AoIP Network Recommendations

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AoIP Pre-sales Information

1 Pre-Sales Overview

Note: *Chapter 1 of this guide is intended to assist you during the pre-sales stage of your design. Chapters 2-8 assist you during the installation phase.*

Audio-over-IP, (a solution for transmitting digital audio signals via IP networks), is gradually replacing traditional point-to-point audio connections. One of the standards developed by the Audio Engineering Society to meet this AoIP networking solution is the AES67 digital audio technical standard; this is used by Clear-Com in several hardware solutions. In this user guide the term AoIP will sometimes be used interchangeably to describe AES67.

To ensure maximum stability of the PTP clock (and audio packets) across the network Clear-Com recommends the use of QoS and IGMP. Furthermore, PTP aware switches should be used where possible as these provide the most stable operation. If PTP aware switches are not feasible, the specific requirements will depend on the topology of the existing network. **See section 1.5 for more detailed examples**.

Ensure your selected Ethernet switch meets the minimum specification required for AES67 (audio only) networks, as detailed in this document. **Minimum Ethernet Switch Requirements for AES67 Audio on page 31**).

For a successful AES67 installation with your Clear-Com system, Clear-Com advises having a network engineer available on site who knows how to configure the network switches and understands the requirements of AES67 systems.

It is best practice to set up and do a bench test (in your office or warehouse) before installing on site, or ensure the customer has a standalone test network where they can install and test new equipment offline before integrating it into the main IP network.

From Arcadia v. 3.0 and above, the Arcadia and Edge intercom stations can function as either Leader or follower only clock (enable/disable **PTP Follower Mode**). However, at the time of writing, other PTP parameters on the Edge/Arcadia Stations cannot be changed. This functionality is planned for future releases. Until then, if using **PTP Follower Mode**, ensure that the external Leader clock is using the AES67 media profile.Clock priority in PTP Leader mode on the Stations (A & B) is set to 127. To enable/disable PTP Follower Mode navigate to **CCM > Hardware > Host > Network >** [select the LAN that has been configured for AES67] **> PTP Follower Mode.**

Time should be set aside to test and debug the IP network infrastructure (as you would an audio/video patch bay) before connecting all devices.

Careful management of Ethernet switch functions, such as QoS, IGMP, VLANs, and multicast IP addresses, along with access to IP test and monitoring tools is required for a successful installation.

Note: *The SMPTE audio standard (SMPTE2110-30) uses the AES67 standard.*

1.1 AoIP - Basic Terms

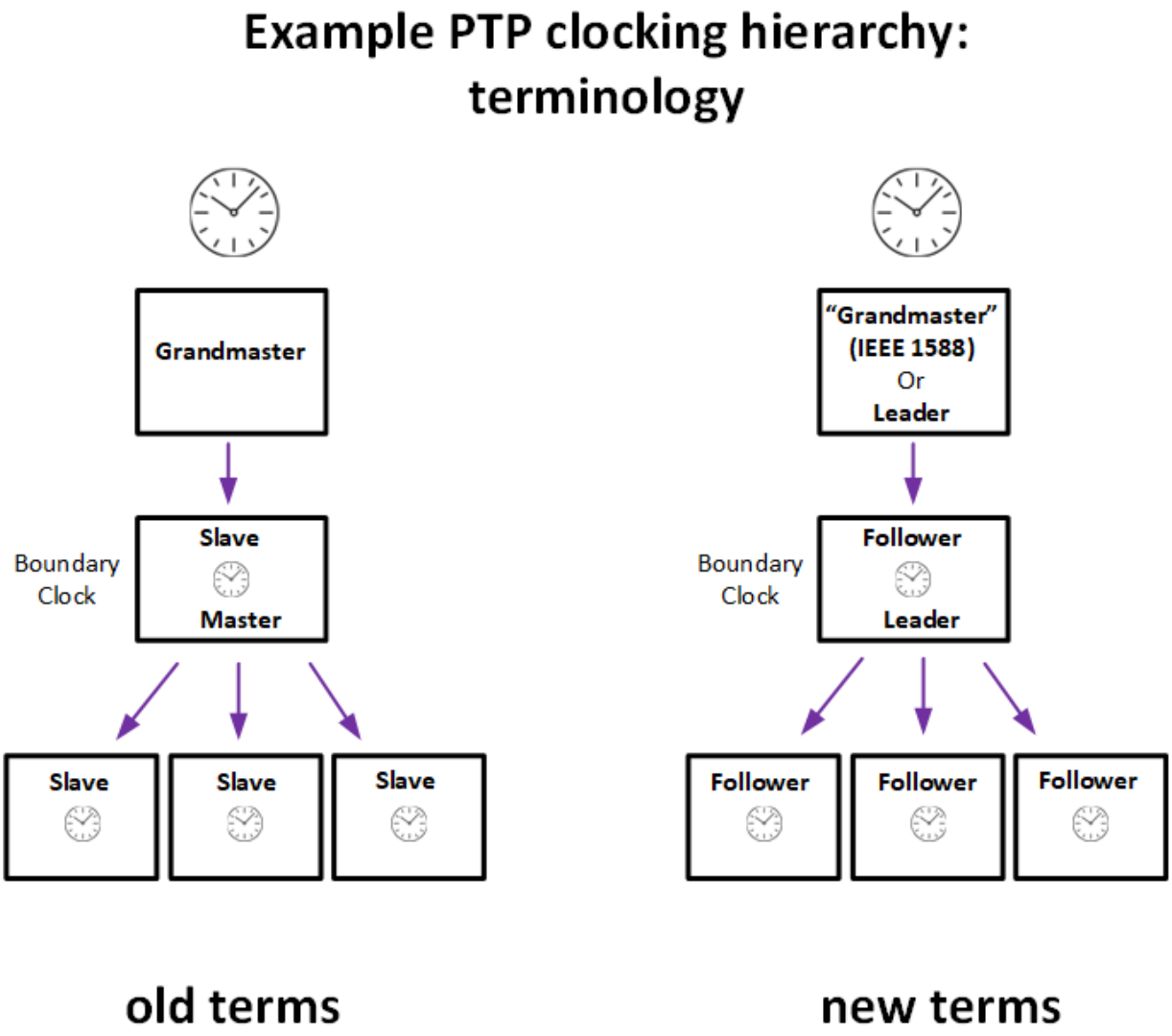
Prior to reading this user guide, you should be familiar with the following terms.

Term	Meaning
PTP / **PTPv2** Precision Time Protocol (IEEE 1588-2008)	PTP is used for timing and synchronization to ensure very low latency and minimum jitter. PTP enables high-accuracy synchronization of clocks and it defines a protocol for messages that devices can send to each other in order to synchronize their clocks throughout a network. PTPv2 is not backwards compatible with PTPv1. PTPv2 has additional features such as transparent clock. functionality and unicast messaging.
PTP Leader / **Follower Clocks** (IEEE 1588 Master/Slave)	The IEEE 1588 standards describes a hierarchical "master/slave" architecture for clock distribution. In this document we use the terms "leader/follower" to describe this hierarchy. The root timing reference is called the Leader (master) clock. When using a precision timing protocol (PTP) network, the leader clock is the main distributor of time on a network, sending time downstream to other follower (slave) clocks residing on the network segment. Followers synchronize their internal clock to the main PTP leader clock.
QoS (Quality of Service)	In the field of computer networks, Quality of Service refers to traffic prioritization and resource reservation control mechanisms rather than the achieved service quality. QoS is the ability to provide different priorities to different applications, users, or data flows, or to guarantee a certain level of performance to a data flow.

Term	Meaning
VLAN (Virtual LAN)	A VLAN is any broadcast domain / subnet that is partitioned and isolated in a computer network. VLANs allow network administrators to group hosts together even if the hosts are not directly connected to the same network switch.
IGMP (Internet Group Management Protocol)	IGMP is a communications protocol used by hosts and routers on a network to establish multicast group memberships. IGMP is an integral part of IP multicast and allows the network to direct multicast transmissions only to hosts that have requested them. **Multicast**: the process where a transmitting device sends out IP data flow / streams. Listening devices can request via their router to listen to the stream. This is more efficient than doing a general broadcast to all devices as the router only sends data to those devices that have asked to join and listen to the multicast stream.
Boundary or Transparent clock?	There are two modes of PTP aware switch which handle network traffic variation in different ways: • A transparent clock (TC) adds a transit timestamp to each sync and follow_up message. This means that the amount of time the packet spends in the switch can be factored out, reducing PDV. • A boundary clock (BC) receives synchronization from the leader clock on one follower port and serves as leader clock to all other ports. This has the benefit of not only factoring out transit time in the switch but also reduces the load on the primary leader clock.

1.1.1 Inclusive Terminology

Clear-Com aims to use inclusive terminology. Inclusive language acknowledges diversity, conveys respect to all, is sensitive to differences, and promotes equality. It helps us to avoid biases perpetuated by words and phrases that can reinforce stereotypes and create false power dynamics. Therefore, some terms that have been in common usage have been replaced. The example below relates specifically to Precision Time Protocol (PTP) terminology.



1.2 AoIP Support

Clear-Com Application Engineers and Tech Support team will always do their best to advise and support, however they are not experts on every make or type of Ethernet switch. It is the responsibility of our customers, partners and system integrators to ensure they have the technical expertize and competence to set up and manage the network switches/network topologies they choose for their projects.

Chapter 1 of this guide (this section) provides a general pre-sales check list when specifying a Clear-Com system working on an AES67 IP network.

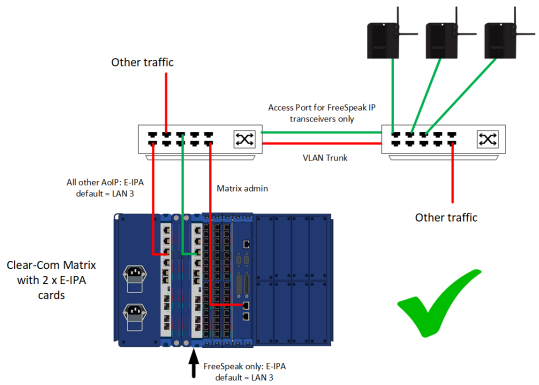
1.3 Planning - Overview

- Clear-Com recommends that for any installation (no matter the size) you have an IP network engineer available on site from either your company or the Ethernet switch supplier, who can review the network topology and network switch selection during the pre-sales phase and installation period.
- Ensure your network engineer reads all of this guide
- Network planning will be different for different scenarios. See **Planning - Different Scenarios on page 12**
- Ensure your selected Ethernet switch meets the minimum specification required for AES67 (audio only) networks, as detailed in this document. **Minimum Ethernet Switch Requirements for AES67 Audio on page 31**
- Clear-Com strongly recommends that you place the FSII IP antenna traffic (or any other AES67 traffic) onto their own set of separate network switches
    - If this is not possible then use VLANS to segregate the FSII IP antennas traffic (or any other AES67 traffic) away from other data (like Dante, admin, or control data)
- If you do not use PTP aware switches but wish to join a mixed media network:

  (a) use a separate E-IPA card for IP transceiver use only

  (b) you should place the FreeSpeak IP transceiver only traffic on a separate access port link between the two switches. All other traffic should be connected via another access port/VLAN trunk or use a dedicated set of switches for the IP transceiver network.

  (c) To maximize the stability of DECT sync on IP transceivers, use 125 µs packet size on the E-IPA card that is used for FreeSpeak.



Note: *Clear-Com equipment uses 1Gb interfaces for AES67 and SMPTE ST2110-30 connections.*

Use the link below for the Clear-Com AoIP Integration form which will help you in planning your installation:

Clear-Com AoIP Integration Form (Customer).

