ALLEN & HEATH AND DANTE

A GUIDE TO CONFIGURING AND OPTIMISING DANTE NETWORKS WITH ALLEN & HEATH DIGITAL MIXING SYSTEMS

Introduction

Dante is an Audio over Internet Protocol (AoIP) developed around traditional I.T. standards and practices. It provides high performance digital media networking that meets the quality requirements of professional live sound, AV installations and broadcast and recording systems. Dante is built on standard Internet Protocols over Ethernet. It distributes multiple streams of digital audio plus integrated control data and clock, with sub millisecond latency, sample-accurate playback synchronization, extreme reliability and high channel count.

This article touches on the standards from which Dante is based, the Allen & Heath products which can utilise Dante and will also provide the reader with an informed choice regarding system requirements, connectivity and configurability.

Standards

The world of I.T. relies heavily on a huge array of standards. As the AV and IT domains converge, those of us in the audio industry would need to overcome a monumental learning curve in order to reach parity with those in I.T.

Dante removes this quantum leap of personal development by relying on a relatively small proportion of existing I.T. standards.

Transport

TCP and UDP are the building blocks for most communication over network equipment. TCP is by far the most widely used but as it requires the recipient to acknowledge receipt of the payload data it will inherently create unwanted latency in the system if all packets fail to be delivered. Conversely, UDP will make a 'best effort' attempt at delivering the payload data with dropped packets simply 'forgotten'.

In time sensitive networks, such as AV delivery, UDP is the transport protocol of choice and sacrifices the guaranteed delivery of data for the preferable latency benefits that 'best effort' methods employ.

Dynamic or Static

An IP address is a unique number allocated to each node within a network and ensures that payload data is efficiently moved from transmitter to receiver. There are two methods to assign an IP address.

Static addressing involves manually assigning an IP address to each node on the network. It requires a certain element of organisation and introduces the possibility of IP conflicts through human error.

Dynamic Host Configuration Protocol (DHCP) automatically assigns IP addresses and is the preferred method for Dante based networks.

Unicast or Multicast?

We need to address two separate data streams when dealing with unicast and multicast transmissions in a Dante network.

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1. Audio Flows

Dante transmits audio in "flows" with each flow typically consisting of several channels of audio. The maximum number of flows, and channels per flow, is determined by the Dante technology utilised by the manufacturer.

The Dante technologies used by Allen & Heath include:

- Summit HC
  SQ Dante, Dante64, Dante128
  - 16 channels per multicast flow
  - 4 channels per unicast flow
  - 128 flows maximum
- Broadway
  DT168, DT164
  - 8 channels per multicast flow
  - 4 channels per unicast flow
  - 16 flows maximum
- Brooklyn II
  M-DANTE
  - 8 channels per multicast flow
  - 4 channels per unicast flow
  - 32 flows maximum

By default, Dante transmits these audio flows as a unicast transmission (transmitter to a single receiver) and for most applications unicast is preferred.

This does not mean that audio cannot be routed to multiple devices, only that payload data is duplicated at the transmitting device and sent to the required receivers.

If an audio channel, or group of audio channels, is being sent to multiple receivers (typically three or more) it is generally considered best practice to send a single multicast packet rather than sending individual packets, with identical payloads, to each receiver.

Multicast flows differ from unicast as packets are duplicated at the switch and for each port. However, the benefit of a potential increase in system scalability has a detrimental effect of increasing switch loads and unnecessary transmission of data to ports that do not require the Dante audio flows.

2. Application Data

In addition to the audio flows, Dante (and AoIP in general) continually transmit discovery, sync and timing messages to the network. These are transmitted via a combination of unicast and multicast, and therefore consideration should be made when designing systems and selecting switches.

If using unmanaged L2 switches, multicast traffic can potentially overload devices on slower link speeds or the switch itself, as multicast is treated as broadcast traffic and duplicated on all ports. Using a Smart or Managed switch can overcome these issues by enabling a protocol called IGMP snooping.

IGMP Snooping

IGMP (Internet Group Management Protocol) snooping is a protocol which allows switches the ability to manage and distribute multicast traffic to only the receivers which require it.

