AoIP Network Recommendations
Document reference

Product Name
Part Number: PUB-00011 Rev C

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1 Introduction to AoIP (AES67 and SMPTE-2110 Compliant Audio)

This guide offers guidance for users joining or developing an AoIP network with Clear-Com products in mind. It starts with a general overview and then provides more detail.

- AES67 and SMPTE 2110 are bridging compliances which allow any compliant devices to participate on a network to transport high quality audio over IP (AoIP).

AES67 (Audio Engineering Society) covers the transmission of audio specifically. SMPTE 2110 (Society of Motion Picture and Television Engineers) is a wider specification that covers a range of media essences (for instance, video and data as well as audio). The SMPTE audio standard (SMPTE 2110-30) includes the AES67 standard. For this reason, you will sometimes see AES67 and SMPTE 2110-30 used interchangeably.

- AES67 and SMPTE 2110-30 offer high quality, high density, low latency audio transport over a LAN
- AES67 operates over standard layer 3 Ethernet or fiber networks and both routable and fully scalable
- The standards use the IEEE1588-2008 Precision Time Protocol (PTPv2)

Find more information about the standards here:
http://www.aes.org/publications/standards/search.cfm?docID=96
https://www.smpte.org/smpte-st-2110-faq

1.1 Which Clear-Com Devices Transmit AoIP?

- The E-IPA interface card. E-IPA-HX-XX (where xx indicates the number of ports licensed on the card).
  - You can buy a port license to transmit to 3rd party AoIP devices
  - Transmitting to another Clear-Com device does not require a license
- Clear-Com IP transceivers (IPTs):
  - FreeSpeak II: FSII-TCVR-IP-19
  - FreeSpeak Edge: FSE-TCVR-5-IP
- The Iris Panel. VI-PNL-XX-XX (where XX-XX indicates the number of keys and panel model)

The Iris panel and the E-IPA card work with two different IP transmission modes:
- Clear-Com proprietary IP technology, IVC
- AES67/SMPTE 2110 (AoIP)

*Note:* This guide deals with AoIP audio transmission, not IVC.
AoIP Networking Overview

When deploying Clear-Com AoIP devices, there are three main scenarios you will probably encounter:

- **Clear-Com only**
  - Trunks and/or IP transceivers. Separate 125 μs network segment recommended. The E-IPA-HX card is the leader clock.

- **Mixed media network without FreeSpeak II** (wireless IP transceivers)
  - Clear-Com (panels and trunks) join a broadcast media network with its own leader clock.

- **Mixed media network with FreeSpeak II**
  - Clear-Com IP transceivers join a broadcast media network with its own leader clock. Use PTP aware switches throughout OR use two E-IPA-HX cards to create a separate network segment for IP transceivers.

In all cases:

- IGMP snooping should be enabled on switches. If you enable IGMP snooping you MUST also have a querier on your network (1 per network). **If IGMP snooping is enabled without an IGMP querier, the IP transceiver and the IP panels will not work.**

- DiffServ QoS is mandatory to ensure high timing accuracy

- Energy Efficient Ethernet (IEEE 802.3az)/Green Switch capabilities must be switched OFF
# 2.1 Overview and General Rules When Setting Up a Network for Use with Clear-Com AoIP Devices

<table>
<thead>
<tr>
<th>Network</th>
<th>System</th>
<th>Switch Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small/Medium Clear-Com only</td>
<td>1-20 IPTs&lt;br&gt;Up to 3 layer-2 hops between PTP Leader and IPTs (must not trunk network with other VLANs)&lt;br&gt;Clear-Com AES67 Traffic Only&lt;br&gt;125 µs packets&lt;br&gt;These figures are for guidance only; or instance: even a small system would require PTP-aware switches if the set up involved using more than 3 switches between the leader clock and follower.</td>
<td>DiffServ QoS&lt;br&gt;IGMP Snooping&lt;br&gt;IGMP Querier</td>
</tr>
<tr>
<td>Large Clear-Com only</td>
<td>&gt; 20 IPTs&lt;br&gt;4 layer-2 hops between PTP Leader and IPTs&lt;br&gt;Clear-Com AES67 Traffic Only&lt;br&gt;125 µs packets</td>
<td>DiffServ QoS&lt;br&gt;IGMP Snooping&lt;br&gt;IGMP Querier&lt;br&gt;PTP-aware Transparent and/or Boundary Clocks (BC recommended)</td>
</tr>
<tr>
<td>Mixed Media without FreeSpeak II</td>
<td>PTP profile is defined by existing networked equipment&lt;br&gt;PTP GM is a dedicated device (likely a GPS Leader clock)&lt;br&gt;Packet time is either 125 µs or 1 ms</td>
<td>DiffServ QoS&lt;br&gt;IGMP Snooping&lt;br&gt;IGMP Querier&lt;br&gt;PTP-aware Transparent and/or Boundary Clocks as required by network size</td>
</tr>
<tr>
<td>Mixed Media with FreeSpeak II*</td>
<td>PTP profile is defined by existing networked equipment&lt;br&gt;PTP GM is a dedicated device (likely a GPS Leader clock)&lt;br&gt;Packet time is either 125 µs or 1 ms&lt;br&gt;1+ IPTs</td>
<td>DiffServ QoS&lt;br&gt;IGMP Snooping&lt;br&gt;IGMP Querier&lt;br&gt;All switches must be PTP-aware.</td>
</tr>
</tbody>
</table>

* When setting up mixed media with Freespeak, Clear-Com recommends isolating the FreeSpeak wireless network using a second E-IPA card to reduce setup complexity.
2.2 Clear-Com Only Devices

In this scenario you will work with the default protocol settings of the E-IPA-HX card. The E-IPA card will act as leader clock for the IP transceivers.

- Use 125 µs packet size
- Use the AES67 media profile

*Note:* When setting up trunk ports you must use IGMP snooping.

