AVB Networking Guide

Keep these important operating instructions. Check www.meyersound.com for updates.
CHAPTER 1: INTRODUCTION

This document is intended to serve as a guide for designing and managing AVB networks using Meyer Sound products. It provides an overview of AVB protocols, the Milan application layer, AVB Devices, network topologies, general best practices, and Meyer Sound’s Compass Control Software to help system operators get the best possible performance from their system.

HOW TO USE THIS MANUAL

Make sure to read these instructions in their entirety before configuring a Meyer Sound loudspeaker system. In particular, pay close attention to material related to safety issues.

As you read these instructions, you will encounter the following icons for notes, tips, and cautions:

- **NOTE:** A note identifies an important or useful piece of information relating to the topic under discussion.
- **TIP:** A tip offers a helpful tip relevant to the topic at hand.
- **CAUTION:** A caution gives notice that an action may have serious consequences and could cause harm to equipment or personnel, or could cause delays or other problems.

Information and specifications are subject to change. Updates and supplementary information are available at www.meyersound.com.

Meyer Sound Technical Support is available at:

- **Web:** www.meyersound.com/support
- **Tel:** +1 510 486.1166
- **Tel:** +1 510 486.0657 (after hours support)

Please have as much of the following information available as possible:

- Topology of the network including a list of devices in the network and details about how they are wired together
- Serial numbers of pertinent devices
- Software versions used in your networked devices
- Any fault indicators available either from Compass or the Galileo GALAXY processor(s) front panel(s)
CHAPTER 2: AVB OVERVIEW

Audio Video Bridging (AVB) is a subset of TSN, Time Sensitive Networking, both of which are terms specified in a collection of IEEE standards written to facilitate the transport of high-performance audio and video on an Ethernet Local Area Network (LAN). These standards specify how to distribute control and multi-channel signals via a single network cable between devices. AVB is based on open source standards that are not owned or licensed by any one entity, ensuring its long-term viability. Meyer Sound has integrated AVB into product designs as the preferred choice for distribution of digital audio signals.

**NOTE:** For more details about the IEEE standards defining AVB, see Appendix A on page 47.

AVB Standards specify additional capabilities to the Ethernet network and provide three major enhancements:

- Precise timing to support low-jitter media clocks and accurate synchronization of multiple streams.
- A simple reservation protocol that allows an application on an endpoint device to reserve the resources necessary to support a particular stream by notifying the various network elements in the path.
- Queuing and forwarding rules that ensure that such a stream will pass through the network within the delay specified by the reservation.

**AVB KEY COMPONENTS**

AVB is defined by three key components:

![Three Key Components of AVB](image)
**Multiple VLAN Reservation Protocol (MVRP)**

MVRP is a standards-based Layer 2 network protocol for automatic configuration of VLAN information on switches. Within a layer 2 network, MVRP provides a method to dynamically share VLAN information and configure the needed VLANs.

In practice, the necessary VLANs for successful transport of AVB data are automatically configured by the AVB switch (which can also configure non-AVB devices). The user does not have to manually configure VLANs for successful transport of AVB data.

**Multiple Stream Reservation Protocol (MSRP)**

MSRP is a signaling protocol that allows nodes communicating on a network to reserve network resources and ensure an adequate quality of service level to communicate data packets. With respect to time-sensitive data, such as audio and video content, this protocol guarantees that the necessary bandwidth is available and prioritizes its transmission over other network traffic.

To initiate a transfer, AVB devices capable of transmitting AVB streams, or Talkers, will advertise their available AVB streams on the network. Listeners respond over the network that they are available. AVB devices capable of receiving AVB streams, or Listeners, will respond over the network that they are available. Once a connection is made between a Talker and Listener, MSRP will ensure the required bandwidth is available to successfully transport the stream from the Talker to the Listener. An end-to-end signaling mechanism to detect the success or failure of the effort is also provided.

**General Precision Time Protocol (gPTP)**

AVB Devices periodically exchange timing information that allows both ends of the link to synchronize their time base reference clock very precisely. This precise synchronization has two purposes:

- Allows synchronization of data streams
- Provides a common time base for sampling/receiving data streams at a source device and presenting those streams at the destination device with the same relative timing.
**MILAN**

Milan is the application layer built onto the AVB network protocol that adds a framework of interoperability for professional Audio/Visual (AV) devices. Milan offers specifications, developed in collaboration between leading manufacturers in the professional AV industry, to ensure interoperability between AVB devices. All of this effort takes place under the umbrella of the Avnu Alliance and is based on existing IEEE standards.

Milan guarantees the interoperability of pro audio network devices by standardizing the implementation of AVB technology. Standardization means every certified device will discover, talk, and work properly with every other certified device. It means audio networks will enjoy plug-n-play functionality without the need for complex or custom network configurations. All of the existing benefits of AVB are maintained, while Milan opens the door for future growth and development.

Milan defines a set of technical profiles including:

- Audio Stream Format
- Media Clocking
- Redundancy
- Device Discovery and Control

**Audio Stream Format**

Milan defines three stream format profiles for professional audio devices based on the IEEE 1722-2016 Standard AAF Audio Format. Before Milan, many devices used a different audio format, AM824, which was more complex and less bandwidth efficient.

While three possible stream format profiles are defined in the Milan specification, only one profile is mandatory, the AVTP\(^1\) Audio Format (AAF). This format must be used by all Milan devices and is universally compatible. See Table 1 for the Milan-compliant audio stream format details.

