APsystems
ALTENERGY POWER

System Design Guide

APsystems YC1000-3
Photovoltaic 3-Phase Grid-connected Microinverter

Version 1.1   3/15

SAVE THESE INSTRUCTIONS! *This manual contains important instructions to follow during installation and maintenance of the APsystems YC1000-3 Photovoltaic Grid-connected Inverter (microinverter). To reduce the risk of electrical shock and ensure the safe installation and operation of the APsystems microinverter, the following symbols appear throughout this document to indicate dangerous conditions and important safety instructions.*

WARNING: This indicates a situation where failure to follow instructions may cause a serious hardware failure or personnel danger if not applied appropriately. Use extreme caution when performing this task.

WARNING SYMBOL

NOTE: This indicates information that is important for optimized microinverter operation. Follow these instructions closely.

NOTE SYMBOL

SAFETY INSTRUCTIONS

✔ **Do NOT disconnect the PV module from the APsystems Microinverter without first disconnecting the AC power.**

✔ Only qualified professionals should install and/or replace APsystems microinverters.

✔ Perform all electrical installations in accordance with local electrical codes.

✔ Before installing or using the APsystems microinverter, please read all instructions and cautionary markings in the technical documents and on the APsystems microinverter system and the PV-array.

✔ Be aware that the body of the APsystems microinverter is the heat sink and can reach high temperatures. To reduce risk of burns, do not touch the body of the microinverter.

✔ *Do NOT* attempt to repair the APsystems microinverter. If it fails, contact APsystems Customer Support (206-855-5100) to obtain an RMA number and start the replacement process. Damaging or opening the APsystems microinverter voids the warranty.

✔ **Do NOT** expose the connections to directed, pressurized liquid (pressure washer, etc.).

✔ **Do NOT** expose the connections to continuous immersion.

✔ **Do NOT** over-tension the AC connector (tension due to pulling or bending the cable near the connector).

✔ Use only provided/authorized connectors and cables.

✔ **Do NOT** allow contamination into the connectors.

✔ Use an authorized terminator to seal the end of the AC Bus Cable. Using another sealing method voids the warranty.

✔ To reduce the risk of fire, connect only to a circuit provided with 25 amperes maximum branch circuit overcurrent protection – in accordance with the National Electrical Code (NEC), ANSI/NFPA 70.

✔ Both AC and DC voltage source are terminated inside this equipment. Each circuit must be individually disconnected before servicing.

✔ DC voltage is supplied to this equipment when the photovoltaic array is exposed to light.

✔ This Utility-Interactive Inverter contains active anti-islanding protection (IEEE1547) and is tested per FCC/IC.

RADIO INTERFERENCE STATEMENT

FCC Compliance: The equipment can comply with the limits for a class B digital device, pursuant to part 15 of the FCC Rules, which are designed to protect against harmful interference in a residential installation. The equipment could radiate radio frequency energy and this might cause harmful interference to radio communications if not following the instructions when installing and using the equipment. But there is no guarantee that interference will not occur in a particular installation. If this equipment causes harmful interference to radio or television reception, the following measures might resolve the issues:

A. Relocate the receiving antenna and keep it well away from the equipment

B. Consult the dealer or an experienced radio/TV technical for help

Changes or modifications not expressly approved by the party responsible for compliance may void the user's authority to operate the equipment.

APsystems YC1000-3 System Introduction

The APsystems microinverter is used in utility-interactive grid-tied applications, comprised of three (3) key elements:

- **APsystems microinverter**

- **APsystems Energy Communication Unit (ECU)**

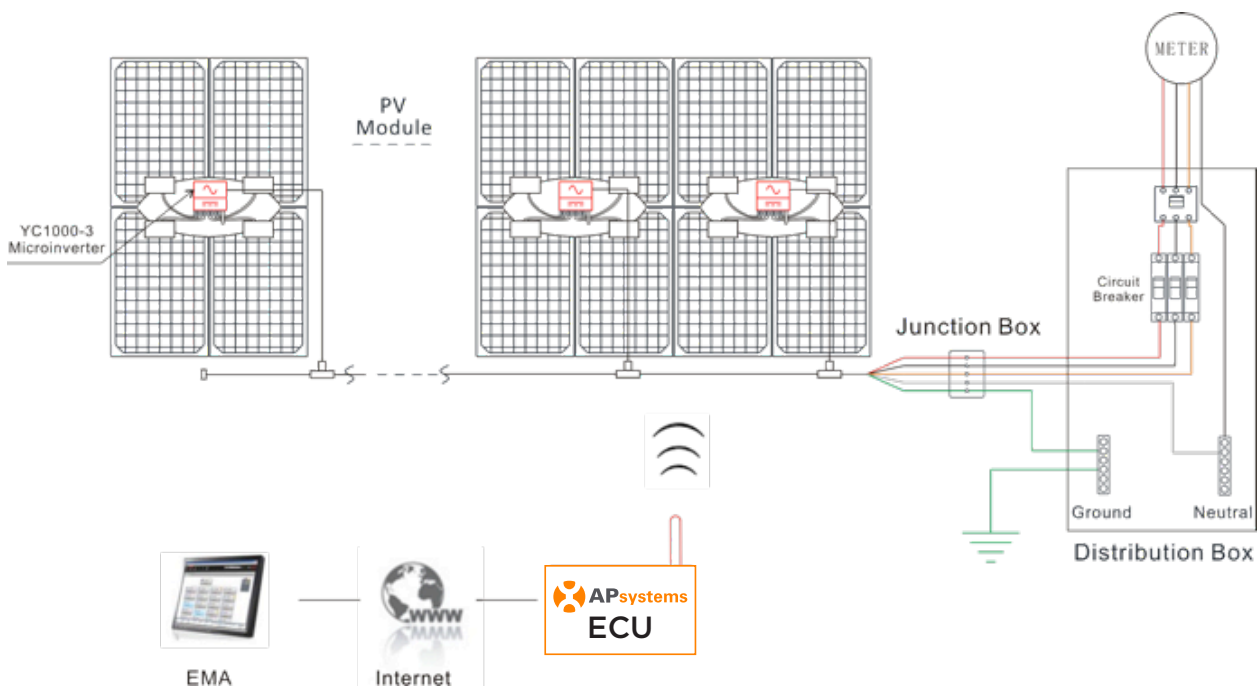- **APsystems Energy Monitor and Analysis (EMA) web-based monitoring and analysis system**

Figure 1

This integrated system improves safety, maximizes solar energy harvest, increases system reliability, and simplifies photovoltaic (PV) system design, installation, maintenance, and management.

APsystems microinverters maximize energy production

Each PV module is operating at the maximum peak power point, which ensures that the maximum power is exported to the utility grid. The APsystems microinverter ensures top performance from the array by maximizing the performance of the module within the array when PV modules in the array are affected by shading.

More reliable than centralized or string inverters

The distributed microinverter system ensures that no single point of system failure exists across the PV system. APsystems microinverters are designed to operate at full power at ambient temperatures of up to +65°C (+149° F). The inverter housing is designed for outdoor installation and complies with the NEMA 4X environmental enclosure rating.

Simple to install

You can install individual PV modules in any combination of module quantity, orientation, type, and power rating.

Smart system performance monitoring and analysis.

The APsystems Energy Communication Unit (ECU) is installed by simply plugging it into any wall outlet and providing it with an Ethernet or Wi-Fi connection to a broadband router. After installing the ECU, the full network of APsystems microinverters automatically reports to the APsystems Energy Monitor and Analysis (EMA) web server. The EMA software displays performance trends, informs you of abnormal events, and controls system shutdown when it is needed. Reference the ECU Manual for installation and operation instructions.

APsystems Three-phase Microinverter

The APsystems YC1000-3-480 microinverters connect with the three-phase grid, and operate with most 60 and 72 cell PV modules. For more information, please see the Technical Data page of this manual.

MODEL NUMBER	AC GRID	PV MODULE	MODULE CONNECTOR
YC1000-3-480	277V/480V	60,72 Cell	MC-4 Type
YC1000-3-208	208V	60,72 Cell	MC-4 Type

Maximum number of inverters per branch/480V = 11 for 15A X 3 Breaker
Maximum number of inverters per branch/208V = 4 for 15A X 3 Breaker

The following diagram shows the APsystems YC1000-3 microinverter schematic:
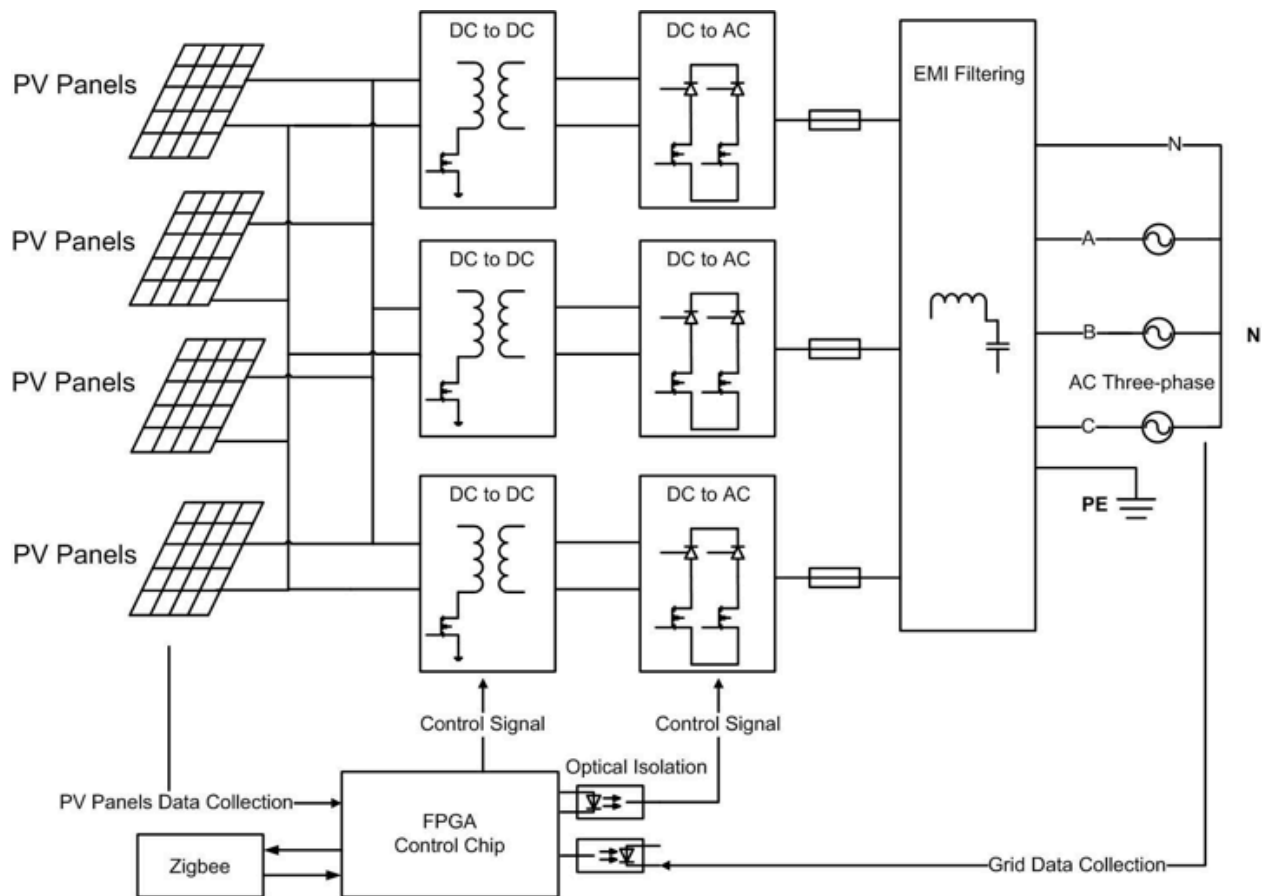
Figure 2

