IPA and IPT Networking

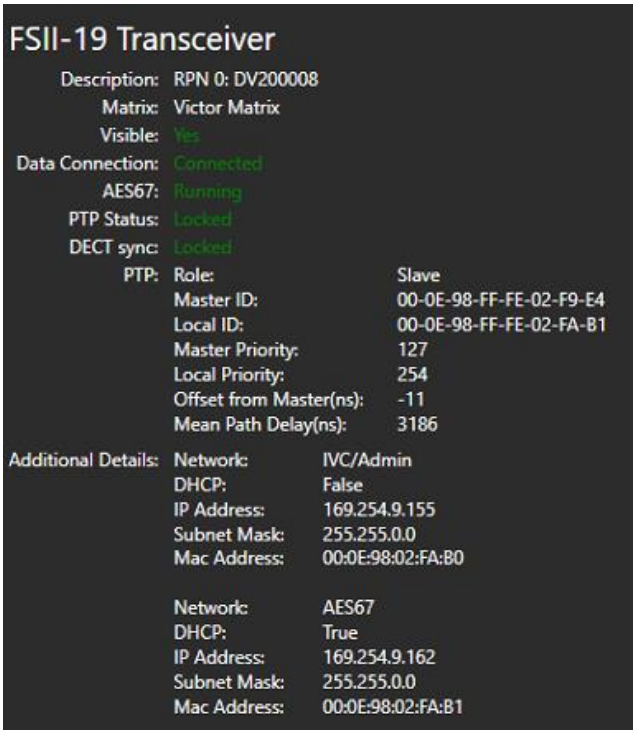
General Rules of Thumb

See below for more details. System sizes are for example only*.

System Size	System	Switch Requirement
Small	1-10 IPTs Up to 3 layer-2 hops between PTP Master and IPTs Clear-Com AES67 Traffic Only	DiffServ QoS
Medium	10-30 IPTs Up to 3 layer-2 hops between PTP Master and IPTs Clear-Com AES67 Traffic Only	DiffServ QoS IGMP Snooping IGMP Querier
Large	> 25 IPTs > 4 layer-2 hops between PTP Master and IPTs Mixed network traffic	DiffServ QoS IGMP Snooping IGMP Querier PTP-aware Transparent and/or Boundary Clocks

*E.g. Even a "small" system would require PTP-aware switches if using more than 3 switches between master and slave.

In terms of tolerance, note the **Offset from Master** and **Mean Path Delay** shown per transceiver (IPT) in EHX Monitoring.



The following figures are guidelines rather than rigid rules. Tolerances will vary depending on the use of external PTP master clocks and where transceivers (and IPA card) are located in the network relative to the master clock.

Parameter	Value (range)	State
Offset from Master (ns)	± 100 ns	Excellent
	± 500 ns	Potential for roaming issues
	± 1000 ns	Issues with roaming likely
	> ± 1000 ns	Cannot roam between transceivers and intermittent loss-of-lock issues
Mean Path Delay (ns)	> 2000000 ns (2 ms)	Issues with audio likely

QoS

AES67 QoS values are used:

Class name	Traffic type	Default DiffServ class (DSCP decimal value)
Clock	IEEE 1588-2008 Announce, Sync, 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 (0) (Default Forwarding)

Note this is DiffServ (RFC2474) and a switch with CoS is not sufficient. QoS is mandatory for a system of any size due to PTP clocking constraints. The switch must therefore support DiffServ QoS and must be set to operate with the values above. Clock traffic **must** be configured in **Strict Priority** mode (not weighted round-robin) to ensure immediate delivery over other types of traffic.

IGMP and Multicast

AES67 & PTP makes use of multicast. To prevent multicast flooding (broadcast) the following is required:

- IGMP Snooping Enabled (per switch).
- IGMP Querier enabled on the network (one only).

For E-IPA & IPT, multicast is only used for Discovery (mDNS) and PTP.
Audio is sent Unicast but using IGMP is essential for other AES67 devices in the same VLAN as well as management of PTP traffic.

Warning: If IGMP Snooping is enabled on any switch, there **must** be an IGMP querier enabled on the network. Multicast traffic can be blocked from reaching a certain endpoint if a querier is not enabled. A switch will eventually forget about a multicast group request from an endpoint. The switch would then stop forwarding that multicast traffic to the endpoint. If PTP (which is multicast) stops reaching a transceiver, it will disconnect from the system. All beltpacks would be forced to roam and communications would fail if the beltpacks cannot all roam to a different transceiver.

PTP

E-IPA-HX uses the AES67 media profile. This is not user configurable.

The definition of the term “profile” may vary depending on switch manufacturers. For example, the Cisco IE 4010 switch has the concept of “profile” but none of the possible options includes a “AES67 media profile”.

In cases where the “AES67 media profile” is not available or specified, the user should make sure the boundary clock switch or grand master clock respects the following criteria:

- PTP messages sent using layer 3 IP packets
- PTP QoS setting must use DSCP tagging with type “expedited forwarding” (i.e. DSCP 46)
- Sync messages sent every 125 ms (**Sync Interval** overleaf)
- Master announcement messages sent every 2 seconds (**Announce Interval** overleaf)

The attribute values are detailed below.

Attribute	Value	Description
Domain Number	0	The domain attribute of the local clock.
Announce Interval	1	The mean time interval between Announce messages. A shorter interval allows faster reactions to the changes in the master-slave hierarchy. The interval should be the same in the whole domain. It's specified as a power of two in seconds. So here 2^1 = 2 seconds between messages. *Adapted from <https://linux.die.net/man/8/ptp4l>*
Sync Interval	-3	The mean time interval between Sync messages. A shorter interval may improve accuracy of the local clock. It's specified as a power of two in seconds. 2^{-3} = 0.125 = 8 per second. *Adapted from <https://linux.die.net/man/8/ptp4l>*
Min Delay Req Interval	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's 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	The number of missed Announce messages before the last Announce messages expires. *From <https://linux.die.net/man/8/ptp4l>*
Priority1	254 (IPT) 127 (IPA)	The priority1 attribute of the local clock. It is used in the best master 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) are priority 254. E-IPA-HXs (card) are priority 127. *Adapted from <https://linux.die.net/man/8/ptp4l>*

PTP Aware Switches

To minimise jitter, larger systems require PTP-aware switches, which stamp PTP packets to account for the residence time in the switch. Such switches are termed **Transparent clocks**. To reduce load on the PTP Grandmaster Clock and clock offset (**Offset from Master**), **Boundary Clocks** can be used. These receive PTP from a Master and serve PTP (as Master) to all other connected devices. Using the guidelines above will determine the need for PTP aware switches. The necessity of such switches depends on the physical size of the network (in terms of number of switches) and the number of devices on the network.

Other Switch Parameters

- 1 Gbps on all interfaces.
- Capable of switch full bandwidth of all ports.
    - E.g. 24 1Gbps ports = 48 Gbps switching capacity.
- EEE (Energy Efficient Ethernet) disabled.

Example Switches

- PTP Aware:
    - Luminex GigaCore26i
    - Cisco IE 4010
- Non PTP Aware:
    - Cisco SG300 (EOL, being replaced by SG350)