<table>
<thead>
<tr>
<th>Milan Compliant Audio Stream Format</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Encapsulation</td>
<td>PCM</td>
</tr>
<tr>
<td>Format</td>
<td>AAF</td>
</tr>
<tr>
<td>Packet Bit Depth</td>
<td>32</td>
</tr>
<tr>
<td>Audio Bit Depth</td>
<td>24</td>
</tr>
<tr>
<td>Number of Channels</td>
<td>1,2,4,6,8</td>
</tr>
<tr>
<td>Sample Rate</td>
<td>48 kHz, 96 kHz</td>
</tr>
<tr>
<td>Samples per PDU (Protocol Data Unit)</td>
<td>6 (48 kHz), 12 (96 kHz)</td>
</tr>
</tbody>
</table>

Any Milan device must be compatible with the specifications listed in Table 1. AVB Talkers can transmit audio streams that contain any of the channel counts or sample rates specified. AVB Listeners must be capable of receiving audio streams that use these channel counts and at least one of the listed sample rates.

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1. Audio Video Transport Protocol, defined by IEEE 1722-2016, see “References for Further Reading” on page 47.
Media Clocking
Milan defines a common clock format that will be supported by all devices capable of transmitting or receiving a media clock through an AVB stream on an audio network. This format is based on an existing format, CRF (Clock Reference Format), as specified in IEEE-1722-2016.

The CRF format specifies that audio and clock data are transmitted in separate streams, allowing for a more efficient timestamp frequency. The result is equal time precision while using less bandwidth.

Redundancy
Redundancy under the Milan standard follows the concept of duplicating network infrastructure into two independent networks, each with its own network switches, cabling, and time domain. Milan also defines a mechanism to allow for a seamless transition from one network to the other in the event of a network failure (e.g., a faulty cable or loss of a network switch). In practical terms this creates true network redundancy with an automatic failover capability that allows for a transition to the Secondary network without any pause or drop of audio.

Device Discovery and Control
IEEE 1722.1 allows for many interpretations for device discovery, meaning devices from different manufacturers may not recognize each other on a network. Milan eliminates this ambiguity and provides consistent requirements that ensure devices can be automatically detected when they are added or removed from a network. Further, Milan mandates that device information, stream connections, status information, and device control be standardized and compatible for all certified devices.

AVB DEVICES

There are four types of AVB devices: AVB Controller, AVB Switch, Talker, and Listener. Certain devices can be more than one type.

AVB Controllers
AVB Controllers manage the AVB network. Routing, clock selection, and other features relevant to the AVB network can be controlled using these devices. The AVB Controller is often software running on a computer connected to the AVB network.

AVB Switch
AVB Switches are specialized network switches required for communication between Talkers and Listeners. Generic off-the-shelf switches should never be used to distribute AVB signals. Only network switches that have been Avnu-certified should be considered when designing or operating AVB networks. The latest list of Avnu-certified hardware, including switches, can be found on the Avnu Alliance website: https://avnu.org/certified-products/

AVB Talker
An AVB Talker is an AVB source device capable of transmitting AVB streams. This device will send AVB streams to an AVB Listener. When a Talker is on the network, it automatically advertises its presence and the streams it is able to transmit.

AVB Listener
An AVB Listener is an AVB destination device capable of receiving AVB streams. This device will receive AVB streams from an AVB Talker. All available streams from all available Talkers on the network will be visible to the Listener automatically.
Source
An AVB Talker has at least one Source, a virtual output. Each Source makes one AVB Stream available on the network.

Sink
An AVB Listener has at least one Sink, a virtual input. Each Sink can receive one AVB Stream.

MEYER SOUND AVB DEVICES

Compass Control Software
Compass is Meyer Sound’s control software for GALAXY and CAL and serves as an AVB Controller. Compass is capable of routing AVB and clock streams between devices, displaying critical network information, and storing logs that detail significant events taking place on the network.

Galileo GALAXY Network Platform
The Galileo GALAXY Network Platform is a digital signal processor that serves as both an AVB Talker and Listener, having capabilities to both transmit and receive AVB audio and clock streams.

NOTE: Meyer Sound Compass 4.3.6 and Compass Go AM824, and their included GALAXY firmware, are the last versions that support AM824 audio format. Compass 4.6 and beyond support AAF audio streams and CRF clock streams. GALAXY processors with different firmware will NOT be compatible with each other. For most applications, Meyer Sound recommends upgrading GALAXY to the latest firmware, available for download: https://meyersound.com/product/compass/#software

CAL Column Array Loudspeaker
CAL is a digitally steerable column loudspeaker that serves as an AVB Listener. It can receive AAF audio and CRF clock streams.

CAUTION: Although CAL cannot transmit audio streams to other AVB devices, it can transmit CRF clock streams to other devices. This capability can cause unexpected results. Use care in creating network topologies, especially primary and secondary, as it will bridge the time domains of the two networks. See “CAL Network Behavior” on page 17.

CAL is not Milan certified but is compatible with and can operate in systems using Meyer Sound devices, such as Galileo GALAXY. In practice, it can be treated as a Milan device in all ways except that it does not support Milan standards for redundancy.
CHAPTER 3: NETWORK CONFIGURATIONS

NETWORK REDUNDANCY OPTIONS

The GALAXY processors support two kinds of network redundancy: Milan and Cable. Milan redundancy, an optional functionality defined in the Milan standard, is a fully redundant network (Figure 1). Cable redundancy (Figure 2), is an additional capability of Meyer Sound GALAXY processors. This configuration is not required or defined by the Milan specification, but provides added flexibility to users.

Meyer Sound recommends using a Milan Redundant topology wherever possible. AVB networks can be configured in a variety of ways, and more robust configurations come at the expense of additional hardware, specifically network switches. Recognizing that specific applications may have restrictions in terms of cost or special requirements, alternative topologies are shown in the following pages. It is the responsibility of the system designer to balance the specific requirements against the available resources for any particular application.

**NOTE:** When connecting third-party devices that might flood the network with multicast streams or non-AAF/CRF packets to a GALAXY, the connection should be made to Port 2, or a switch connected to the Secondary network. Connecting these devices to the Primary network or GALAXY Port 1 could cause unstable network behavior in extreme cases involving many devices (100+) or large amounts of multicast traffic. This practice should be followed when connecting RM Servers to the same network to which GALAXY processors are connected.

