Tutorial 2: 
HomePlug information and pairing tutorial

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2.1 HomePlug introduction

2.1.1 What is HomePlug, and how does eGauge use this?

HomePlug is a specification of Power Line Communications used to transmit networking data over existing power lines. It is commonly used to create a network bridge over a home or building where Wi-Fi can not work or is not convenient. A HomePlug adapter can be connected to a router with Internet access, and another can be placed elsewhere in the building so network devices may connect to it.

![Figure 2.1: Actiontec HomePlug 1.0 (eGauge2)](image1)

![Figure 2.2: Actiontec HomePlug AV (EG301x)](image2)

![Figure 2.3: TP-Link HomePlug AV (EG301x)](image3)

The eGauge EG3010 contains a HomePlug chipset and will transmit data over the existing power lines to a HomePlug adapter and into the network to enable Internet access.

2.1.2 Technical and environmental considerations

**Phasing**

HomePlug communication travels along the phase connected to L1 of the eGauge. The HomePlug adapter must be plugged into an outlet on the same phase as L1.

**Signal Deterioration and Loss**

HomePlug signals can be filtered out by surge suppressors and noise filters, and will deteriorate as the length of wire between the eGauge unit and HomePlug outlet increases. Factors such as load and noise generated by other devices will affect the maximum distance communicable. Typically, between 50 and 100 feet of wire is suitable for the devices to communicate without disruption.

If the power lines that supply the building are protected with a TVSS system in the breaker panel, the HomePlug signal will quickly be dissolved when the devices try to communicate across circuits. A work around for this situation would be to put the HomePlug adapter’s outlet on the same breaker as the eGauge.
If distance and noise become an issue for the signal, an outlet can be added closer to the panel where eGauge is located (again, the outlet needs to be on L1 relative to the eGauge inputs).

**Voltage Limitations**

The HomePlug AV adapters sold by eGauge Systems LLC are rated for voltages up to 240Vac (50 or 60Hz). Sites operating at higher voltages require a small transformer to step down the voltage to a range suitable for the HomePlug adapter. The transformer must be small enough so as not to filter out the HomePlug signal.

For 3-phase/277V (480V-phase-to-phase) installations, eGauge Systems LLC stocks a transformer kit, which will step down 277Vac down to 120Vac, suitable for powering the HomePlug adapter. The transformer is rated for 25VA of power, suitable for powering another one or two auxiliary devices, provided total power consumed does not exceed 25VA.

Please see [http://www.egauge.net/docs/277v-hpt-manual.pdf](http://www.egauge.net/docs/277v-hpt-manual.pdf) for more information on the transformer kit.

**Multiple HomePlugs on a Network**

A single power line location can support up to 16 HomePlug devices, so you can have many eGauges communicated via a single HomePlug Ethernet adapter. Communication may be affected above that limit.

Issues arise if there are multiple HomePlug Ethernet adapters connected to the same network. For example, if eGauge01 and HomePlug01 are connected to the same network as eGauge02 and HomePlug02, a routing loop will occur and is very likely to cause the network to crash.

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1 The eGauge model EG30xx has built-in Ethernet and may be used to circumvent the need for a HomePlug adapter.
The solution is to provide eGauge01 and HomePlug01 a separate HomePlug encryption key, such as Key01, while eGauge02 and HomePlug02 are on another, such as Key02.

See 2.2 Changing the HomePlug encryption key to change HomePlug device’s security keys.

2.1.3 How secure is HomePlug communication?

EG301x models uses the HomePlug Green PHY specification and is compatible with HomePlug AV using 128-bit AES encryption. The EG301x and HomePlug AV adapter may be paired using push buttons located on the devices.

eGauge2 models uses a HomePlug 1.0 link to transmit data to the installation site’s LAN. The data on this link is encrypted with 56-bit Data Encryption Standard (DES).

By virtue of the technical limitations described previously, the reach of the HomePlug signal is usually constrained to a single building. More specifically, most transformers will stop the HomePlug signal. For this reason, there is little risk of a third party intercepting the communication. Furthermore, due to the nature of how HomePlug works, even if the HomePlug signal were detectable, it would be exceptionally difficult for a third-party device to interpret the point-to-point traffic between two other devices. Therefore, for most owners of HomePlug devices, privacy of communication is assured without any further steps.

Even if a neighbor could pick up the HomePlug signal, any traffic other than broadcast traffic is difficult to snoop on because the transmission-characteristics of power-lines is so poor that, in practice, communication between any pair of devices cannot be picked up by a third device. In other words, the worst that could happen in such a scenario is that the neighbor could pick up some broadcast traffic or could use your Internet connection for their own purposes.