1.4 Planning - Different Scenarios

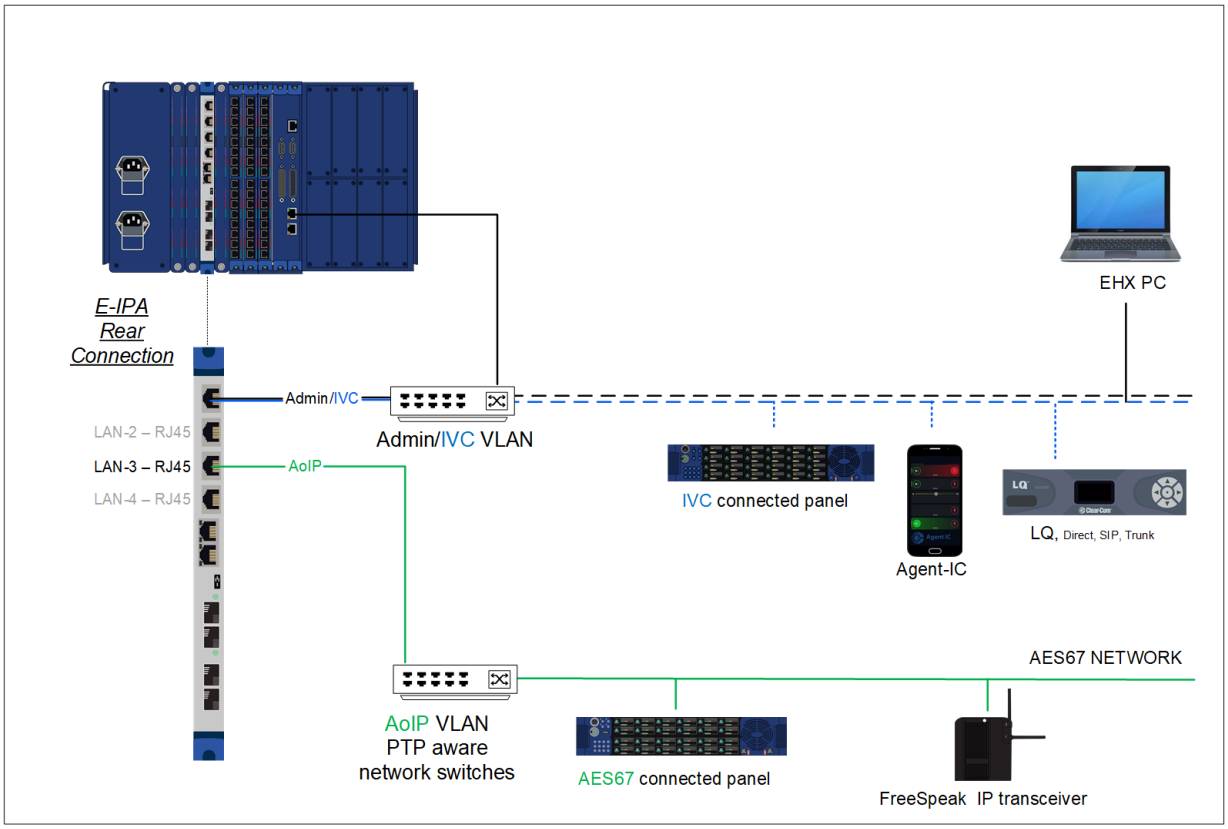
Clear-Com endpoints can connect using the AES67 protocol to the following host devices:

- An Eclipse matrix fitted with an E-IPA-HX card
- A FreeSpeak Edge/Arcadia Station

Endpoints that can be connected include:

- Clear-Com IP Transceivers (FreeSpeak / Edge)
- Clear-Com V-Series Iris panels
- 3rd party AES67 external equipment, such as sound consoles or speakers.

1.5 Eclipse Matrix With Clear-Com Only, Less Than 20 Endpoints



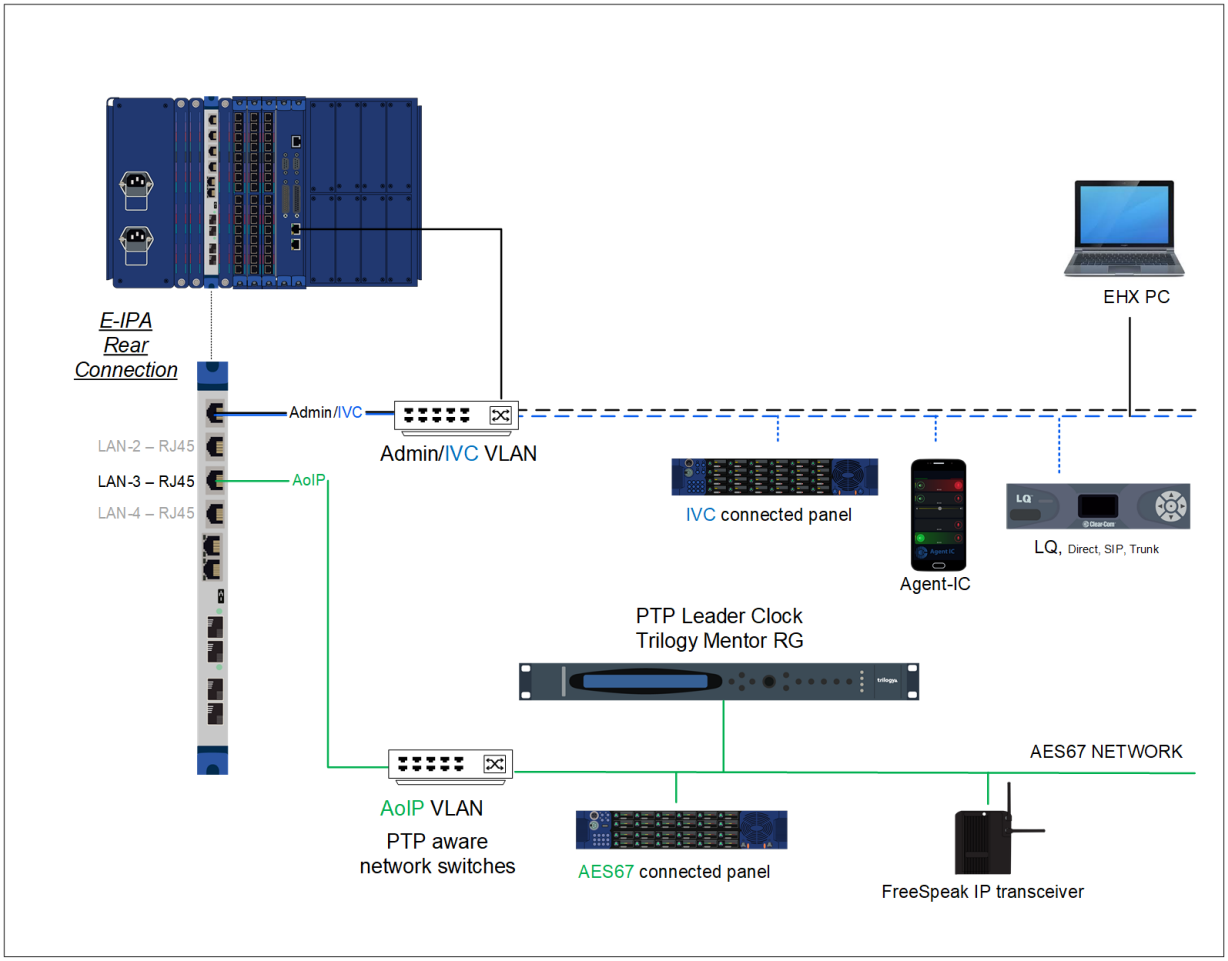
Endpoints: IP transceivers (IPTs), Iris panels. Dante on its own network.

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

- 125 µs packet size
- Use the AES67 media profile in EHX
- Configure QoS, IGMP snooping and IGMP querier
- Set the Host device to have static IP address
- Set IPTs/ Iris panels to use static IP address (two IP addresses needed per IPT or Iris panel) or set the IPTs/ Iris panels to use DHCP and enable DHCP server on your Ethernet switch
- Do not use the 169.254.xx.xx IP range (link-local) for either host or endpoints
- The use of VLANs to separate different data types on the network is recommended to ensure minimum delay of PTP clock and audio packets

- Do not stack core network switches as the PTP data does not pass across the control plane when switches are in the stacked configuration mode
- Do not mix the AES67 data on inter-ETH switch trunk ports with other data, even if using 10GB uplinks. Instead link the AES67 data via access ports or a separate dedicated trunk port
- Check ping delay is <2ms from Host to IPT / Iris panel. Check using in-built monitoring tools that PTP clock delay (offset from master – OFM) is<100ns (preferred), max <500ns for IP antennas
- If you are using VLANS to separate Dante traffic from IPTs, ensure that Dante DiffSerc mapping is correctly setup on the switches
- Use of PTP non-aware switches is possible (but not recommended) if the number of switch hops is less than three between the PTP leader clock and the endpoint

1.6 Eclipse Matrix With Clear-Com Only, More Than 20 Endpoints



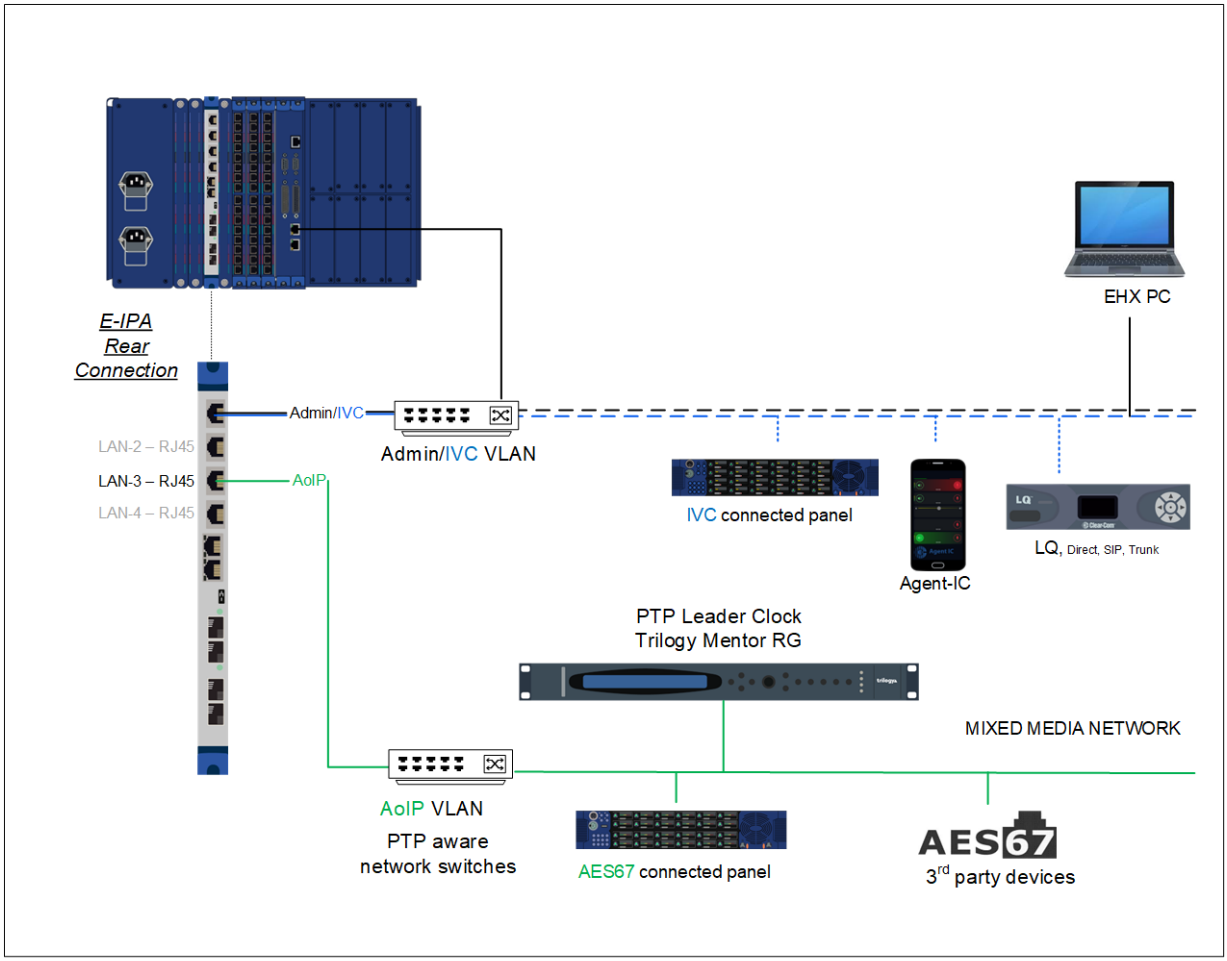
Endpoints: IPT transceivers, Iris panels, no AES67 audio streams to non Clear-Com audio devices, no Dante

In this scenario you will work with the default protocol settings of an external PTP leader clock acting as leader clock for all end points.

- 125 µs packet size
- Use the AES67 media profile in EHX
- Configure QoS, IGMP snooping and IGMP querier
- Set the Host device to have static IP address
- Set IPTs/ Iris panels to use static IP address (two IP addresses needed per IPT or Iris panel) or set the IPTs/ Iris panels to use DHCP and enable DHCP server on your Ethernet switch
- Do not use the 169.254.xx.xx IP range (link-local) for either host or endpoints

- The use of VLANs to separate different data types on the network is recommended to ensure minimum delay of PTP clock and audio packets
- Do not stack core network switches as the PTP data does not pass across the control plane when switches are in the stacked configuration mode
- Do not mix the AES67 data on inter-ETH switch trunk ports with other data, even if using 10GB uplinks. Instead link the AES67 data via access ports or a separate dedicated trunk port
- Check ping delay is <2ms from Host to IPT / Iris panel. Check using in-built monitoring tools that PTP clock delay (offset from master – OFM) is<100ns (preferred), max <500ns for IP antennas
- If you are using VLANS to separate Dante traffic from IPTs, ensure that Dante DiffSerc mapping is correctly setup on the switches
- Use of PTP non-aware switches is possible (but not recommended) if the number of switch hops is less than three between the PTP leader clock and the endpoint

1.7 Eclipse Matrix With Mixed Media Network - No FreeSpeak IP Transceivers



Endpoints: Iris panels, third-party AES67 audio streams, Dante on a separate network

In this scenario you will work with the default protocol settings of an external PTP Leader clock acting as Leader clock for all end points.

