

Networking and PLC Considerations for Commercial Installations

This document addresses the many facets of networking and communications for Enphase Microinverter Systems, with an emphasis on how to configure commercial installations for decades of trouble-free operation and monitoring.

Power Line Communications (PLC) Considerations for Commercial Projects

Power Line Communications are the means by which Enphase Microinverters communicate with the Envoy™ Communications Gateway. Enphase equipment sends and receives signals, in the 100-150kHz range, over the same conductors that the AC system power travels.

Site Documentation

Due to the complexity of the communications protocols and the critical role they play in monitoring, reporting, and diagnosis of any issue that may arise, proper site documentation is an essential part of bringing a commercial Enphase installation up on Enlighten. A well-documented installation also provides for a much smoother Operating and Maintenance (O&M) regimen over the lifetime of the completed system. A detailed installation map, wiring diagram, and branch layout can ensure that Enphase personnel have all the necessary information to diagnose and resolve any issues that arise. These documents can also help to minimize any on-site troubleshooting.

Installation map

- Provide an installation map, either in a digital format (e.g., PDF, Excel, AutoCAD, etc.) or upload/scan the devices as they are installed
- List all microinverter serial numbers and the communication domain to which they belong
- Clearly indicate each communication domain within the array as a whole
- Indicate the Envoy serial number responsible for communicating with each domain

Branch Layout

- Include the branch layout in the installation map
- Indicate the start and end of each branch as well as each microinverter in that branch

Wiring Diagram/schematic

- Include all the electrical equipment used in the installation
- Include all equipment from the main service entrance to the end of each branch
- You can use abbreviations for areas of the system that are redundant
- Include conductor sizes and lengths for all circuit sections

In the event that the activation of a system requires extra support from Enphase or the installer, these maps and documents will ensure that all the proper information is readily available and that issues can be resolved in a timely manner.

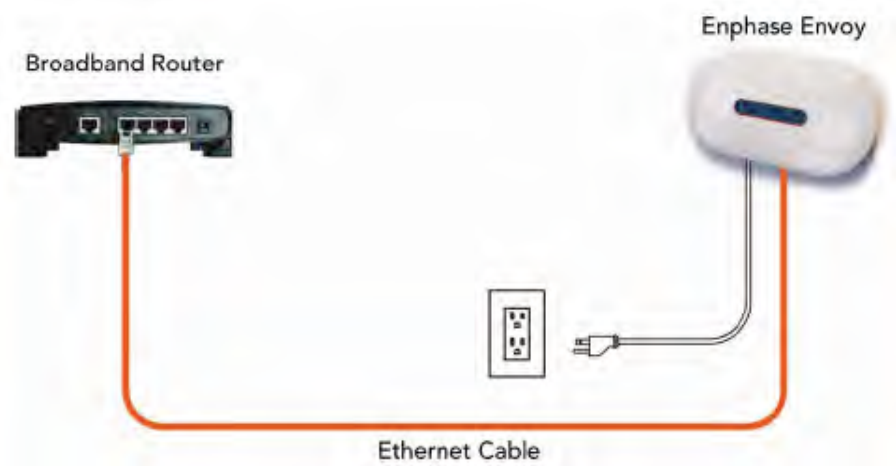
LAN/WAN Considerations for Commercial Projects

Envoy Communications

With all Enphase installations, communication between the array and the Envoy Communications Gateway is key to system monitoring and maintenance. The Envoy communicates with the microinverters in the solar array via the power lines on the premises. The Envoy then communicates with the Enphase Enlighten™ Monitoring and Analysis web application via its Ethernet cable, which is connected to the premises' broadband router.

The Envoy, in this sense, acts just as another computer at the premises, connecting through a standard Ethernet LAN (Local Area Network) cable and using standard TCP/IP protocols.

While it is a trivial task to make this connection in a residential setting, the commercial installation usually requires additional considerations.



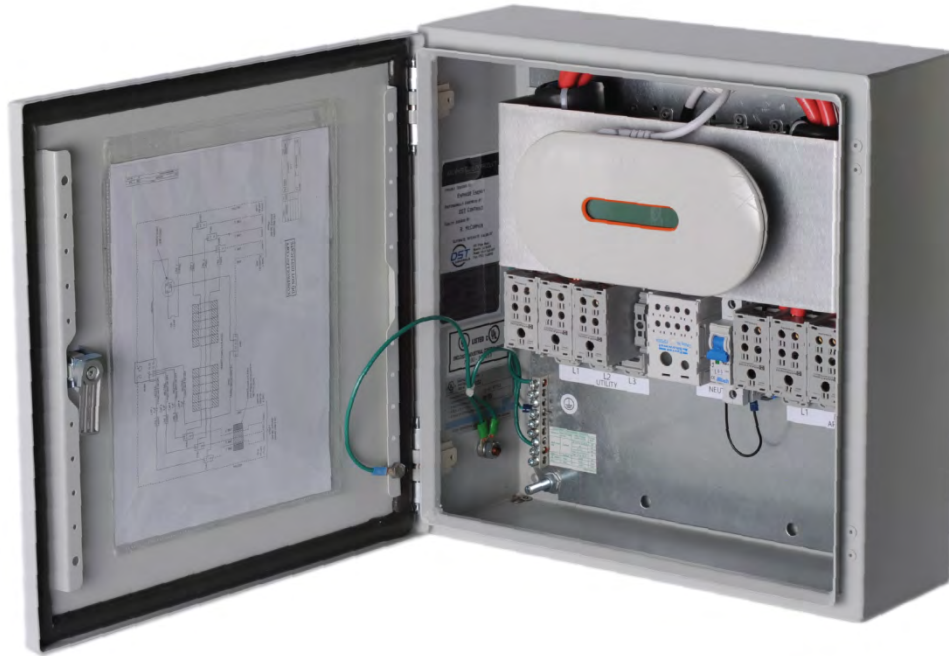
The LCF (Line Communications Filter) Envoy