2.3 Joining a Mixed Media Network (No FreeSpeak)

In this case, the network is likely to have an existing leader clock. You will need to configure PTP profile and other parameters to match that of the existing network. For instance:

- PTP profile (AES67 or SMPTE 2110)
- Packet time (1 ms or 125 µs)

If you are not disabling the E-IPA card leader clock you should take care with Clock priorities 1 and 2. (To disable the E-IPA clock; enable PTP follower mode in **E-IPA-HX Card properties > Protocol settings**).

2.4 Joining a Mixed Media Network (With FreeSpeak)

Clear-Com IP transceivers work best with 125 µs packet time (the devices need to be highly synchronized to achieve DECT and RF synch between transceivers). In a network that mixes 1 ms and 125 µs packet sizes it is easy to experience jitter issues on 125 µs network traffic.

Methods of mitigating this risk include:

- Using two E-IPA-HX cards and putting the IP transceivers into their own network segment.
- If using one E-IPA card, use PTP aware switches throughout the network.

Recommended practice is to use more than one E-IPA-HX card if you are working with a this set up.

*Note:* Before joining equipment, Clear-Com or otherwise to an established media network, we recommend that the equipment is configured and tested in a standalone TEST network.
3

Precision Time Protocol (PTP)

PTP is a protocol used to synchronize clocks in a network, and it can synchronize devices with sub-microsecond accuracy.

Taking steps (discussed below) to optimise clocking accuracy in your network will ensure an efficient environment for all your AoIP devices.

IEEE 1588 PTP uses a leader/follower clocking architecture, with a leader clock synchronizing each network segment. An elected grand leader will provide the root clocking reference.

*Note: The E-IPA card can act as a leader clock. If you do not wish the E-IPA to take over clocking you must enable PTP Follower mode in the E-IPA card properties.*

3.1

PTP Tolerance (Offset from the Leader Clock)

3.1.1 The IP Transceiver

Clear-Com IP transceivers have higher than average timing accuracy requirements due to the need to synchronize the devices in a radio frequency (RF) space.

The following table shows guidelines, rather than rules, as tolerances will vary depending on the use of external PTP leader clocks and where transceivers (and E-IPA card) are located in the network relative to the leader clock.

<table>
<thead>
<tr>
<th>PTP parameters</th>
<th>Value (range)</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offset from the leader clock (OFM)</td>
<td>± 100 ns</td>
<td>Excellent</td>
</tr>
<tr>
<td></td>
<td>± 500 ns</td>
<td>Potential for roaming issues</td>
</tr>
<tr>
<td></td>
<td>± 1,000 ns</td>
<td>Issues with roaming likely</td>
</tr>
<tr>
<td></td>
<td>&gt;± 1,000 ns</td>
<td>Cannot roam between transceivers and intermittent loss-of-lock issues</td>
</tr>
<tr>
<td>Packet travel time* + OFM</td>
<td>• Packet time@ 125 µs &gt; 2 ms</td>
<td>No audio</td>
</tr>
<tr>
<td></td>
<td>• Packet time@ 1 ms &gt; 20 ms</td>
<td></td>
</tr>
</tbody>
</table>

* When E-IPA card is PTP leader, mean path delay (MPD) is the same as packet travel time.

**Offset from Leader (OFM) and Mean Path Delay (MPD)** are shown per transceiver in the EHX Configuration Software. Navigate to System > Monitoring.
3.1.2 The Iris Panel

The Iris panel has a markedly greater PTP (in this case, OFM) tolerance than the IP transceiver. This is because the panels do not have to synchronise in an RF space. Both devices, however, have the same audio buffer (link offset). Link offset is hard coded to the devices, so any audio with greater than 2 ms (@ 125 µs packet time) /20 ms (@ 1 ms packet time) total packet time difference (OFM + packet travel time) will be dropped.

<table>
<thead>
<tr>
<th>Packet time</th>
<th>PTP parameters</th>
<th>Value (range)</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>125 µs</td>
<td>Packet travel time* +OFM</td>
<td>&gt; 2,000,000 ns (2 ms)</td>
<td>No audio</td>
</tr>
<tr>
<td>1 ms</td>
<td>Packet travel time* +OFM</td>
<td>&gt;20,000,000 ns (20 ms)</td>
<td>No audio</td>
</tr>
</tbody>
</table>

* When E-IPA card is PTP leader, mean path delay (MPD) is the same as packet travel time.
3.2 Path Delay Variation (PDV)

PDV (commonly referred to as jitter) refers to the variation, end to end, between packet delivery times. In an active network, the load can change very quickly and this can cause packet delivery time to change. PDV can have a very detrimental impact on synchronization and should be limited as much as possible (see How to Improve Clocking Accuracy and Reduce PDV).

Clear-Com IPTs have a high clocking accuracy requirement due to the need to achieve RF device synchronization.

Taking steps to reduce PDV in your network will ensure an efficiently synchronized environment for all of your AoIP devices.

3.3 How to Improve Clocking Accuracy and Reduce PDV

3.3.1 Prioritization of PTP Traffic Using Quality of Service (QoS)

The AES67 standard (included in SMPTE 2110-30) imposes rules on manufacturers regarding QoS prioritization. The devices and the network must follow the AES67 recommendations to ensure a uniform understanding of priorities between all devices.

QoS is mandatory when using Clear-Com AoIP equipment.