- Use an external PTP Leader clock (GPS preferred), such as the Trilogy Mentor RG
- Use PTP aware switches in boundary clock or transparent clock mode
- Set the IPA card to PTP follower mode
- Use 125µs or 1ms packet size
- Use the AES67 media profile on all PTP enabled devices such as the PTP Leader clock, E-IPA card and all PTP aware switches
- Set the Host device to have static IP address

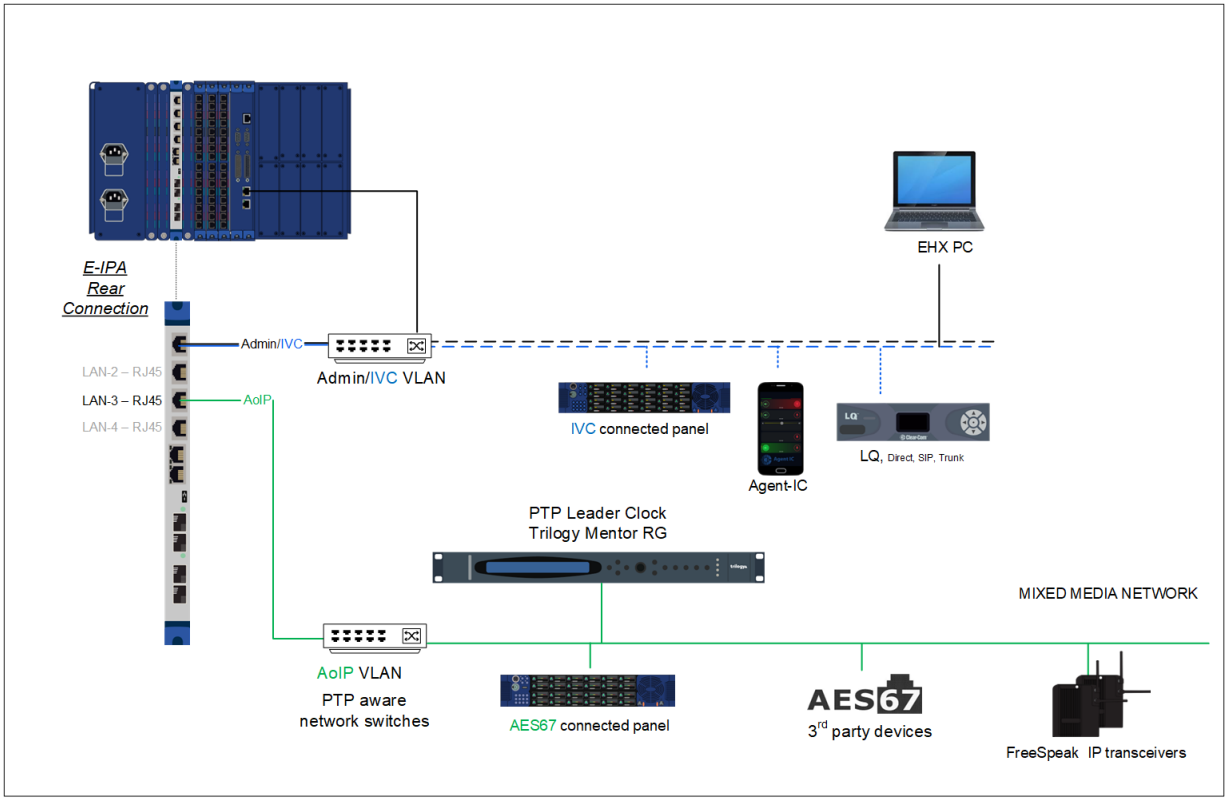
- Set Iris panels to use static IP address (two IP addresses needed per Iris panel) or set the IIris panels to use DHCP and enable DHCP server on your Ethernet switch
- Do not use the 169.254.xx.xx IP range (link-local) for either host or endpoints
- Configure QoS, IGMP snooping and IGMP querier
- The use of VLANs to separate different data types on the network is recommended to ensure minimum delay of PTP clock and audio packets.
- Do not stack core network switches as the PTP data does not pass across the control plane when switches are in the stacked configuration mode
- Do not mix the AES67 data on inter-ETH switch trunk ports with other data, even if using 10GB uplinks. Instead link the AES67 data via access ports or a separate dedicated trunk port
- Use of PTP non-aware switches is possible (but not recommended) if the number of switch hops is less than three between the PTP leader clock and the endpoint

1.7.1 Dante Installations

AES67 systems that also include Dante require special attention as the QoS (Diffserv) settings on the Dante packets need to be remapped using Dante DDM or QoS rules within the Ethernet switch.

AES67 PTP packets should always be placed in the highest priority queues on the switch. Re-map both Dante PTP and audio packet QoS values to match standard AES67 QoS values or place the whole Dante network on a separate set of network switches.

1.8 Eclipse Matrix With Mixed Media Network With FreeSpeak IP Transceivers



Endpoints: IPT transceivers, Iris panels, third party AES67 audio streams, Dante

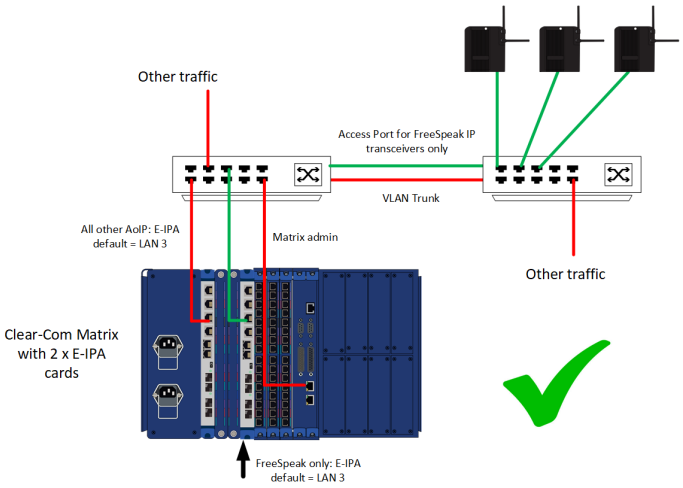
In this scenario you will work with the default protocol settings of an external PTP Leader clock. The external GM ("Grandmaster" IEEE 1588) will act as Leader clock for all end points.

- Use an external PTP leader clock (GM) (GPS preferred), such as the Trilogy Mentor RG
- Use PTP aware switches in boundary clock or transparent clock mode
- Do NOT use stacked core switches as they do not pass PTP in stacked mode
- Set the IPA card to PTP follower mode
- You must use 125 µs packet size with FreeSpeak II IP transceivers
- Use the AES67 media profile on all PTP enabled devices, such as the PTP Leader clock, E-IPA card and all PTP aware switches
- Configure QoS, IGMP snooping and IGMP querier
- Set the Host device to have static IP address
- Set IPTs/ Iris panels to use static IP address (two IP addresses needed per IPT or Iris panel) or set the IPTs/ Iris panels to use DHCP and enable DHCP server on your Ethernet switch
- Do not use the 169.254.xx.xx IP range (link-local) for either host or endpoints
- Do not mix the AES67 data on inter-ETH switch trunk ports with other data, even if using 10GB uplinks. Instead link the AES67 data via access ports or a separate dedicated trunk port
- Check ping delay is <2ms from Host to IPT / Iris panel. Check using in-built monitoring tools that PTP clock delay (offset from master – OFM) is<100ns (preferred), max <500ns for IP antennas
- If you are using VLANS to separate Dante traffic from IPTs, ensure that Dante DiffSerc mapping is correctly setup on the switches
- Use of PTP non-aware switches is possible (but not recommended) if the number of switch hops is less than three between the PTP leader clock and the endpoint
- If you do not use PTP aware switches but wish to join a mixed media network:

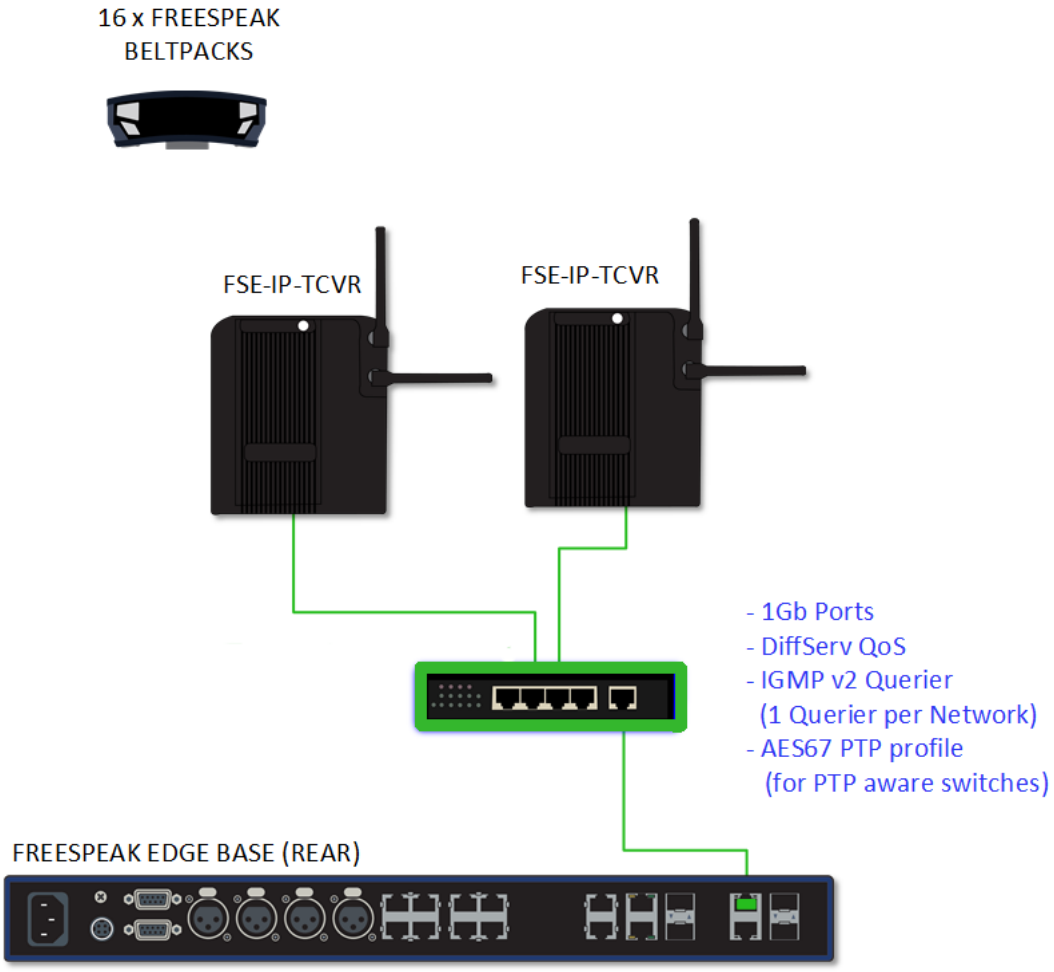
  (a) use a separate E-IPA card for IP transceiver use only

  (b) you should place the FreeSpeak IP transceiver only traffic on a separate access port link between the two switches. All other traffic should be connected via another access port/VLAN trunk or use a dedicated set of switches for the IP transceiver network.

(c) To maximize the stability of DECT sync on IP transceivers, use 125 µs packet size on the E-IPA card that is used for FreeSpeak.



1.9 FS Edge or Arcadia Stations With Clear-Com Only, Less Than 20 Endpoints



Endpoints: IP transceivers, no Dante

In this scenario you will work with the default protocol settings of the FS Edge/Arcadia Station with the Station acting as the PTP Leaderclock for all endpoints.