This section of the document covers the details involving in designing a system using the APsystems YC1000-3-480 microinverters (Maximum number of inverters per branch/480V = 11 for 15A X 3 Breaker).

Calculate the Required Number of Microinverters

1. Determine the number of PV panels needed to meet the system requirements.

    kW/PV STC Output = Number of PV Panels Required

    For example, for a 300kW system, using 260W (STC) 60 cell panels;

    300kW/260W STC = 1,153.8 panels required (round up to 1,154)

2. Calculate the required number of YC1000-3s.

    Number of Panels Required/4 = Required Number of YC1000-3s

    Following the example calculations;

    1,154 Panels/4 = 288.5 inverters required (round up to 289)

NOTE: This example calculation is assuming that the PV layout supports four (4) panels per microinverter. Use three (3) rather than four (4) in cases where the PV layout supports three (3) panels per microinverter.

In the example above, a 300kW system, using 260W (STC) PV panels, requires 1,154 panels, and **289** YC1000-3-480 microinverters, with a "real power output" of 259.6kW.

Calculate the Number of Branches/Subsystems and ECUs

The practical number of inverters that can monitored by a single ECU is 100, so keep that in mind when calculating the number of branches and subsystems you need to design into your system.

3. Determine the number of branches/subsystems to meet the system requirements.

    Number of inverters required/100 inverters per ECU = Branches/ Subsystems and ECUs

    Continuing to use the previous example, we determined that the system would require 289 YC1000-3-480 microinverters.

    289/100 = 2.89 Branches/Subsystems and ECUs (round up to 3)

Calculate the Number of Inverters in a Branch/Subsystem

You'll want to balance the branches/systems as closely as possible.

4. Determine the number of inverters per branch/subsystem.

    Number of Inverters Required/Number of Branches = Number of Inverters per Branch 289/3 = 96.3 Inverters per Branch

In this example, the system would have three (3) branches/subsystems – two (2) with 99 inverters each, and the third having 91 to maximize the circuit layout.

Example System Design Requirements

For a **300kW** system, using **260W** (STC) 60 cell panels:

- 1,154 Panels
- 289 YC1000-3-480
- 3 Branches/Subsystems and ECUs
- 2 Branches = 99 Inverters & 1 Branch = 91Inverters

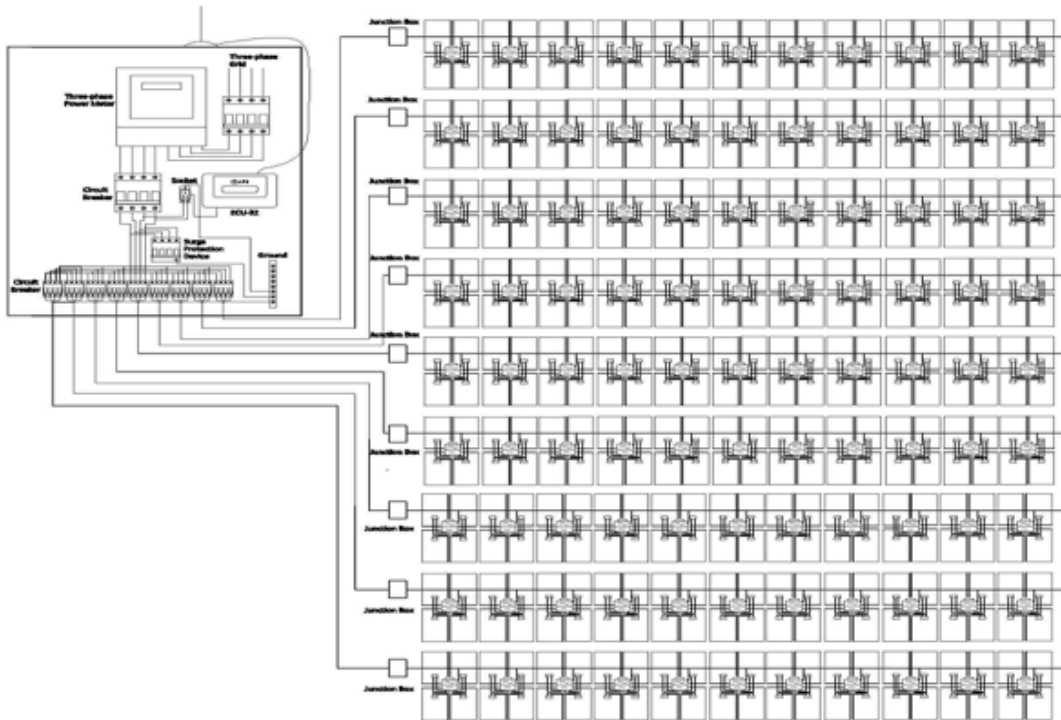## Example System Diagrams

Figure 3

Branch/Subsystem #1 and #2 – Each with 99 inverters
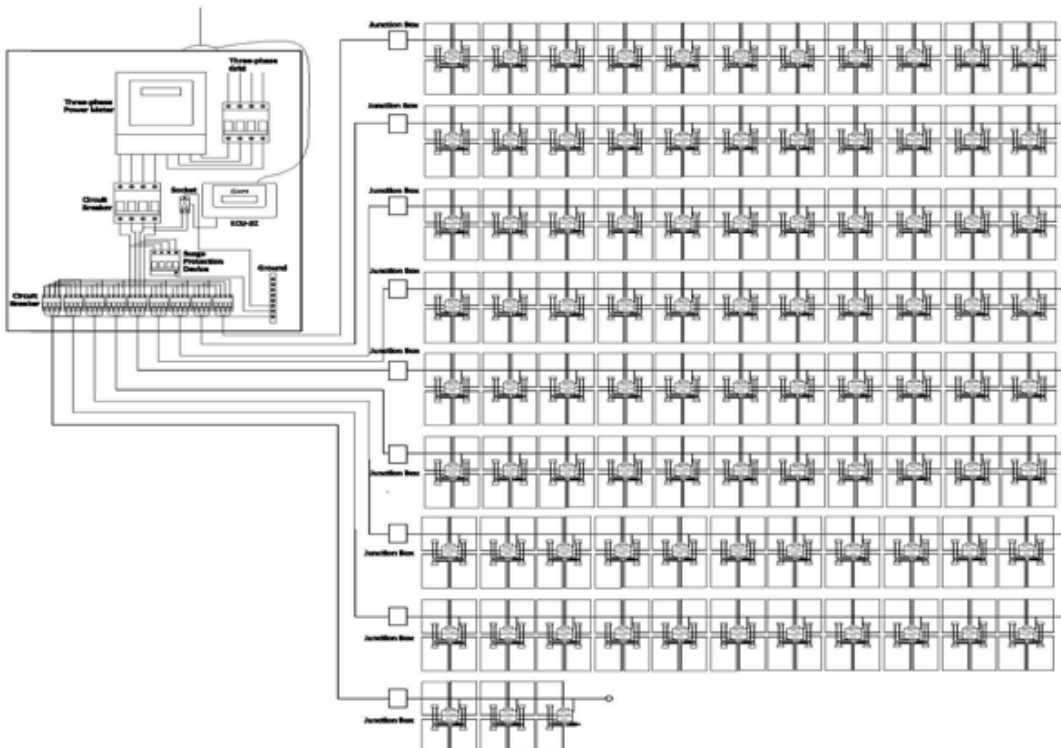

Figure 4

Branch/Subsystem #3 – with 91 inverters

Additional Components

There are a number of additional components (beyond the PV panels, microinverters and ECUs) that need to be designed into a system depending on the overall design requirements. They are as follows:

Distribution Panel Box *(Not supplied by APsystems)*
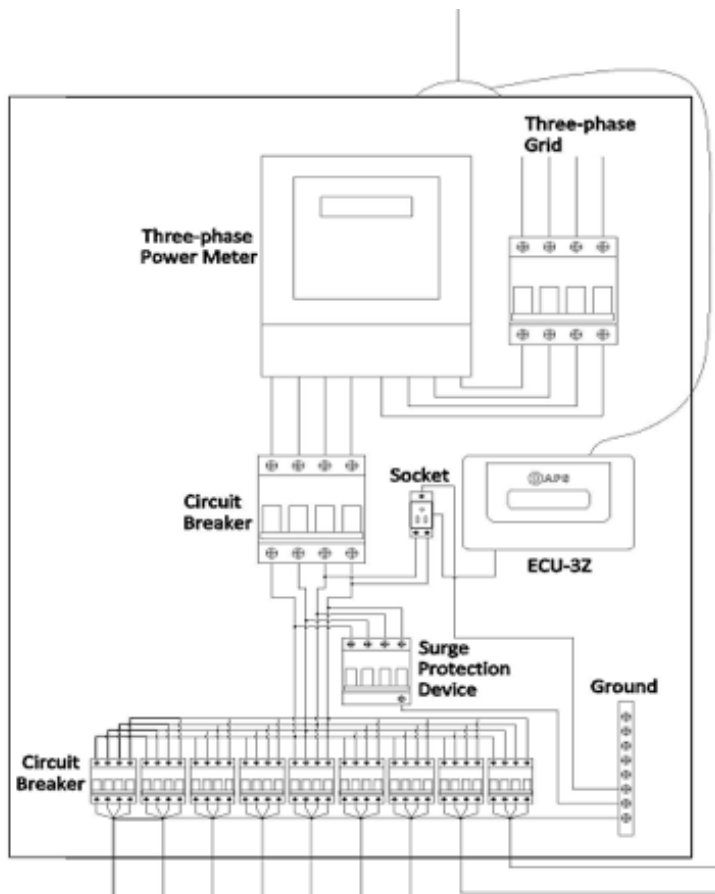
The Distribution Panel Box is used to house circuit breakers, meters, etc.