*Note: CoS is not sufficient for use with Clear-Com AES67 devices.*

The switches used must support DiffServ QoS (RFC 2474) and be set to operate with the AES67 standard values shown in the following table:

<table>
<thead>
<tr>
<th>Class name</th>
<th>Traffic type</th>
<th>Default DiffServ class (DSCP decimal value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Media</td>
<td>RTP and RTCP media stream data</td>
<td>AF41 (34) (Assured Forwarding)</td>
</tr>
<tr>
<td>Best Effort</td>
<td>IEEE 1588-2008 signalling and management messages. Discovery and connection management messages.</td>
<td>DF (O) (Default Forwarding)</td>
</tr>
</tbody>
</table>
**Note:** Some third party devices (for instance, Dante) use different DSCP values for PTP and Media. These clash with the values in the chart above. In these cases, it may be necessary to re-mark DSCP values. This can be done in your network switch configuration.

### 3.3.2 Switch Priority Queues

The following apply:

- The Clock queue must be configured in Strict Priority mode, not Weighted Round-Robin
- The Clock class must be the highest-level priority
- The Clock and Media packets should not be placed at the same priority
- If QoS trust options are available, ensure DSCP is trusted.

### 3.3.3 PTP Settings

The E-IPA card has two available PTP profiles, AES67 and SMPTE 2110 (ST 2059-2). These default values, shown in the table below can be adjusted as appropriate. However, in most cases you will use the standard PTP values defined by the profiles.
<table>
<thead>
<tr>
<th>Attribute</th>
<th>AES67 Profile</th>
<th>SMPTE Profile</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domain Number</td>
<td>0</td>
<td>127</td>
<td>The domain attribute of the local clock.</td>
</tr>
<tr>
<td>Announce Interval</td>
<td>1</td>
<td>-2</td>
<td>The mean time interval between Announce messages. A shorter interval allows faster reactions to the changes in the leader-follower hierarchy. The interval should be the same in the whole domain. It is specified as a power of two in seconds. $2^1 = 2$ seconds between messages. Adapted from <a href="https://linux.die.net/man/8/ptp4l">https://linux.die.net/man/8/ptp4l</a></td>
</tr>
<tr>
<td>Sync Interval</td>
<td>-3</td>
<td>-3</td>
<td>The mean time interval between Sync messages. A shorter interval may improve accuracy of the local clock. It is specified as a power of two in seconds. $2^{-3} = 0.125 = 8$ per second. Adapted from <a href="https://linux.die.net/man/8/ptp4l">https://linux.die.net/man/8/ptp4l</a></td>
</tr>
<tr>
<td>Min Delay Req Interval</td>
<td>0</td>
<td>0</td>
<td>The minimum permitted mean time interval between Delay_Req messages. A shorter interval allows faster reactions to the changes in the path delay. It is specified as a power of two in seconds. $2^0 = 1$ second. Adapted from <a href="https://linux.die.net/man/8/ptp4l">https://linux.die.net/man/8/ptp4l</a></td>
</tr>
<tr>
<td>Announce Receipt Timeout</td>
<td>3</td>
<td>3</td>
<td>The number of missed Announce messages before the last Announce messages expires. From <a href="https://linux.die.net/man/8/ptp4l">https://linux.die.net/man/8/ptp4l</a></td>
</tr>
<tr>
<td>Priority1</td>
<td>254 (IPT)</td>
<td>254 (Iris panel)</td>
<td>The priority1 attribute of the local clock. It is used in the best leader selection algorithm. Lower values take precedence. Must be in the range 0 to 255. The default value for a generic AES67 device is 128. IPTs (transceivers) and Iris panels are priority 254. E-IPA-HXs (card) are priority 127. Adapted from <a href="https://linux.die.net/man/8/ptp4l">https://linux.die.net/man/8/ptp4l</a></td>
</tr>
</tbody>
</table>

The definition of profile may vary depending on switch manufacturers.
If the profile you require is not available or specified, make sure that the boundary clock switch or grandleader clock respects the following criteria:

- PTP messages must be sent using layer 3 IP packets
- PTP QoS setting must use DSCP tagging with type expedited forwarding (that is, DSCP 46)
- Leader announcement messages sent every 2 seconds

### 3.3.4 Spanning Tree Protocol (STP/RSTP)

Multiple possible routes between the PTP leader and the follower(s) will very likely increase PDV. Do one of the following:

- Make sure that there is only one physical route between the leader and follower.
- Enable STP/RSTP which closes multiple routes when they are found.

### 3.3.5 PTP Aware Switches

PTP aware switches can be configured to prioritize PTP traffic. Although a PTP aware switch is more expensive than the alternative, its benefits are often worth the extra cost because a network consisting of PTP aware switches can almost eliminate PDV. PTP aware switches automatically prioritise PTP traffic so a network incorporating PTP aware switches is less sensitive to the disruptive effects that can be generated by other network traffic.

*Note: A boundary clock breaks up the grandleader hierarchy and will take over clock synchronization if the grandleader is lost. A transparent clock cannot do this.*

### 3.3.6 VLANs

If you still experience synchronization problems on your network, (high jitter or offset from the leader) after trying the above steps (for example, QoS and PTP profile) then consider setting up a separate VLAN for Clear-Com AES67 traffic.

### 3.4 Internet Group Management Protocol (IGMP)

*Note: Clear-Com devices only support IGMP. They do not support Single Source Multicast (SSM). If you are transmitting to a network that uses SSM, this will require additional configuration on your switch.*
AES67 supports both unicast and multicast streaming. For multicast, AES67 specifies the use of the IGMPv2 (RFC 2236) protocol for management of traffic. With IGMP snooping properly configured on network switches, multicast traffic is only forwarded to ports where active listeners are present. This prevents saturation of bandwidth and reduces clutter on the network. For more information about configuring switches with IGMP snooping, see Configuration for Network Switches with IGMP Snooping.

The following apply:

- Clear-Com AoIP devices use multicast for device discovery and PTP
- IGMPv2 snooping is recommended when using Clear-Com AoIP devices.

**Note:** If IGMP is enabled, without the IGMP querier, the devices will not work as the switch will stop forwarding multicast packets.