**NOTE:** Analog signals can also be used as a backup; with this approach, there will be no automatic failover in the event of a network failure.
Milan Redundancy
The most robust network configuration is a fully redundant network, referred to as Milan Redundancy (this optional functionality is defined in the Milan standard). This topology uses two independent networks; each network consists of discrete cabling, network switches, and time domains. Both networks distribute audio signals simultaneously. In the event of a network failure, there is no pause or drop in audio, as audio is already being transmitted across the Secondary network.

A control computer running Compass software can be connected to either network. If control redundancy is desired, a second computer can be connected to the other network, or a second network interface card in the same computer can be connected to the Secondary network.

All Primary network connections should be made to AVB port 1 on GALAXY processors. All Secondary connections should be made to AVB port 2. Figure 3 shows one possible configuration that demonstrates Milan Redundancy.

*AVNU Certified Network Switches

Figure 3: Milan Redundancy Configuration
Primary Network Only—Cable Redundancy

The Primary Network Only—Cable Redundancy configuration, a Meyer Sound feature that is not part of the Milan standard, provides redundancy for the cabling paths between switches and AVB devices but consists of only a single network. Each AVB port of a GALAXY is connected to the same switch. While not as robust as operating dual independent networks, this configuration offers an additional layer of protection beyond simply running one cable from each AVB device.

*AVNU Certified Network Switches

Figure 4: Primary Network Only—Cable Redundancy Configuration
Primary Network Only—No Redundancy
The Primary Network Only—No Redundancy configuration is the simplest and least robust configuration available. Each GALAXY connects to a network switch via AVB port 1. AVB port 2 is not used. A loss of any single cable, bridge, or device will result in at least a partial loss of audio or control.

Figure 5: Primary Network Only Configuration
CAL NETWORK BEHAVIOR

CAL network behavior is similar to GALAXY but with two significant differences:

• CAL will bridge gPTP information between a Primary and Secondary Network
• CAL can receive AVB/AAF audio and CRF clock streams but can only transmit CRF clock streams to other AVB devices.

When a CAL is connected to both the Primary and Secondary networks, it will bridge the time domains of the two networks. gPTP information will no longer be redundant. This time-domain bridging means CAL is not capable of true Milan redundancy, and is not Milan certified.

Synchronization of an AVB network is dependent on a stable master clock. If the master clock device changes, it can temporarily degrade the quality of the audio on the network.

The Primary and Secondary networks use independent time domains. When a CAL is connected to both networks, it bridges them and creates a network with a single gPTP time domain. Instead of having a master clock for each network, one device will serve as the gPTP master clock for both. The master clock device is chosen based on the Best Master Clock (BMC) algorithm. This algorithm first considers which device has the lowest “Priority 1” value, a parameter that is fixed and inherent for a Milan AVB device. If there is a tie, the device with the lowest MAC address will be selected as the master.

CAL network redundancy behaves similarly to GALAXY—a failure of a component of the Primary network will result in a seamless transition to the Secondary network without any pause or break in audio. However, unlike GALAXY, the clock will become unlocked for a short period (generally several seconds) before automatically locking again. During this period audio will continue to pass, but there may be phase drift until the clock re-locks.
CAL AND GALAXY

CAL Redundancy

Figure 6 shows an example system consisting of a console source, a single GALAXY, and a single CAL. The connections shown here between CAL, GALAXY, and network switches can be expanded to accommodate additional devices. CAL bridges the gPTP information between the two networks.

Figure 6: CAL Redundancy Configuration
CAL Cable Redundancy

In the configuration shown in Figure 7, the network behaves identically to the GALAXY only example shown in Figure 4 for Cable Redundancy. It is not as robust as using separate switches but offers additional reliability compared to using a single network cable between AVB devices and switches. This configuration is a Meyer Sound extension to redundancy and not part of the Milan redundancy specification.

Figure 7: CAL Cable Redundancy Configuration
CAL Primary Only—No Redundancy

The CAL Primary Only configuration (Figure 8) is the simplest and least robust, with only a Primary network and a single network cable that connects each AVB device to a switch.

*AVNU Certified Network Switch

Figure 8: CAL Primary Only Configuration
CHAPTER 4: BEST PRACTICES

Every application involving design and operation of networks must be evaluated on a case-by-case basis. Listed below are Meyer Sound best practices applicable to the deployment of Meyer Sound devices.

CLOCKING

Precise synchronization of audio signals is a necessity for high quality sound reproduction. Even very slight offsets in time between sound sources can significantly degrade audio quality. Two separate clocking mechanisms are present in an AVB Milan network: General Precision Time Protocol (gPTP) and Media Clocks.

Generalized Precision Time Protocol (gPTP)

IEEE 802.1AS defines generalized Precision Time Protocol (gPTP). gPTP provides a 'wall clock' for the entire network, or an absolute time reference that can be used to synchronize media clocks. A master clock is automatically selected using the Best Master Clock Algorithm (BMCA). The BMCA will select the device as the master that it deems to have the most accurate clock on the network. If it determines multiple devices offer equivalent clock precision, it will choose the device with the lowest MAC address.

Every AVB/TSN packet of information transmitted by a Talker includes a timestamp. The timestamp represents an objective, absolute time that is not based on any relative relationships. The source of this absolute time is the master device, and gPTP synchronizes every other device on the network to this clock.

Media Clocks

A media clock domain is a subset of an AVB domain composed of end stations using the same common media clock for sampling, transmission and rendering of audio signals. For Meyer Sound systems, the media clock is manually selected by the user within Compass. Two types of media clock can be chosen: a CRF stream or an AAF audio stream. Milan-certified devices will offer a CRF clock and AAF clock.

NOTE: Meyer Sound recommends that a CRF stream be selected as the media clock when available because it uses less bandwidth than dedicating an empty AAF audio stream for this purpose.

