery voltage

7.4 Technical specification Solar Inverter:

- Output power 2.5 kW
- Output voltage: 230 V, single phase
- Output waveform: pure sinewave
- Equipped with a communication interface for remote monitoring

7.5 Technical specifications of Battery Bank:

- Battery type: LiFePo4

- Output voltage: 51.2 VDC
- Total battery capacity: 10.000 Wh
- Cycling capacity: 2000 cycles at 90 % Depth of Discharge)
- Suggested brands: XUP, BYD

7.6 Technical specification for safety Aspect.

For the safety aspect, ATM provides the Personal Protective Equipment according to the Laboratory ATM requirements, namely: Medicine for First Aid in Accidents, Personel Protective Equipment, and Fire extinguishers.

8. LIST of TYPES of EQUIPMENT TO BE PURCHASED (SUMMARY)

No.	Detail components	Type/Specification/Example	Total	Unity
1	PV ARRAY	5 x 6 meter		
a	Solar Modul Monocrystaline 350Wp	SUPSM-350	15	unit
b	Solar cell modul Frame 5 x 6 m	H = 2m	1	set
c	DC Combiner Box, 4 in 1 out	150VDC	1	set
d	PV Connector	ekiv MC4	6	set
e	PV Cable 4-6mm2	1000VDC	80	m
f	Cable Combiner - SCC	HYYHY 2x16mm2	7	m
g	Accessories	Acc	1	lot
2	CONTROLLER			
a	Solar Charge Controller MPPT, 65A	VT-65	1	unit
b	Inverter bidirectional 3.5 kVA	XTM 4000-48	1	unit
c	Display	RCC-03	1	unit
d	CAN to CAN interface	Xcom-CAN	1	unit
e	Interface	Xcom-485	1	set
f	Solar Inverter, 2.5kW	Sunny Boy 2.5	1	unit
3	BATTERY			
	Lithium PO4 Battery, 5.12 kWh	SUPBLP-512100	2	unit

4	CONTROL PANEL BOX			
a	Box Panel 60 x 60 x 200 cm	Outdoor	1	set
b	Fuse 100A + fuse holder	NT-00	3	set
c	MCCB 63A		1	unit
d	DC Arrester	200 V	2	unit
e	AC Arrester	220V	2	unit
f	MCCB 100 A, 2 pole		2	unit
g	MCB 16A		3	unit
h	MCB 10A		2	unit
i	fuse UTE		2	pcs
j	Bussbar, insulator, schoen, duct cable, cable etc		1	lot
k	Wiring cable		1	lot
	Battery cable, red	NYAF 16 mm2	4	m
	Battery cable, black	NYAF 16 mm2	4	m
	AC Cable	NYAF 4-6 mm2	10	m
	Communication Cable: scc-Inverter-battery		5	m

5	GROUNDING AND LIGHTNING PROTECTION			
	Flexible conduit		6	m
	Cable tray - 3m		2	pcs
	Spitzen & Pipe		2	unit
	Ground Rod 5/8" - 4m		3	pcs
	Cadwell		4	pcs
	BC Cable 16 mm		30	meter
	Accessories		1	lot
6	Fence			
	BRC fence, galvanized	Iron Plate, 6mm, Tinggi 1.2m	14	sheet
	BRC Pole, Galvanized		14	set
	Swing Door	1m	1	set
7	Pyranometer		1	unit
	Weather Station		1	unit
8	DATA MANAGER & Power Supply		1	unit
	Cable to Pyranometer & Weather Station		1	lot
9	kWh meter			

	KWh meter export-import	Mk7MI	1	unit
10	PLC - 8 DI, 6 DO		1	Unit
	PLC for System Monitoring			
11	IIoT Gateway - c/w Wifi Card	Flexy 205	1	set
12	Cable & Accessories		1	set
13	Installation and Delivery Services		1	lot
14	Certificate of Operation Worthiness (SLO)		1	set

9. APPENDIX/DETAILED OF SOLAR POWER PLANT EQUIPMENT.

A-1. SOLAR MODULE

- Type of module: Monocrystalline Silicon.
- Capacity per Module: minimal 350 Wp
- Solar module efficiency: minimal 18%.
- Multiplication *Vpm x Ipm* ≥ 350 Wp
- Solar Module output (*Peak Power Output*) per unit with a minimum of 350 Wp, manufacturer test result characteristics are read on the module (*Manufacture, Serial Number, Peak Watt Rating, Peak Current, Peak Voltage, Open Circuit Voltage* dan *Short Circuit Current*).
- The solar module performance data label is affixed to the back of the module.
- Has a waterproof junction box and cable connectors with IP 65 that meet TUV standards.
- Using domestic products, proven by attaching a copy of the Industrial Business License and a valid certificate of 40% achievement of Domestic Component Level issued by the Ministry of Industry.
- PV modules that are merged into an array / sub-array of one type have the same

parameter characteristics. The construction of merging the module must be neat, strong, and sturdy.