In larger commercial installations, the number of addressable Enphase Microinverters usually exceeds the capacity of a single Envoy (up to 210). The commercial integrator must build the site based on building blocks (domains) that include one LCF Envoy and a given number of microinverters, depending on microinverter type and service. Limits are shown in the following table. The commercial integrator can then increase these multiples to complete the size of the overall installation.

Service type/ Microinverter model	Microinverters Supported
208 Vac three-phase, approx 36 kW AC	
M215-60	166
M190-72	189
M210-84	171
240 Vac single-phase, approx 24 kW AC	
M215-60	111
M190-72	126
M210-84	114

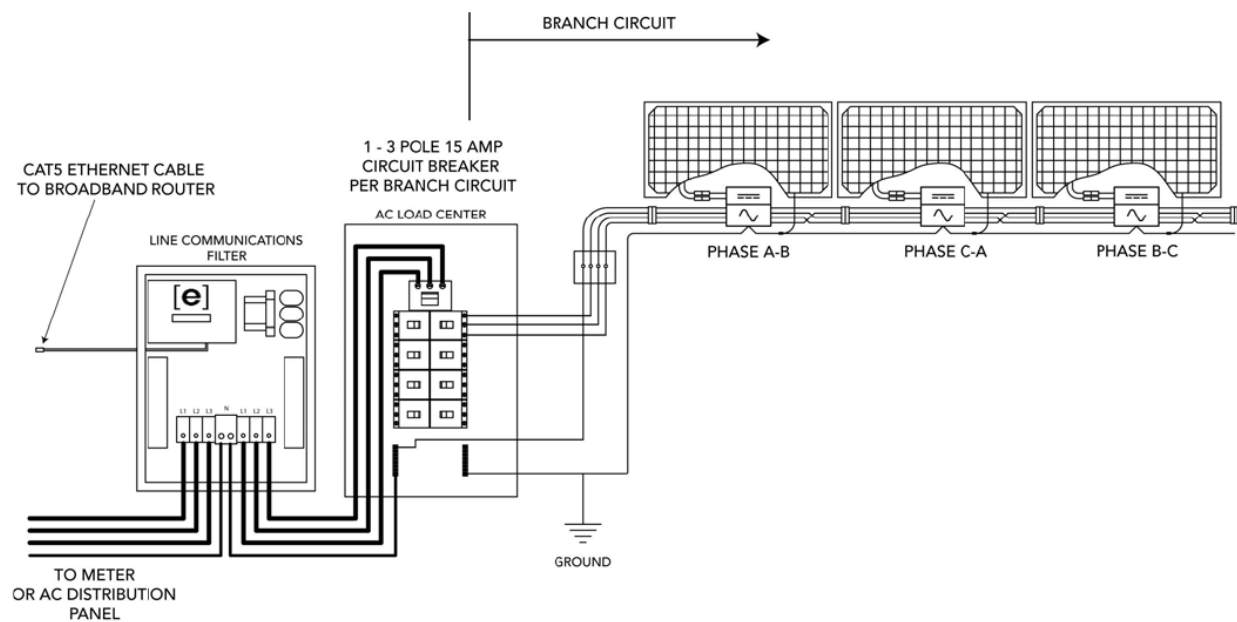
Where multiple Envoys are required, the LCF Envoy is needed, one LCF Envoy for each communications domain. The LCF Envoy isolates the power line communications of one domain (or group) from any other co-located group of microinverters and Envoy.

The LCF Envoy contains terminations for phase conductor lines in and out. By running phase conductors through the LCF, the Enphase 143kHz communication signal is filtered out. Inside the enclosure is an Envoy as well as a single electrical receptacle for powering it, as shown in the following photo:



Single-Line LCF Envoy

The single-line diagram for the LCF Envoy is shown in the following:



One end of the LAN/Ethernet cable coming into the LCF enclosure plugs into the Envoy's Ethernet port. The other end of that Ethernet cable connects to a broadband router in a network infrastructure, which ultimately leads to an Internet connection.

Note that there is no master/slave networking architecture. Each Envoy device must be independently connected to an upstream Internet port.

Envoys plugged into a networking switch or router are no different in this context than a computer or laptop plugged into a networking switch or router. They use the same CAT5 Ethernet cable that any other computer would use.