CRF behaves similarly to a Word Clock. While gPTP automatically synchronizes the clocks of all devices on the network, it does not synchronize sampling rates for signals transmitted by Talkers. To transmit synchronized media clocks, a Talker must distribute a clock stream to other devices. gPTP is the time to which watches are synced; CRF is the synchronous arrival of streams based on the gPTP. Digital devices are not perfect timekeepers, but their synchronization can be ensured via CRF.

Clock Reference Format (CRF), as defined in IEEE 1722-2016, Clause 10, is the media clock format used by Milan-certified devices, including all Meyer Sound devices. Unlike the master gPTP clock, for each Listener, the system designer/user must manually select a CRF clock stream in Compass software. This approach allows a Listener to synchronize audio data from multiple Talkers.

Distribution of Media Clocks

The same media clock stream should be selected for all Listeners on the network. The media clock should never be cascaded. If different Listeners select different media clock streams, their outputs will not be synchronized. Any devices that share audio between them need to share the same media clock.

CAUTION: Never cascade media clocks. Even small timing differences between devices can cause audible audio degradation.
COMMON SYSTEM CLOCK FOR MULTIPLE INTERCONNECTED GALAXY

When connecting multiple GALAXY devices together, it is imperative that one common system clock be used. Clocks should never be daisy-chained. Even small timing differences can cause audio degradation that is audible. Figure 9, Figure 10, and Figure 11 illustrate some of the more common cascaded GALAXY clocking situations for networked GALAXY processors.

Figure 9 illustrates a situation where an Analog or Asynchronous AES3 input must be sent through several GALAXY. While an audio signal may be daisy-chained from one GALAXY to the next, it is worth repeating that the clock must never be daisy-chained. In the case illustrated in Figure 9, GALAXY 1 receives an Analog or Asynchronous AES3 input, and its System Clock should be set to Internal to use the device clock. For an AES3 Asynchronous signal, the Asynchronous AES3 Sample Rate Converters (ASRC) must be enabled on that input.

Succeeding GALAXY (in this case GALAXY 2, 3, 4 and 5) must receive their Media Clock from the same source (GALAXY 1), which can be accomplished by using a CRF clock (Clock Reference Format Packets) from GALAXY 1.

Figure 10 illustrates a situation where an AES3 signal aligned to a Word Clock must be sent through several GALAXY. Again, the clock cannot be daisy-chained along with the audio signal. In this case, if GALAXY A (which must be a GALAXY 816-AES3) receives an AES3 input synchronized at its source to a Word Clock, its System Clock should be set to the Word Clock received from the same source via the BNC connector. In this case, the ASRC must be disabled.

Succeeding GALAXY (GALAXY B, C, D and E which can be any GALAXY model) must receive their Media Clock from the same source (GALAXY A). This configuration can be accomplished by using a CRF clock (Clock Reference Format Packets) from GALAXY A. The ASRC for succeeding GALAXY (B, C, D, and E) must also be disabled.
Figure 11 illustrates a situation where an AVB signal coming into the first GALAXY must be sent through several GALAXY. Again, the clock cannot be daisy-chained along with the audio signal. In this case, the source of the AVB signal must also provide the Media Clock, because GALAXY 1 would add latency, as it is essentially daisy-chained itself from the input source. In this case, all GALAXY (1–5) can receive the same Media Clock by dedicating 1 of the available 32 AVB channels to act as a system clock.
Signal Path Delays

In many applications, the signal path between a Talker and a Listener (such as a GALAXY or CAL) will vary throughout the system. The most significant influence of this variance occurs when a signal passes through a network switch, or a “switch hop.” Every switch hop introduces an increase in signal transit time between the Talker and Listener. Different signal paths can include a different number of switch hops relative to each other. In Figure 12, for example, the CAL on the left receives signals with only one switch hop, whereas the CAL on the right will receive signals that have accumulated two switch hop delays. All signals must arrive synchronously at the Listener regardless of their signal path. The mechanism to ensure this synchronization is Presentation Time.

![Figure 12: Switch Hops Introduce Signal Delay](image)

Presentation Time

Because all AVB devices on a network use a common time reference (gPTP), and the network knows the transition time between Talker and Listener, the Talker includes a time stamp, set in the future, for when the signal is to be ‘presented’ at the output of the Listener—the Presentation Time. Including a time stamp ensures that signals are reproduced simultaneously at different Listeners regardless of the different transmission paths between Talkers and Listeners. Devices with more switch hops will need more time to receive the signals.

For example, in Figure 13, CAL Pair #2 will need more time than CAL Pair #1, because signals must pass through two switches. Similarly, CAL Pair #3 will need more time than CAL Pair #1 or #2. In this case, the Talker should send a Presentation Time time stamp that uses the master clock value plus some additional time to account for the worst case delay through the system, which would be experienced by CAL Pair #3.
The AVB interface in Compass displays the calculated worst-case latency between Talkers and Listeners, called “MSRP Accumulated Latency.” This value is determined by the number of switch hops between Talker and Listener. The Presentation Time should always be set to a value higher than the MSRP Accumulated Latency to ensure no degradation of audio quality. The maximum (and default) Presentation Time is 2 ms. The Presentation Time can be adjusted to lower values within the Compass software.

Presentation Time is a fundamental property of AVB. While automatic, the ability to adjust Presentation Time is possible with Meyer Sound and some other AVB devices.

Figure 13: Adjusting Presentation Time
CHAPTER 4: BEST PRACTICES

WIRING

• Without use of media extenders, the maximum recommended cable length for CAT5e or better network cabling is 100 meters (300 feet).

• Media extenders or Media translators should be used with caution and must be pre-qualified as some may store and then forward data, breaking timing.

• GALAXY processors and CAL loudspeakers include 2 AVB ports on each device (labeled 1 and 2). AVB port 1 should always be used by default.

• If a Milan redundant network (see “Milan Redundancy” on page 14) is used (Primary and Secondary), all Primary network connections should be made to port AVB 1 and all Secondary connections on AVB 2.