- Performance Characteristics at Standard Test Conditions and at low radiation conditions are fully informed and are the comprehensiveness of the solar module.
- "Atma Jaya Catholic University of Indonesia", a serial number, and "Made in Indonesia" are laminated (not glued) in the glass module of the solar module.
- Connections between solar modules using a plug-in socket connection. Interconnection cables must comply with photovoltaic application standards (rating 1000 VDC).
- Array module output should go through the Fuse before entering the Inverter or Solar Charge Controller.
- Testing certification: B2TE-BPPT
- Warranty: 20 years (1% degradation per year)
- Attach certificates and product test results from the national B2TE-BPPT institution according to SNI 04-3850-2:1995.
- Attach a copy of the ISO 9001, ISO 14001, and OHSASS 18001 Management Certificate from the factory.
- Attach Domestic Component Level 40% from the Ministry of Industry.
- Factory of the Solar module should have Flash Test equipment and Micro Crack Detector, and be willing to attach the flash test result together with each serial number (not sampling) to each user as a quality warranty of the supplied solar module.
- Attach calibration certificates for the flash testing equipment from domestic or foreign test institutions.

A-2. BATTERY INVERTER

- Total output power :minimum 3500VA
- Inverter type : Bidirectional

- Number of Inveter :minimal 1 unit
- Output Voltage : 220-230VAC, 50Hz, single phase
- DC input voltage : minimum 48 Vdc
- AC Input : 160 – 260VAC, 45 – 60 Hz
- Output wave : pure sine wave
- Maximum Efficiency : 95 % according to IEC testing standard
- *Total Harmonic Distortion* (THD): ≤ 2%
- Frequency : 50 Hz
- Protection System : *over current, over load, short circuits, over temperature, over/under voltage.*
- Indicator : LED / LCD display
- Feature : Battery temperature, sensor, Battery equalization.
- Warranty : 5 years minimum (attach factory warranty terms)
- equipped with display, data logger and integrated remote monitoring system (RS-485), Synchronizer with Solar Charge Controller.
- Equipped with control management to manage the input and output energy from the inverter.
- Features a battery temperature sensor, battery boost, equalization to prevent loss of battery capacity and battery life time.
- Attach the copy of ISO 9001 and ISO 1001 certificate.
- Attach the offered inverter manual book.
- Attach Agency Registration Letter from Ministry of Trading as a proof of single agent appointment.

A-3. SOLAR CHARGE CONTROLLER (SCC)

- Total minimum capacity : 4000 watt
- SCC minimum number : 1 unit
- Control system Algorithm : MPPT (Maximum Power Point Tracking).
- Minimum efficiency : ≥98% (Stated in the test report results from an accredited independent institution)

- Product test : Test result and certificate of efficiency testing result.
- Nominal input voltage : minimum 48 VDC.
- Protection system : *Reverse Polarity Protection, High battery voltage protection, low battery voltage protection, overload protection*
- Feature : Fast and safe battery charging system
- Product warranty : minimum 5 years (proven by Factory Warranty Terms)
- Attach ISO 9001 and ISO 14001 certificate
- Attach Agency Registration Letter from Ministry of Trading as a proof of single agent appointment.
- Equipped with protection against dust, insects and water spray into the SCC with minimum Protection Index: IP54.

A-4. BATTERY BANK

Using Lithium Ferro Phosphate (LiFePo4) battery type with specification:

- Battery type : LifePo4 battery
- Output voltage : 51.2 VDC
- Total capacity battery : 10.000 Wh
- Suggested operational temperature :below 25-55 °C
- Cycling capability :at least 2000 cycle at DOD (Depth of Discharge) 100%
- Warranty : minimum 5 years
- Domestic Component Level :minimum 40%
- minimum technical life time 10 years at temperature 25-55 ^{o}C
- Equipped with connection system that can prevent corrosion and short circuit (including during installation)
- Battery placement should be safe towards other equipment.
- The battery connector uses copper and is provided with an insulating shield to make it safe for the operator
- Battery holder should be corrosive resistant.