Devices without multicast management are unable to do this and broadcast traffic on all ports, IGMP snooping simply manages this process by controlling the multicast traffic, reducing switch loads and improving network fatigue.

It is worth noting that in most applications, where Dante is implemented within a standalone Gigabit network, IGMP snooping will not be required.

When deploying Dante on larger networks, especially those with converged traffic, it is recommended to enable and configure IGMP snooping. It is also required when using Wi-Fi devices on the same network, as multicast

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traffic will flood a wireless network using L2 Wireless Access Points.

QoS

In packet switched data networks, all kinds of different traffic can exist within the same infrastructure. If there is enough "bandwidth" available in the cables connecting devices together, traffic will flow smoothly through the network. "Bandwidth contention" is the scenario that occurs when there is momentarily more traffic existing in the network than there is capacity for.

With time critical traffic like audio data, it is important to make sure that if this occurs the time critical traffic passes through the network without the delays caused by the 'traffic jam'. We can use Quality of Service to achieve this.

Dante devices "mark" the different kinds of traffic they produce as shown in the table below using the DSCP or Diffserv standard. A switch can be instructed to apply priority rules to traffic marked in this way. Bearing in mind that each 1 Gigabit cable can carry more than 512 channels of Dante audio in each direction, the likelihood of "bandwidth contention" in a Gigabit network is very low.

Dante marks Diffserv to provide an easy way for managers of complex IT networks to address issues they may run into – this is a whole world away from needing to employ these techniques in a concert sound installation.

Priority	Usage	DSCP Label	Hex	Decimal	Binary
High	Time critical PTP events	CS7	0x38	56	111000
Medium	Audio, PTP	EF	0x2E	46	101110
Low	(reserved)	CS1	0x08	8	001000
None	Other traffic	BestEffort	0x00	0	000000

Dante DSCP label values for QoS packet prioritisation.

As with IGMP, QoS is something which should only be required with systems that rely on multicast audio traffic, converged networks and those which deploy 100Mb equipment and in real world scenarios will rarely be required.

WANs, LANs & VLANs

A WAN (Wide Area Network) is a network which connects two or more LANs together typically over a large geographical distance with the internet being the largest and most well-known WAN.

Conversely a LAN (Local Area Network) is usually a stand-alone network consisting of two or more nodes within the same physical location i.e. a home or office network we use every day.

A VLAN (Virtual Local Area Network) is an effective tool for the audio engineer. A VLAN allows the segregation of a LAN into logically partitioned networks all using the same infrastructure. Individual ports on a switch can be assigned as being a member of a pre-determined VLAN, such as audio (VLAN 1) and lighting (VLAN 2). Traffic for both systems are now logically separate from one another, any errors or overloads on one network will not adversely affect the other and a de-lineation of responsibility can clearly be made.

Performance

Discovery

We briefly touched on the subject of IP addressing in the previous section and concluded that networked systems could be addressed either statically or dynamically. In addition to this, Dante utilises a set of technologies termed as zero-configuration networking (zeroconf) - Apple users may recognise the term 'Bonjour' which is an implementation of zeroconf. IPv4 link local is an automatic addressing scheme for zeroconf networks and

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enables connected nodes within a network to self-assign IP addresses. Coupled with mDNS and DNS-SD, zeroconf offers the user a true plug-and-play standard with automatic device/channel discovery and network assignment.

Clock Sync

As with any time-sensitive data, clock synchronisation is of paramount importance when delivering glitch free audio. Dante implements a packet-based clock using PTP (Precision Time Protocol) IEEE 1588-2002 which has a hierarchal master/slave distribution and a guaranteed sync tolerance of +/-1μs.

Master and slaves are determined via an election process and are based on four pre-defined parameters.

1. Are any devices set to "Enable sync to external"?
2. Are any devices set as a "preferred master"?
3. Which device has the highest quality clock?
4. Which device has the lowest MAC address?

If more than one device is set to "Enable sync to external", the election process will cascade until only one device remains as the system Master. If for any reason the master clock device fails, slaves will run off their internal clock, a re-election process will start, and a new master will be determined. This process takes place almost instantaneously and will not interrupt the audio in the form of silence and glitches.