Figure 5

A typical Three-Phase Distribution Panel Box showing circuit breaker and meter placement.

AC Bus Cable *(Supplied by APsystems)*

The AC Bus Cable is an innovative cabling system used to connect APsystems YC1000-3 Microinverters. AC Bus Cable has a T-connector for each YC1000-3 microinverter, with connectors placed every 2 meters for portrait applications, or 4 meters for landscape applications. The AC Bus Cable is 14AWG, and is terminated in an AC branch circuit junction box.

AC End Cable (Not supplied by APsystems)

AC End Cables are used to connect the AC branch circuit junction box to the circuit breakers in the distribution panel box. Load, type, voltage drop, power loss and temperature etc. should be considered when selecting the end cable's wire size. Because PV systems are installed outdoors, the cables should be good quality, for example type YJV or VV are preferred, and the current density in the range of 2-4A/mm2. Power loss should not be more than 2% of the whole system.
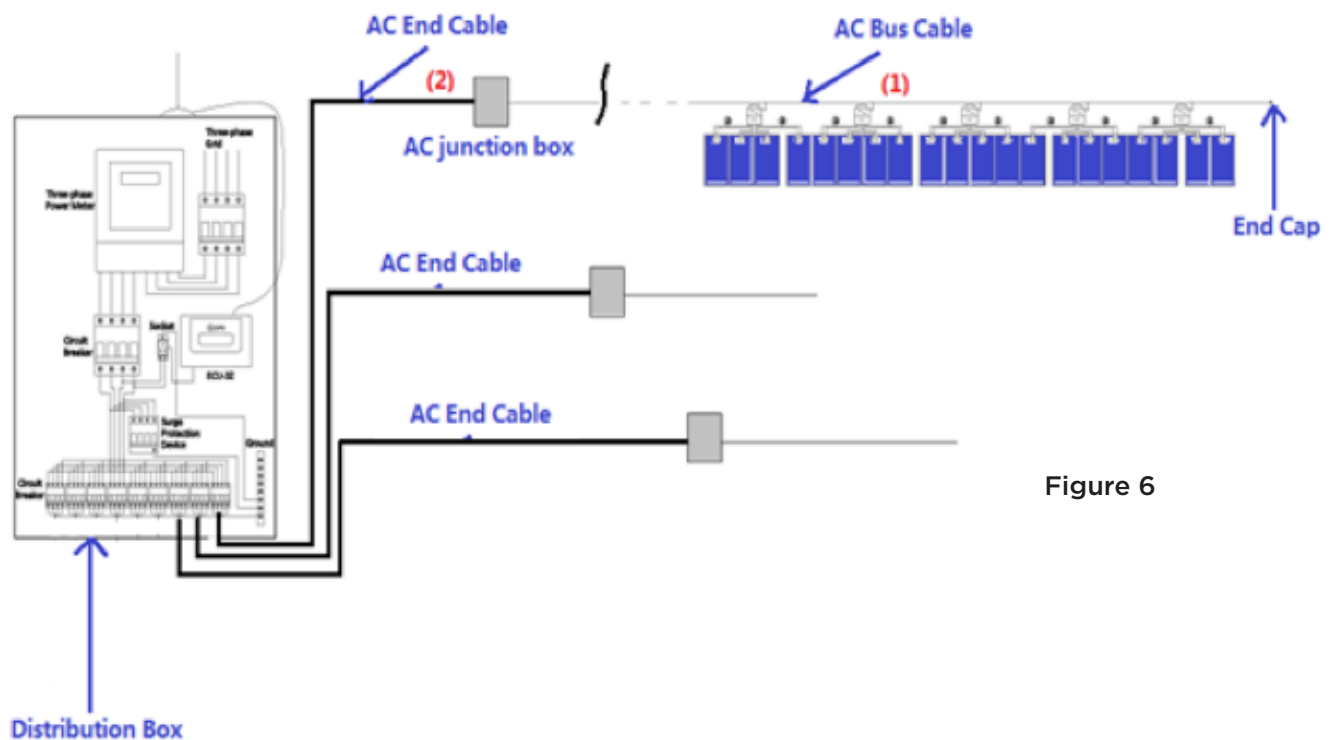
Figure 6

System diagram showing AC Cable and AC End Cable placement

AC End Cap (Supplied by APsystems)

A protective end cap needs to be installed at the end of each AC Bus Cable in the system to prevent moisture intrusion.
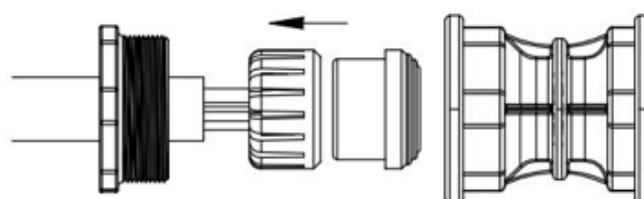

Figure 7

Diagram of AC End Cap Assembly

AC T-Connector Cap *(Supplied by APsystems)*

The AC T-Connector CAPsystems are used to seal each of the unused T-Connectors on the AC Bus Cable to prevent moisture intrusion.
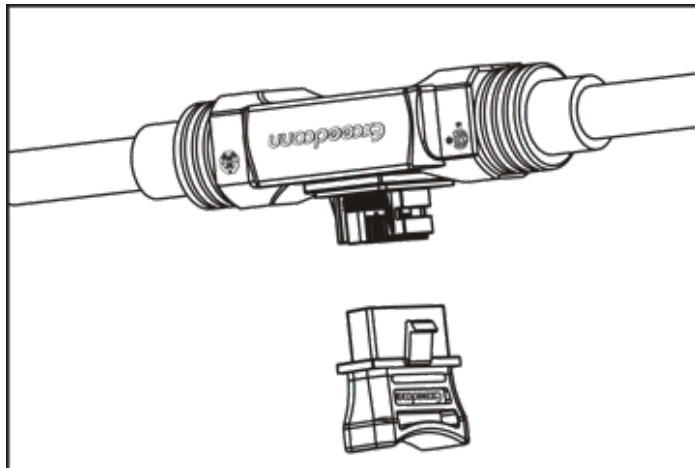

Figure 8

AC Branch Circuit Junction Box *(Not supplied by APsystems)*

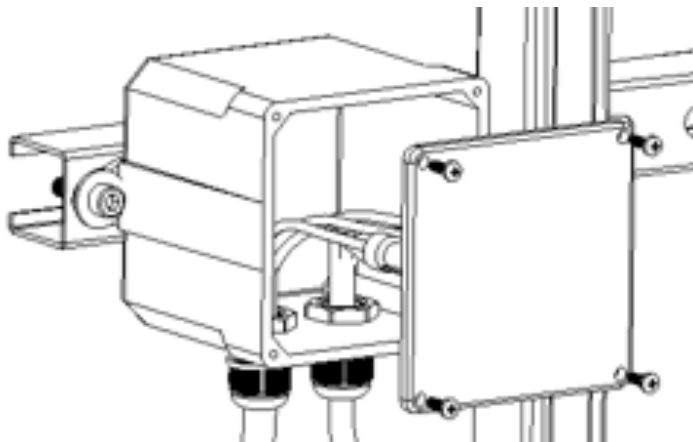The AC Branch Circuit Junction Box is used to connect each AC Bus Cable to AC Cable Ends.

Figure 9

Revenue Grade Metering System (Optional – Not supplied by APsystems)

Revenue grade metering is often required for commercial projects that are financed or receive incentives from government organizations. These projects usually require metering accuracy within 2% to meet revenue grade requirements. Incentive programs also require that a Performance Data Provider provide monthly production reporting.

Even though the APsystems ECU is rated to +/-5% accuracy, it can be paired with a 2% rated revenue grade meter to meet reporting requirements.

Surge Protection Device (Optional – Not supplied by APsystems)

A surge protection device is to protect the system from significant grid surges – like a lightening strike.

Example List of Materials

Using the previous example, for a **300kW** system, using **260W** (STC) 60 cell panels, the List of Materials would be as follows:

Component	Quantity	Description
260W PV Module	1154	60 Cell
Microinverters	389	APS YC1000-3-480
Distribution Box	3	One (1) for each branch/subsystem
ECU	3	APS ECU-3Z One for each branch/subsystem
AC Bus Cable	27	Based on overall system layout. 2 meters between each connector
AC Junction Box	27	One (1) for each of the AC Bus Cables
AC End Cable	27	One (1) for each AC Junction Box
AC End Cap	27	One (1) for each AC Bus Cable
3-Phase Circuit Breaker	33	26 – 15A X 3 Note: Limit of 11 YC1000-3-480 per 15A circuit string) 1 – 15A (One for the 97 inverter branch) Note: Limit of 11 YC1000-3-480 per 15A circuit string) 6 – 160A (Two for each of the three branches)
Production Meter	3	One (1) for each branch
Surge Protection Device	3	One (1) for each branch

Figure 10

Example Summary

The 300kW commercial system is divided into 3 subsystems. Every subsystem has 99 (or 91) YC1000-3 microinverters, one (1) ECU-3Z, and one surge protection device, and two 160A breakers etc.