- Using domestic products and proven by attaching an Industrial Business Permit and a Domestic Component Level certificate from the Ministry of Industry minimum at 40%
- Attach certificate or product testing result (SNI)
- Attach a copy of the ISO 9001, ISO 14011, and OHSAS 18001 certificates from the factory.
- Attach brochure/original catalog and the manual book of the proposed battery.
- Attach factory warranty terms from the factory.

A-5. CABLE AND GROUNDING SYSTEM

a. Connection cables between solar modules must be placed in the cable tray/duct. The cable tray/duct is placed under the PV array and attached to the PV array support.
b. The power cable from the PV Array to the Solar Charge Regulator must be placed in a conduit and into the power cabinet
c. Each cable connection must use suitable and well-insulated cable terminals and connectors (not direct connections).
d. Installation materials and equipment grounding must be adjusted to the generating capacity
e. The grounding system of the PV array buffer uses a yellow-green 10mm2 type conductor (SPLN/SNI). The cross-section must be electrically connected to the PV array support (using cable boots and bolts).

A-6. PANEL/ENCLOSURE

This panel is used for the placement of the Solar controller, Inverter, Battery, and AC and DC protection components. The panel is equipped with a main/separator switch, current limiting Mini Circuit Breaker (MCB), terminal switch, and busbar. The top, left, right and rear frames are closed, so that service personnel will be protected from

the danger of touching active parts. The panels are equipped with ventilation on the sides, ventilation holes must be protected so that animals or small objects and water do not easily enter the panel.

i. Protection system :*fuse* dan *circuit breaker*, *surge protection* for 220V. *Surge protection* is modular, pluggable, and has a working function indicator.
ii. Installation cable :Cable type NYAF/NYYHY
iii. Material : non-combustible metal, humidity resistant, sturdy with a thickness minimum of 1.5 mm.
iv. Panel color :Creme
v. Equipped with DC battery protection for capacity before entering either the solar charge controller or the inverter.
vi. Attach a picture of the battery connection system and a one-line diagram of the battery protection system and the rating calculation of the components of the protective equipment used.

INPUT PV

- All connections on cable terminals must meet standards or use a connection system to ensure good and assured connection quality.
- Equipped with a modular current limiter, has a function indicator and a maximum working voltage of 1000 VDC (IEC 60269-6). Type Fuse gPV with current capacity according to the output power. A backup fuse must be provided at least 10% of the number of fuses used.
- Equipped with Surge Protection for photovoltaic applications (IEC 61643-1). Surge protection is modular, pluggable, and has a working function indicator
- Equipped with Isolator Switch, for safe isolation during maintenance.

A-7 Network Monitoring System (NMS)

- Feature : Collecting performance data of Solar Power Plant.
- Communication System : GSM/GPRS/LAN
- NMS Number : 1 unit

A-8 Module Array Support

- The foundation is made of cast concrete with a diameter of 10 mm and is plastered with fine plaster. The foundation has a cross-sectional area of 30 x 30 cm and a minimum height of 60 cm. The foundation has a minimum depth of 40 cm (The height of the foundation above the ground level is at least 20 cm)
- Solar module support poles must be made of sturdy and strong metal made of pipes with a minimum diameter of 3 inches with a minimum thickness of 2 mm with anti-rust finishing or hot deep galvanized on all parts of the surface.
- Solar module support poles on the foundation are free-standing, the bottom of the support pole must have a base plate (square shaped) with the same material as the PV array support pole with a minimum thickness of 8 mm and a size of 20 x 20 cm. This base plate is perforated on all four sides for bolt pairs (anchors) planted in the foundation with a minimum depth of 30 cm.
- The height of the PV array is at least 2.2 meters from the ground at the lowest level.
- The distance between the solar module support poles is a maximum of 4 meters so that the module array arrangement is not sloping (remains flat) and solid
- PV Support must be designed taking into account the angle of inclination of the solar module. The tilt angle of the solar module is adjusted to the conditions of each location in order to obtain optimal irradiation energy.

The slope design of the solar module is obtained from the software simulation results

- The location of the PV Array must be arranged/designed in such a way that there is no shading that falls on the surface of the PV Array. Similarly, the distance between buildings and the PV Array.