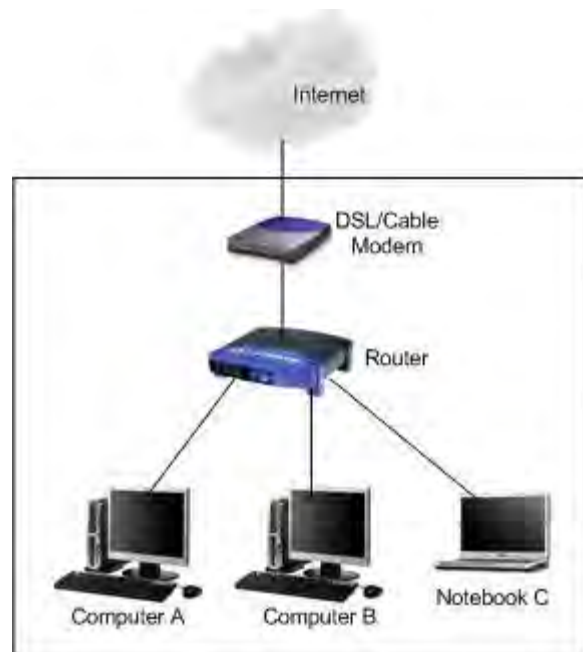
Typical Commercial Network Setups

Typical Ethernet Network Topology, Residential

In a typical residential networking setup, the LAN portion is that which is on the "inside" of the local network. In the following diagram, this encompasses Computer-A, Computer-B, Notebook-C and the Router.

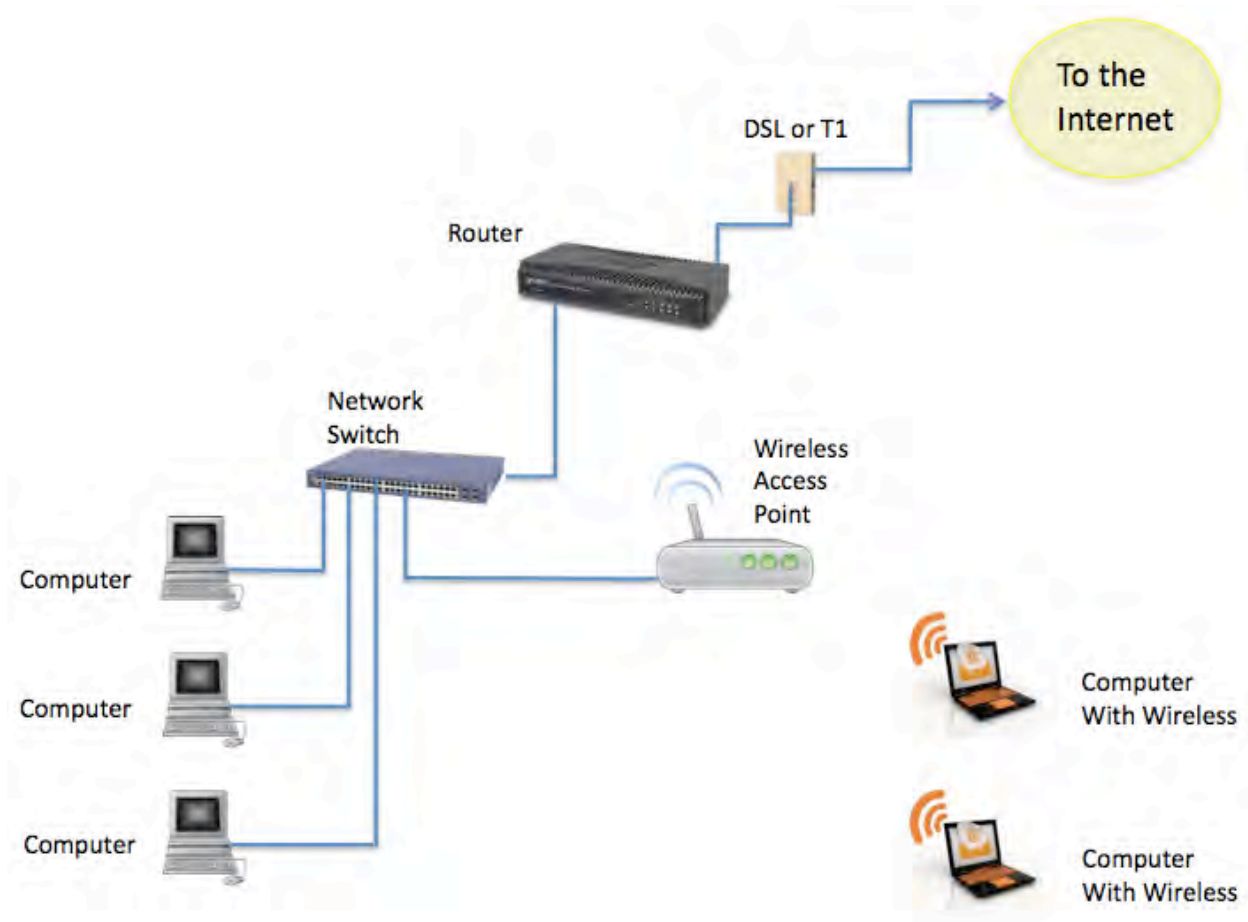
The WAN (Wide Area Network) portion is that which is on the "outside" of the local network. In the diagram above, this encompasses the "WAN" port of the Router and the DSL/Cable Modem. The WAN is the upstream connection to the Internet.

The Router may also include wireless (WiFi) services, and there may be one or more laptop computers in the residence that access that Router via WiFi.



Typical Ethernet Network Topology, Commercial

The typical, commercial LAN/WAN setup is a little more involved, but the components are the same. The following diagram reflects a typical, small commercial network design.