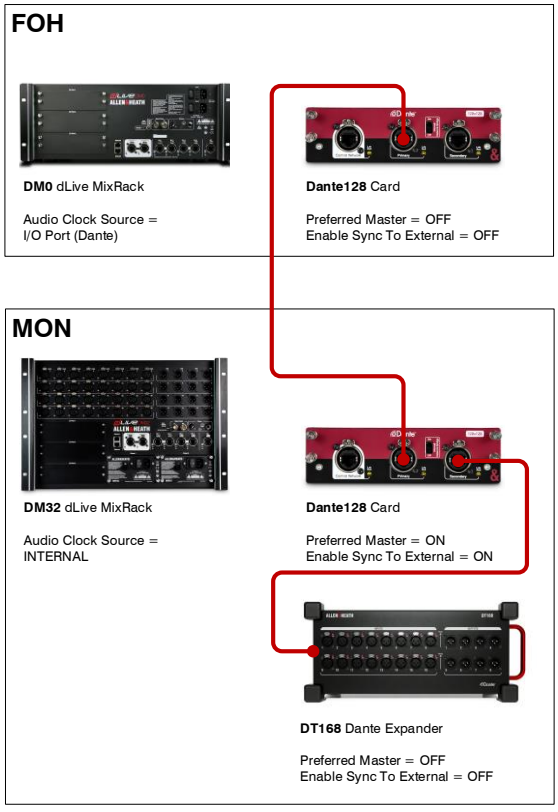
It is important to remember that, when adding a Dante option card or Dante enabled expander into any Allen & Heath system, the Dante device(s) and mixer are treated as separate devices in terms of clock sync.

The Dante card as it appears in Dante Controller should be set to "Preferred master" & "Enable sync to external". If multiple Dante cards are present in the system, only one should be set to "Preferred master" & "Enable sync to external".

Accordingly, Dante expanders should not be set to "Preferred master" & "Enable sync to external" as they will receive clock from the master Dante card.

The mixer should be set to 'Internal' from the console touchscreen. This essentially makes the Dante card the master clock for the Dante network, but it still derives its clock from the mixer.

The following diagram shows a simple system consisting of a FoH/monitor configuration with example clock settings.

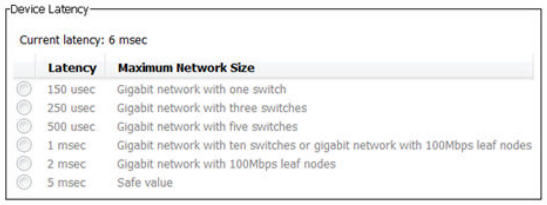


An example of a correctly configured Dante clock setup in a FOH/MON system

Latency

Latency is a crucial element of any audio system and lower latencies mean fewer phase issues caused by direct and amplified sound sources. Fortunately, Dante network latency is deterministic, meaning latency can be pre-determined and any changes to the network will not affect the network latency in any way.

Allen & Heath devices are shipped with 1ms latency as a default value but there are multiple options to set the device latency within Dante Controller.