Each of the branch/subsystems are divided into 8 or 9 circuit strings, and every circuit string has 11 or 12 YC1000-3-480 microinverters (except for the last circuit string in the 91 inverter subsystem that has 3 because that is simply the way the system lays out). See the detailed electrical diagram below:
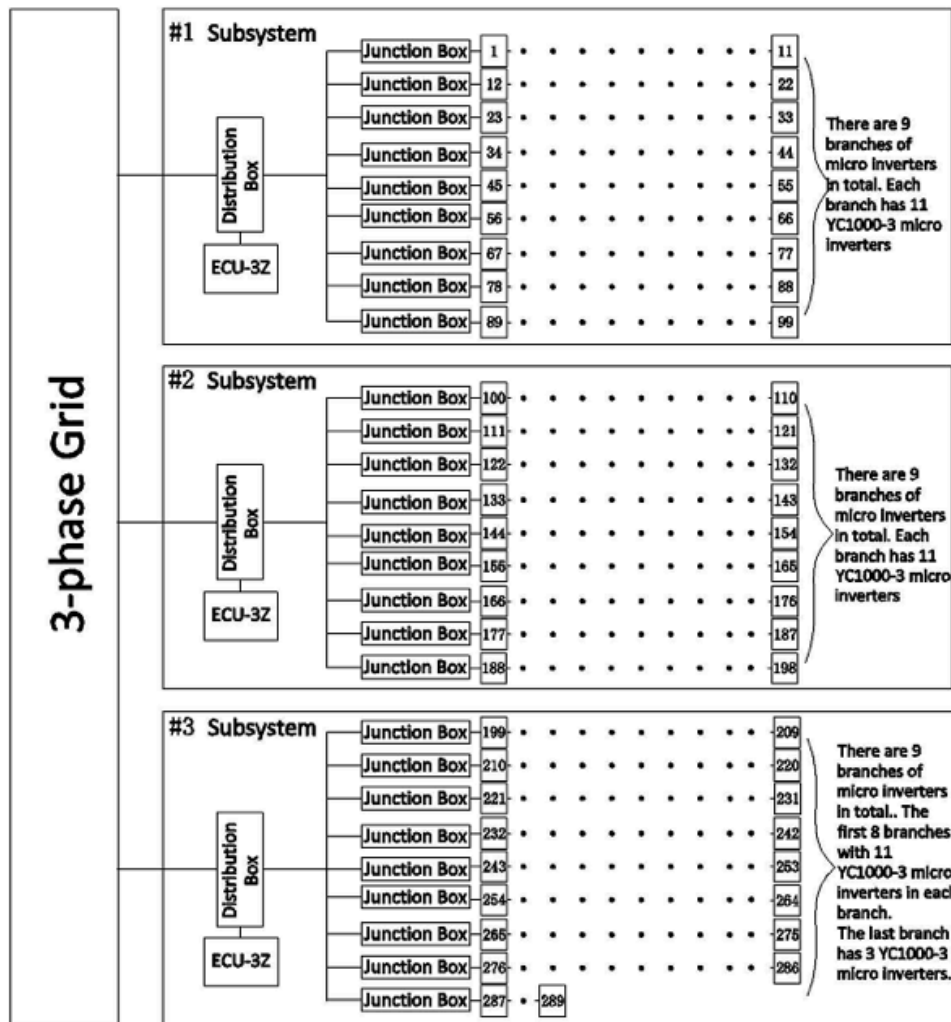
Figure 11
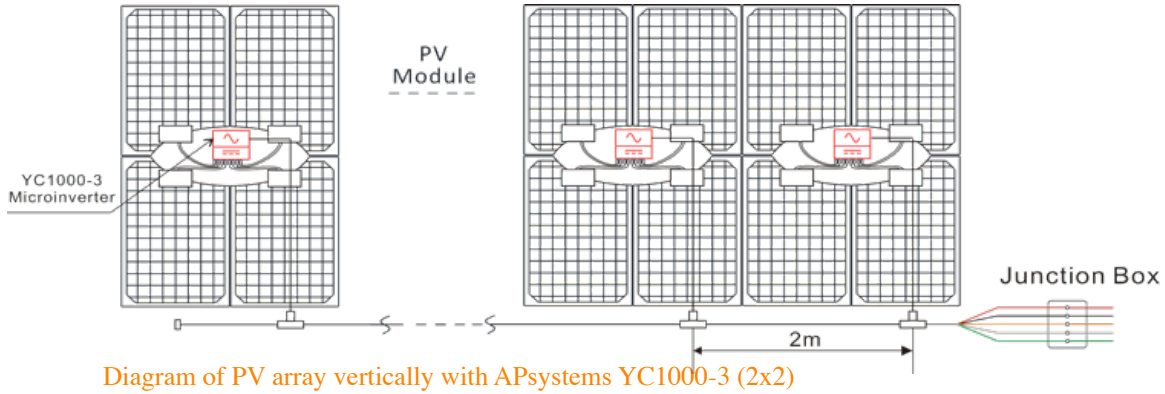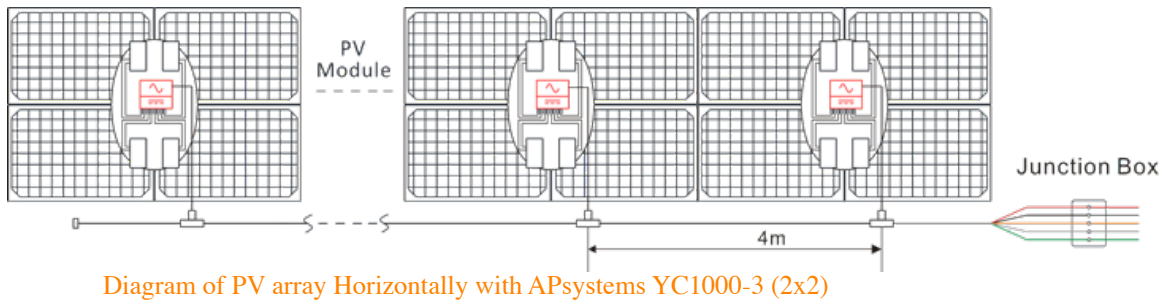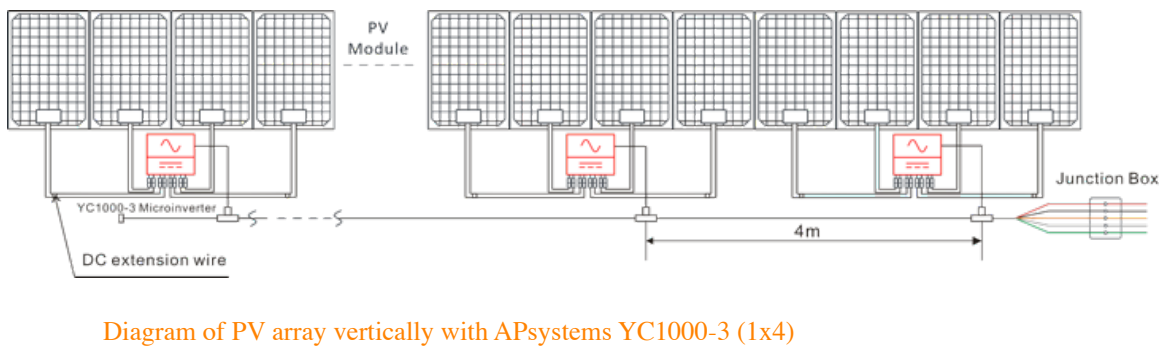
Module and Inverter Layouts – 60 and 72 Cell

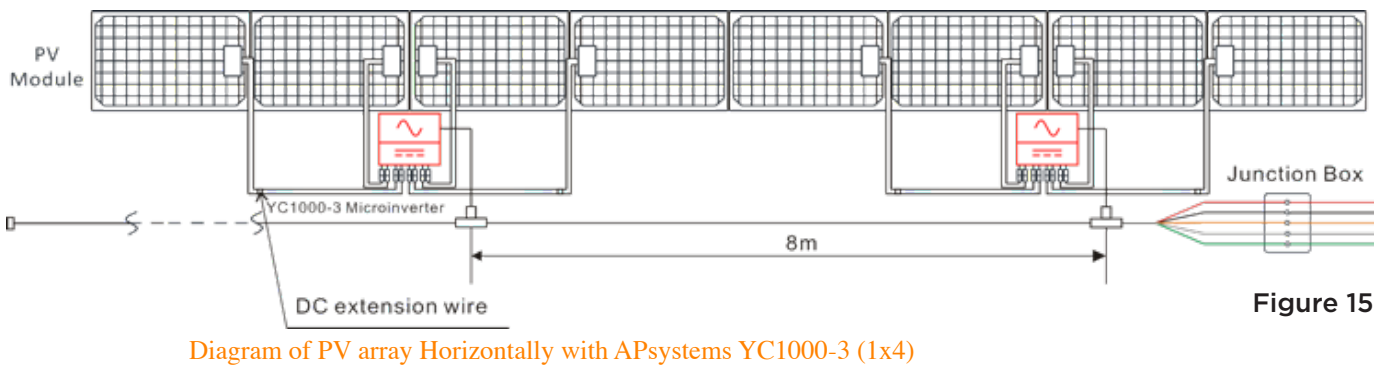**Figure 12**

Diagram of PV array vertically with APsystems YC1000-3 (2x2)

Figure 13

Diagram of PV array Horizontally with APsystems YC1000-3 (2x2)

Figure 14

Diagram of PV array vertically with APsystems YC1000-3 (1x4)