• If cable redundancy (“Primary Network Only—Cable Redundancy” on page 15) is used, both ports should be connected to the same switch.

BANDWIDTH

One of the fundamental characteristics of AVB is that bandwidth is reserved for audio signals regardless of other types of network traffic. Adequate bandwidth is still required even when AVB signals are given priority. Networks should be designed with ample bandwidth to accommodate current and future needs.

When a Talker advertises a stream on the network, it also advertises the required bandwidth the stream requires. Network components will compile a list of all available streams network wide, and a Listener can request that a stream be delivered. The path from the Talker to the Listener is analyzed to ensure the bandwidth is available. If the bandwidth is available, the connection can be reserved, and the bandwidth is reserved for the specific path between Talker and Listener. In the event that required bandwidth is not available, the Talker and Listener will be notified before a connection is made.

The values below give a sense of bandwidth allocation to keep in mind when designing Milan AVB networks.

• 33 eight-channel GALAXY formatted streams can be safely transmitted using a 1 Gb/s link at 75% Bandwidth Usage (up to 264 channels).

• All Avnu-certified switches are capable of a throughput of at least 1 Gb/s, and gigabit-capable network cabling should always be used.

NOTE: These figures assume no other network traffic on the network. 75% bandwidth usage is standard for many switches, but most switches allow this number to be adjusted.

Network hardware should be compared against estimated bandwidth requirements to ensure the necessary infrastructure is available.

PERSISTENT CONNECTIONS

Connections made between Meyer AVB Talkers and Listeners are persistent if they are made using Compass. Connections made using a third-party controller are not persistent. Once the connection is made between a Talker and Listener, the stream will be reserved and a network path maintained between the two devices.

These connections will remain in the event that a device is no longer present on the network (due to loss of a network connection, device powered down, etc.). The stream will still be reserved between devices and will be available when the device comes back online.

AVB connections are based on Group and Entity names. If an Entity name or Group name changes, the connection will be lost, and a new connection must be made using the new name. If an Entity or Group name is changed, then changed back to the original Entity or Group name, the connection must still be remade in Compass.
GALAXY snapshots preserve any AVB connections—any AVB connections stored with the snapshot will be recalled with the snapshot.

**NOTE:** Meyer Sound’s Galileo GALAXY Network Platform has a built-in AVDECC controller.

CAL presets do not maintain or store AVB connections. If a new preset is loaded, the AVB connection must be made.

**ADDING DEVICES TO EXISTING NETWORK**

When an AVB device is introduced to an existing network, there is a possibility it can affect network behavior. It is possible a new device introduced to the network could behave as a CAL—bridging the gPTP information between the two networks. This behavior will not occur if introducing a Milan-certified device to the network.

**CAUTION:** Adding a network switch to an existing network could also affect the master clock selection of the network, which could cause a temporary degradation of audio quality.

**ORDER OF OPERATIONS**

One of the most helpful techniques to ensure smooth network behavior is to follow a prescribed order of operations when creating and working with an AVB network. More specifically, the order in which devices are powered on, cable connections are made, and devices are manipulated by AVB controllers can affect network behavior. The following is a suggested order of operations in order to help ensure smooth network behavior.

1. Make physical network connections before connecting power. Before AVB devices are powered on in the system, all wiring connections should be made, including Talkers, Listeners, and network switches.
2. When possible, apply power to all devices at the same time. This approach creates an environment where discovery between devices happens simultaneously and avoids possible network confusion by introducing additional devices into an existing network infrastructure.
3. Name Entities and Groups. Entity and Group names are used for identification between devices and AVB stream connections. Each Entity and Group should be given a unique and identifiable name. For Meyer Sound devices, the entity name can be changed from within Compass software.
4. Connect clocks before distributing audio. Select a clock stream for each Listener. One Talker should be chosen to distribute a clock stream to all Listeners in the network. Never cascade or daisy-chain device clocks. Once the clock stream has been selected, lock it by selecting it from the “Clock Mode” drop-down menu underneath “System Clock.”
5. Route audio: create connections for audio between Talkers and Listeners. Talkers will automatically advertise their available streams to the network. The user simply selects each Listener and then selects a specific stream and channel of audio to be routed to each sink on the Listener.

In the event that devices are added to an operating network and unexpected behavior results, powering down all AVB devices and following this prescribed order of operations is a good first troubleshooting step.
CHAPTER 5: COMPASS CONTROL SOFTWARE

Compass provides a graphical user interface to control all the features offered by the GALAXY processor and the CAL Loudspeaker, as well as to control other non-AVB capable devices. It can also integrate with the RMServer, Meyer Sound’s Remote Monitoring System, to monitor health and status of any Meyer Sound loudspeaker equipped with an RMS module.

**NOTE:** It is assumed the reader is already familiar with Compass software. To browse all Compass support videos, visit [https://meyersound.com/product/compass/#support-videos](https://meyersound.com/product/compass/#support-videos)

**NOTE:** For more information about the GALAXY processor and control of it via the Compass software, see the GALAXY User Guide (PN 05.230.005.01) available at [www.meyersound.com/documents](http://www.meyersound.com/documents).

MANAGING AVB AND GALAXY PROCESSORS WITH COMPASS

This section of the document provides an example of how to use Compass Control Software to manage Galileo GALAXY processors on an AVB network. (For brevity, Compass Control Software is referred to as “Compass” and the Galileo GALAXY processors as “GALAXY” in the following pages.)

The example illustrated in Figure 14 uses similar equipment to what is shown in Figure 3, Milan Redundancy Configuration, on page 14 including:

- Five GALAXY 816 processors
- Two Avnu Certified Network Switches (Primary and Secondary)

![Figure 14: Example Milan Redundancy Topology](image-url)
**Configuring GALAXY Network Settings**

Connect each GALAXY to the Primary switch using AVB Port 1, and to the Secondary switch using AVB Port 2.