For extra security and when using HomePlug devices in an apartment or condo, where multiple residences may be powered by a single transformer, it is possible to increase security by establishing a new encryption key to be used for HomePlug traffic. By default, HomePlug 1.0 devices, for use with the eGauge2 are configured to encrypt communication using the default password “HomePlug”. HomePlug AV, for use with the EG301x models, have a default encryption password “HomePlugAV” The HomePlug page under Settings on eGauge can be used to change the default password to a secret password. See 2.2 Changing the HomePlug encryption key on how to change your HomePlug device’s passwords.
2.2 Changing the HomePlug encryption key

2.2.1 Push-button timing for EG301x and HomePlug AV adapters

**EG301x push-button timing**

<table>
<thead>
<tr>
<th>Push Duration:</th>
<th>Status LED:</th>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 – 3 sec</td>
<td>rapidly blinks blue &amp; black</td>
<td><strong>Join mode</strong>: device will attempt to join an existing HomePlug AV network.</td>
</tr>
<tr>
<td>13 – 16 sec</td>
<td>rapidly blinks red &amp; blue</td>
<td><strong>Leave mode</strong>: device randomizes its HomePlug AV encryption key, thus leaving any networks it may have been a member of.</td>
</tr>
<tr>
<td>20 – 30 sec</td>
<td>rapidly blinks red &amp; green</td>
<td><strong>Factory reset</strong>: device restores itself to factory defaults.</td>
</tr>
</tbody>
</table>

**Table 2.1: EG301x push-button times**

**Actiontec PWR-500/PWR-200 HomePlug AV push-button timing**

<table>
<thead>
<tr>
<th>Push Duration:</th>
<th>LEDs:</th>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 – 3 sec</td>
<td>All LEDs blink on and off</td>
<td><strong>Join mode</strong>: device will attempt to join an existing HomePlug AV network.</td>
</tr>
<tr>
<td>5 – 10 sec</td>
<td>All LEDs turn off and on. LK LED should remain off</td>
<td><strong>Leave mode</strong>: device randomizes its HomePlug AV encryption key, thus leaving any networks it may have been a member of.</td>
</tr>
<tr>
<td>14 sec</td>
<td>All LEDs turn off and on</td>
<td><strong>Factory reset</strong>: device restores itself to factory defaults.</td>
</tr>
</tbody>
</table>

**Table 2.2: Actiontec HomePlug AV PWR-500/PWR-200 push-button times**

**TP-Link TL-PA2010 HomePlug AV push-button timing**

<table>
<thead>
<tr>
<th>Push Duration:</th>
<th>LEDs:</th>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 second</td>
<td>Power (top) LED blinks on and off</td>
<td><strong>Join mode</strong>: device will attempt to join an existing HomePlug AV network.</td>
</tr>
<tr>
<td>10 – 11 sec</td>
<td>All LEDs turn off and on. Link LED (middle) should remain off</td>
<td><strong>Leave mode</strong>: device randomizes its HomePlug AV encryption key, thus leaving any networks it may have been a member of.</td>
</tr>
</tbody>
</table>

**Table 2.3: TP-Link TL-PA2010 HomePlug AV push-button times**
2.2.2 Push-button pairing on EG301x and HomePlug adapter AV

eGauge model EG301x can be paired with HomePlug AV adapters using the push buttons located next to the Ethernet port on the eGauge, and the underside of the HomePlug adapter. The eGauge’s push button is internal, so a standard 0.8mm paper clip can be used to activate the push-button located directly behind the hole. Table 2.1 contains the different push-button actions and timing for the EG301x, and table 2.2 contains the different push-button actions and timing for the Actiontec PWR-500 HomePlug AV adapter (see table 2.3 for the TP-Link TL-PA2010 push-button timing).

1. To begin, verify the HomePlug AV adapter and EG301x are powered and within communication range of each other. The HomePlug adapter does not need to be connected to the internet during this phase.

2. Hold the EG301x reset button for 13 – 16 seconds. The eGauge LED will rapidly blink red and blue. Let go of the reset pin at this point. The eGauge will be dissociated with any HomePlug networks, and the LED will alternate between blue and cyan (or solid blue if a static IP is assigned).

3. Hold the HomePlug adapter push button for the appropriate time to initiate leave mode. All LEDs will turn off momentarily. The LNK/Link LED will not be illuminated after this, as the key will be randomized and dissociated with any HomePlug network communication.

4. Hold the eGauge reset pin for 0.5 – 3 seconds. The status LED will begin to rapidly blink blue and black. The eGauge is now in join mode.

5. Hold the HomePlug AV adapter push button for the appropriate time to initiate join mode. The PWR/Power LED will alternate on and off until it is paired or it times out.

The devices will pair. This can take 5 – 120 seconds depending on the signal strength. The eGauge status LED will show green, indicating a good HomePlug link. The LK/Link LED on the HomePlug AV adapter will also illuminate, indicating a HomePlug link.