Dante Controller device latency options

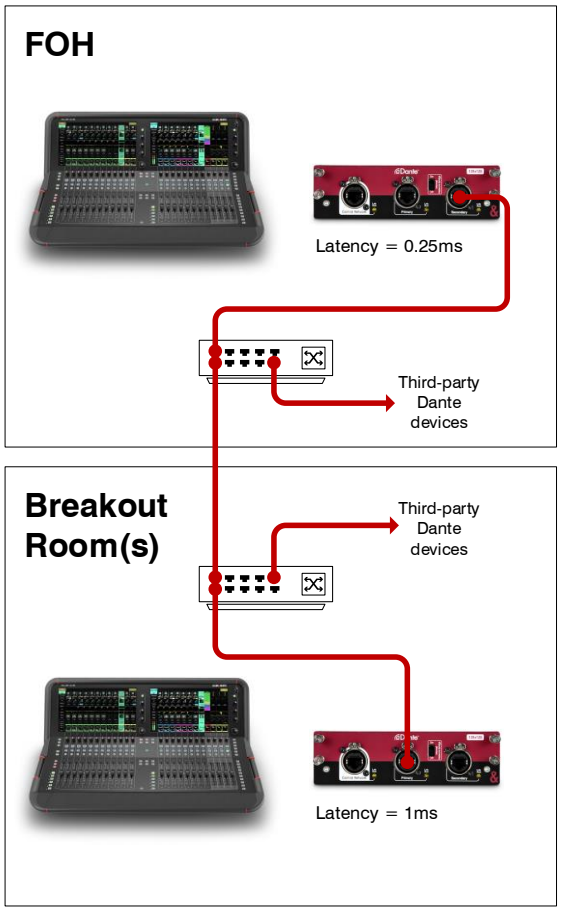
In theory, Dante latency can be set as low as 150µs, but each pre-determined value will depend on the system architecture itself.

The larger the network and use of slower link speeds, the higher the latency setting should be set. If the latency setting is set too low for the deployed system, there will be silence.

Mixing Latency

Different latencies can co-exist on a Dante network. This can be extremely beneficial in systems which require critical and non-critical audio divisions.

For example, a venue consisting of a live audio programme with breakout rooms for recording or broadcast can exist with different latency settings. In the following diagram the FOH system is configured to operate at 0.25ms whilst the breakout rooms, where latency is less critical, could be set to 1ms or higher.



A basic Dante network with mixed latencies

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Redundancy

There are numerous methods to achieve network redundancy in a Dante network. We shall look at some of the other methods later in this document but for now we will concentrate on the recommended and preferred way to achieve redundancy.

Dante devices are manufactured with two ports – Primary and Secondary. Redundancy is achieved by simply connecting both ports to the system. However, there are some very important rules to observe when deploying the Primary and Secondary ports.

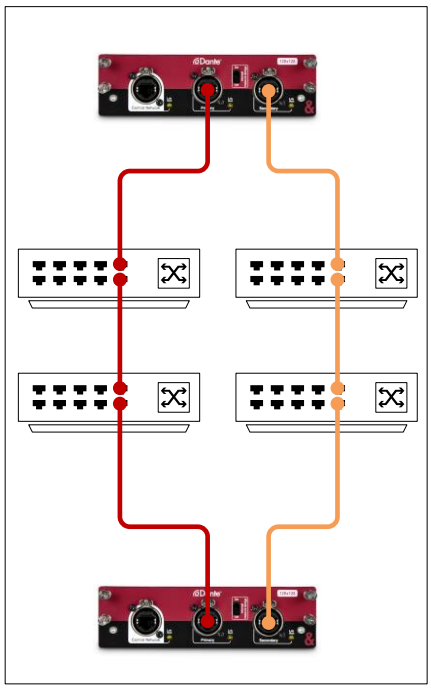
The Primary and Secondary ports cannot share the same infrastructure; they must be physically isolated. Separate switches and cables are required for the Secondary ports. In the event of a cable or switch failure, Dante will automatically switch to the Secondary network with no audible effects.

The Secondary network must be a stand-alone network; The Primary network can integrate with converged network data traffic, whereas the Secondary network must consist entirely of its own switches and cable infrastructure as other data types will not converge on this network.

In addition to the above, Allen & Heath Dante devices ship with the option of a 'switch-mode' configured via Dante Controller. This allows the bridging of the Primary and Secondary ports to allow 'daisy-chaining' of devices and the connection of a laptop running DVS on the same card i.e. FoH/Mon split with DVS for recording.