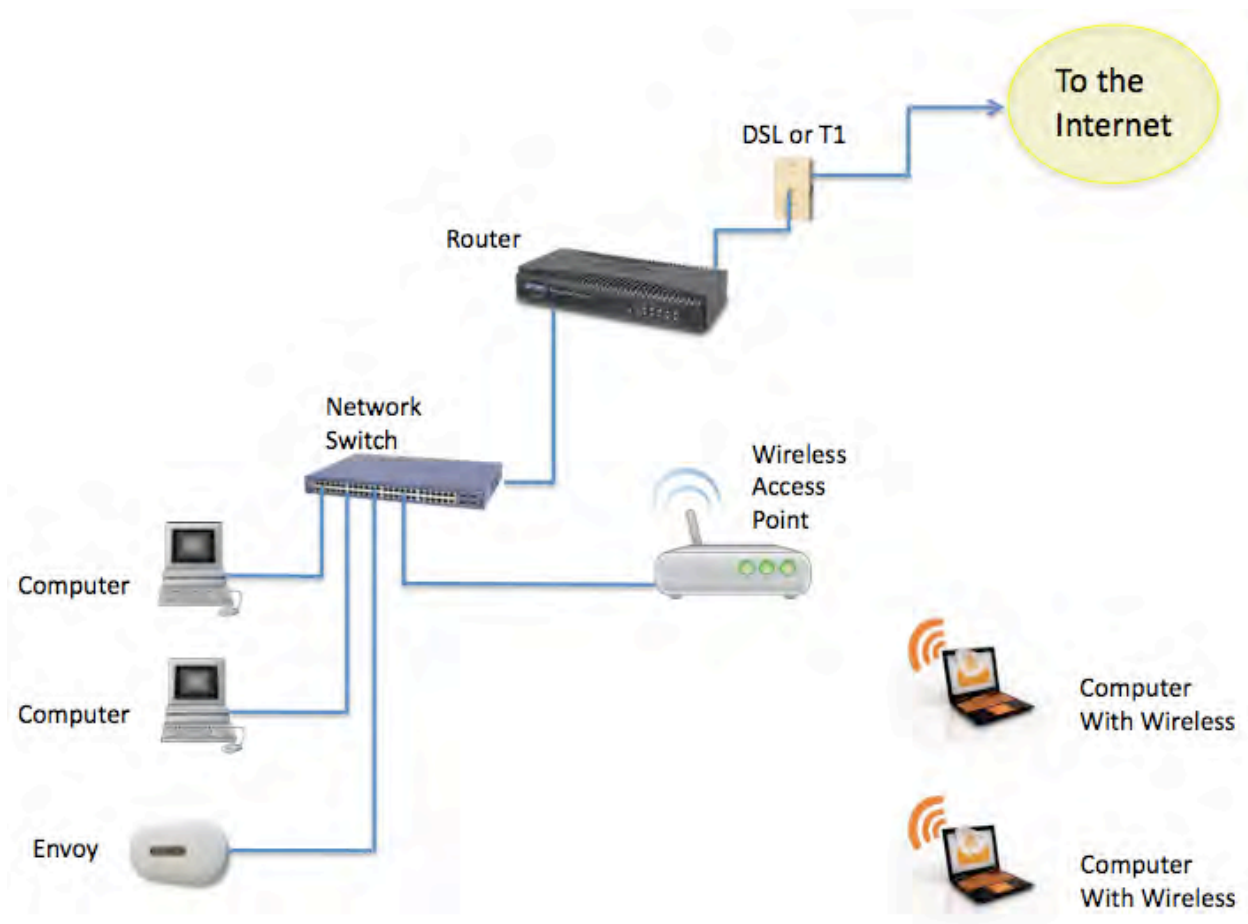


The computers are connected to the Network Switch via standard Ethernet cables. The computers with wireless (WiFi) capability access the LAN via a separate Wireless Access Point, which itself is connected to the Network Switch.

The Network Switch is connected upstream to the Router. The Router then plugs into the wall plate where the business has a DSL or T-1 connection to the Internet.

Typical Ethernet Network Topology, Commercial with Enphase Envoy

The following diagram replaces one of the computers with an Envoy. The Envoy connects to the wired LAN just like another computer would.