![Figure 2.1: Actiontec PWR-500 reset button](image1)

![Figure 2.2: EG301x reset pin](image2)
2.2.3 Pairing the eGauge2 or EG301x HomePlug communications through the web interface

Required information
To change the HomePlug encryption key you must know the Device-ID and MAC address for each device (HomePlug and/or eGauge) you wish to put on the same HomePlug network. The MAC address printed on the back of the eGauge will differ by the last bit when viewed from HomePlug settings, as the HomePlug and Ethernet protocols have different MAC addresses.

The Device-ID is a unique 16 character long string unique to each HomePlug device in the format XXXX-XXXX-XXXX-XXXX where X is an uppercase letter. Different manufacturers may identify this value by a different name; Netgear adapters say PWD, IOGear DEK, and Actiontec Device ID or DEK. The MAC address is a 12 character hexadecimal (valid characters are 0 to 9 and A to F) string unique to every network device. It may be in the format XX:XX:XX:XX:XX:XX, or just XXXXXXXXXXXX (Where X is 0 to 9, or A to F). Be sure to match Device-IDs to their corresponding MAC addresses in the following section.

Note that the HomePlug adapter will likely have to be unplugged to view this information, and the eGauge may need to be turned off or removed from the panel if mounted. The MAC address for the eGauge is also available on the installation sheet that shipped with the device, and under View → Device Status on the eGauge when logged in.
Interface configuration steps

The HomePlug password will be changed for the eGauge you are configuring it from, as well as any devices you enter the Device-IDs to. You will NOT see the eGauge currently being used listed on the page! Once you change the password on the devices, they will no longer be able to communicate to devices that do not have the same password or encryption key!

1. Connect to your eGauge.
2. Open the Settings page by clicking the **Settings** link above the upper right corner of the eGauge page.
3. Click on **HomePlug** on the left hand navigation bar.
4. Find the correct MAC address on the listing with the one obtained from the device you wish to pair with the eGauge.
5. Enter the **Device-ID** (or DEK, PWD, etc) to that device.
6. Repeat this step for any additional eGauges you are pairing with this encryption key.
7. Choose a password for the HomePlug network.
8. Click **Save**. You should receive a confirmation message the pairing was successful. If the Device-ID was entered incorrectly, you will get an error and the password will not save.
2.3 Recovery of HomePlug devices

In the event the HomePlug password does not get established on all devices correct, communication with the eGauge may be lost.

There are two ways of rescuing an “orphaned” device.

**Recovery of HomePlug device via eGauge HomePlug interface**

The HomePlug configuration screen on the eGauge has an option for adding the MAC address of an “invisible” device. Here you can enter the MAC address address of an eGauge or a HomePlug that has a unique encryption key with no way to communicate.

![Image](image.png)

**Figure 2.1: Rescuing an orphaned device**

The above situation could be used to reset the encryption key on a HomePlug AV device that has MAC address 22:C0:FF:EE:34:5A and restore communication.

**Recovery of HomePlug 1.0 device via computer software**

These utilities work on Windows computers only, and are designed for HomePlug 1.0. There are other available HomePlug programs but only the Actiontec and Netgear utilities have been tested by eGauge. It is strongly advised you complete all HomePlug pairing via the eGauge interface as these software utilities may operate less clearly or allow you to modify other HomePlug devices unintentionally.

Netgear HomePlug 1.0 configuration utility (under the Software area)

http://support.netgear.com/product/XE104

Actiontec HomePlug 1.0 configuration utility (hosted on eGauge.net):

https://www.egauge.net/misc/HPE100T_Utility.exe

**Recovery of HomePlug AV device via computer software**

TP-Link has a configuration utility that can be used to reset the TL-PA2010 HomePlug adapter or update firmware. This tool may be found at:


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As these HomePlug 1.0 products are discontinued, compatibility of the associated software is not guaranteed.
2.4 Example HomePlug network setups

![Image of eGauge unit with HomePlug network setup]

**Figure 2.1: A single eGauge unit with a HomePlug**

If another HomePlug device is added to the network, the “SecurePassword!” network will be unable to communicate with these new devices (unless those devices’ passwords are set to “SecurePassword!”).

![Image of setting password on multiple eGauges]

**Figure 2.2: Setting a password on multiple eGauges connected to the same HomePlug**

If another HomePlug adapter or eGauge is powered on in range, by default it will not be able to communicate with this group after the password is set.
If the remote eGauge with MAC F8:2F:5B... is communicating with the HomePlug adapter ending with DA:25 in one location and the current eGauge is communicating with HomePlug adapter ending in DA:E5 in another location on the same network, they must have different encryption keys or it can cause a networking loop disrupting all communication on the network.

Note that after configuring the current eGauge to only communicate with HomePlug ending in DA:E5, it will NO LONGER SEE the other eGauge (F8:2F:5B...) and Actiontec adapter (ending in DA:25), as they will be on a different HomePlug network. At this point, changing the password for those devices must be done from the web interface of eGauge F8:2F:5B...