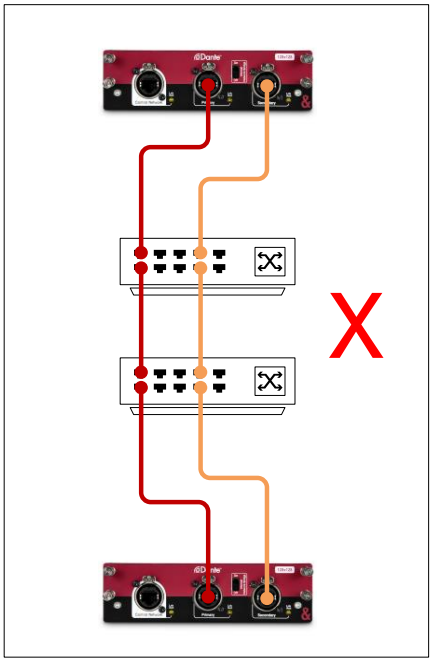
This option is only recommended when deploying small stand-alone systems, it should be noted that there will be no redundancy and each device hop will introduce additional latency.

Correct method



A correctly configured redundant Dante connection with discrete network hardware for both the Primary and Secondary connections

Incorrect method



An incorrectly configured redundant Dante connection with shared network hardware for the Primary and Secondary connections

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Hardware

The Network Switch

When designing Dante networks, switch choice is arguably the single most important piece of equipment within the system. A poor switch choice will lead to sub-standard network performance, audible artefacts and a dissatisfied client. Bandwidth, or lack of, is the single biggest pinch point in a system and therefore it is imperative that Gigabit switches are used in Dante deployment. Gigabit switches have 10x the bandwidth of their fast Ethernet equivalents, resulting in increased channel count and system scalability. Latency is decreased and audio quality is increased as higher sample rates can be utilised.

Network switches have varying types with differing specifications from vendor to vendor; Unmanaged, Managed and a hybrid of the two termed as Smart switches are the main categories that need to be considered.

Unmanaged switches are essentially plug and play devices which offer no user configuration, basic L2 switching and are thus the most cost effective.

Managed switches offer the user full control of a vast array of features through an embedded web browser and/or CLI. Most managed switches will support both L2 switching and L3 routing with control of features such as VLAN assignment, QoS, IGMP, Spanning Tree and Link Aggregation to name just a few. Regarding hardware features, managed switches often have stacking ports and optional SFP fibre module slots, which will be discussed later. This comprehensive feature set make these switches the most expensive option.

Smart switches are a combination of the above and in general offer a level of control which suits the applications for AoIP deployment. Access is provided via an embedded web browser and include features such as VLAN assignment, QoS, IGMP, Spanning Tree and Link Aggregation. Smart switch variants are also available with stacking ports and SFP ports and are a more cost-effective solution than their fully managed counterparts.

Switch choice will depend on many factors such as network scalability, required control and budget but for Dante and AoIP networks minimum requirements would be a 1Gb switch with preference for the type of control offered in Smart switch specifications.

It should also be noted that the use of EEE (Energy Efficient Ethernet) switches based on the IEEE802.az standard should not be used with Dante networks. If using unmanaged switches, ensure that they do not support this standard and if using Smart or fully managed switches, ensure they allow for this function to be disabled.

Connecting the Network

As with switches there are many choices to be made when connecting a Dante network and many of these choices are intrinsically linked to the type of switch deployed. Dante devices support and connect via twisted pair copper cabling only, however the switches used within the network can be connected using copper or fibre cabling.

Twisted Pair

Copper cabling is defined by the Ethernet over twisted pair IEEE standards. There are various categories of cabling namely being CAT5 and CAT6 with various enhanced and augmented versions also available.

CAT5 (100BASE-T) only supports networks of 100MB and is generally not recommended for modern Dante networks.

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CAT5e (1000BASE-T) supports Gigabit networking is inexpensive and simple to terminate and install.

CAT6 (1000BASE-TX) and CAT6a (10GBASE) have greater noise rejection, with 6a supporting 10 Gigabit networking. However, it is difficult to work with in terms of cable stiffness, has stringent termination techniques and should therefore only be installed by trained personnel.

All Ethernet category cabling comes in unshielded or shielded variants and when used in areas prone to high EMI, consideration should be made as to whether the shielded variant is used.

Cables also come in stranded and solid cored variants.

Stranded cables are generally more flexible and are generally used for loose cabling such as patch and stage cables. Due to physical and electrical characteristics stranded cables attenuate signal greater than their solid core equivalents and therefore it is recommended to use only branded, premium cables of this type. Sub-standard cables may result in reduced cable runs of only 60 to 70m.