A-9. FENCE And GATE SPECIFICATION

The work specified in this section includes providing material, labor, transportation, equipment and services necessary for the installation of Fences and Fencing as shown in the approved drawings.
The work carried out must be in accordance with the specifications:

- Minimum height 1.2 m
- Material in the form of Galvanized BRC
- Must be able to withstand wind Pressure
- Piles must be installed on a concrete foundation
- Gate: Single Swing, width: 1m

A-10. PLC SPECIFICATION

Main	
range of product	Modicon M221
product or component type	Logic controller
[Us] rated supply voltage	100...240 V AC
discrete input number	9, discrete input conforming to IEC 61131-2 Type 1
analogue input number	2 at 0...10 V
discrete output type	Relay normally open
discrete output number	7 relay
discrete output voltage	5...125 V DC 5...250 V AC
discrete output current	2 A

Complementary	
discrete I/O number	16
maximum number of I/O expansion module	4 for transistor output 4 for relay output
supply voltage limits	85…264 V
network frequency	50/60 Hz
inrush current	40 A

maximum power consumption in VA	49 VA at 100...240 V with max number of I/O expansion module 33 VA at 100...240 V without I/O expansion module
power supply output current	0.325 A 5 V for expansion bus 0.12 A 24 V for expansion bus
discrete input logic	Sink or source (positive/negative)
discrete input voltage	24 V
discrete input voltage type	DC
analogue input resolution	10 bits
LSB value	10 mV
conversion time	1 ms per channel + 1 controller cycle time for analogue input analog input
permitted overload on inputs	+/- 30 V DC for 5 min (maximum) for analog input +/- 13 V DC (permanent) for analog input
voltage state 1 guaranteed	>= 15 V for input
voltage state 0 guaranteed	<= 5 V for input
discrete input current	7 mA for discrete input 5 mA for fast input
input impedance	3.4 kOhm for discrete input 100 kOhm for analog input 4.9 kOhm for fast input
response time	35 µs turn-off, I2...I5 terminal(s) for input 10 ms turn-on for output 10 ms turn-off for output 5 µs turn-on, I0, I1, I6, I7 terminal(s) for fast input 35 µs turn-on, other terminals terminal(s) for input 5 µs turn-off, I0, I1, I6, I7 terminal(s) for fast input 100 µs turn-off, other terminals terminal(s) for input
configurable filtering time	0 ms for input 3 ms for input 12 ms for input
output voltage limits	125 V DC 277 V AC
maximum current per output common	6 A at COM 1 7 A at COM 0
absolute accuracy error	+/- 1 % of full scale for analog input
electrical durability	100000 cycles AC-12, 120 V, 240 VA, resistive 100000 cycles AC-12, 240 V, 480 VA, resistive 300000 cycles AC-12, 120 V, 80 VA, resistive 300000 cycles AC-12, 240 V, 160 VA, resistive 100000 cycles AC-15, cos phi = 0.35, 120 V, 60 VA, inductive 100000 cycles AC-15, cos phi = 0.35, 240 V, 120 VA, inductive 300000 cycles AC-15, cos phi = 0.35, 120 V, 18 VA, inductive 300000 cycles AC-15, cos phi = 0.35, 240 V, 36 VA, inductive 100000 cycles AC-14, cos phi = 0.7, 120 V, 120 VA, inductive 100000 cycles AC-14, cos phi = 0.7, 240 V, 240 VA, inductive 300000 cycles AC-14, cos phi = 0.7, 120 V, 36 VA, inductive

	300000 cycles AC-14, cos phi = 0.7, 240 V, 72 VA, inductive 100000 cycles DC-12, 24 V, 48 W, resistive 300000 cycles DC-12, 24 V, 16 W, resistive 100000 cycles DC-13, 24 V, 24 W, inductive (L/R = 7 ms) 300000 cycles DC-13, 24 V, 7.2 W, inductive (L/R = 7 ms)
switching frequency	20 switching operations/minute with maximum load
mechanical durability	20000000 cycles for relay output
minimum load	1 mA at 5 V DC for relay output
protection type	Without protection at 5 A
reset time	1 s
memory capacity	256 kB for user application and data RAM with 10000 instructions 256 kB for internal variables RAM
data backed up	256 kB built-in flash memory for backup of application and data
data storage equipment	2 GB SD card (optional)
battery type	BR2032 lithium non-rechargeable, battery life: 4 year(s)
backup time	1 year at 25 °C (by interruption of power supply)
execution time for 1 KInstruction	0.3 ms for event and periodic task
execution time per instruction	0.2 µs Boolean
exct time for event task	60 µs response time
maximum size of object areas	255 %C counters 512 %KW constant words 255 %TM timers 512 %M memory bits 8000 %MW memory words
realtime clock	With
clock drift	<= 30 s/month at 25 °C
regulation loop	Adjustable PID regulator up to 14 simultaneous loops
counting input number	4 fast input (HSC mode) at 100 kHz 32 bits
counter function	Pulse/direction A/B Single phase
integrated connection type	USB port with mini B USB 2.0 connector Non isolated serial link serial 1 with RJ45 connector and RS232/RS485 interface Ethernet with RJ45 connector
supply	(Serial)serial link supply: 5 V, <200 mA
transmission rate	1.2...115.2 kbit/s (115.2 kbit/s by default) for bus length of 15 m for RS485 1.2...115.2 kbit/s (115.2 kbit/s by default) for bus length of 3 m for RS232 480 Mbit/s for USB
communication port protocol	USB port: USB - SoMachine-Network Non isolated serial link: Modbus master/slave - RTU/ASCII or SoMachine-Network Ethernet
port Ethernet	10BASE-T/100BASE-TX 1 port with 100 m copper cable