- In this set up it is assumed that you have a dedicated switch for the Clear-Com Base and its transceivers
- Configure QoS, IGMP snooping and IGMP querier
- Set the Host device to have static IP address
- Set IPTs/ Iris panels to use static IP address (two IP addresses needed per IPT or Iris panel) or set the IPTs/ Iris panels to use DHCP and enable DHCP server on your Ethernet switch
- Do not use the 169.254.xx.xx IP range (link-local) for either host or endpoints

- The use of VLANs to separate different data types on the network is recommended to ensure minimum delay of PTP clock and audio packets
- Do not stack core network switches as the PTP data does not pass across the control plane when switches are in the stacked configuration mode
- Do not mix the AES67 data on inter-ETH switch trunk ports with other data, even if using 10GB uplinks. Instead link the AES67 data via access ports or a separate dedicated trunk port
- Check ping delay is <2ms from Host to IPT / Iris panel. Check using in-built monitoring tools that PTP clock delay (offset from master – OFM) is<100ns (preferred), max <500ns for IP antennas
- If you are using VLANS to separate Dante traffic from IPTs, ensure that Dante DiffSerc mapping is correctly setup on the switches
- Use of PTP non-aware switches is possible (but not recommended) if the number of switch hops is less than three between the PTP leader clock and the endpoints

Note: *From Arcadia v. 3.0 and above, the Arcadia and Edge intercom stations can function as either Leader or follower only clock (enable/disable **PTP Follower Mode**). However, at the time of writing, other PTP parameters on the Edge/Arcadia Stations cannot be changed. This functionality is planned for future releases. Until then, if using **PTP Follower Mode**, ensure that the external Leader clock is using the AES67 media profile.*

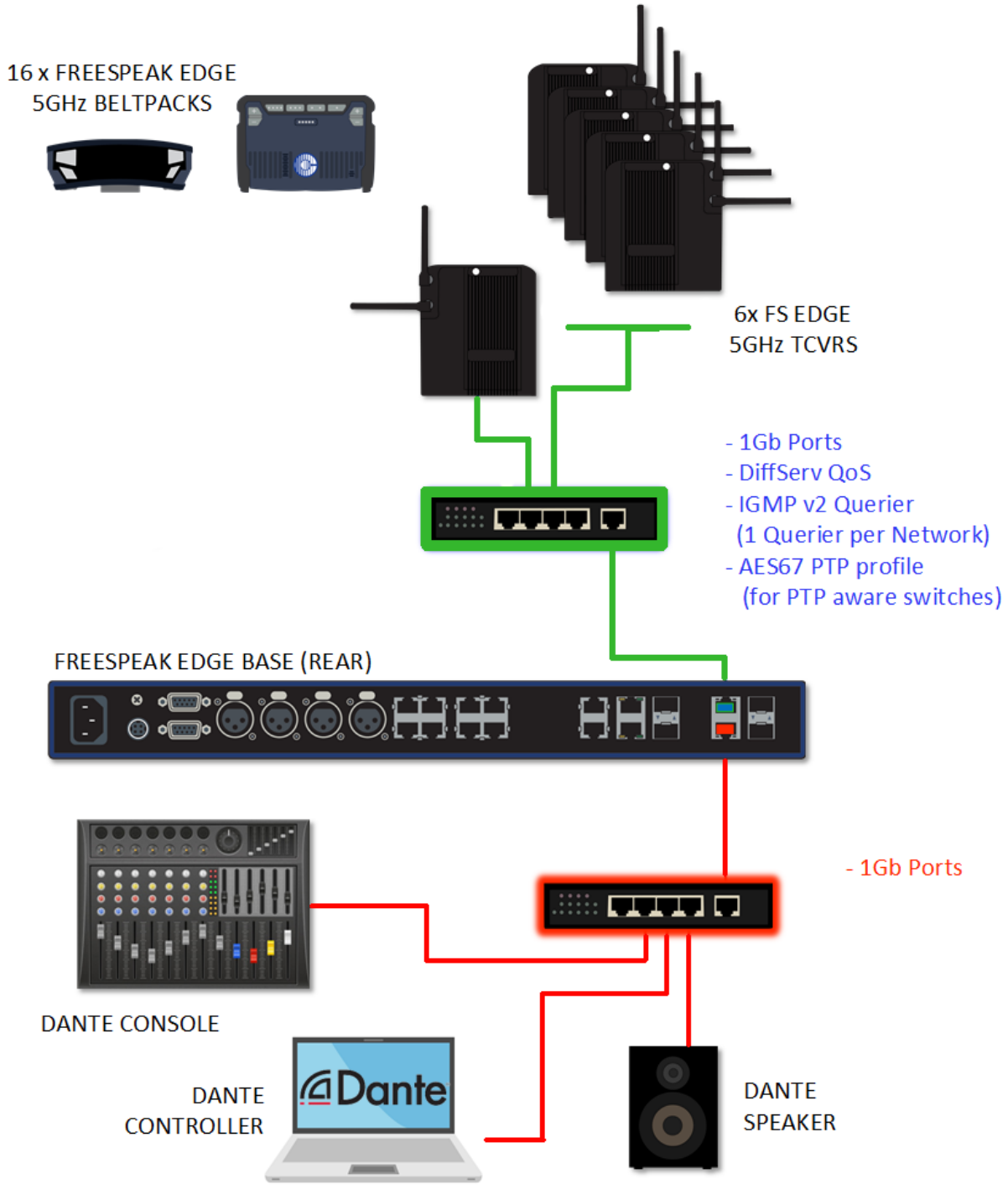
Note: *Clock priority in PTP Leader mode on the Stations (A & B) is set to 127.*

Note: *To enable/disable PTP Follower Mode navigate to **CCM > Hardware > Host > Network >** [select the LAN that has been configured for AES67] **> PTP Follower Mode.***

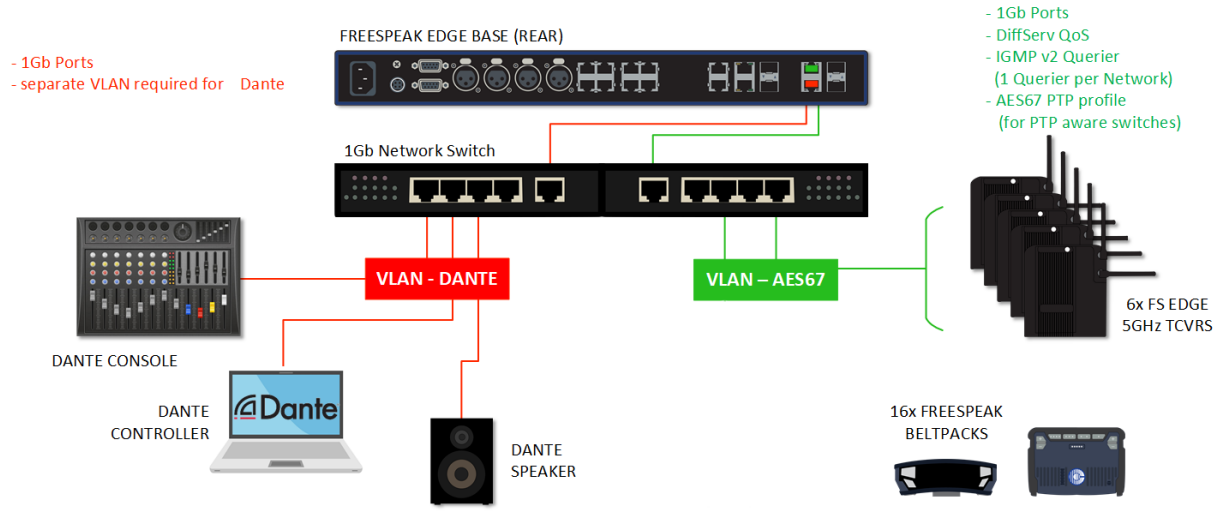
1.10 FS Edge or Arcadia Stations With Mixed Media With IP Transceivers

Endpoints: IP transceivers, Dante

1.10.1 Example 1



1.10.2 Example 2



In this scenario you will split the LAN connections on the FS Edge/Arcadia Station to ensure LAN X is only used for connection to the FreeSpeak IPT network with LAN Y only used for connection to the Dante audio network. LAN X and LAN Y **must not** be connected to the same VLAN.

For the FreeSpeak IP transceiver network use the default protocol settings of the FS Edge/Arcadia Station with the Station acting as the PTP Leader clock for all FreeSpeak IP transceivers.

- 125 µs packet size (default setting)
- AES67 media profile (default setting)
- Configure QoS, IGMP snooping and IGMP querier
- Set the Host device to have static IP address
- Set IPTs to use static IP address (two IP addresses needed per IPT or set the IPTs to use DHCP and enable DHCP server on your Ethernet switch
- Do not use the 169.254.xx.xx IP range (link-local) for either host or endpoints
-

- The use of VLANs to separate different data types on the network is recommended to ensure minimum delay of PTP clock and audio packets
- Do not stack core network switches as the PTP data does not pass across the control plane when switches are in the stacked configuration mode
- Do not mix the AES67 data on inter-ETH switch trunk ports with other data, even if using 10GB uplinks. Instead link the AES67 data via access ports or a separate dedicated trunk

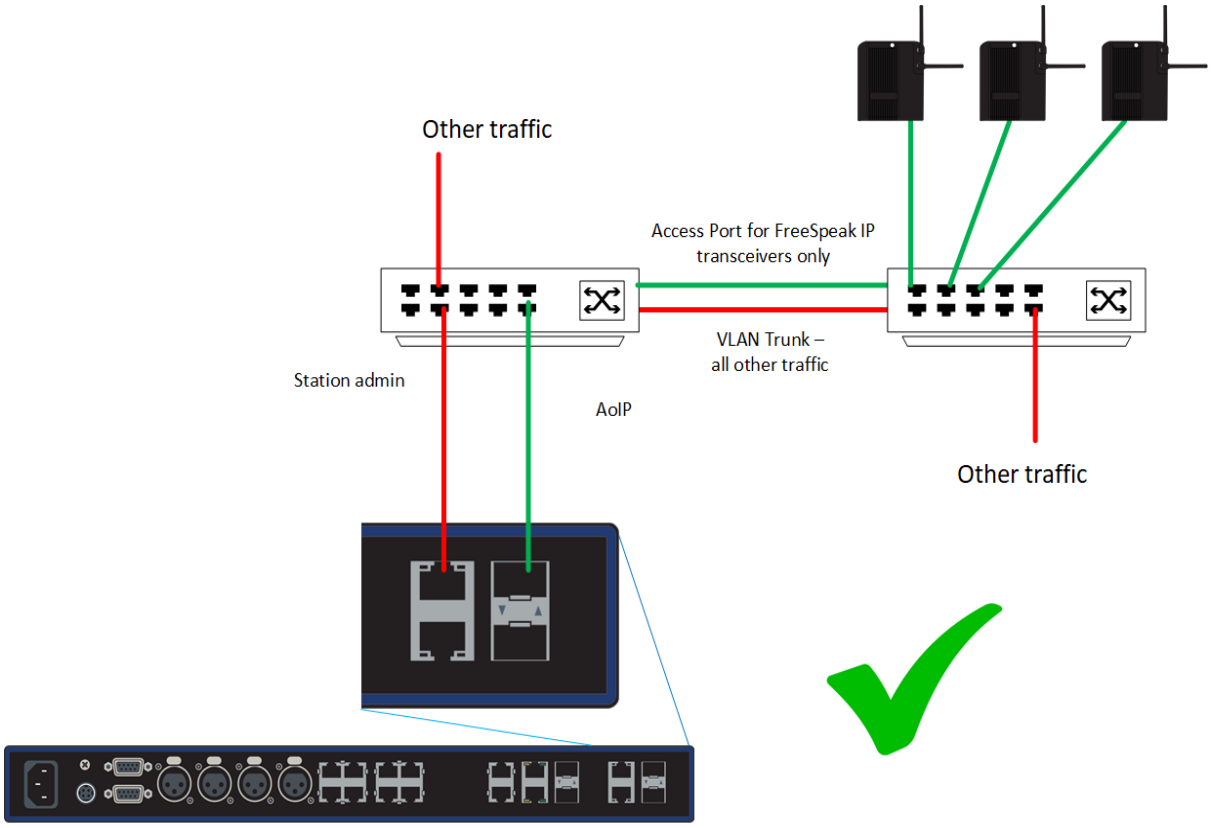
port

- Check ping delay is <2ms from Host to IPT / Iris panel. Check using in-built monitoring tools that PTP clock delay (offset from master – OFM) is<100ns (preferred), max <500ns for IP antennas
- If you are using VLANS to separate Dante traffic from IPTs, ensure that Dante DiffSerc mapping is correctly setup on the switches
- The use of PTP non-aware switches is possible if the number of switch hops is less than three between the PTP Leader clock and the end point
- For the Dante audio network use the default protocol settings of the Dante devices
- Use the Audinate DDM or Dante controller to setup all Dante devices
- If using multiple switches see the example below.

Note: *From Arcadia v. 3.0 and above, the Arcadia and Edge intercom stations can function as either Leader or follower only clock (enable/disable **PTP Follower Mode**). However, at the time of writing, other PTP parameters on the Edge/Arcadia Stations cannot be changed. This functionality is planned for future releases. Until then, if using **PTP Follower Mode**, ensure that the external Leader clock is using the AES67 media profile.*

Note: *Clock priority in PTP Leader mode on the Stations (A & B) is set to 127.*

Note: *To enable/disable PTP Follower Mode navigate to **CCM > Hardware > Host > Network >** [select the LAN that has been configured for AES67] **> PTP Follower Mode.***



Rear view - Arcadia Base Station

If PTP aware switches are not available and multiple switches are being used you should use the network set up illustrated above.