Establish the network connection between Compass and each GALAXY processor.

1. Connect the computer running Compass to the Primary network switch with Cat5e or better network cable.
2. Launch Compass
3. Select the Processors tab. The devices that have been automatically discovered will be listed under the Inventory tab.
4. If one or more processors are not listed, click “Find Devices” (upper-left).
5. Click “Connect” for each GALAXY. The Inventory tab contents should appear similar to Figure 15.

6. Access the network settings for each GALAXY by clicking on the appropriate GALAXY processor tab, then the Settings tab, and then the Network tab.

7. Enter an easily recognizable Entity Name and Group Name to identify each device. Once set, names should not be changed, because AVB connections are based on Entity and Group Names—changing the Entity or Group Name will break any existing AVB connections.
NOTE: Selecting the “Edit Network Settings” button (Figure 16) from the Network tab also enables editing of the Entity Name and Group Name. Network type and IPv4 settings can also be modified from the Edit Network Settings pop-up (Figure 17).

NOTE: The Client/Server connection between GALAXY processors does not require setting IP Addresses. Compass uses IPv6 to connect to the processors. If the switches are properly configured and the cabling is correctly routed, Compass will automatically connect to the GALAXY processors. If IPv6 addressing is not available, the GALAXY processors will default to IPv4 addresses as an alternate method of configuration. If using a third-party controller that requires IPv4, GALAXY processors can be assigned IPv4 addresses. If assigning IPv4 addresses to a GALAXY processor, the Port 1 address and the Port 2 address cannot be the same. For more information, see the GALAXY User Guide (PN 05.230.005.01) available at www.meyersound.com/documents.

Figure 16: Network Settings tab for the FOH GALAXY processor

Figure 17: Edit Network Settings Pop-up
Routing AVB Signals Between Meyer Sound Devices

1. Select the Input and Output tab to open the signal routing interface. For this example, AES3 input signals have been selected for FOH GALAXY inputs A and B (Figure 18).

The AES3 input signal can be seen on the meters of Inputs A and B in the Overview tab of the FOH GALAXY (Figure 19). The signals driving Inputs A and B can be transmitted to other devices in the system via AVB. There are three ways an AVB signal can be routed between GALAXY processors: Outputs, Input Splits, and Matrix Inputs.
2. Select another GALAXY tab to choose a processor that will receive AVB signals from the FOH GALAXY. In Figure 19, for example, the available tabs are L-2, L-1, R-1 and R-2.

3. Select its Input and Output tab. This tab displays the available inputs A-H. In this example Channel A is selected, and an AVB source is chosen from the pull-down menu (Figure 20).

4. Select an AVB Input for Channel A to open the AVB Input Channel Select pop-up, which displays other AVB devices on the network and the AVB sources from each that can be selected as an input (Figure 21).
The Group Name drop-down menu displays the groups that are available on the network. When a group is selected (in this case 'SYS A'), the entities within the group are displayed and can be selected. After an Entity is selected, its available AVB sources (entitled “Talker Streams” in Compass) are displayed.

**GALAXY AVB Talker (Source) Streams**

GALAXY processors have six AVB sources:

- **Outputs 1-8—AAF, 96kHz, 8 Channels**
  Using this stream, one of the output channels 1-8 of the Talker (FOH GALAXY) may be assigned to a Listener. The audio in this channel is AAF format, 96kHz.

- **Outputs 9-16—AAF, 96kHz, 8 Channels**
  Using this stream, one of the output channels 9-16 of the Talker (FOH GALAXY) may be assigned to a Listener. The audio in this channel is AAF format, 96kHz.

- **SIM Outputs—AAF, 96kHz, 8 Channels**
  These SIM probe point stream channels are Console and Processor. The processor probe points are enabled with the Enable SIM 3 Overview button. Their signal path location is selected with the Console and Processor Probe point drop-down menus.

- **Input Split—AAF, 96kHz, 8 Channels**
  Using this stream, one of the input channels A-H of the Talker (FOH GALAXY) may be assigned to a Listener. This signal is post-processing. The audio in this channel is AAF format, 96kHz.

- **Outputs 1-8 —AAF, 48kHz, 8 Channels**
  Using this stream, one of the output channels 1-8 of the Talker (FOH GALAXY) may be assigned to a Listener. The audio in this channel is AAF format, 48kHz.

- **Outputs 9-16—AAF, 48kHz, 8 Channels**
  Using this stream, one of the output channels 9-16 of the Talker (FOH GALAXY) may be assigned to a Listener. The audio in this channel is AAF format, 48kHz.

**Secondary Network Connections**

When an AVB input stream is selected as a Listener’s input, there is a “Connect Secondary” toggle box (Figure 22) that can be set to connect this stream via the Secondary network as well. This selection will make the AVB connection between Talker and Listener on both the Primary and Secondary networks. If unchecked (disabled), only the Primary network connection will be made. It is enabled by default, however it only works if there is more than one switch on the network.
If the Secondary network is connected, the input channel display will show identical information for both the Primary and Secondary network. The Primary network is represented with a capital letter, A-H, while the Secondary network is represented with a lowercase letter, a-h (Figure 23).

**AVB Control Mode**

The AVB Control Mode drop-down menu allows a user to select whether AVB connections will be made using Compass (Internal Controller) or a third-party software controller (External Controller).
Internal Controller is the default setting, and when this mode is selected, AVB connections are established using Compass.

In External Controller mode, input sinks are not mapped to input channels. If Compass is used to assign an AVB stream to an input sink, that sink will not be routed to an input channel—in other words, no connection is made.

Instead, third party controllers are used. In the external controller, the user can map input sinks to input channels and then route AVB streams accordingly.

**Channel Selection Types**

The Channel Selection drop-down menu controls which group of eight inputs will be displayed (Figure 25). The default setting is Inputs—this setting displays Inputs A-H, which can receive Analog, AES, and AVB signals. The other options are Matrix Inputs 9-32. These inputs can only receive AVB signals.