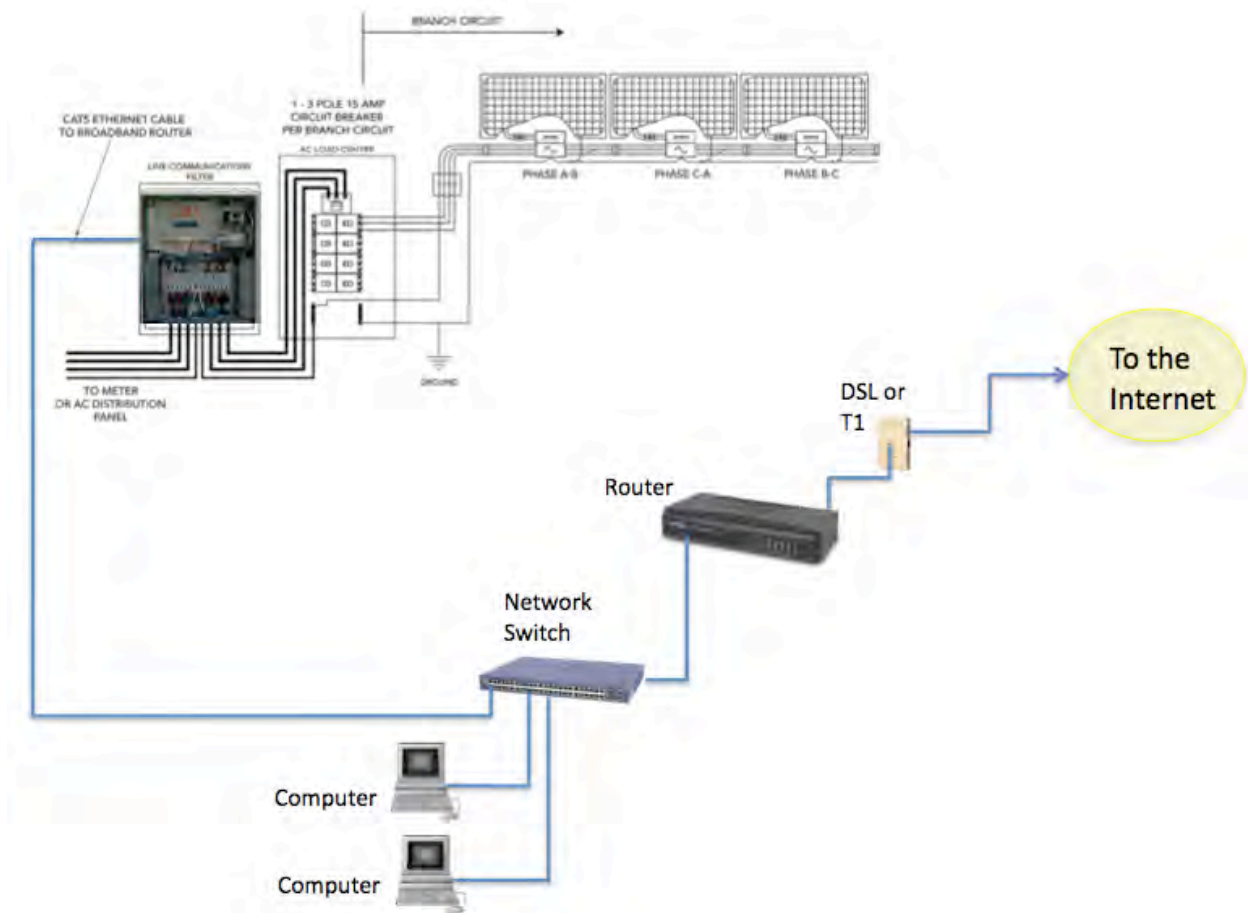


The business may have multiple LCF Envoys, each with its own independent Internet connection.

Enphase Commercial Deployment Examples

Typical Commercial Deployment, Single LCF Envoy

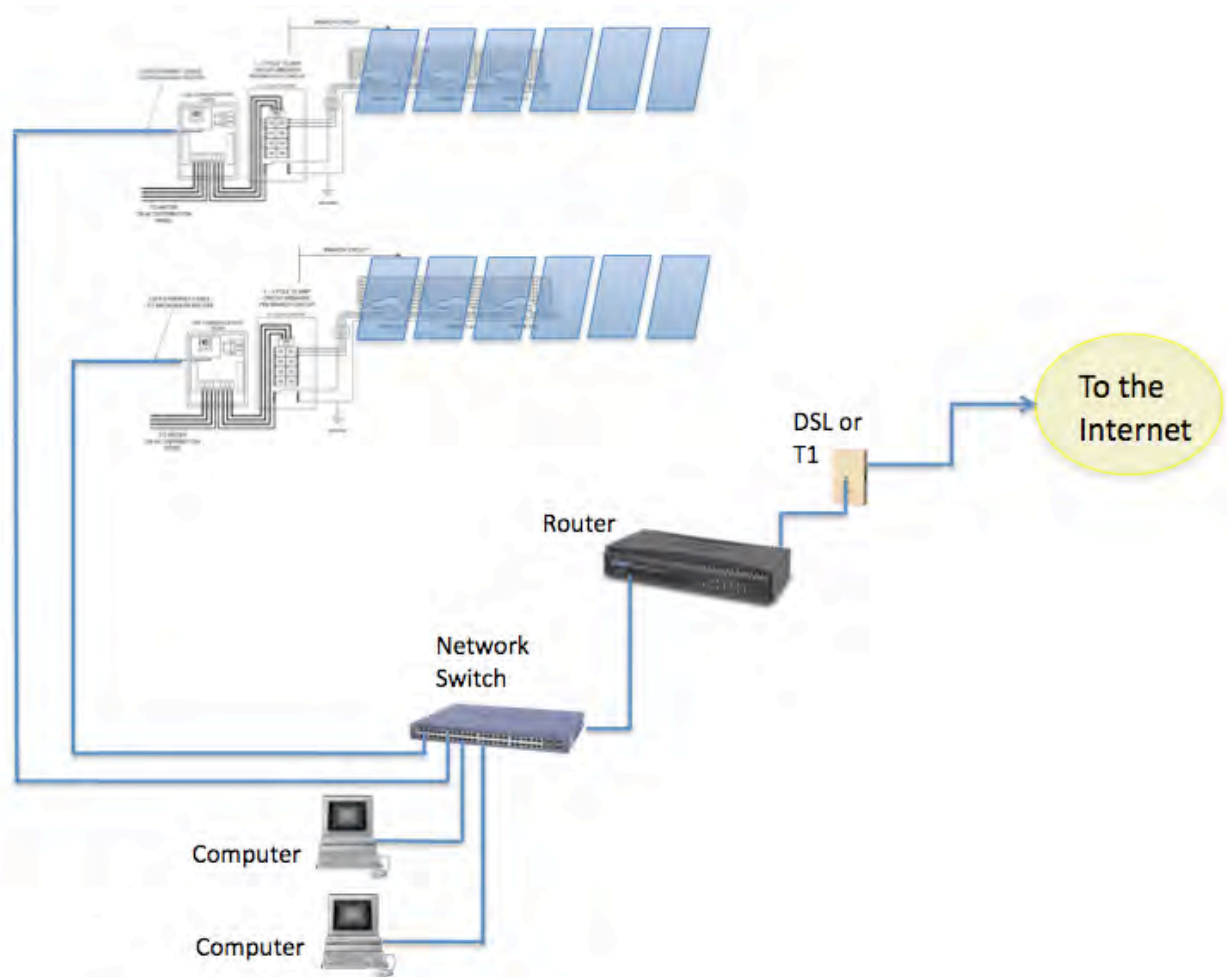
If you now take what you know about LAN/WAN in a commercial setting and picture the Envoy inside the LCF, near the solar array(s), the model should look like the following diagram.