Arcadia/Edge PTP Settings

- **QoS Tags**
  - Clock: DSCP=46, Expedited Forwarding (EF)
  - Media: DSCP=41, Assured Forwarding (AF)
  - Management: DSCP=0, Best Effort (DF)
- **PTP Parameters**
  - PTP domain: 0
  - Priority 1 & 2: 127
  - Announce interval: 1/2s
  - Sync rate: 8/s
- **Media Profile**
  - AES67 Media Profile

1.10.3 Dante Installations

AES67 systems that also include Dante require special attention as the QoS (Diffserv) settings on the Dante packets need to be remapped using Dante DDM or QoS rules within the Ethernet switch.

AES67 PTP packets should always be placed in the highest priority queues on the switch. Re-map both Dante PTP and audio packet QoS values to match standard AES67 QoS values or place the whole Dante network on a separate set of network switches.

1.11 Installation

Clear-Com recommends that for any installation (no matter the size) you have a network engineer available on site from either your company or the Ethernet switch supplier who can setup the Ethernet switches correctly and review the network topology.

The following is a general pre-sales checklist for your installation:

- Access to IP test and monitoring tools is required for a successful installation.
- Order at least one extra additional day of Clear-Com support (on site or remote) to cover IP setup.
- **Bench testing**: Before joining equipment, Clear-Com or otherwise, to an established media network, Clear-Com recommends that the equipment is configured and tested in a standalone test network.
- Preconfigure switches, Clear-Com equipment and third-party equipment using the test system and check they are operational before taking them on site.
    - Check SFPs (on switches)
    - Check QoS, IGMP snooping, IGMP querier, VLAN and VLAN trunk settings
    - Document switch configurations
    - Document all equipment IP addresses and multicast address.
    - Use the EHX or CCM monitoring screen to ensure correct operation of Clear-Com devices.
    - Check CAT5e/6 cables using a CAT5 certification tester tool.

Note: *The use of CAT cable qualifiers and validators is strongly recommended as not all CAT5/6 cables meet true specification.*

Clear-Com FreeSpeak IP Transceivers (IPTs) require a higher-than-average PTP timing accuracy.

The following table shows guidelines for roaming between antennas.

To prevent roaming problems the PTPv2 packet offset from the PTP Leader clock value **must not exceed ± 1000 ns** when using IPT transceivers.

PTP parameters	Value (range)	IPT RF Performance
Offset from the PTP Leader clock max. (OFM - Offset From Master, IEEE 1588)	± 100 ns	Excellent
	± 500 ns	Potential for roaming issues
	± 1,000 ns	Issues with roaming likely
	>± 1,000 ns	Cannot roam between transceivers and intermittent loss-of-lock issues
Overall audio packet time @125us	Audio delay must not be more than 2 ms or it will result in loss of audio.	
Overall audio packet time @ 1ms	Audio delay must not be more than 20 ms or it will result in loss of audio.	

Note: *Methods of Mitigating Risk:*

- Separate IPTs and 3rd party devices into their own network segment
- Using two Clear-Com Eclipse Matrix 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
- If using FS Edge/Arcadia Station, separate the IP transceiver network by using different LAN connections rear of the base unit for different network traffic.

1.12 Dante Installations

AES67 systems that also include Dante require special attention as the QoS (Diffserv) settings on the Dante packets need to be remapped using Dante DDM or QoS rules within the Ethernet switch.

AES67 PTP packets should always be placed in the highest priority queues on the switch. Re-map both Dante PTP and audio packet QoS values to match standard AES67 QoS values or place the whole Dante network on a separate set of network switches.

QoS default values		
	AES67	**Audinate/Dante**
PTP v2	46	56
Audio	34	46

1.13 Support

For further support, please contact your local Clear-Com Sales Partner or Clear-Com Support at:

email: support@clearcom.com

web: clearcom.com/support

Solution Finder: Solution Finder

Use the link below to access a non-exhaustive list of switches used in Clear-Com installs (Solution Finder):

Switches used with Clear-Com.

1.14 Minimum Ethernet Switch Requirements for AES67 Audio

Required features:

- Managed switch
- 1 Gbps bandwidth for every port
- Non-blocking switch
- EEE (Energy Efficient Ethernet) or Green Ethernet needs to be disabled
- Configurable QoS - Quality of Service prioritization of audio traffic
- Fiber to Copper conversion preferable using the SFP/mini-GBIC form factor
- IGMP snooping/ querying must be properly configured

Recommended features:

- PTP Aware Switches (that support boundary clock or transparent clock mode)

Note: *Not all Ethernet switches (SKU) in the same product range support PTP mode. Check with the switch provider as additional software licenses might have to be purchased to enable PTP mode.*

Note: *Non-blocking switch means switching capacity equal to 2 x number of ports (Tx/Rx).*

Example switch capacity

Number of ports on the switch	Individual port capacity	Overall capacity
24	1Gbps	24 ports x 1 Gbps X2 (full duplex) = **48 Gbps**

Example switch recommendations

System Size	Switch type	Switch model (as of October 2024)
Less than 20 Clear-Com endpoints	Transparent clock	Netgear AV M4250 Cisco CB350 Luminex GigaCore
More than 20 Clear-Com endpoints	Boundary clock	Netgear M4350-40X4C or M4350-16V4C Arista, all Current models Cisco 9300 with PTP license Luminex GigaCore

AoIP Installation

2 AoIP Installation

2.1 AES67 and SMPTE 2110-30 Compliant Audio

This document 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.

The AES67 interoperability standard for streaming audio-over-IP from the Audio Engineering Society is referenced by the SMPTE ST 2110 standard for transport of PCM digital audio (SMPTE ST 2110-30). This introduction explains the key points of constraints in the SMPTE ST 2110 standard with respect to the AES67 standard. In addition, important commonalities are explained in order to provide a broader knowledge on how these constraints might affect interoperability between devices strictly adhering to SMPTE ST 2110 and devices following the requirements set forth in AES67.

SMPTE ST 2110-30 can be seen as a subset of AES67. The general operational principles and mandatory requirements for stream transport, packet setup, and signalization defined by SMPTE ST2110 are identical to those of AES67. However, SMPTE ST 2110 defines further constraints to which AES67 implementations must adhere in order to ensure full compatibility:

- Support of the PTP profile defined in SMPTE ST 2059-2
- An offset value of zero between the media clock and the RTP stream clock
- Required option to force a device to operate in PTP follower-only mode
- Support of IGMP v2 and v3.

Clear-Com devices can support either the AES67 or the SMPTE ST2059-2 media profile.

Both standards:

- Provide high quality, high density, low latency audio transport over a LAN
- Operate over standard layer 3 Ethernet or fiber networks and are both routable and fully scalable
- Use the IEEE1588-2008 Precision Time Protocol (PTPv2)

However:

- AES67 systems use the **AES67 media profile**
- ST2110-30 systems use the **SMPTE ST 2059-2 media profile**

Note: *The SMPTE audio standard (SMPTE2110-30) can be seen as a subset of the AES67 standard but with some tighter constraints. For this reason, we will mainly refer to AES67 throughout this document (but term SMPTE2110-30 can be used interchangeably)*

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

Note: *Find more information about the AoIP standards here:*

http://www.aes.org/publications/standards/search.cfm?docID=96

https://www.smpte.org/smpte-st-2110-faq

3 AoIP Network Setup

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

The following sections are for guidance only. For instance, even a small system would require PTP-aware switches if the set up involved using more than 3 switches between the PTP Leader clock and the follower clock.

3.1 Eclipse Matrix With Clear-Com Only Devices on the Network (<20 Endpoints)

	System	Switch Requirements
Small/Medium Clear-Com only <20 Endpoints Endpoints: IP transceivers, Iris panels, no AES67 streams to non Clear-Com audio devices, no Dante	**<20 in total of IP transceivers + Iris panels**: Up to 3 layer-2 hops between PTP leader clock and IPTs. 125 µs packets Use E-IPA card or Edge / Arcadia Station as the PTP leader clock	DiffServ QoS IGMP Snooping IGMP Querier When setting up Clear-Com intelligent linking with AES67 ports you must use IGMP snooping

For more information, see **Eclipse Matrix With Clear-Com Only, Less Than 20 Endpoints on page 13**.

3.1.1 Eclipse Matrix With Clear-Com Only Devices on the Network (>20 endpoints)

	System	Switch Requirements
Large Clear-Com only >20 Endpoints Endpoints: IP transceivers, Iris Panels, no AES67 streams to non Clear-Com audio devices, no Dante	**>20 in total of IP transceivers + Iris panels**: 3 layer-2 hops between PTP leader clock and IPTs unless using PTP aware switches. Clear-Com AES67 Traffic Only 125 µs packets Use an external PTP leader clock as a dedicated device (with GPS) AND Set E-IPA card to PTP follower clock mode **Edge / Arcadia stations - if using with more than 20 IPTs, use external leader clock and/or boundary clock**	DiffServ QoS IGMP Snooping IGMP Querier PTP-aware transparent and/or boundary clocks (BC recommended)

For more information see **Eclipse Matrix With Clear-Com Only, More Than 20 Endpoints on page 15**.

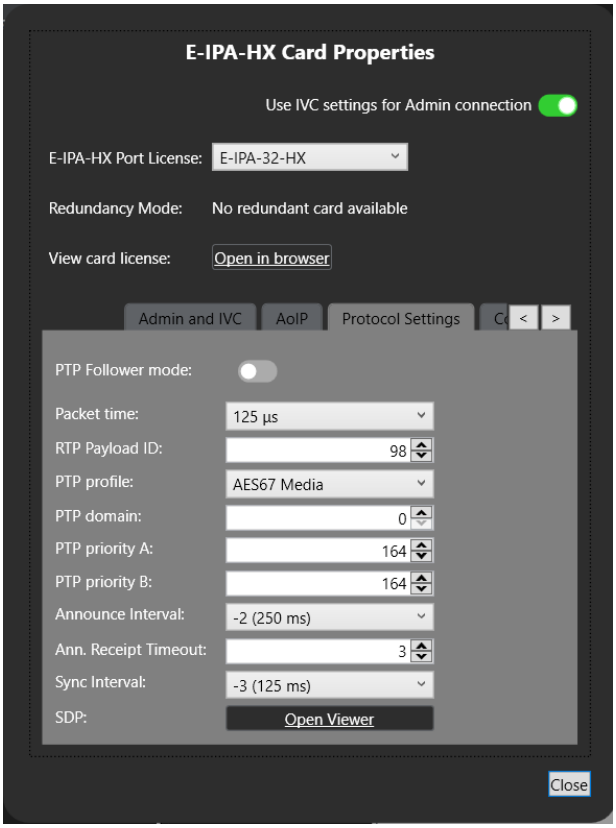
3.1.2 Eclipse Matrix With Mixed Media Network - No FreeSpeak IP Transceivers

	System	Switch Requirements
Mixed Media Network **without** FreeSpeak II transceivers Endpoints: Iris panels, third party AES67 audio streams, Dante	PTP profile is defined by existing networked equipment. Use an external PTP leader clock as a dedicated device (with GPS) AND Set E-IPA card to PTP follower clock mode. Packet time is either 125 µs or 1 ms	DiffServ QoS IGMP Snooping IGMP Querier PTP-aware Transparent and/or Boundary Clocks as required by network size

For more information see **Eclipse Matrix With Mixed Media Network - No FreeSpeak IP Transceivers on page 17**.

If you are not enabling the E-IPA card PTP follower mode you should take care with Clock priorities 1 and 2. We recommend setting the E-IPA clock 1 & 2 properties to be higher than 128.

To enable PTP follower mode go to: **E-IPA-HX Card properties > Protocol settings**).



Note: *From Arcadia v. 3.0 and above, the Arcadia and Edge intercom stations can function as either Leader or follower only clock (enable/disable **PTP Follower Mode**). However, at the time of*

*writing, other PTP parameters on the Edge/Arcadia Stations cannot be changed. This functionality is planned for future releases. Until then, if using **PTP Follower Mode**, ensure that the external Leader clock is using the AES67 media profile.*

Note: *Clock priority in PTP Leader mode on the Stations (A & B) is set to 127.*

Note: *To enable/disable PTP Follower Mode navigate to **CCM > Hardware > Host > Network >** [select the LAN that has been configured for AES67] **> PTP Follower Mode.***

3.1.3 Eclipse Matrix With Mixed Media Network With FreeSpeak IP Transceivers

	System	Switch Requirements
Mixed Media network with FreeSpeak II transceivers Endpoints: IP transceivers, Iris panels, third party AES67 audio streams, Dante	PTP profile is defined by existing networked equipment Use an external PTP leader clock as a dedicated device (with GPS) AND Set E-IPA card to PTP follower clock mode. Packet time is 125 µs More than 1 IP transceiver on the system	DiffServ QoS IGMP Snooping IGMP Querier All switches must be PTP-aware.

For more information see **Eclipse Matrix With Mixed Media Network With FreeSpeak IP Transceivers on page 19**.

> ***Before** joining equipment, Clear-Com or otherwise, to an established media network, Clear-Com recommends that the equipment is configured and tested on a standalone test network.*

3.1.4 FS Edge or Arcadia Stations with Clear-Com only (< than 20 Endpoints)

See **FS Edge or Arcadia Stations With Clear-Com Only, Less Than 20 Endpoints on page 22**

3.1.5 FS Edge or Arcadia Stations with Mixed Media with IP Transceivers

See **FS Edge or Arcadia Stations With Mixed Media With IP Transceivers on page 24**.