communication service	DHCP client Ethernet/IP adapter Modbus TCP server Modbus TCP slave device Modbus TCP client
local signalling	1 LED (green) for PWR 1 LED (green) for RUN 1 LED (red) for module error (ERR) 1 LED (green) for SD card access (SD) 1 LED (red) for BAT 1 LED per channel (green) for I/O state 1 LED (green) for SL Ethernet network activity (green) for ACT Ethernet network link (yellow) for Link (Link Status)
electrical connection	Removable screw terminal block for inputs removable screw terminal block for outputs terminal block, 3 terminal(s) for connecting the 24 V DC power supply connector, 4 terminal(s) for analogue inputs Mini B USB 2.0 connector for a programming terminal
maximum cable distance between devices	Shielded cable: <10 m for fast input Unshielded cable: <30 m for output Unshielded cable: <30 m for digital input Unshielded cable: <1 m for analog input
insulation	Between input and internal logic at 500 V AC Non-insulated between analogue input and internal logic Non-insulated between analogue inputs Between supply and ground at 1500 V AC Between sensor power supply and ground at 500 V AC Between input and ground at 500 V AC Between output and ground at 1500 V AC Between supply and internal logic at 2300 V AC Between sensor power supply and internal logic at 500 V AC Between output and internal logic at 2300 V AC Between Ethernet terminal and internal logic at 500 V AC Between supply and sensor power supply at 2300 V AC
marking	CE
sensor power supply	24 V DC at 250 mA supplied by the controller
mounting support	Top hat type TH35-15 rail conforming to IEC 60715 Top hat type TH35-7.5 rail conforming to IEC 60715 plate or panel with a fixing kit

A-11. IoT GATEWAY SPECIFICATION

Routing: Routing capability between LAN and WAN Ethernet interface and Ethernet to serial gateway

Ethernet to Serial Gateways MODBUS TCP to MODBUS RTU;

Data Acquisition Protocols OPC UA, MODBUS/RTU, MODBUS/TCP, Unitelway, DF1, PPI, MPI (S7), PROFIBUS (S7), FINS
Hostlink, FINS TCP, EtherNet/IP™, ISO TCP, Mitsubishi FX, Hitachi EH, ASCII, BACnet/IP. Stored in 2500 internal tags

Data Publishing Protocols OPC UA, Modbus, MQTT, SNMP

Alarms Alarms notification by email, SMS, FTP put and/or SNMP traps. 4 Thresholds : low, lowlow, high, highhigh + Deadband and activation delay.Alarm logs in http and via FTP, Alarm cycle: ALM, RTN, ACK and END

Datalogging Internal data base for data logging (real-time logging and historical logging up to 1,000,000 timestamps). Retrieval of the database with files transferred by FTP or email

SD card reader YES, for easy commissioning (firmware upgrade, backup).

Router IP filtering, IP forwarding, NAT, Port forwarding, Proxy, Routing table, DHCP client/server

VPN Tunnelling Open VPN either in SSL UDP or HTTPS

VPN Security VPN sessions are end-to-end encrypted using SSL/TLS protocol.

Programmable Script interpreter for Basic language, Java 2 Standard Edition environment

Synchronization Embedded real-time clock, manual setup via http or automatic via NTP

File Management FTP client and server for configuration, firmware update and data transfer

Website Embedded web interface with setup wizards for configuration and maintenance (no extra software needed). Authentication with login/password and session control for security. Possibility of uploading custom web GUI.