Note that the Envoy is mounted inside of the LCF enclosure, but still needs a standard Ethernet cable to an upstream Internet connection.

Typical Commercial Deployment, Multiple LCFs

Now picture multiple LCFs, each with a built-in Envoy. Each of those Envoy communicates (via the power lines) with its own domain of microinverters. The following diagram shows two LCFs, each with their own microinverters and attached photovoltaic (PV) modules.



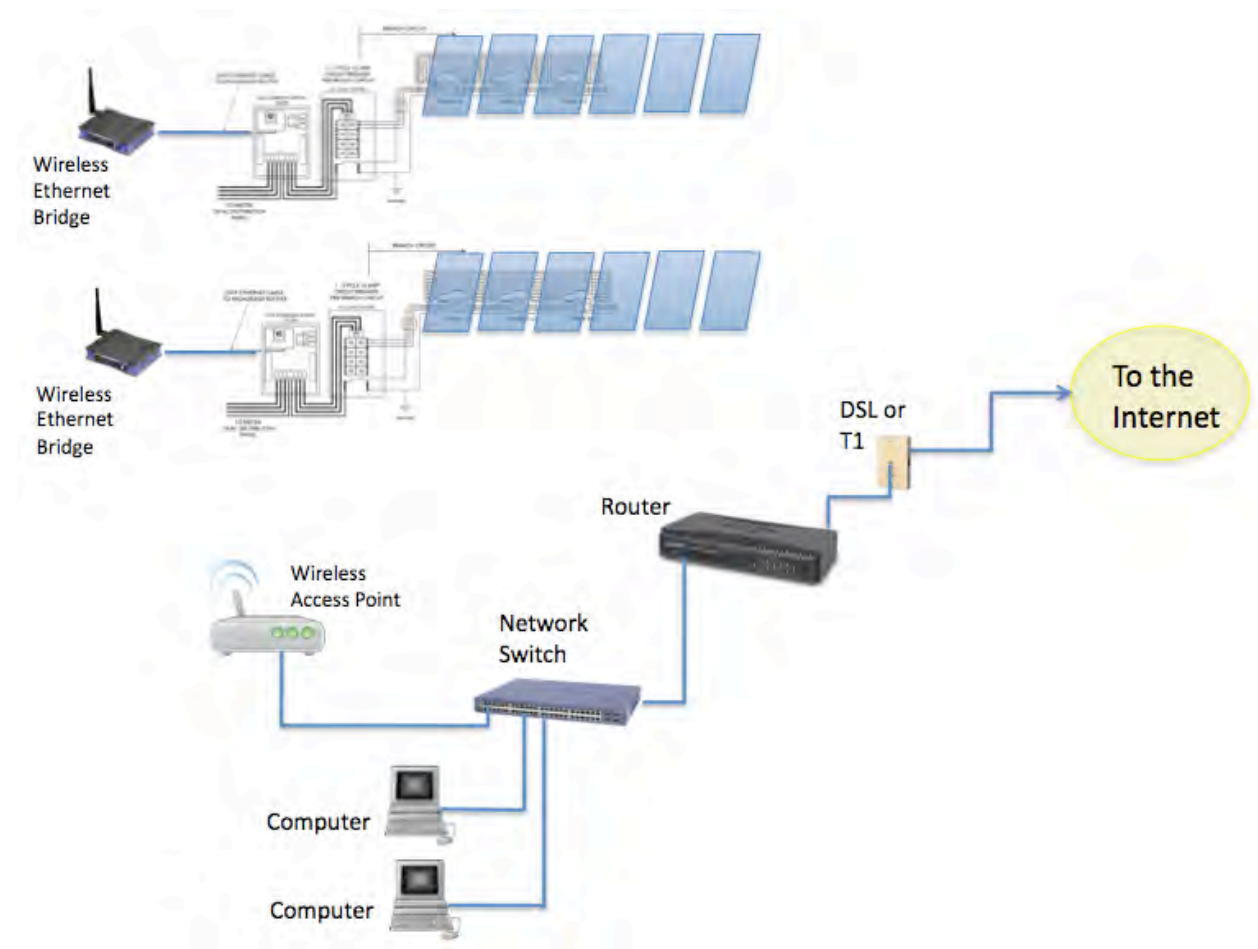
This model can scale as large as is needed. For each additional communications domain, add another LCF Envoy. Using the filtering mechanism of the LCF, the power line communications from one communications domain is isolated and separated from any others.