**AVB Clock Selection**

The AVB Clock Selection drop-down menu allows a CRF clock stream source to be selected and assigned as the media clock for the device. Selecting the drop-down menu will open the AVB Input Channel Select window, listing the available CRF clock streams which are selectable (Figure 26).

Redundancy behaves identically for the CRF clock stream as it does for an AVB/AAF audio stream. Selecting the “Connect Secondary” button in the AVB Input Channel Select window will make the same connection on the Secondary network as on the Primary.
See Chapter 4, “Best Practices,” for details about how to properly distribute a media clock across a system. The general rule of thumb is that the media clock should not be cascaded or daisy-chained. The same media clock should be selected for every Listener on the network.

System Clock
The System Clock, Clock Mode drop-down menu allows the user to select which media clock to use as a device-synchronizing clock (Figure 27). For most applications, use the CRF clock stream that is selected in the AVB Clock Selection menu. It can also be locked to an AVB/AAF audio stream, AES synchronous input, the GALAXY internal clock, or Word Clock (GALAXY 816-AES only).

Clock Status reflects the status of the currently selected clock, and should read “Locked.” If the clock status is not locked, behavior associated with non-synchronized clocking may occur.

![System Clock Status Drop-down](image)

AVB Diagnostic Tools
Compass provides several diagnostic tools to indicate the status and performance of an AVB network. Adjacent to each input channel or matrix insert channel are columns of network parameters and information. The following parameters are displayed when an AVB input source is selected.

The first two columns in Figure 28 (Enable ASRC and Clock Status) only apply to incoming AES signals and are covered in the Galileo GALAXY User Guide (PN 05.230.005.01).

![Connection, Diagnostic Information](image)

Media Status
The Media Status column indicates whether the AVB media clock is locked or unlocked. If the clock status indicates not locked, behavior associated with non-synchronized clocking may occur.
**Input Sample Rate**

The Input Sample Rate field shows the sample rate of the incoming AVB stream (this rate will always be either 48k or 96k).

**Stream Info**

Pressing the “Info” opens the “AAF Stream Info” window.

![AAF Stream Info Window](image)

*Figure 29: AAF Stream Info Window*
The column headings of the AAF Stream Info window indicate the device and AVB stream selected. This window is divided into two parts. The left column represents the Primary network, and the right column represents the Secondary network.

### Connection Error

If a stream connection cannot be negotiated, the details of why will be shown in this field. However, Listener Counters should be referred to for quality of the Connection. Figure 30 provides a window illustration showing the interface appearance when a Stream Interrupted error has occurred. In the Figure 31 illustration, there were no errors detected.

![Figure 30: Errors Detected](image)

![Figure 31: No Errors Detected](image)
Group
The Group name is used to associate multiple AVB entities into a logical grouping. To establish AVB connections between devices, they must have the same Group name.

Entity Name
The Entity name is used to uniquely identify an AVB entity. All Entity Names must be unique within a Group. An Entity Name is equivalent to a Device Name.

Stream
The Stream Name is used to identify a specific AVB stream within an entity.

Channel
The Channel Name is used to identify a specific channel within an AVB stream.

Stream Format
The Stream Format as specified in the IEEE 1722-2016 Standard for a Transport Protocol for Time-Sensitive Applications in Bridged Local Area Networks.

Media Status
The Media Status column indicates whether the Listener AVB stream is locked to the Media Clock rate of the Talker.

MSRP Accumulated Latency
The MSRP Accumulated Latency is the worst case amount of time it will take a signal to pass from the Talker to the Listener. This value is calculated when the Stream Reservation value is propagated from the Talker to the Listener.

Presentation Time Offset
The Presentation Time Offset is the pre-determined offset that AVB packets are given to ensure they all are “presented” at the output of AVB listeners simultaneously, regardless of the signal path between Talker and Listeners. The maximum value of Presentation Time Offset is 2 ms.

Listener Counters
The Listener Counters will turn red when a new error has occurred (see Figure 30). New errors can be acknowledged by Left Clicking on a cell that has a red background. The error counter will remain at the numerical value until the AVB stream is reconnected, but the background will return to its default color. This feature can be used to track if new errors occur in the AVB Stream after error acknowledgment. The Compass Log contains entries with the error details and timestamp information.

Stream Interrupted
The Stream Interrupted counter is incremented each time the stream playback is interrupted for any reason other than a user-initiated Disconnect.
**Sequence Mismatch**
The Sequence Mismatch counter is incremented each time a packet is received out of order or if a packet is dropped.

**Media Reset**
The Media Reset counter is incremented each time the Listener is notified of a Talker MEDIA_RESET event.
(When listening to a Meyer Sound device, a MEDIA_RESET will occur when the rate of the incoming AAF data is not in sync with the Listener device's media clock.)

**Timestamp Uncertain**
The Timestamp Uncertain counter is incremented each time the Listener is notified of a TIMESTAMP_UNCERTAIN event.
(When listening to a Meyer Sound device a TIMESTAMP_UNCERTAIN will occur when the clock master changes.)

**Unsupported Format**
The Unsupported Format counter is incremented each time data is received that did not match the currently selected format.

**Late Timestamp**
The Late Timestamp counter is incremented each time a packet is received with a timestamp that is outside the current presentation time buffer.

**Early Timestamp**
The Early Timestamp counter is incremented each time a packet is received with a timestamp that is outside the current presentation time buffer.
MANAGING AVB AND CAL WITH COMPASS

This section provides an example to illustrate the use of Compass to manage CAL when AVB inputs are used. The equipment from the previous example is used with the addition of a CAL 64 to the network.

CAL can receive AVB audio streams (AAF) and clock streams (CRF). CAL can transmit CRF streams to other devices, but cannot transmit AVB/AAF audio streams to other devices.