Figure 15

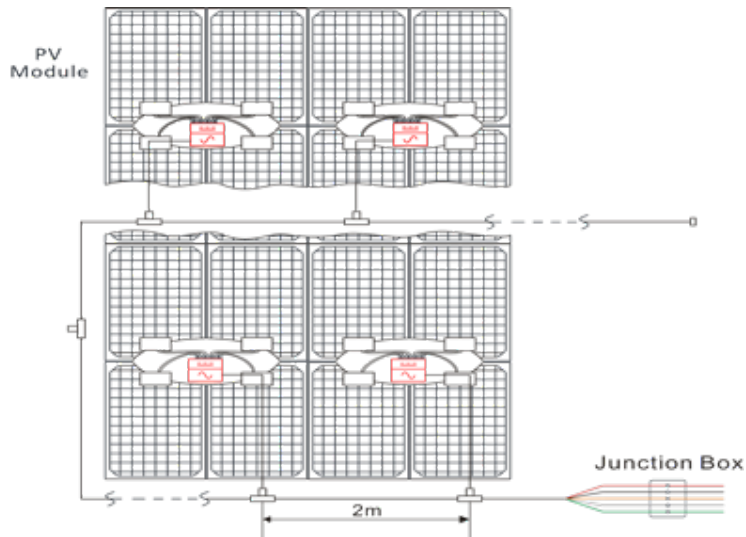Diagram of PV array Horizontally with APsystems YC1000-3 (1x4)

Figure 16

Diagram of PV array vertically with APsystems YC1000 AC bus connection (2x2)
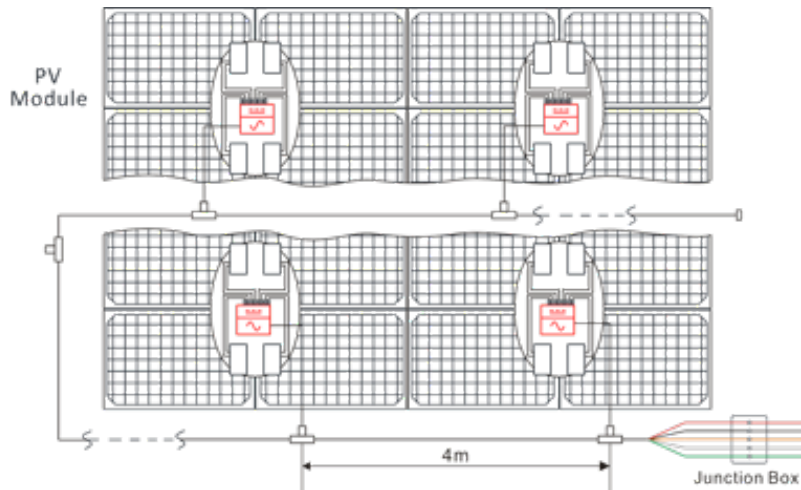

Figure 17

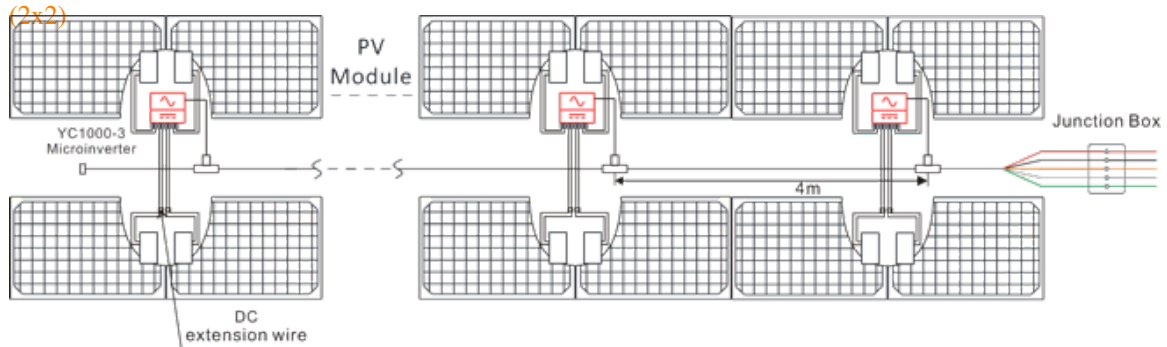Diagram of PV array Horizontally with APsystems YC1000 AC bus connection (2x2)

Figure 18

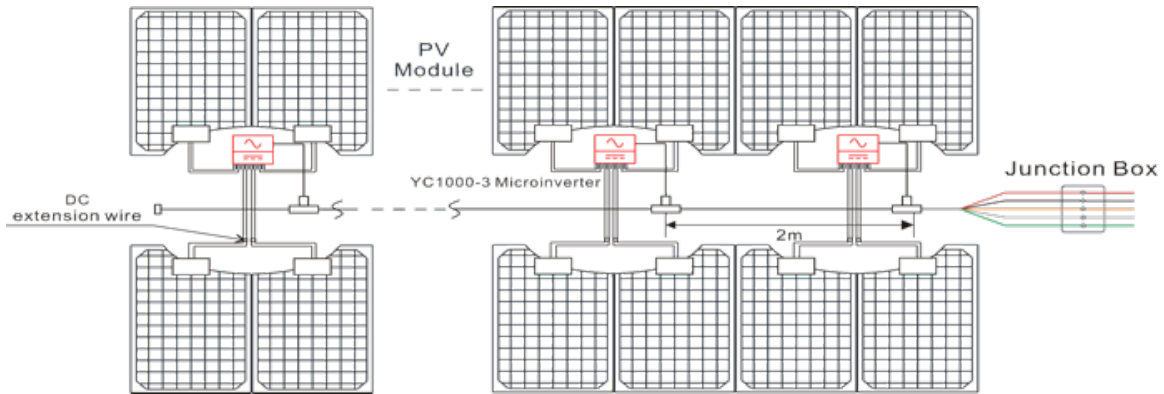Diagram of PV array vertically with distance by APsystems YC1000 (2x2)

Figure 19

Diagram of PV array Horizontally with distance by APsystems YC1000 (2x2)
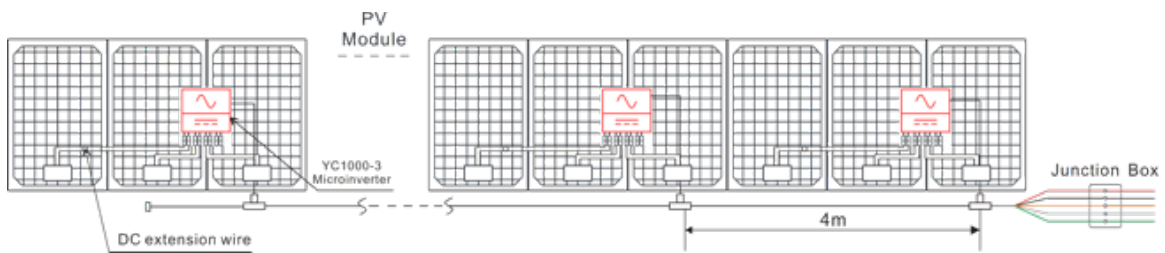
Module and Inverter Layouts – 96 Cell

Figure 20

Diagram of PV array Horizontally with APsystems YC1000-3 (1x3)
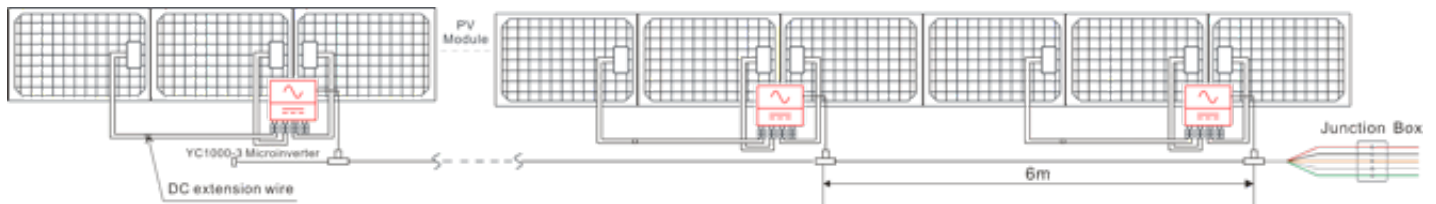

Diagram of PV array Horizontally with APsystems YC1000-3 (1x3)
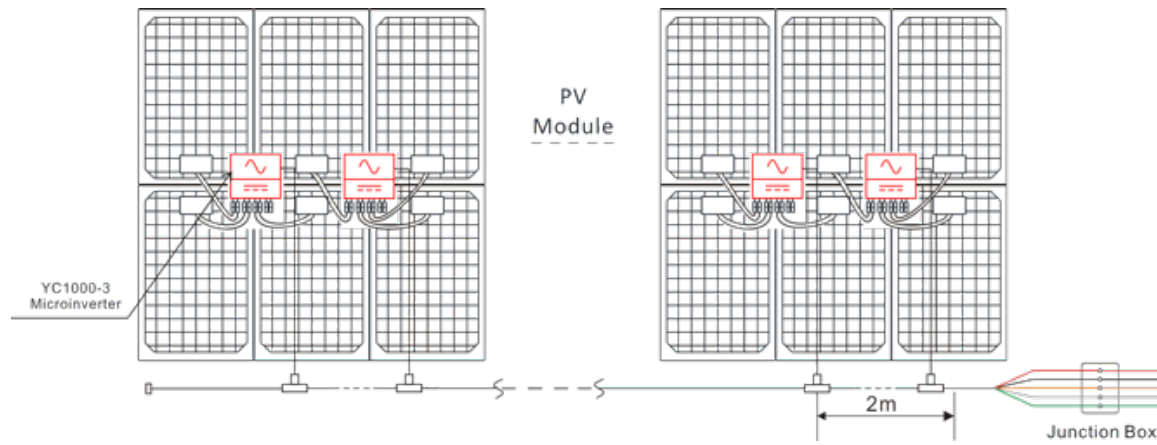
Figure 21

Figure 22

Diagram of vertically with APsystems YC1000-3
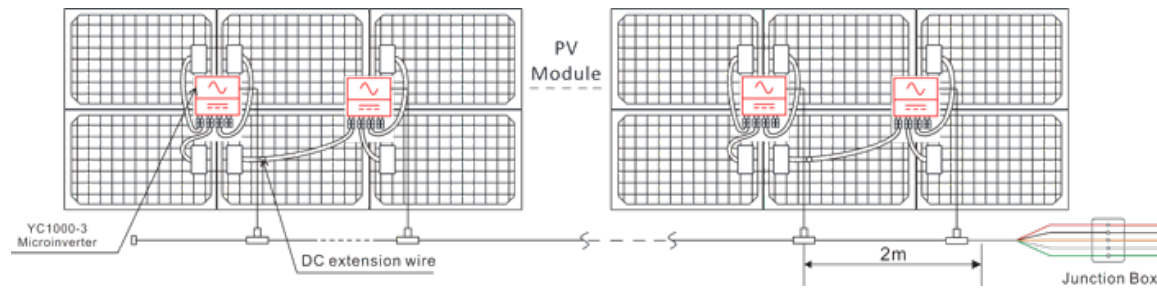