Typical Commercial Deployment Ethernet Network using a Wireless LAN

In commercial deployments, the installer may want to use a Wireless Access Point to provide Internet connectivity to one or more of the LCF Envoyos.

This way, only the Wireless Access Point needs the hard-wired connection to an Internet switch or router. In turn, it provides WiFi services to each of the LCF Envoyos.

The Envoy does not have wireless capability built-in, so each one would require its own wireless Ethernet bridge to pass data from the LCF Envoy to the Wireless Access Point as shown in the following diagram.



Wireless Technologies

Consumer-grade WiFi devices have varying ranges of operation. Not all WiFi vendors specify the unobstructed distance for which their product will provide wireless coverage.

Wireless specification 802.11g is the current standard, with 802.11n recently ratified. Check vendor specifications for claims of distance/coverage, and remember to factor in obstructions, such as buildings, walls, etc.

Wireless Adapter for Use with the Envoy

The Envoy does come with a USB port, but it not configured for WiFi support. However, the Netgear WNCE2001 device is about the size of a deck of cards, and more importantly it can be powered through the Envoy's USB port. The device still connects to the Envoy through an Ethernet cable, but is a lot less cumbersome than some other Ethernet (to WiFi) bridges.

Wireless Vendors:

- Linksys: <http://home.cisco.com/en-us/wireless/linksys/>
- Netgear: <http://www.netgear.com>
- Ubiquity Networks: <http://www.ubnt.com/>
- Meraki: <http://meraki.com/>

Wireless Routers

WiFi routers provide a wireless gateway to the Internet. Wireless vendors Linksys and Netgear produce WiFi routers that are installed in large numbers and that are solid and reliable. Units come with installation DVDs / software for easy setup, have excellent documentation, and come with phone/online technical support.

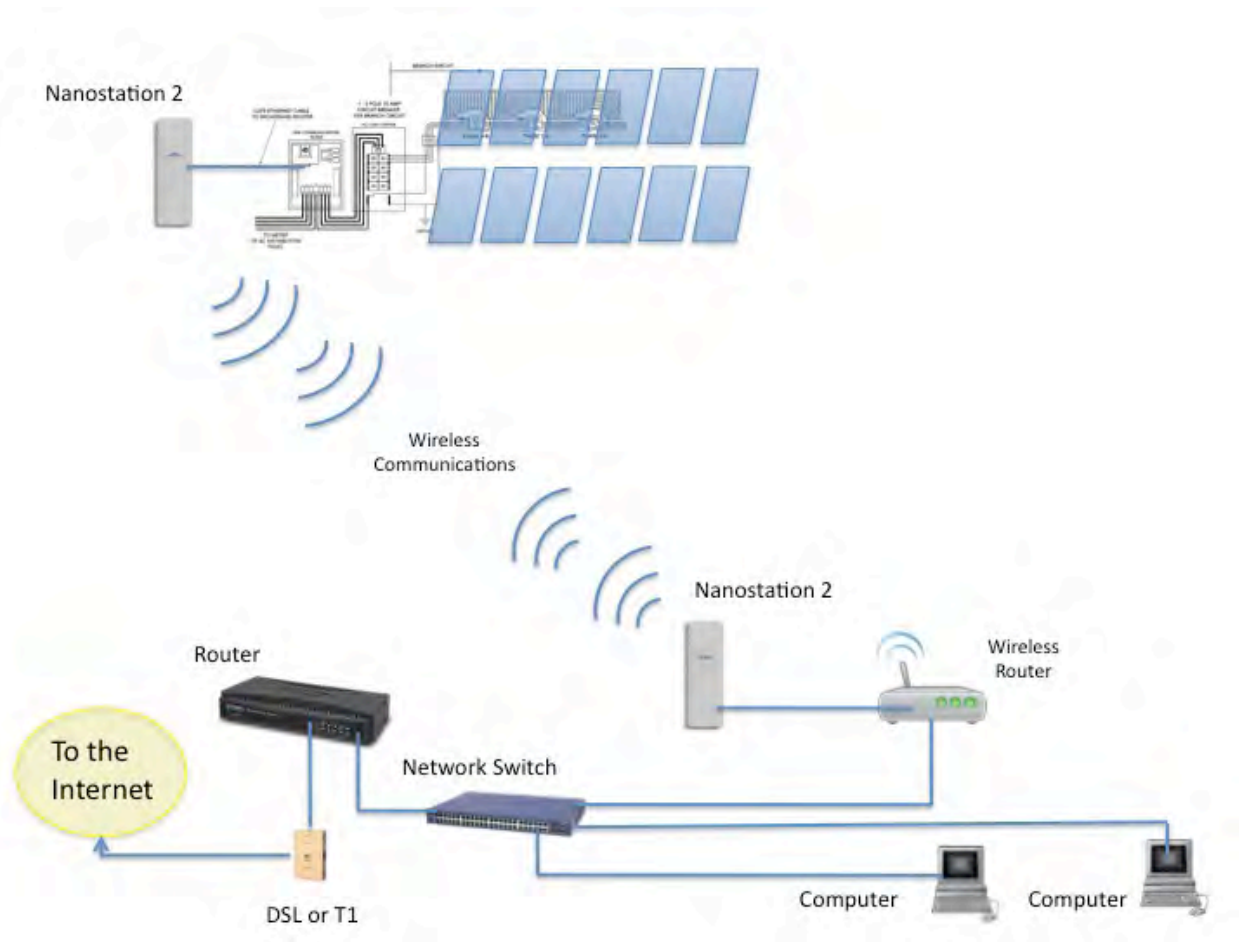
Wireless Ethernet Bridges

A wireless Ethernet bridge converts a wired Ethernet device for use on a wireless network. (Think of it as an external wireless network card). The Linksys WET610N and Netgear WNCE2001 are often recommended.