### 3.4.1 Configuration for Network Switches with IGMP Snooping

The following apply:

- If IGMP snooping is enabled on a switch, one device on the network must also have an IGMP querier enabled (one per network).
- If available, IGMP querier election should be enabled.

### 3.5 AoIP Audio

Clear-Com AoIP devices use:

- **Unicast**: Iris and IP transceivers (FreeSpeak II and FreeSpeak Edge)
- **Multicast**: trunks and directs link offset (audio buffer)
  - 125 µs packet time: 2ms
  - 1 ms packet time: 20ms

### 3.6 Bandwidth

Use a non-blocking switch.

Example switch capacity

<table>
<thead>
<tr>
<th>Number of ports on the switch</th>
<th>Individual port capacity</th>
<th>Overall capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>1Gbps</td>
<td>24 ports x 1 Gbps X2 (full duplex) = 48 Gbps</td>
</tr>
</tbody>
</table>
1 x FS II IPT bandwidth usage: ~7 Mbps.

1 x FS Edge IPT: ~ 9.6 Mbps

1 x Iris panel bandwidth usage: ~5 Mbps, then ~1.5 Mbps for each additional channel (up to a total of 3 channels, so ~8 Mbps).

Clear-Com recommends not using more than 75% of the bandwidth on any one switch.

Note: 100m is the maximum cable length for copper cable, depending on cable quality. For distances over 80m you should use CAT6 cable.

### 3.7 AoIP Bandwidth Calculation

<table>
<thead>
<tr>
<th>Bandwidth</th>
<th>Channels</th>
<th>48000</th>
<th>48000</th>
</tr>
</thead>
<tbody>
<tr>
<td>AES Direct</td>
<td>1</td>
<td>16</td>
<td>4.224</td>
</tr>
<tr>
<td>*</td>
<td>1</td>
<td>24</td>
<td>4.608</td>
</tr>
<tr>
<td>1</td>
<td>32</td>
<td>4.992</td>
<td>78</td>
</tr>
<tr>
<td>2</td>
<td>16</td>
<td>4.992</td>
<td>78</td>
</tr>
<tr>
<td>2</td>
<td>24</td>
<td>5.760</td>
<td>90</td>
</tr>
<tr>
<td>2</td>
<td>32</td>
<td>6.528</td>
<td>102</td>
</tr>
<tr>
<td>3</td>
<td>16</td>
<td>5.760</td>
<td>90</td>
</tr>
<tr>
<td>3</td>
<td>24</td>
<td>6.912</td>
<td>108</td>
</tr>
<tr>
<td>3</td>
<td>32</td>
<td>8.064</td>
<td>126</td>
</tr>
<tr>
<td>4</td>
<td>16</td>
<td>6.528</td>
<td>102</td>
</tr>
<tr>
<td>4</td>
<td>24</td>
<td>8.064</td>
<td>126</td>
</tr>
<tr>
<td>4</td>
<td>32</td>
<td>9.600</td>
<td>150</td>
</tr>
<tr>
<td>IRIS</td>
<td>1</td>
<td>32</td>
<td>4.992</td>
</tr>
<tr>
<td>2</td>
<td>32</td>
<td>6.528</td>
<td>102</td>
</tr>
<tr>
<td>3</td>
<td>32</td>
<td>8.064</td>
<td>126</td>
</tr>
<tr>
<td>4</td>
<td>32</td>
<td>9.600</td>
<td>150</td>
</tr>
<tr>
<td>IPT</td>
<td>2</td>
<td>32</td>
<td>6.528</td>
</tr>
<tr>
<td>EDGE</td>
<td>4</td>
<td>32</td>
<td>9.600</td>
</tr>
</tbody>
</table>

* Default setting
4 Switch Topology

4.1 Example of a Switch Set Up Used at Clear-Com

Key

- Cat5e/6a Ethernet cable 23/24 AWG (max 100m)

10 IPTs connected to this switch

10 IPTs connected to this switch

CISCO IE4010 Boundary clock

CISCO SG350

E-IPA Leader clock

6 Iris panels connected to this switch
4.2 Example Using Switch Hops and Grandleader Clock

![Diagram showing network topology with E-IPA card and Trilogy Mentor RG grandleader clock]

E-IPA card
PTP leader clock

PTP follower 1
PTP follower 2
PTP follower 3
PTP follower 4

Note: in this configuration, RSTP/STP needs to be enabled

4.3 Routing over subnets

Routing across subnets requires the following network provisioning:
• High bandwidth, guaranteed bandwidth to support audio streams, low network latency and very low network jitter.

• The use of QoS, IGMP and VLANS to separate the AES67/ST2110 streams from other data on the network.

• The Ethernet switch fabric to be made up of enterprise grade switches that support boundary / transparent clock mode.

• Ensure Spine / Leaf uplinks are large enough to supports all end points on the leaf receiving audio.

This can be achieved by using:

• Private or leased fiber connections

• Private or leased lines like Multi Protocol Label Switching (MPLS) or similar services

**Important notes**

From EHX v.12.1 or later, enter **gateway information** into the E-IPA-HX, Freespeak IP transceiver (IPT), or Iris Panel IP address settings.

The same rules and network provisions required to support Clear-Com devices on a layer 2 network also apply to a routed layer 3 network.

The switch acting as the layer 3 router must also have the ARP proxying capabilities enabled. Otherwise, the AES67 packets might be routed incorrectly.

### 4.3.1 Remote location topologies

If you are looking to deploy endpoints across different locations, there are typically two topologies.

**Single*** Grandleader located at one site.

*Note there may be a pair of GLs located at the main site for redundancy.

**Note:** *The network blocks are shown for simplicity but may contain several switches in the overall topology.*
Local and remote * Grandleaders

*Note there may be a pair of GMs located at each site for redundancy.

Both GMs must be GPS locked, no PTP passes across the two sites.