Figure 23

Diagram of PV array Horizontally with APsystems YC1000-3

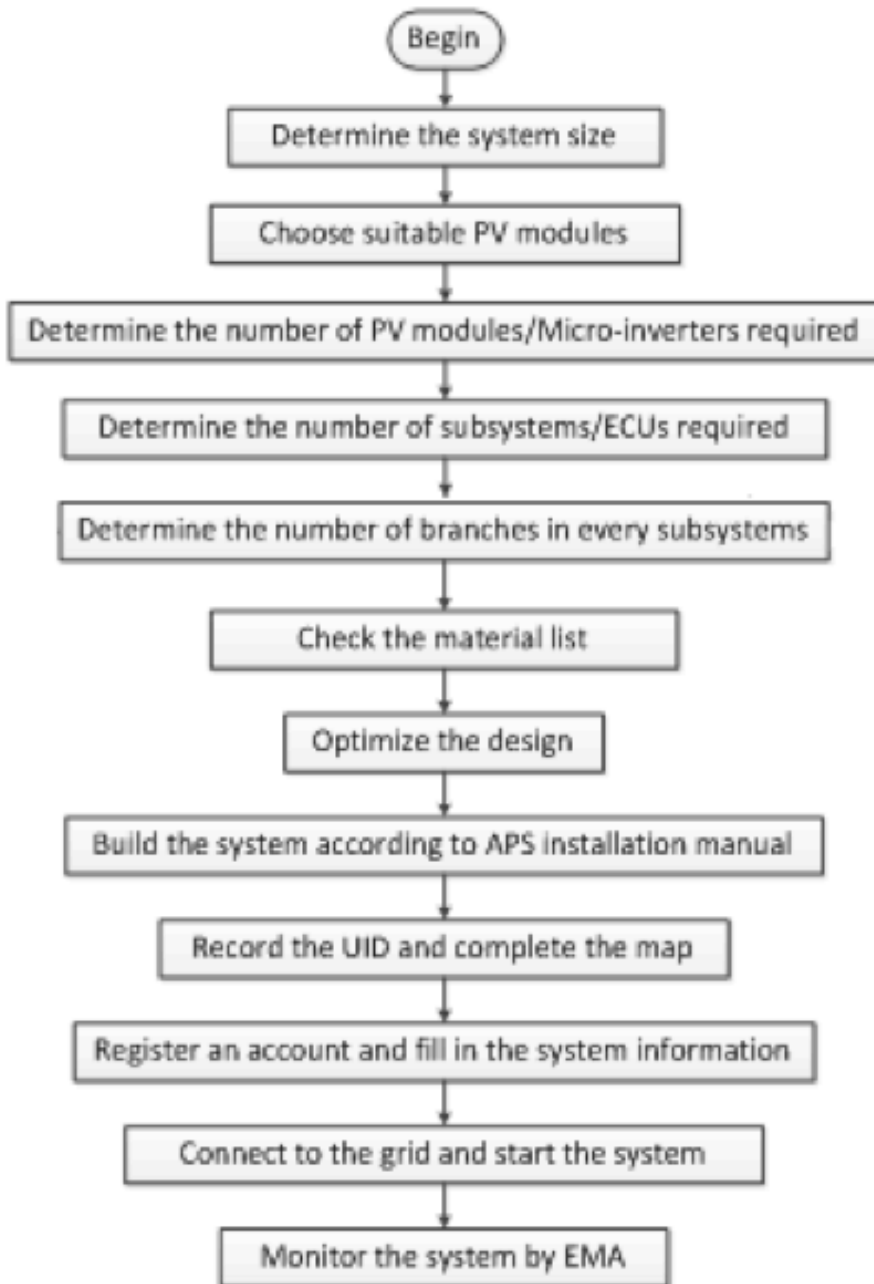## Flowchart for Designing a Commercial System

Figure 24

APsystems Microinverter System Installation

WARNING: Perform all electrical installations in accordance with local electrical codes.

A PV system using APsystems microinverters is simple to install. Each microinverter easily mounts on the PV racking, directly beneath the PV module(s). Low voltage DC wires connect from the PV module directly to the microinverter, eliminating the risk of high DC voltage. Installation *MUST* comply with local regulations and technical rules.

NOTE: An AC GFCI device ***should not*** be used to protect the dedicated circuit to the APsystems microinverter even though it is an outside circuit. None of the small GFCI devices (5mA-30 mA) are designed for back feeding and will be damaged if back fed. In a similar manner, AC AFCIs have not been evaluated for back feeding and may be damaged if back fed with the output of a PV inverter.

WARNING: Be aware that only qualified professionals should install and/or replace APsystems microinverters.

WARNING: Before installing or using an APsystems microinverter, please read all instructions and warnings in the technical documents and on the APsystems microinverter system itself as well as on the PV array.

WARNING: Be aware that installation of this equipment includes the risk of electric shock.

WARNING: Do not touch any live parts in the system, including the PV array, when the system has been connected to the electrical grid.

WARNING: This system has fixed trip limits and should not be aggregated above 30 KW on a single point of common connection.

NOTE: We strongly recommend that you install surge protection devices in the dedicated meter box.

Additional Installation components from APsystems

✳ AC Bus Cable

✳ AC End Cap

✳ AC Bus T-Connector CAPsystems

Required Parts and Tools

✳ AC connection junction box(s)

✳ Mounting hardware suitable for module racking

✳ Sockets and wrenches for mounting hardware

✳ Phillips screwdriver

✳ Torque wrench

NOTE: The AC output is bonded to ground. The neutral is not. Over-current protection for the AC output circuit needs to be provided in the end installation. A disconnect switch needs to be provided for the AC output circuit (may be required by local code or jurisdiction).

Installation Procedures

APsystems microinverters are designed to only operate when they can sense power coming from the grid. Even if they are plugged into the PV array, they will not turn themselves on until they can read power from the grid.

WARNING: Do NOT connect APsystems microinverters to the utility grid or energize the AC circuit until you have completed all of the installation procedures as described in the following sections.

NOTE: It is best to plug in the ECU and verify Internet connectivity early in the installation process if you are going to be installing an ECU to monitor the system. This allows the ECU software to update itself with the latest firmware.

Step 1 – Install the AC Branch Circuit Junction Box
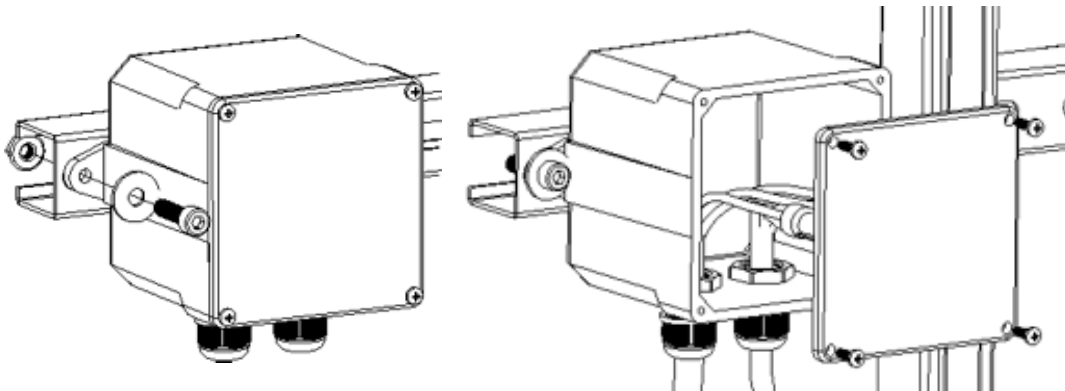
Figure 25

A. Install an appropriate junction box at a suitable location on the PV racking system (typically at the end of a branch of modules).

B. Connect the open wire end of the AC bus cable into the junction box using an appropriate gland or strain relief fitting.

C. Wire the conductors: L1- RED; L2 - BLACK; L3 - ORANGE; N - WHITE; PE – GREEN.

D. Connect the AC branch circuit junction box to the point of utility interconnection.

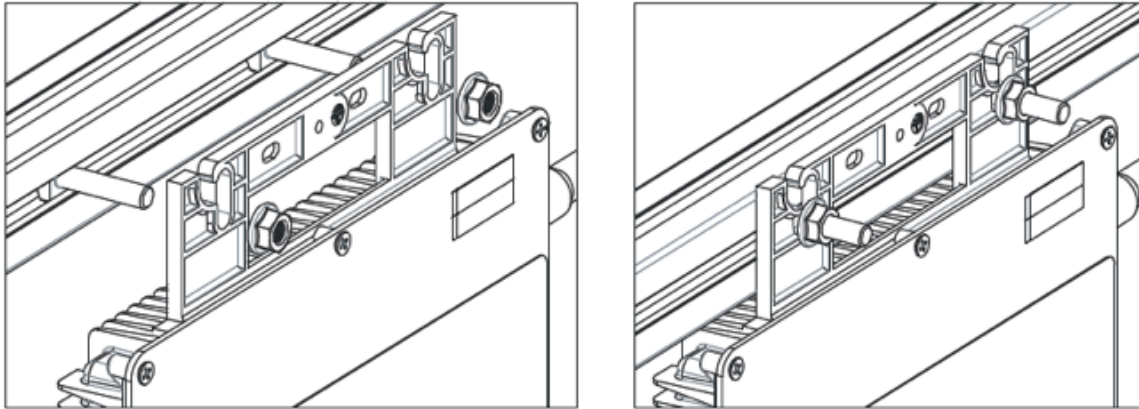## Step 2 – Attach the APsystems Microinverters to the Racking

Figure 26

A. Mark the location of the microinverter on the rack, with respect to the PV module junction box or any other obstructions.