4 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 optimize clocking accuracy in your network will ensure an efficient environment for all your AoIP devices.

IEEE 1588 PTP uses a "master/slave" clocking architecture (referred to in this document as "leader/follower"), with a PTP Leader clock synchronizing each network segment. An elected primary leader clock (IEEE 1588 "grandmaster" or GM) will provide the root clocking reference.

Note: *The media nodes (E-IPA , Edge, Arcadia) can act as a PTP Leader clock. If you do not want the node to take over clocking, enable* ***PTP Follower Mode*** *on that device.*

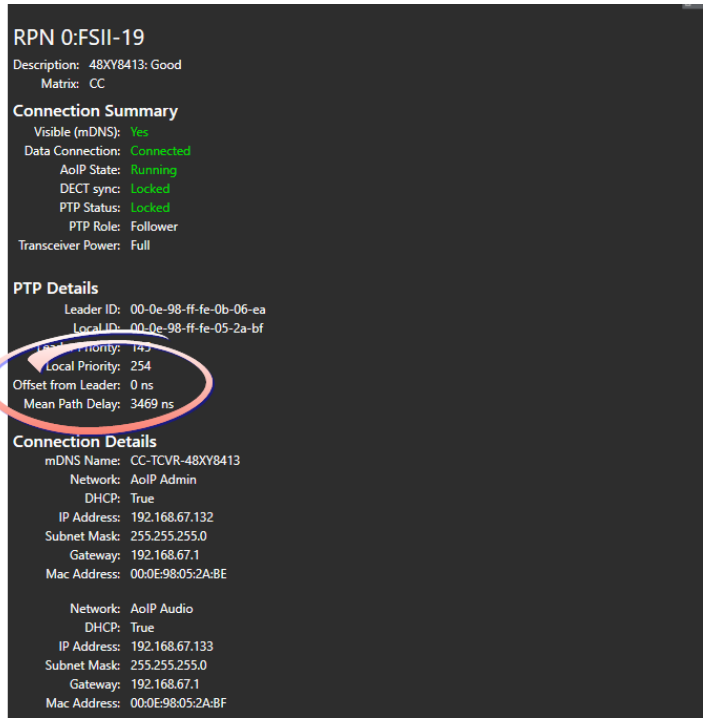
4.1 PTP Tolerance (Offset From the Leader Clock)

4.1.1 The IP Transceiver

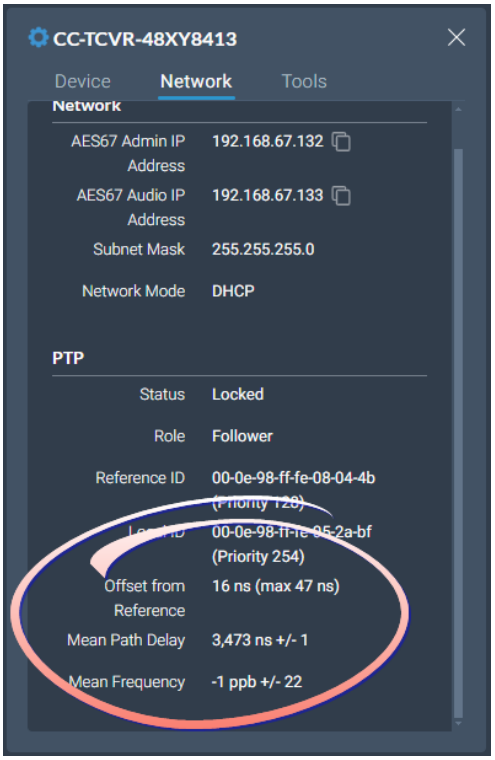
To maximize the stability of DECT sync on IP transceivers, use 125 µs packet size on the E-IPA card or Base Station (125 µs is the default setting in both cases).The following table shows mandatory values the AES67 network should achieve. with the OFM value between 100-500ns max. Tolerances will vary depending on the use of external PTP leader clocks and where transceivers (and E-IPA card or Edge/Arcadia Station) are located in the network relative to the leader clock.

PTP parameters	Value (range)	Performance
Offset from the Leader clock max. (OFM - Offset From Master, IEEE 1588)	± 100 ns	Excellent
	± 500 ns	Potential for roaming issues
	± 1,000 ns	Issues with roaming likely
	>± 1,000 ns	Cannot roam between transceivers and intermittent loss-of-lock issues
Packet travel time* + OFM	• Packet time@ 125 µs > 2 ms	No audio
	• Packet time @ 1 ms > 20 ms	
* When E-IPA card (or Edge/Arcadia Station) is PTP Leader clock, Mean Path Delay (MPD) is the same as packet travel time.		

Offset from leader clock (OFM, Offset From Master IEEE1588) and **Mean Path Delay (MPD)** are shown per transceiver in the EHX Configuration Software. Navigate to **System > Monitoring**.



The PTP status per transciever shown in the Arcadia CCM:



4.1.2 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 synchronize 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.

Packet time	PTP parameters	Value (range)	Performance
125 µs	Packet travel time* +OFM	> 2,000,000 ns (2 ms)	No audio
1 ms	Packet travel time* +OFM	>20,000,000 ns (20 ms)	No audio

* When E-IPA card (or Edge/Arcadia Station) is PTP Leader clock, mean path delay (MPD) is the same as packet travel time.

4.2 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 **Improving Clocking Accuracy and Reducing PDV on page 43**).

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.

4.3 Improving Clocking Accuracy and Reducing PDV

4.3.1 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: *Class of Service (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:

Class name	Traffic type	Default DiffServ class (DSCP decimal value)
Clock	IEEE 1588-2008 Announce, Synch, Follow_Up, Delay_Req, Delay_Resp, Pdelay_Req, Pdelay_Resp and Pdelay_Resp_Follow_Up packets	EF (46) (Expedited Forwarding)
Media	RTP and RTCP media stream data	AF41 (34) (Assured Forwarding)
Best Effort	IEEE 1588-2008 signaling and management messages. Discovery and connection management messages.	DF (O) (Default Forwarding)

Note: *Some third-party devices (for example, Dante) use different DSCP values for PTP and Media. These conflict 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.*

4.3.2 Switch Priority Queues

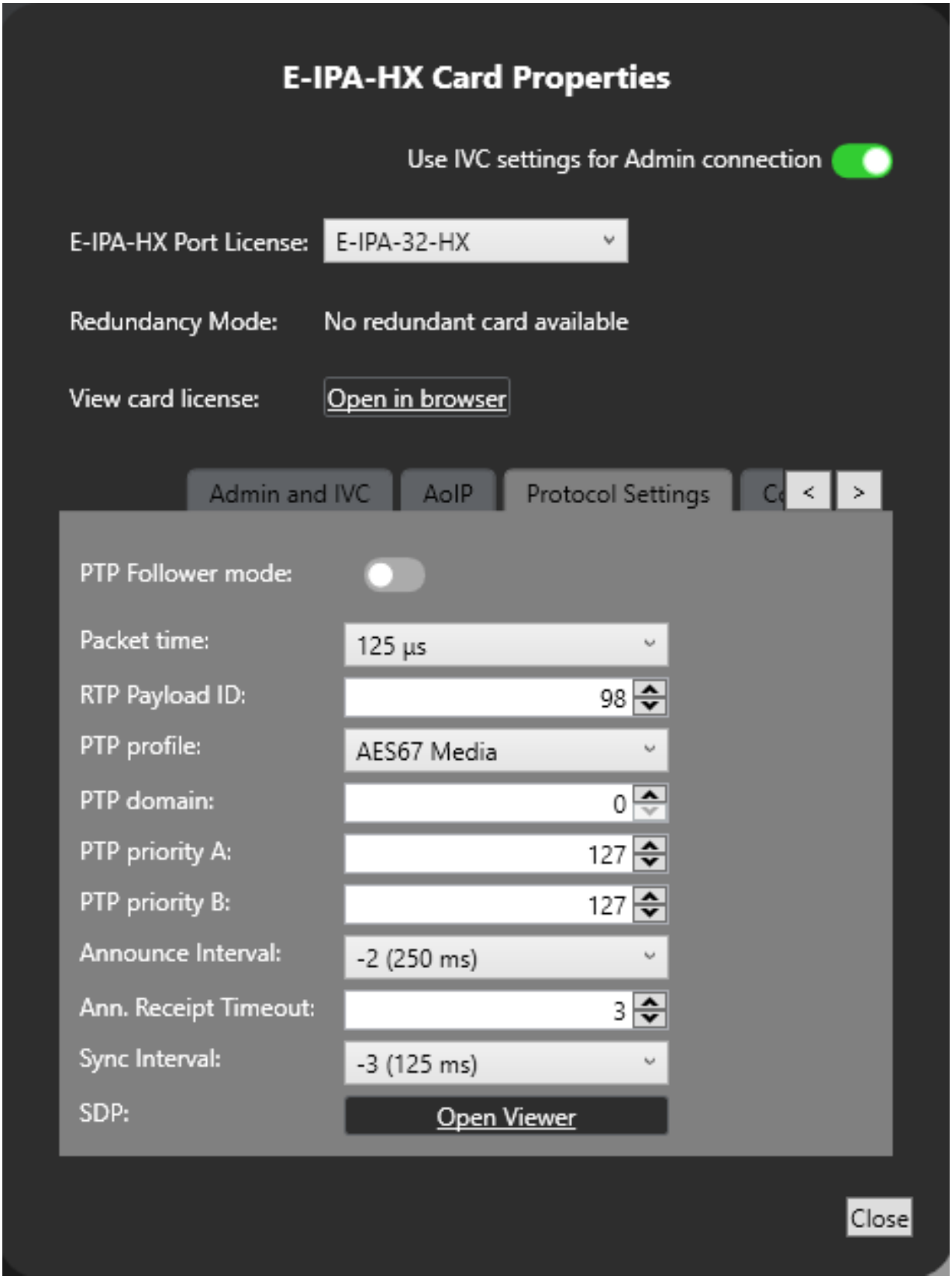
The following apply:

- 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.
- All other data queues should be Weighted Round-Robin.

4.3.3 PTP Settings

The E-IPA card has two PTP profile presets, AES67 Media and SMPTE 2110 (ST 2059-2). Values can be adjusted for non-standard cases. **All devices in a PTP domain must have matching PTP configuration**.

The configuration here is for the E-IPA card and all endpoints connecting to that card.



Note: *From Arcadia v. 3.0 and above, the Arcadia and Edge intercom stations can function as either Leader or follower only clock (enable/disable **PTP Follower Mode**). However, at the time of writing, other PTP parameters on the Edge/Arcadia Stations cannot be changed. This*

*functionality is planned for future releases. Until then, if using **PTP Follower Mode**, ensure that the external Leader clock is using the AES67 media profile.*

Note: *Clock priority in PTP Leader mode on the Stations (A & B) is set to 127.*

Note: *To enable/disable PTP Follower Mode navigate to **CCM > Hardware > Host > Network >** [select the LAN that has been configured for AES67] **> PTP Follower Mode.***

Attribute	AES67 Profile	SMPTE Profile	Description
Domain Number	0	127	The domain attribute of the local clock.
Announce Interval	1	-2	The mean time interval between Announce messages. A shorter interval allows faster reactions to the changes in the reference-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* <https://linux.die.net/man/8/ptp4l>
Sync Interval	-3	-3	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* <https://linux.die.net/man/8/ptp4l>

Attribute	AES67 Profile	SMPTE Profile	Description
Min Delay Req Interval	0	0	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* <https://linux.die.net/man/8/ptp4l>
Announce Receipt Timeout	3	3	The number of missed Announce messages before the last Announce messages expires. *From* <https://linux.die.net/man/8/ptp4l>
Priority1	254 (IPT) 254 (Iris panel) 127 (IPA) 127 Edge/Arcadia Station		The priority1 attribute of the local clock. It is used in the best Leader clock selection algorithm (BMA - Best Master Clock, IEEE1588). 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* <https://linux.die.net/man/8/ptp4l>

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 PTP Leader 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)
- PTP Leader clock announcement messages sent every 2 seconds

4.3.4 PTP Aware Switches

PTP aware switches limit the impact of the switch itself on the stability of synchronization. The transit time (the time from the packet entering the switch and exiting the switch) is variable and

this introduces jitter even when QoS is configured correctly. PTP aware switches can remove this variation.

There are two modes of PTP aware switch which handle the variation in different ways:

- A transparent clock (TC) adds a transit timestamp to each sync and follow_up message. This means that the amount of time the packet spends in the switch can be factored out, reducing PDV.
- A boundary clock (BC) receives synchronization from the Leader clock on one follower port and serves as Leader clock to all other ports. This has the benefit of not only factoring out transit time in the switch but also reduces the load on the Leader clock.