The Envoy does come with a USB port, but it is not configured for WiFi support. (The port is currently used for engineering diagnostics.) However, you can power the Netgear WNCE2001 through the Envoy's USB port. The Netgear WNCE2001 is about the size of a deck of cards, the device still connects to the Envoy through an Ethernet cable, but is a lot less clunky than some other Ethernet (to WiFi) bridges.

Wireless Hi-Gain Antenna Systems

Wireless Hi-Gain Antenna systems are for use when the distance from the LCF to a wireless router is over 500ft. Ubiquiti Networks directional Nanostation 2s are recommended. The system is made for outdoor use, and a variety of mounting brackets are available. Configuration is accomplished through a web interface and a number of tools are available to verify signal strength between devices.



Wireless Mesh Network

A wireless mesh network is a communications network made up of multiple wireless bridges and antennas organized in a mesh topology. This topology would be used at sites with multiple buildings, where cabling would be extremely difficult. Ubiquity Networks makes a weatherproof Nanostation 2 with PicoStation M units. Meraki Networks also makes a weatherproof unit called the OD2, which is an Omni-directional WIFI access point. The OD2 can connect an LCF and transmit a signal to extend reach to other OD2 devices.



Network Basics and Troubleshooting

DHCP and Self Assigned IP Address (169.254.x.x)

When the Envoy first boots up, it is configured to perform a DHCP (Dynamic Host Configuration Protocol) broadcast, requesting an IP address from a DHCP source. This source can be a server/computer, but almost all consumer-grade broadband routers also provide DHCP services as well. This is the usual source of IP addresses for network hosts (computers, laptops, and the Envoy).

If the LCD window of the Envoy displays an IP address beginning with “169.254.”, this means that it was unable to receive an IP address from a DHCP source, and so it assigned this address to itself. Check your Ethernet cabling and check that the router is providing DHCP services.

DHCP versus Static IP Addressing

If the site owner prefers not to use DHCP, the Envoy can be set up to use a static IP address.

- Use the Envoy’s web-interface to navigate to the ADMINISTRATION page. The Username is “admin”, and password is “admin”. Click the “Network Connectivity” menu item. This allows you to see if the Envoy is using DHCP or Static-IP, and allows you to change this setting if needed.
- Click “Check Network Connectivity” to view the Envoy connections.

For more information on how to use the Envoy Interface, refer to the **Envoy Communications Gateway Installation and Operation Manual** at <http://www.enphase.com>.



WARNING: Do not change the Envoy DHCP setting to use a static IP address unless you also reserve the same IP address on your broadband router. See the section on DHCP Reservations in your router's setup manual. Failure to reserve the static IP address on the router will result in duplicate IP addresses and intermittent Internet connection problems with your Envoy.

MAC Filtering

Check to see if MAC Filtering is in use at the site. This has nothing to do with Apple Macintosh computers, but rather, refers to the MAC (Media Access Control) address that each individual network card possesses. The MAC Address is a 48-bit address, which uniquely identifies that piece of hardware. MAC Filtering, then, is a security mechanism by which routers allow administrators to specify which devices can use the router for access to the Internet. This prevents unauthorized/unknown personnel from using the router to get to the Internet.

An example of a MAC address would be:

00:17:F2:D6:B1:45

MAC addresses contain six pairs of characters, including any number 0-9 and letters A-F. The MAC address of the Envoy will begin with:

00:D0:69:41:

If MAC filtering is in use at the site, you will need to identify the specific MAC address of your Envoy for the purpose of adding it to list of authorized devices on the router. To do this, browse to the home page of the Envoy's web-service using an ordinary web-browser. The home page contains that specific Envoy unit's MAC address. The MAC address is also located on a sticker that is located on the back of the Envoy.

Firewall Settings

The Envoy initiates **outbound** connections to Internet servers. Such connections may be restricted by firewall rules set up on the site's broadband router. Broadband routers typically allow all outbound connections but restrict any/all inbound connections.

If outbound firewall rules are applied at the site, you must configure a static IP address for the Envoy and add new rules that allow outbound access as follows:

Direction	Source	Protocol	Port	Destination
OUT	<Envoy IP address>	TCP	443	reports.enphaseenergy.com
OUT	<Envoy IP address>	TCP	443	securereports.enphaseenergy.com
OUT	<Envoy IP address>	TCP	443	home.enphaseenergy.com
OUT	<Envoy IP address>	UDP	123	us.pool.ntp.org

The Envoy connects to these servers using their DNS names. If you add firewall rules for Envoy reporting, Enphase recommends using the DNS names rather than the underlying IP addresses. This is because the IP addresses are subject to change without notice.



WARNING: Do not change the Envoy DHCP setting to use a static IP address unless you also reserve the same IP address on your broadband router. See the section on DHCP Reservations in your router's setup manual. Failure to reserve the static IP address on the router will result in duplicate IP addresses and intermittent Internet connection problems with your Envoy.

Conclusion

The networking and communications side of installing a commercial Enphase Microinverter System is fairly straightforward. Following the recommended practices in this document will minimize communications issues with your commercial installations.