B. Mount one microinverter at each of these locations using hardware recommended by your module racking vendor.

WARNING: Prior to installing any of the microinverters, verify that the utility voltage at the point of common connection matches the voltage rating on microinverter label.

WARNING: Do not mount the microinverter in a location that allows exposure to direct sunlight. Allow a minimum of ¾" (1.5 cm) between the top of the roof and the bottom of the microinverter for proper ventilation.

Step 3 – Attach the ZigBee Antenna to the Microinverter
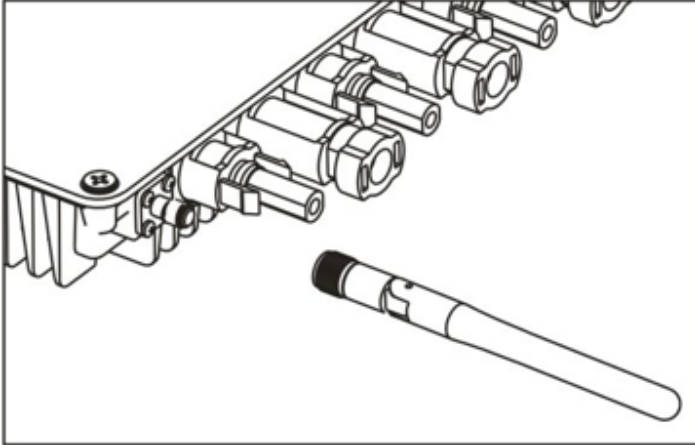
Figure 27

Step 4 - Connect the APsystems Microinverter AC
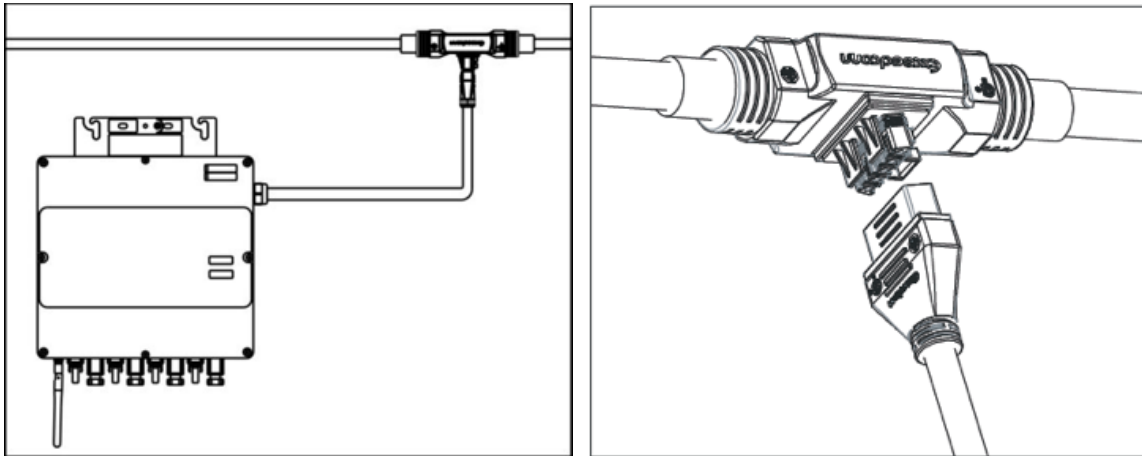
Figure 28

NOTE: Cover all unused "T" connectors on the AC BUS Cable with Sealing CAPsystems to protect the "T" connectors.

Figure 29

Step 5 - Install a Protective End Cap at the end of the AC Bus Cable

A. Wire stripping   **B.** Insert the cable end into the gasket clamp

Figure 30

Nut   Gaske Clamp   Seal   Body

C. Insert five wires into the five cable clamps   **D.** Rotate the nut until the latching mechanism meets the base

Figure 31 & 32

2.5N·m

Step 6 - Connect the APsystems Microinverters to the PV Modules

Place the PV modules into position on the racking and connect the DC input cables to the microinverters based on optimum layout configuration (up to four PV modules per microinverter).
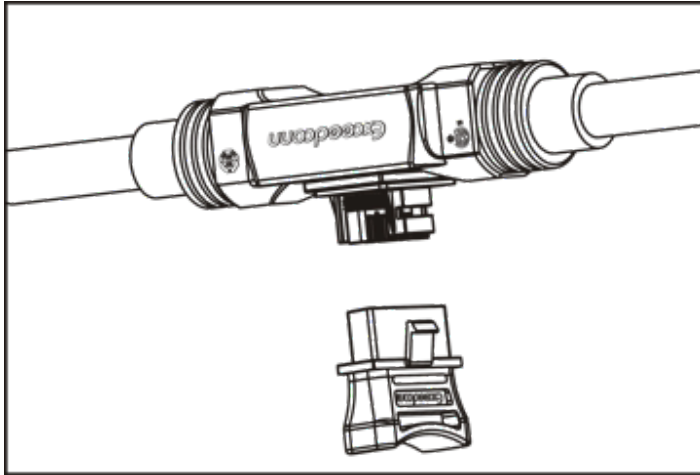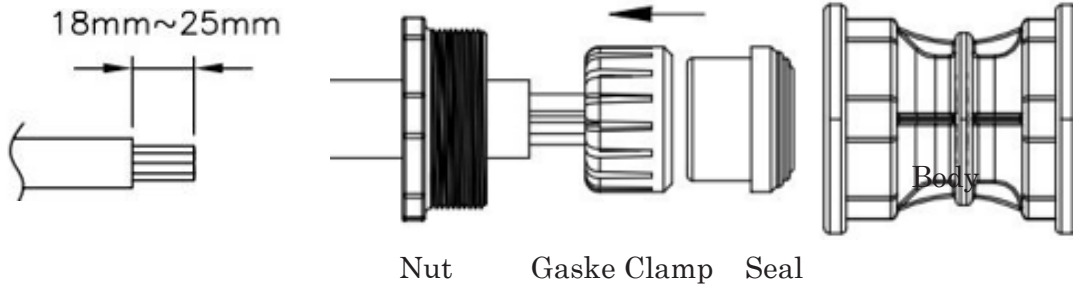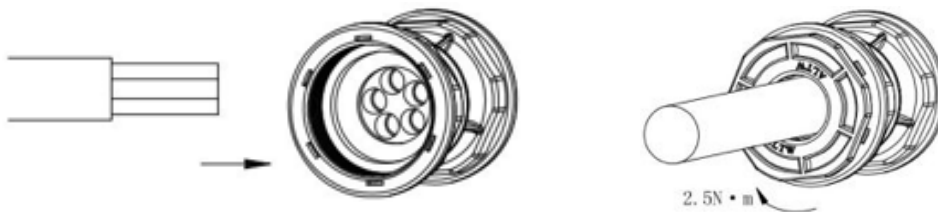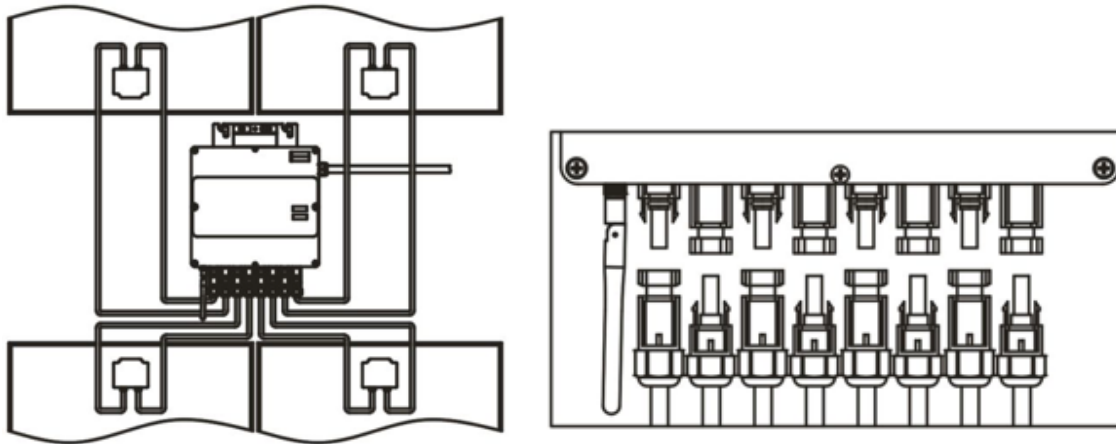

Figure 33 & 34

WARNING: Double check to make sure all of the AC and DC wiring has been correctly installed. Ensure that none of the AC and/or DC wires are pinched or damaged. Make sure that all of the junction boxes are properly closed.

Step 7 - Complete the APsystems Installation Map

Fill in the APsystems Warranty Cards, which provide system information and the installation map. Feel free to provide your own layout if a larger or more intricate installation map is required. The layout map provided is designed to accommodate labels in vertical or horizontal orientation to meet all the field PV connections.

NOTE: You can find a Warranty Card in the Appendix of this manual.

1. Each APsystems microinverter has removable serial number labels. Peel a label off, and affix it to the respective location on the APsystems installation map.

2. Fill out the warranty cards and email to APsystems at
   support@APsystems.com.

3. Register the system using your Installer Account on the
   APsystems EMA. You can then use the EMA website to view de-
   tailed performance of the PV system.
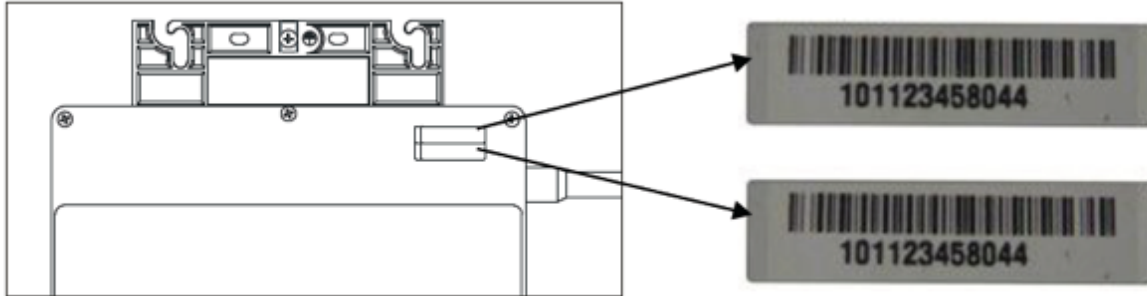
Example of Installation Map and Warranty Card

Figure 36

To operate the APsystems microinverter PV system:

1. Turn ON the AC circuit breaker on each microinverter branch circuit.

2. Turn ON the main utility-grid AC circuit breaker. Your system will start producing power after a five-minute safety delay period.