The IPA will pass PTP domain information to the IPT (or Iris Panel) and hence the PTP profile at the remote site must match the PTP profile at the local side.

**Note:** The network blocks are shown for simplicity but may contain several switches in the overall topology.

The network must still meet OFM and overall packet time limits as outlined in this document.
5 Switch Settings

This section describes how to configure the Luminex GigaCore26i switch and the Cisco SC300.

5.1 Switch Settings for the Luminex GigaCore26i

All configuration can be achieved from the Web interface. QoS is pre-configured, you only need to configure IGMP and PTP.

IP address configuration

Do the following:

1. Locate the default IP address on the sticker on the back of the switch. Configure your PC/laptop to be on the same subnet with a different IP address.

2. Using a web browser, type the default IP address of the switch into your address bar. The Settings page will load from the switch.

3. Once on the Settings page, go to Global in the left navigation, and then change the IP Settings parameters

4. Click Apply.
5. On your browser, type the newly configured IP address of the switch to bring up the Settings page.

**IGMP global setting**

Do the following:

1. Go to **Global > Device Settings** and deselect the **IGMP unknown-flooding state**.
Configure a group/VLAN and assign it to physical ports

Do the following:

1. Go to **Groups**.
2. Use the wheel to select a free group (that is, VLAN).
3. Click on **Advanced** and configure the **VLAN ID** that will be used on the network.
4. Click **Apply**.

5. Click on **Assign** followed by all the ports you want within this VLAN. The port color will change to match the group/VLAN color on the wheel. Click on **Assign** again to confirm.

Group/VLAN setting for IGMP and PTP

Do the following:
1. Go to **Groups**.
2. Use the wheel to select the proper group (that is, VLAN).
3. Activate IGMP by check-marking the following options:
   - Snooping
   - Querier.
4. Activate PTP by check-marking **PTPv2**, and then select the **E2E** mode.
5. Click **Apply** to save the configuration.

**Notes:** All ports will be access ports (that is, untagged) UNLESS assigned to the ISL group, in which case the port will be configured as a trunk and all traffic coming in and out will be VLAN-tagged.

Only one group/VLAN can have PTP activated at a given time. Make the activated group/VLAN transporting PTP data and AES67 media traffic.

All changes done through the Web interface are activated immediately and automatically saved.
5.2 Switch Settings for the Cisco SG350X-24PD

Model Note: Cisco offers SG350 and SG350X models. There is one key difference in that the SG350X models offer Cisco XG Ports, used for switch stacking. Differences in each model are explained below each section. Screen captures using SG350X.

Apply the following configuration changes:

1. Disable the Energy Efficient Ethernet (EEE), via Port Management > Green Ethernet > Properties
   a. Disable EEE by unchecking selection.
   b. Apply and Save

![Screen capture of SG350X-24PD showing Port Management settings]

Model Note: There are no configuration differences between models.

2. Enable IGMP Snooping and Querier, via Multicast > IPv4 Multicast Configuration > IGMP Snooping
   a. Enable IGMP Snooping Status
   b. Enable IGMP Querier Status
   c. Select the VLAN assigned for AES67, and choose Edit
   d. Enable IGMP Snooping Status
e. Enable **Immediate Leave**

f. Enable **IGMP Querier Status**

g. Set **IGMP Querier Version to v2**

h. Define a **Querier Source IP Address**

**This may be set to auto if using a single switch or a single querier. If using Querier Proxy configurations across multiple switches, choose your Querier address using User Defined.**

i. **Apply** and **Save**

---

**Model Note**: There are no configuration differences between models.

3. **Configure the QoS Trust settings** via **Quality of Service > QoS Basic Mode > Global Settings**

   a. Set **Trust Mode** to **DSCP**

   b. **Apply** and **Save**
Model Note: There are no configuration differences between models.

4. Configure the Queue Priorities via Quality of Service > General > Queue
   a. Set ALL Queues to use Strict Priority
   b. Apply and Save
Model Note: There are no configuration differences between models.

5. DSCP to Queue Mapping

Before configuring the Queue mapping, we should understand the Queue Table variances between switch models.

DSCPs in Clear-Com

- The clock class (46 – EF) must be in the highest priority
- The audio class (34 – AF41) must be in the next highest priority
- Best Effort (0 – BE) must be in the lowest priority

Queue Table
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>DSCP</td>
<td>Service Class</td>
<td>1-4 Queue</td>
<td>1-8 Queue</td>
<td>1-7 Queue + Stack (8)</td>
</tr>
<tr>
<td>0 (BE)</td>
<td>Best Effort</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>34 (AF41)</td>
<td>Audio Traffic</td>
<td>3</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>46 (EF)</td>
<td>Expedited Forwarding</td>
<td>4</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Network Control</td>
<td>Inter-switch</td>
<td>n/a</td>
<td>n/a</td>
<td>8</td>
</tr>
</tbody>
</table>

- 1-4: Queue 1 has the lowest priority, where Queue 4 has the highest priority.
- 1-8: Queue 1 has the lowest priority, where Queue 8 has the highest priority.
- 1-7+Stack (8): Queue 1 has the lowest priority, where Queue 7 has the highest priority. Queue 8 is used for Network (Stack) Control.

**Notes** If using *802.1p COS*, the Queues are prioritized differently due to Layer 2 limitations. Please consult your Cisco Manual.

If using *QOS-Advanced*, please consult your Cisco Manual

The prioritization of services on your network is ultimately a network design and administration decision and will vary depending on network use. Because of this, we can only present the following examples as used on networks with dedicated VLANs for Clear-Com AES67 devices.

A. **Configure the QoS to 1-7 Queue mapping** (SG350X) (Stack Configuration)

(Using Queue 1-7, where Queue 8 is used for Network Stack Control).