Configuring CAL Network Settings

Configuring network settings and selecting an AVB input for a CAL is very similar to GALAXY. When Compass is connected to a CAL, select the AVB tab to manage the AVB inputs and make Clock Mode selections (Figure 32).

![Figure 32: Compass CAL Control Tab](image)

The AVB tab allows the CAL Entity and Group Names to be changed and displays the IPv6 and MAC Addresses, as well as the device’s Serial Number.
AVB Clock Selection and System Clock

As with other CAL input signal types, when the connection is made, it must be selected as the Active Input in the Input Settings tab for the signal to be reproduced (Figure 33).

Figure 33: CAL Control Tab in Compass
The Clock Mode also needs to be selected, typically to the appropriate CRF stream (Figure 34). After the Clock Mode has been selected, ensure the Clock Status is updated to "Locked."

AVB Input Selection
AVB Input Settings are similar to the GALAXY Input and Output settings tab. Each CAL has three audio sinks to receive AVB/AAF signals and one clock sink to receive a CRF clock signal.

Media Clock Selection
Selecting an audio or clock stream is similar to GALAXY. For each AVB input, any available AVB stream from a Talker on the network can be selected. Media Clocks should never be cascaded. The same Media Clock should almost always be used for every device on the network. Because GALAXY B is receiving its Media Clock from GALAXY A, the CAL should also receive its Media Clock from GALAXY A.

Secondary Network Connections
Unlike GALAXY, there is no option to select to connect the Secondary network. If the CAL is connected to both networks, it will connect to the Secondary by default.
When the AVB stream connection is established, it is displayed next to the input channel label.
APPENDIX A: RESOURCES

REFERENCES FOR FURTHER READING

• AES11-2009, “AES recommended practice for digital audio engineering—Synchronization of digital audio equipment in studio operations”.


• IEEE 802.1AS-2011, “IEEE Standard for Local and Metropolitan Area Networks—Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks”.

• Avnu Professional Audio Functional and Interoperability Specification, Formats

IEEE WORKING GROUPS

• IEEE 1722 Working Group — Layer 2 transport protocol working group for time-sensitive streams

• IEEE 1722.1 Working Group — AVB/TSN discovery enumeration, connection management and control

USEFUL WEBSITES

• https://avnu.org/Milan — Avnu Alliance web site for Milan

• https://webstore.ansi.org/SDO/IEEE — Institute of Electrical and Electronics Engineers Standards store

• http://www.aes.org/publications/standards/ — Audio Engineering Society Standards in Print store

• https://avb.statusbar.com — a collection of links, tools and open source code for Audio Video Bridging (AVB) and Time Sensitive Networking (TSN) technologies
APPENDIX B: GLOSSARY

The following defines some of the terms used in AVB Networking.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAF</td>
<td>AVTP (Audio Video Transport Protocol) Audio Format</td>
</tr>
<tr>
<td>AVB</td>
<td>Audio Video Bridging</td>
</tr>
<tr>
<td>AVB Listener</td>
<td>A device that is capable of receiving AVB streams from an AVB Talker. All available streams from all available AVB Talkers that have the same Group Name on the network will selectable by the AVB Listener as inputs.</td>
</tr>
<tr>
<td>AVB Stream</td>
<td>A unidirectional flow of AVTP frames with the same unique Stream ID. AVB Streams can vary in format, channel count, and other parameters.</td>
</tr>
<tr>
<td>AVB Talker</td>
<td>A device that is an AVB source capable of transmitting AVB streams. This device will send AVB streams to an AVB Listener. When an AVB Talker is on the network, it advertises its presence and the streams it is able to transmit.</td>
</tr>
<tr>
<td>AVDECC</td>
<td>Audio Video Discovery, Enumeration, Connection Management, and Control (protocol for AVB devices defined by IEEE 1722.1)</td>
</tr>
<tr>
<td>AVTP</td>
<td>Audio Video Transport Protocol</td>
</tr>
<tr>
<td>Channel</td>
<td>The Channel Name is used to identify a specific channel within an AVB stream.</td>
</tr>
<tr>
<td>CRF</td>
<td>Clock Reference Format</td>
</tr>
<tr>
<td>Group Name</td>
<td>Associates multiple AVB devices connected to the same network. The Group Name must be identical for an AVB Talker (Source) and AVB Listener (Sink) to establish AVB connections.</td>
</tr>
<tr>
<td>MSRP</td>
<td>Multi-Stream Reservation Protocol</td>
</tr>
<tr>
<td>MSRP Accumulated Latency</td>
<td>The worst case amount of time it will take a signal to pass from the AVB Talker to the AVB Listener. This value is calculated when the Stream Reservation value is propagated from the AVB Talker to the AVB Listener.</td>
</tr>
<tr>
<td>PDU</td>
<td>Protocol Data Unit—single unit of information transmitted among entities of a network.</td>
</tr>
<tr>
<td>Presentation Time</td>
<td>A timestamp an AVB Talker sends, set in the future with respect to the master clock time, for when the signal is to be ‘presented’ at the output of the AVB Listener. This approach ensures that signals are reproduced simultaneously at different AVB Listeners regardless of the varying path lengths a signal may have to traverse.</td>
</tr>
<tr>
<td>Sink</td>
<td>An AVB Listener has at least one Sink, a virtual input. Each Sink can receive one AVB Stream.</td>
</tr>
<tr>
<td>Source</td>
<td>An AVB Talker has at least one Source, a virtual output. Each Source makes one AVB Stream available on the network.</td>
</tr>
<tr>
<td>Stream Format</td>
<td>The combination of samples per frame, channels per frame, sample rate, and bit depth of a data stream, which is specified in the IEEE 1722-2016 Standard, Transport Protocol for Time-Sensitive Applications in Bridged Local Area Networks.</td>
</tr>
<tr>
<td>TSN</td>
<td>Time Sensitive Network</td>
</tr>
</tbody>
</table>