NOTE: The status LED for on each microinverter will blink green three (3) times to indicate normal operation once DC power is applied. It is important to understand that this "start up" sequence occurs once the first module is connected to the microinverter and is successfully generating DC power. The "start up" sequence does NOT reoccur as additional modules are connected to the same microinverter.

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3. The APsystems microinverters will start to send performance data to the ECU. The time required for all the microinverters in the system to report to the ECU will vary depending on the number and configuration of microinverters in the system. You can verify proper operation of the APsystems Microinverters via the ECU. See the ECU Installation and Operation Manual for more information.

Troubleshooting

Qualified personnel can use the following troubleshooting steps if the PV system does not operate correctly:

Status Indications and Error Reporting

START UP LED

Three (3) short green blinks, when DC power is first applied to the microinverter, indicates a successful microinverter start up. It is important to understand that this "start up" sequence occurs once the first module is connected to the microinverter and is successfully generating DC power. The "start up" sequence does NOT reoccur as additional modules are connected to the same microinverter.

OPERATING LED

Flashing Slow Green (10 sec. gap) – Producing power and communicating with ECU

Flashing Fast Green (2 sec. gap) – Producing power and not communicating with ECU

Flashing Red – Not producing power

Other Faults

All other faults are reported to the ECU. Refer to the *ECU Installation and Operation Manual* for a list of additional faults and troubleshooting procedures.

WARNING: Only qualified personnel should troubleshoot the APsystems microinverter.

WARNING: Never disconnect the DC wire connectors under load. Ensure that no current is flowing in the DC wires prior to disconnecting. An opaque covering may be used to cover the module prior to disconnecting the module.

WARNING: Always disconnect AC power before disconnecting the PV module wires from the APsystems microinverter. The AC connector of the first microinverter in a branch circuit is suitable as a disconnecting means once the AC branch circuit breaker in the load center has been opened.

WARNING: The APsystems microinverter is powered by PV module DC power. Make sure you disconnect and reconnect the DC connections to watch for the three short LED flashes indicating start up.

Troubleshooting a non-operating APsystems microinverter

To troubleshoot a non-operating APsystems microinverter, follow the steps below in order:

1. Verify the utility voltage and frequency are within ranges shown in the Technical Data of this manual.

2. Check the connection to the utility grid. Verify utility power is present at the inverter in question by removing AC, then DC power. **Never disconnect the DC wires while the microinverter is producing power.** Re-connect the DC module connectors and watch for three short LED flashes.

3. Check the AC branch circuit interconnection between all the microinverters. Verify that the inverters are energized by the utility grid as described in the previous step.

4. Make sure that any AC breaker are functioning properly and are closed.

5. Check the DC connections between the microinverter and the PV module.

6. Verify the PV module DC voltage is within the allowable range shown in the Technical Data of this manual.

7. If the problem persists, please call APsystems Technical Support at (206) 855-5100 (Option #2).

WARNING: Do not attempt to repair the APsystems microinverter. If troubleshooting methods fail, return the microinverter to your distributor for replacement.

Replace an APsystems Microinverter

Follow the following procedure to replace a failed APsystems microinverter:

1. Remove the APsystems microinverter from the PV Module, in the following order:

   a. Disconnect the AC by opening the branch circuit breaker.
   b. Cover the module with an opaque cover.
   c. Disconnect the first AC connector in the branch circuit.
   d. Disconnect the PV module DC wire connectors from the microinverter.
   e. Remove the microinverter from the PV array racking.

2. Install a replacement microinverter to the rack.

3. Connect the AC cable of the replacement microinverter and the neighboring microinverters to complete the branch circuit connections.

4. Close the branch circuit breaker, and verify operation of the replacement microinverter.

- Install the APsystems YC1000-3 microinverter under the module, out of rain and sun. Do not mount the microinverter in a position that allows long-term exposure to direct sunlight, or vertically which might allow water to collect in the DC connector recess.

- Ensure that all the AC and DC wiring is correct, making sure that none of the AC and DC wires are pinched or damaged. All of the AC isolators should be properly closed (You will hear "click" which means the AC cable connection is ok).

- Select and install the proper cable size when connecting the inverter to the grid. The power loss should not be more than 2% of the entire system. Please see refer to the detailed information below (***Voltage Rise***).

- Allow a minimum of 1.5 centimeters (0.59") between the top of the roof and the bottom of the microinverter.

- Make sure the inverter's antenna points vertically toward the ground, strengthening the ZigBee communication between ECU and YC1000-3s.

Voltage Rise

Voltage rise must be considered when designing a photovoltaic system. Over-voltage rise will consume more power, and may also trigger the protection functionality within the microinverter, so we advise that the total voltage rise should not be more than 2% on a single branch. The table below gives the calculation results of the voltage rise on each microinverter of a branch with YC1000-3 operating at full load.

YC1000-3 Vrise for 480V/60Hz, 5 wire, 2m Portrait AC Bus 14 AWG cable.

YC1000-3 Quantity	6	7	8	9	10	11
VRise(V)	0.1104	0.1325	0.1546	0.1767	0.1988	0.2209
%	0.027%	0.033%	0.038%	0.044%	0.049%	0.055%

Figure 37

YC1000-3 Vrise for 480V/60Hz, 5wire, Maximum end cable length for 12AWG&14AWG

AWG	6	7	8	9	10	11
#14	123m	105m	92m	82m	73m	67m
#12	153m	131m	115m	103m	92m	83m

Figure 38

WARNING: Be sure to verify the voltage and current specifications of your PV module match with those of the microinverter.

WARNING: You must match the DC operating voltage range of the PV module with the allowable input voltage range of the APsystems microinverter.

WARNING: The maximum open circuit voltage of the PV module must not exceed the specified maximum input voltage of the APsystems microinverter.
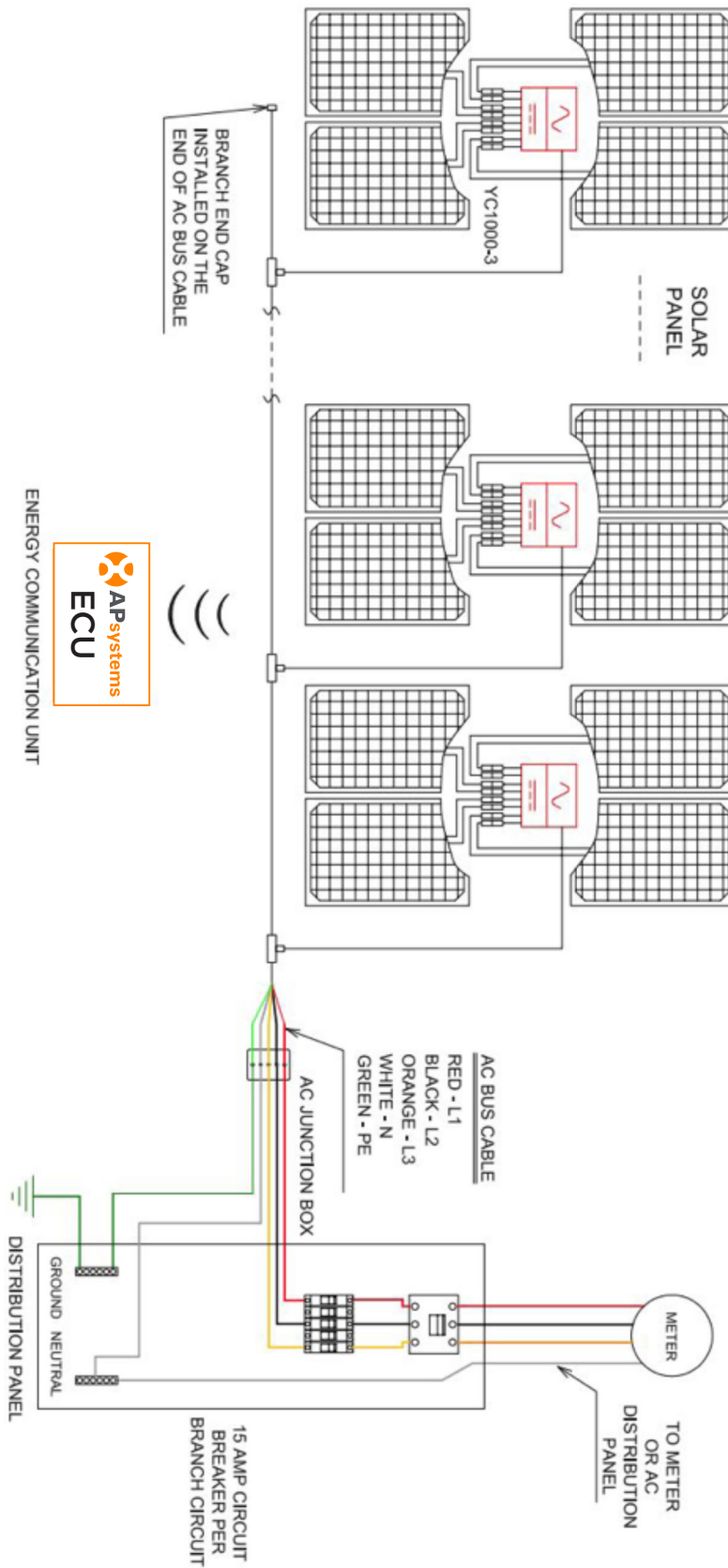
Figure 39

BRANCH END CAP INSTALLED ON THE END OF AC BUS CABLE

SOLAR PANEL

YC1000-3

ENERGY COMMUNICATION UNIT

APsystems
ECU

AC BUS CABLE
RED - L1
BLACK - L2
ORANGE - L3
WHITE - N
GREEN - PE

AC JUNCTION BOX

DISTRIBUTION PANEL

GROUND   NEUTRAL

15 AMP CIRCUIT BREAKER PER BRANCH CIRCUIT

METER

TO METER OR AC DISTRIBUTION PANEL