Quality of Service > General > DSCP to Queue

a. Check that **0 (BE)** is defaulted to **Queue 1**

b. Change 34 (AF41) to Queue 6
c. Check that 46 (EF) is defaulted to Queue 7

B. Configure the QoS to 1-8 Queue mapping (SG350) (Stand Alone Switch) (Using Queue 1-8 – Switch standalone)

Quality of Service > General > DSCP to Queue

a. Check that 0 (BE) is defaulted to Queue 1
b. Change 34 (AF41) to Queue 7
c. Change 46 (EF) to Queue 8


**Note:** Default values above for other services will be different.

(Optional, suggested if possible)

6. **Configure a local DHCP Server**

   Display Mode: Advanced

   ![DHCP Server Configuration](image)

**IP Configuration > DHCP Server > Properties**

**Enable DHCP Server**

![DHCP Server Options](image)

**Note:** Enables this switch as a local DHCP Server.

DHCP Server can be configured as a proxy elsewhere.
7. **Configure a local DHCP Network Pool**

In the example below, we chose to use a specific DHCP Address range of 10.50.67.101-10.50.67.199. This leaves a range of static and dynamic IPs within the subnet. The DHCP Pool can then be used simply for discovering devices before setting to static, or for normal use.

**IP Configuration > DHCP Server > Network Pools**

**Add a Network Pool**

![Network Pool Configuration](image)
Notes: **Subnet IP Address:** use the subnet assigned to AES67 devices.

**Address Pool Start/Stop:** you may use the entire range or split up the subnet between static and dynamic addresses.

**Lease Duration:** set this to **infinite**. If a lease expires on a Clear-Com AES67 device, the address will drop, but the unit will not request a new lease until it is restarted or power cycled.
5.3 Switch Settings for the Cisco SG300

Do the following:

1. Disable the Energy Efficient Ethernet (EEE).

2. Enable IGMP Snooping and Querier.
3. Configure the QoS Trust settings.

4. Configure the Queue Priorities.
5. Configure the QoS to Queue mapping.
5.4 Artel Quarra 1G / 10G AES67 PTP Setup Guide (Boundary Clock)

This guide makes the assumption that the E-IPA card will be PTP grandleader and is using the E-IPA's default protocol settings (pictured below).

If using an external GM or custom protocol settings, make sure the differences are reflected in the PTP Clock Configuration section of this guide.

**E-IPA-HX Card Properties**

- **Use IVC settings for Admin connection**
- **E-IPA-HX Port License:** E-IPA-32-HX
- **Redundancy Mode:** No redundant card available
- **View card license:** [Open in browser]

**PTP Follower mode:**
- **Packet time:** 125 μs
- **RTP Payload ID:** 98
- **PTP profile:** AES67 Media
- **PTP domain:** 0
- **PTP priority A:** 127
- **PTP priority B:** 127
- **Announce Interval:** -2 (250 ms)
- **Ann. Receipt Timeout:** 3
- **Sync Interval:** -3 (125 ms)
- **SDP:** [Open Viewer]

**Configuration → Green Ethernet → Port Power Savings:**
- Uncheck Power Saving for all ports connected to Clear-Com devices
- Click 'Save'
Configuration → IPMC → IGMP Snooping → Basic Configuration:
• Check ‘Snooping Enabled’, ‘Leave Proxy Enabled’ and ‘Proxy Enabled’
• Click ‘Save’

Configuration → IPMC → IGMP Snooping → VLAN Configuration:
• Click ‘Add New IGMP VLAN’
• Check ‘Snooping Enabled’
• Check ‘Querier Election’
• Select ‘Forced IGMPv2’ under Compatibility
• Click ‘Save’

Configuration → QoS → QoS Ingress Port Classification:
• Check ‘DSCP Based’ for all ports
• Click ‘Save’
Configuration → QoS → DSCP-Based QoS Ingress Classification:

• Change the ‘QoS Class’ values for ‘DSCP 34 (AF31)’, and ‘DSCP 46 (EF)’ to 4 and 7 respectively.

• Check the ‘Trust’ box for both DSCP 34 and 46

Configuration → PTP → PTP Clock Configuration:

• Click ‘Add New PTP Clock’

• Select ‘Ord-Bound’ from the ‘Device Type’ dropdown menu

• Click ‘Save’
Configuration → PTP → PTP Clock Configuration:

- Click the ‘Clock Instance’ of the new clock (Clock Instance 0 in this example) in order to open this ‘PTP Clock’s Configuration and Status’ page and amend the settings under each header below:

  - ‘Port Enable and Configuration’ : Check all ports that need to subscribe to PTP

  - Clock Default DataSet’ :
    - ‘2 Step Flag’ = ‘True’
    - ‘Dom’ = ‘0’
    - ‘Protocol’ = ‘IPv4Multi’

  - ‘Clock Time Properties DataSet’ :
    - ‘UtcOffset’ = ‘37’

  - Click ‘Save’
Configuration → PTP → PTP Clock Configuration:

• Click the ‘Clock Instance’ of the new clock (Clock Instance 0 in this example) in order to open this ‘PTP Clock’s Configuration and Status’ page:

  • ‘Port Enable and Configuration’ : Click ‘Ports Configuration’

    • For all ports:

      • Announce Interval ‘Anv’ = ‘1’

      • Announce Receipt Timeout ‘ATo’ = ‘3’

      • Sync Interval ‘Syv’ = ‘-3’

    • Click ‘Save’

Maintainance → Configuration → Save Startup-config:

• Click ‘Save Configuration’ to make these changes persist after power cycle.
5.5 Artel Quarra 1G / 10G AES67 PTP Setup Guide (Transparent Clock)

This guide makes the assumption that the E-IPA card will be PTP grandleader and is using the E-IPA's default protocol settings (pictured below)

If using an external GM or custom protocol settings, make sure these differences are reflected in the PTP Clock Configuration section of this guide.