4.3.5 VLANs

If you still experience synchronization problems on your network, (high jitter or offset from the Leader clock) after trying the above steps outlined in **Improving Clocking Accuracy and Reducing PDV on page 43** (for example, QoS and PTP profile) then consider setting up a separate VLAN for Clear-Com AES67 traffic.

4.4 Internet Group Management Protocol (IGMP)

Note: *From EXH v.14 and up, Clear-Com supports both Single Source Multicast (SSM) and Any Source Multicast (ASM). Before that, only ASM is supported.*

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 on page 48**

4.4.1 Configuration for Network Switches with IGMP Snooping

The following apply:

- IGMPv2 is required when using Clear-Com AoIP devices (IGMPv3 if using 2022-7 network redundancy).
- 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.

4.5 Single Source Multicast (SSM) or Any Source Multicast (ASM)

Compared to ASM, SSM (Single Source or Source Specific Multicast) limits the source of packets that are delivered to a receiver, which reduces network demands and improves security. Receivers explicitly request the source address of the packets they want to receive.

When using AES67 direct multicast streams and SSM is enabled, the E-IPA card will send out the desired source IP address in the IGMPv3 packet. The request to route an audio stream from a specific source is handled by the network switch nodes. Therefore, SSM requires IGMPv3 capable switches and querier.

Note: *We suggest that you work within the designated IP range for SSM: 232/8 (232.000.000.000 to 232.255.255.255)*

Note: *Note: Rx Multicast IP addresses across a single E-IPA card must be unique. No two Rx streams can listen to the same multicast IP address*

For information on SSM see: https://www.rfc-editor.org/rfc/rfc4607

SSM	ASM
IGMP Querier (Keep Alive)	IGMP Querier (Keep Alive)
IGMPv3 (Group, Source)	IGMPv2 (Group)
PIM-SSM (Sparse Mode)	PIM-Sparse / PIM-Dense
RANGE 232.0.0.0 to 232.255.255.255	RANGE 239.0.0.0 to 239.255.255.255
	Rendezvous Point (RP)
Only desired source routed by network	Undesired sources routed by network

4.6 AoIP Protocols

Each Clear-Com PTP device (E-IPA-HX card, Edge/Arcadia Station, Iris panel or IP transceiver) uses the following protocols:

- PTP data packets (multicast) to sync to the PTP Leader clock on the network
- AES67 audio data packets (unicast) to pass audio between E-IPA-HX card or Edge/ Arcadia Station and the Iris or IP transceiver
- Auto discovery using mDNS (Clear-Com devices only)
- ST2110-30 audio data packets (multicast) to pass AES67 audio between:

- AES67 trunk lines between Clear-Com matrices
- The E-IPA-HX card and 3rd party AES67 audio devices
- The IPA card supports SAP announcements and the import of SDP files when connecting to 3rd party AES67 audio devices

4.7 AoIP Bandwidth Calculation

			0.125 ms		1 ms	
	Channels	Bit depth	B. Width	Pkt Size	B. Width	Pkt Size
AES Direct	1	16	4.224	66	1.200	150
*	**1**	**24**	**4.608**	**72**	**1.584**	**198**
	1	32	4.992	78	1.968	246
	2	16	4.992	78	1.968	246
	2	24	5.760	90	2.736	342
	2	32	6.528	102	3.504	438
	3	16	5.760	90	2.736	342
	3	24	6.912	108	3.888	486
	3	32	8.064	126	5.040	630
	4	16	6.528	102	3.504	438
	4	24	8.064	126	5.040	630
	4	32	9.600	150	6.576	822
IRIS	1	32	4.992	78	1.968	246
	2	32	6.528	102	3.504	438
	3	32	8.064	126	5.040	630
	4	32	9.600	150	6.576	822
IPT	2	32	6.528	102	3.504	438
EDGE	4	32	9.600	150	6.576	822

*** Default setting**

4.7.1 Bandwidth

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 or single switch port.

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

If you are using a network with a large number of endpoints, consider the uplink ports used on switches. Trunks/access ports between switches in this case may need higher bandwidth than regular switch ports.

5 SMPTE 2022-7 Network Redundancy (Red/Blue Networks)

EHX v.14 and above

SMPTE 2022-7 is used for network redundancy and performance, allowing for the creation of a single reconstructed output stream through seamless protection switching at the RTP audio packet level.

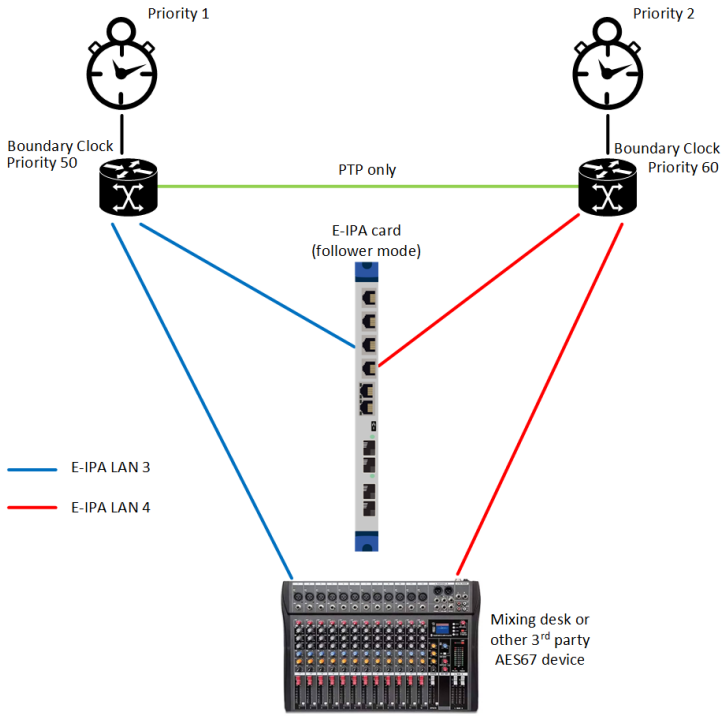
When you enable ST 2022-7 in EHX (E-IPA **Card Properties**), the system sends and/or receives a second identical copy of the data, mitigating the loss of one network path and picking up missing packets.

2022-7 Redundancy can be set up between E-IPA cards or with 3rd party AES67 devices. At the time of writing, Clear-Com IP panels and transceivers do not support 2022-7.

Note: *When 2022-7 is enabled in EHX, SAP is automatically disabled.*

Note: *The E-IPA-HX card is not designed to replace an external leader clock (IE 1588 "Grandmaster").*

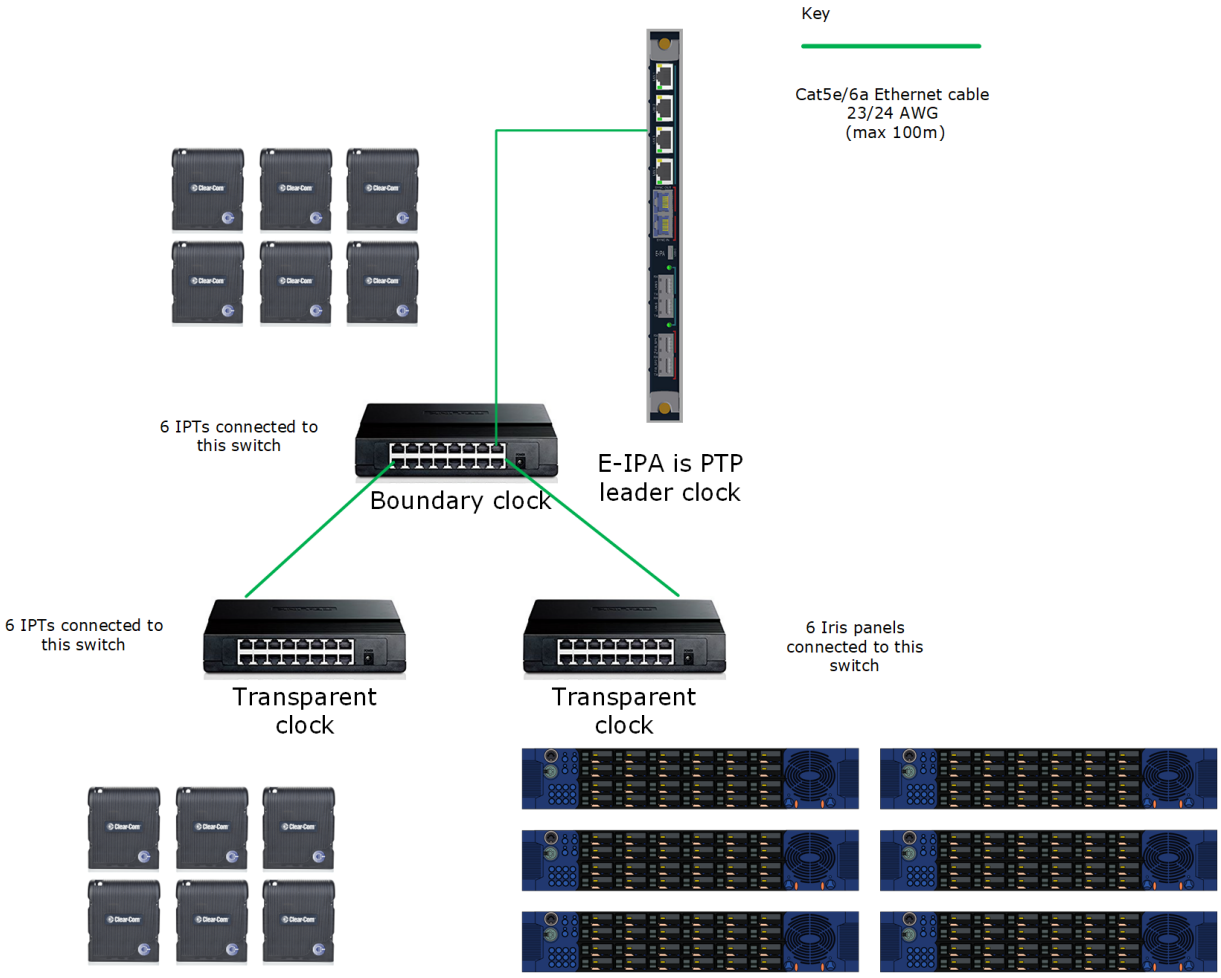
When using 2022-7 with AoIP, network redundancy relies on stable, robust and well-constructed PTP clocking. The following schematic allows for PTP redundancy and network redundancy:



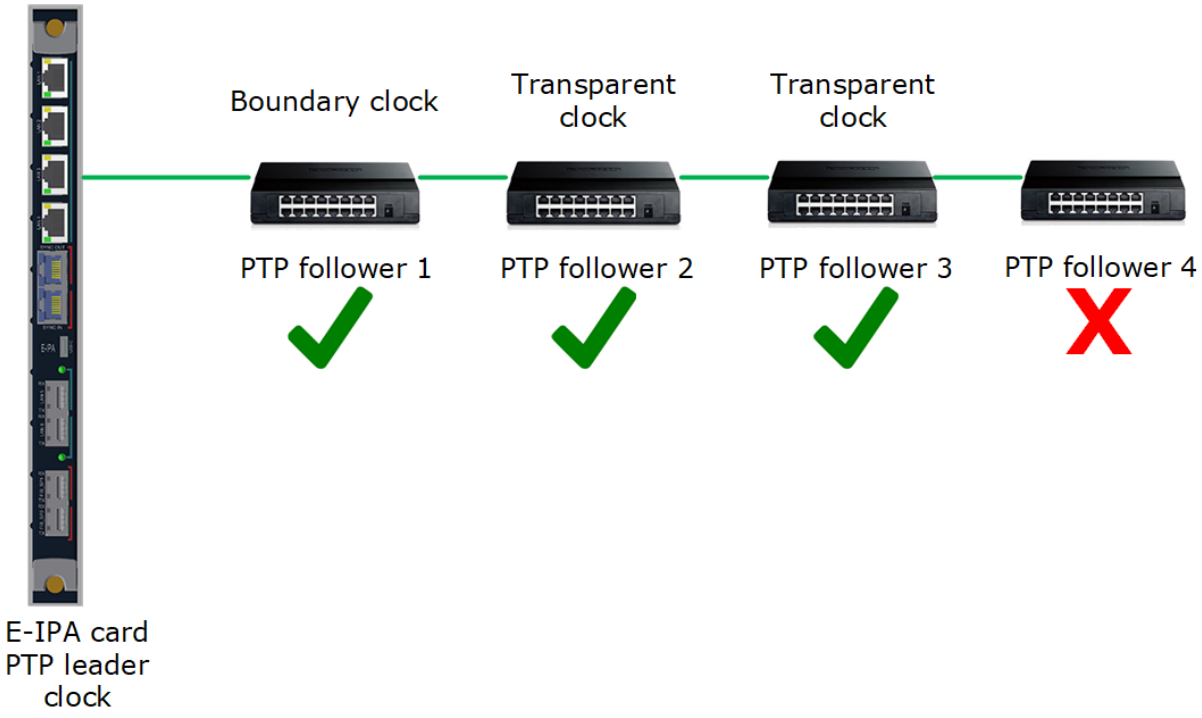
For more detail see PTP Architecture and Best Practices, Master Class 2 of 3, Imagine Communications. Last accessed: 10 September 2024