![E-IPA-HX Card Properties](image)

**Configuration → Green Ethernet → Port Power Savings:**

- Uncheck Power Saving for all ports connected to Clear-Com devices
- Click 'Save'
Configuration → IPMC → IGMP Snooping → Basic Configuration:

• Check ‘Snooping Enabled’, ‘Leave Proxy Enabled’ and ‘Proxy Enabled’
• Click ‘Save’

Configuration → IPMC → IGMP Snooping → VLAN Configuration:

• Click ‘Add New IGMP VLAN’
• Check ‘Snooping Enabled’
• Check ‘Querier Election’
• Select ‘Forced IGMPv2’ under Compatibility
• Click ‘Save’

Configuration → QoS → QoS Ingress Port Classification:

• Check ‘DSCP Based’ for all ports
• Click ‘Save’
**Configuration → QoS → DSCP-Based QoS Ingress Classification:**

- Change the ‘QoS Class’ values for ‘DSCP 34 (AF31)’, and ‘DSCP 46 (EF)’ to 4 and 7 respectively.

- Check the ‘Trust’ box for both DSCP 34 and 46

**Configuration → PTP → PTP Clock Configuration:**

- Click ‘Add New PTP Clock’

- Select ‘E2eTransp’ from the ‘Device Type’ dropdown menu

- Click ‘Save’
Configuration → PTP → PTP Clock Configuration:

- Click the ‘Clock Instance’ of the new clock (Clock Instance 0 in this example) in order to open this ‘PTP Clock’s Configuration and Status’ page and amend settings under each header below:
  
  - ‘Port Enable and Configuration’ : Check all ports that need to subscribe to PTP
  - ‘Clock Default dataSet’:
    
    - ‘2 Step Flag’ = ‘True’
    - ‘Dom’ = ‘0’
    - ‘Protocol’ = ‘IPv4Multi’
    - ‘DSCP’ = ‘46’
  
  - Click ‘Save’

Maintenance → Configuration → Save Startup-config:

- Click ‘Save Configuration’ to make these changes persist after power cycle.
6 Troubleshooting Tips

This section provides general network troubleshooting advice, and specific configuration rules for the Eclipse HX E-IPA card.

6.1 General Network Troubleshooting

The following general troubleshooting tips apply:

- Minimum switch spec: 1 G ports, switching or line speed is 2 x port count, supports DiffServ QoS.
- Check network topology: how many hops between the grandleader PTP clock and the IPT transceiver/Iris panel.
- DHCP or static IP addresses: check for IP clash
- Ensure all the switches have the same DiffServ QoS settings
  - PTP data packets set to DiffServ EF(46) and placed in the highest queue
  - Media (RTP/RTCP AES67 audio) packets set to DiffServ AF41 (34) and placed in the 2nd highest queue.
- If possible separate the Clear-Com equipment onto a separate LAN or VLAN without any other manufacturers’ equipment. Then check for errors.
- Use the EHX monitoring screen to check PTP status of the transceivers
- Use Wireshark or PTP Track Hound to verify PTP packets are getting to the correct devices
- Use the mirrored port function on the Ethernet switch to help with the Wireshark capture
- Use the EHX monitoring screen to check which device is the PTP grandleader clock and if that device is stable.
- Ensure that IGMP snooping is enabled on the LAN/VLAN that the IP Transceivers are connected to.
  - Ensure that only one IGMP querier is enabled on this network
- If using a Spine Leaf network topology, ensure that RSTP is enabled on inter-switch connections
- Double check that any boundary clock device is set up correctly
• Ethernet switches can be programmed so that each port:
  ◦ Only allows one device per port and this is controlled by the MAC address of the device (sometimes known as ‘sticky ports’). If a device with a different MAC address is connected it will shut the Ethernet port down.
  ◦ Slowly learns if the connected device is another Ethernet switch or a host (end) device. The time taken to learn about the connected device can be over 30 secs before the port starts to forward data (sometimes referred to as PortFast setting).
  ◦ Contact your IT administrator about STP and PortFast settings on your Ethernet switches.

6.2 E-IPA Configuration Rules

The following apply:

• Admin & IVC must be on different subnets if split.
• AES67 must not be connected to the same LAN/VLAN as Admin & IVC, unless sharing the same rear connection.
• Do not connect more than one cable from the E-IPA to the same LAN/VLAN. Otherwise, a broadcast storm could occur.
• When using Clear-Com AoIP ports:
  ◦ Direct (AoIP stream)
  ◦ Direct (AoIP channel)
Trunk (AoIP); the E-IPA card AoIP LAN port must have a static IP address.

DHCP is not enabled when using AoIP ports.
7 Limited Warranty

Clear-Com warrants that at the time of purchase, the equipment supplied complies with any specification in the order confirmation when used under normal conditions and is free from defects in workmanship and materials during the warranty period.

During the warranty period Clear-Com, or any service company authorized by Clear-Com, will in a commercially reasonable time remedy defects in materials, design, and workmanship free of charge by repairing, or should Clear-Com in its discretion deem it necessary, replacing the product in accordance with this limited warranty. In no event will Clear-Com be responsible for incidental, consequential, or special loss or damage, however caused.

7.1 Warranty Period

The product may consist of several parts each covered by a different warranty period. The warranty periods are:

- Cables, accessories, components, and consumable items have a limited warranty of 90 days.
- Headsets, handsets, microphones, and spare parts have a limited warranty of one year.
- UHF wireless IFB products have a limited warranty of one year.
- UHF wireless intercom systems have a limited warranty of three years.
- All other Clear-Com and Drake brand systems and products, including beltpacks, have a limited warranty of two years.

The warranty starts at the time of the product’s original purchase. The warranty start date for contracts which include installation and commissioning will commence from the earlier of date of the Site Acceptance Test or three months from purchase.

7.2 Technical Support

To ensure complete and timely support to its customers, Clear-Com’s User Support Center is staffed by qualified technical personnel. Telephone and email technical support is offered worldwide by the User Support Center.