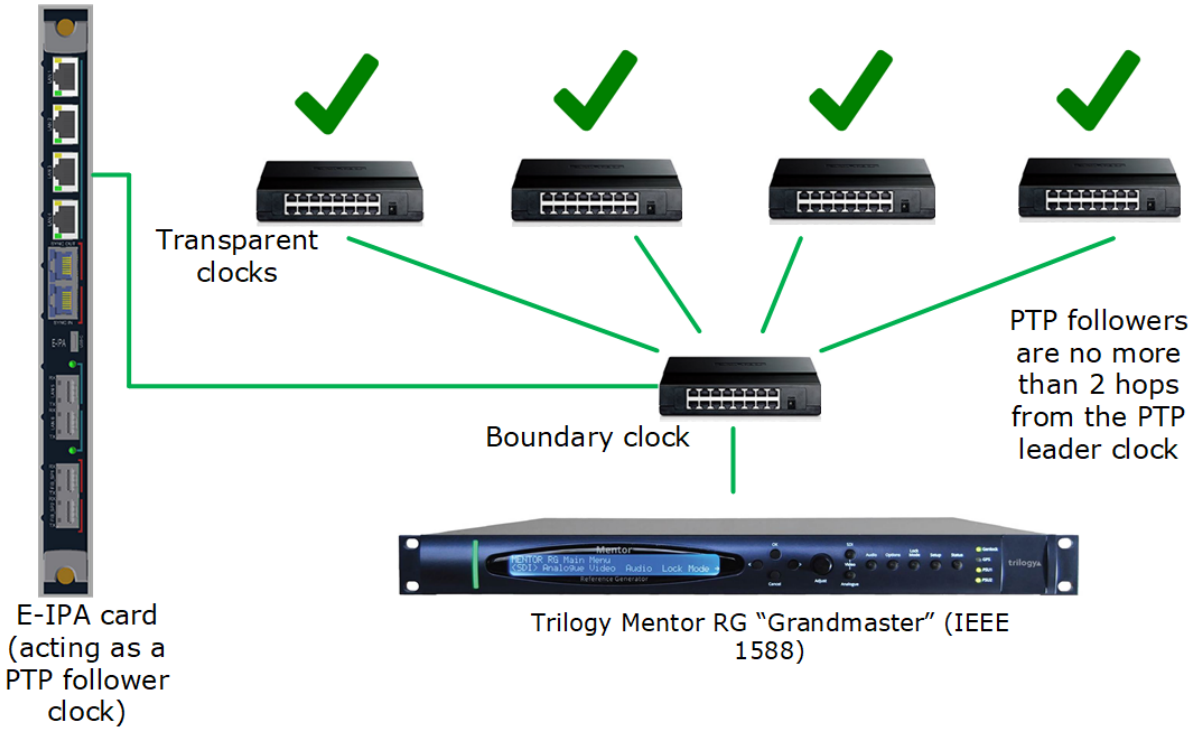
6 Switch Topology

6.1 Example of a Switch Setup



6.2 Example Using Switch Hops and PTP Leader Clock





For more examples see FAQ article: Where in the AES67 network should I place the PTP Grandmaster (leader)?

6.3 Routing across subnets

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

From EHX v.13.0. ARP proxying is no longer mandatory.

Routing across subnets requires the following network provisioning:

- Enter gateway information:
    - the E-IPA-HX interface/Arcadia Station
    - FreeSpeak IP transceiver
    - Iris panel IP settings
- 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 streams from other data on the network.
- Use enterprise grade switches that support boundary / transparent clock mode.
- Ensure Spine / Leaf uplinks are large enough to support all end points on the leaf receiving audio.

Important note

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. Routing across subnets is supported from EHX v12.1.

Note: *It is possible to route over remote locations, but that set up is beyond the current scope of this guide. Please contact your Clear-Com representative, or look in the Solution Finder for more information.*

7 Detailed Switch Setup Information

Use this link for detailed information about switches used at Clear-Com: Network Switches for AES67.

8 Troubleshooting Tips

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

8.1 General Network Troubleshooting

The following apply:

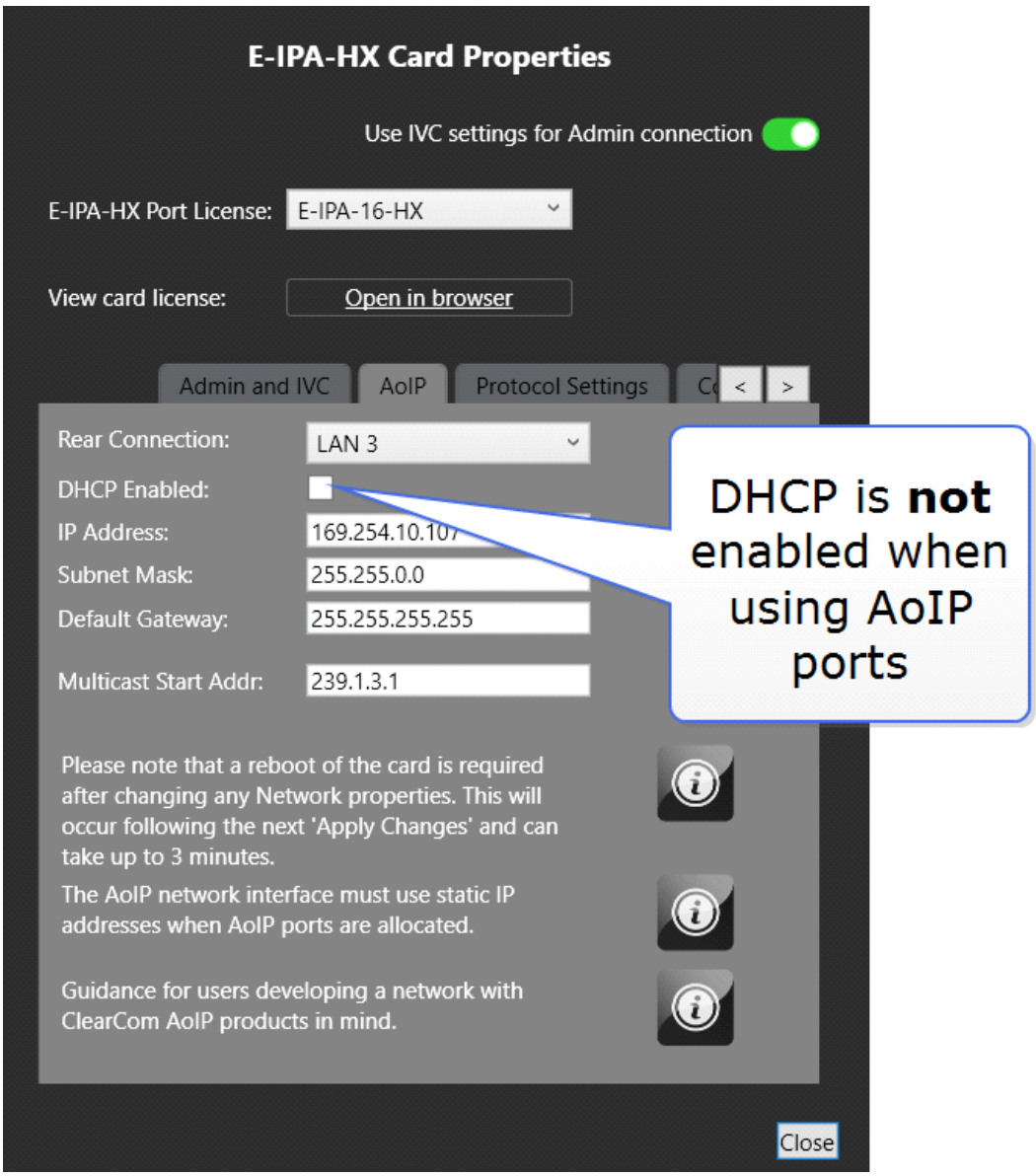
- Verify the switch meets the minimum specification outlined in section 1.13 **Minimum Ethernet Switch Requirements for AES67 Audio on page 31** in this manual.
- Check network topology: how many hops between the PTP Leader clock and the IPT transceiver/Iris panel?
- Do not stack core network switches as the PTP data does not pass across the control plane when switches are in the stacked configuration mode
- Verify that there are no duplicate IP addresses on the network
- Set the Host device to have static IP address
- Set IPTs/ Iris panels to use static IP address (two IP addresses needed per IPT or Iris panel) or set the IPTs/ Iris panels to use DHCP and enable DHCP server on your Ethernet switch
- Do not use the 169.254.xx.xx IP range (link-local) for either host or endpoints
- 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.
- Clear-Com strongly recommends that the PTP network is configured in two-step mode
- If possible separate the Clear-Com equipment onto a separate VLAN without any other manufacturers' equipment. Then check for errors
- Use the EHX or Arcadia 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 or Arcadia monitoring screen to check which device is the PTP Leader clock and if that device is stable

- Ensure that IGMP snooping is enabled on the VLAN that the AoIP devices are connected to
    - Ensure that only one IGMP querier is enabled on this network
- If FSII IPT traffic (or otherwise) is split onto a separate access port for connections between switches check that RSTP **per VLAN** is enabled as opposed to RSTP (see diagram at the bottom of **Eclipse Matrix With Mixed Media Network With FreeSpeak IP Transceivers on page 19**)
- 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 MAC address security and PortFast settings on your Ethernet switches.
- Spanning Tree Protocol (STP/RSTP)
    - Multiple possible routes between the PTP Leader clock and the follower clock(s) will very likely increase Path Delay Variation (PDV). Do one of the following:
        - Make sure that there is only one physical route between the Leader clock and follower clock.
        - Enable STP/RSTP which closes multiple routes when they are found.
- If you still experience synchronization problems on your network, (high jitter or offset from the PTP Leader clock) after trying the steps outlined in **Improving Clocking Accuracy and Reducing PDV on page 43** (for example, QoS and PTP profile) then consider setting up a separate VLAN for Clear-Com AES67 traffic.

8.2 E-IPA Configuration Rules

The following apply:

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



- A license must be purchased to allow the IPA card to support connection to 3rd party AES67 audio devices

9 Glossary

9.1 Inclusive terminology

This document aims to use inclusive terminology. Inclusive language acknowledges diversity, conveys respect to all, is sensitive to differences, and promotes equality. It helps us to avoid biases perpetuated by words and phrases that can reinforce stereotypes and create false power dynamics. Therefore, some terms that have been in common usage have been replaced.

9.2 PTP Clocking

Old Term	New Term
Grandmaster clock	"Grandmaster" (IEEE 1588) PTP primary leader clock
Master clock	Leader
Slave clock	Follower clock

9.3 Other Relevant Terms

Term	Description
Audio Format	Payload format of audio data - also known as ‘encoding’.
Bonjour	Apple´s implementation of zeroconf. DiffServ Differentiated Services- mechanism for classifying and managing network traffic, prioritization of services (e.g. low latency traffic).
DSCP	The differentiated services code point (DSCP) is a 6-bit field in the IP packet header that is used for classification purposes. DSCP is part of the differentiated services architecture.
IGMP	Internet Group Management Protocol (IGMP) is a communications protocol used by hosts to report their multicast group memberships to IPv4 routers.
IP	Internet Protocol - used to build logical units (subnets) in a network.
HTTP	Hyper Text Transfer Protocol - data transmission for application layer, e.g. websites.

Term	Description
Latency	Delay introduced by packetizing or buffering - number of samples per frame divided by sample rate - also known as ‘frame size’.
mDNS	Multicast DNS - resolves host names to IP addresses, part of zeroconf.
Multicast	One sender to many receivers.
Packet	Formatted unit of data - consists of control information and user data (payload).
Packet Time	The real-time duration of the media data contained in a media packet. For example, a packet containing 24 samples of 48 kHz audio has a packet time of 24 ÷ 48 kHz = 500 microseconds. Short packet times allow for lower latency but introduce overhead and high packet rates that may overtax some devices or networks. Long packet times imply higher latency and require additional buffering which may not be available on memory - constrained devices.
PTP	Precision Time Protocol - used to synchronize clocks throughout a network- defined in IEEE 1588-2008.
QoS	In the context of a computer network this term refers to traffic prioritization and resource control mechanisms.
RTP	Real Time Transport Protocol - used for transmission of real time data.
RTCP	Real Time Control Protocol - controls quality of transmission and negotiates QoS parameters.
RTSP	Real Time Streaming Protocol - controls media streaming server.
SDP	Session Description Protocol- describes the configuration of a stream Session Describes the stream parameters (audio format, number of channels.
Unicast	Point to point connection between sender and receiver.
URL	Uniform Resource Locator- a web address.