The User Support Center is available to Clear-Com’s customers during the full course of their warranty period. Telephone support during the warranty period will be offered at no charge between 09:00 and 17:00 according to the customer’s local time zone.
In addition, for customers who purchase an Extended Warranty or Service Contract, 24-hour customer support is offered immediately upon purchase of such agreement. For more information, contact your authorized dealer, distributor, or sales representative.

Instructions for reaching Clear-Com’s User Support Centers are given below.

**Americas and Asia-Pacific Headquarters California, United States**
Tel: +1.510.337.6600
Email: CustomerServicesUS@clearcom.com

**Europe, Middle East, and Africa Headquarters Cambridge, United Kingdom**
Tel: +44 1223 815000
Email: SalesSupportEMEA@clearcom.com

**Canada Office Quebec, Canada**
Tel: +1 (450) 653-9669

**China Office Beijing Representative Office Beijing, P.R.China**
Tel: +8610 65811360 / 65815577

Once the standard warranty period has expired, the User Support Center will continue to provide telephone support if you have purchased an Extended Warranty or Service Contract. In these cases, you will have access to telephone support 24 hours per day, 7 days per week.

### 7.3 Warranty Repairs and Returns

Before returning equipment for repair, contact a User Support Center to obtain a Return Material Authorization (RMA). Clear-Com representatives will give you instructions and addresses for returning your equipment. You must ship the equipment at your expense, and the support center will return the equipment at Clear-Com’s expense.

For out-of-box failures, use the following contact information:

**Americas and Asia-Pacific Headquarters California, United States**
Tel: +1.510.337.6600
Email: CustomerServicesUS@clearcom.com

Europe, Middle East, and Africa Headquarters Cambridge, United Kingdom
Tel: +44 1223 815000
Email: SalesSupportEMEA@clearcom.com

Canada Office Quebec, Canada
Tel: +1 (450) 653-9669

China Office Beijing Representative Office Beijing, P.R.China
Tel: +8610 65811360 / 65815577

Clear-Com has the right to inspect the equipment and/or installation or relevant packaging.

7.4 Non-Warranty Repairs and Returns

For items not under warranty, you must obtain an RMA by contacting the User Support Center. Clear-Com representatives will give you instructions and addresses for returning your equipment.

You must pay all charges to have the equipment shipped to the support center and returned to you, in addition to the costs of the repair.

7.5 Extended Warranty

If you purchase an Extended Warranty, you are also given access free of charge to the User Support Center 24 hours a day, 7 days a week.

You can purchase an extended warranty at any time during the first two years of ownership of the product. The purchase of an extended warranty extends to five years the warranty of any product offered with a standard two-year warranty. The total warranty period will not extend beyond five years. Any purchase of an extended warranty provides 24 x 7 customer support in addition to the warranty immediately upon purchase of the warranty extension.

Note Clear-Com does not offer warranty extensions on UHF wireless intercom systems, or on any product with a 1-year or 90-day warranty.
7.6 Service Contract

Clear-Com also offers service contracts that provide 24 x 7 telephone support, advance replacements, training, proactive maintenance, on-site visits, and no charge for repair or replacement of equipment. For more information, contact your authorized dealer, distributor, or sales representative.

7.7 Liability

THE FOREGOING WARRANTY IS CLEAR-COM’S SOLE AND EXCLUSIVE WARRANTY. THE IMPLIED WARRANTY OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE AND ANY OTHER REQUIRED IMPLIED WARRANTY SHALL EXPIRE AT THE END OF THE WARRANTY PERIOD. THERE ARE NO OTHER WARRANTIES (INCLUDING WITHOUT LIMITATION WARRANTIES FOR CONSUMABLES AND OTHER SUPPLIES) OF ANY NATURE WHATSOEVER, WHETHER ARISING IN CONTRACT, TORT, NEGLIGENCE OF ANY DEGREE, STRICT LIABILITY OR OTHERWISE, WITH RESPECT TO THE PRODUCTS OR ANY PART THEREOF DELIVERED HEREUNDER, OR FOR ANY DAMAGES AND/OR LOSSES (INCLUDING LOSS OF USE, REVENUE, AND/OR PROFITS). SOME STATES DO NOT ALLOW THE EXCLUSION OR LIMITATION OF INCIDENTAL OR CONSEQUENTIAL DAMAGES OR THE LIMITATION ON HOW LONG AN IMPLIED WARRANTY LASTS, SO THE ABOVE LIMITATIONS MAY NOT APPLY TO YOU.

IN ANY EVENT, TO THE MAXIMUM EXTENT PERMITTED UNDER APPLICABLE LAW, CLEAR-COM’S LIABILITY TO CUSTOMER HEREUNDER SHALL NOT UNDER ANY CIRCUMSTANCES EXCEED THE COST OF REPAIRING OR REPLACING ANY PART(S) FOUND TO BE DEFECTIVE WITHIN THE WARRANTY PERIOD AS AFORESAID.

This warranty does not cover any damage to a product resulting from cause other than part defect and malfunction. The Clear-Com warranty does not cover any defect, malfunction, or failure caused beyond the control of Clear-Com, including unreasonable or negligent operation, abuse, accident, failure to follow instructions in the manual, defective or improperly associated equipment, attempts at modification and repair not approved by Clear-Com, and shipping damage. Products with their serial numbers removed or defaced are not covered by this warranty.

This warranty does not include defects arising from installation (when not performed by Clear-Com), lightning, power outages and fluctuations, air conditioning failure, improper integration with non-approved components, defects or failures of customer furnished components resulting in damage to Clear-Com provided product.

This limited warranty is not transferable and cannot be enforced by anyone other than the original consumer purchaser.
This warranty gives you specific legal rights and you may have other rights which vary from country to country.