Solid core cabling, which is generally found in most buildings can be used up to the standard 100m length, if installed and terminated correctly.

Fibre

In large network deployments the 100m distance constraint found with copper cabling can be a genuine issue. This is especially prevalent in installed applications, as containment routes do not necessarily take the shortest route. Fortunately, with the correct switch choice we can mitigate this constraint with the use of fibre.

Most smart and managed switches ship with SFP (Small Form-factor Pluggable) ports that accept optional modules. These will allow a fibre backbone to be installed between switches, increasing distance and bandwidth, whilst reducing latency and eliminating noise.

Fibre cabling can be placed broadly into two categories; Singlemode and Multimode. They are not interchangeable, but converters are available if required. Singlemode is mainly used for very long runs, usually several kilometres, whilst Multimode on the other hand is used for local, inter-building or shorter campus connections.

Cable Type	Core/Cladding Diameter (μm)	Type	1Gigabit Ethernet 1000BASE-SX	1 Gigabit Ethernet 1000BASE-LX	10 Gigabit Ethernet 10GBASE	40 Gigabit Ethernet 40GBASE	100 Gigabit Ethernet 100GBASE
OM1	62.5/125	Multimode	275 Meters	550 Meters (mode conditioning	33 Meters	Not supported	Not supported
OM2	50/125	Multimode	550 Meters	patch cable required)	82 Meters	Not Supported	Not supported
OM3	50/125	Multimode		550 Meters	300 Meters	100 Meters	100 Meters
OM4	50/125	Multimode			400 Meters	150 Meters	150 Meters
OS2	9/125	Singlemode	5 km at 1310 nm	5 km at 1310 nm	10 km at 1310 nm		

Comparison of fibre cable types

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When selecting fibre cable, it is important to consider the grade of the cable. The table shows the varying grades of fibre cables and the distance/data rates which they support.

As a general recommendation for multimode applications, OM3 cable offers a balance of future proofing and lower costs.

Storms, Trees & Links

When connecting multiple switches, consideration must be made regarding network performance. A poor design could lead to broadcast storms and again it comes down to the type of switches deployed within the network.

Broadcast Storms

Broadcast storms occur when a loop is introduced to the network. When a loop is present and broadcast or multicast traffic is initiated, packets will continually be re-broadcast by each switch until eventually the network comes to a standstill. If using an unmanaged switch, there is very little that can be done except to physically break the loop and re-start the network. Smart and fully managed switches on the other hand can make use of a protocol called Rapid Spanning Tree Protocol (RSTP).

Rapid Spanning Tree Protocol (RSTP)

RSTP creates a logical, loop free topology whilst still allowing redundant loop connections between switches.

However, RSTP is not without its drawbacks to the audio network. If a path is removed i.e. a cable is unpatched, RSTP automatically calculates a new path via a redundant connection. This in turn causes a network outage whilst the new convergence is calculated. RSTP convergence can be anything between 2-3 seconds. Those with older switches, which only support STP, convergence can be anything between 30 and 50 seconds. Fortunately, this can also be mitigated by means of using VLANs, as RSTP can be disabled per VLAN whilst leaving the remaining network traffic with RSTP enabled.

Link Aggregation Group (LAGs)

Link Aggregation Group (LAG) is a method by which a 'trunk' is created by linking multiple ports on a switch and therefore, cables between switches. Depending on switch manufacturer it is possible to link both standard ports and SFP ports to become a LAG member.

LAG advantages are an increase in bandwidth and cable redundancy is added to the network. However, if a cable is unpatched or fails, there can be a silence of around 0.5s. Conversely, disadvantages are that Smart or Managed switches are required at both ends of the link, increasing cost.

Both LAG and RSTP can be used as a simple form of redundancy with the network but as discussed previously, the only way to achieve this with no audible artefacts is to use Dante's Primary and Secondary ports with redundant hardware.

Products

Dante functionality can be added to any dLive, Avantis, SQ, AHM or ME system via the use of optional audio networking cards.

Additionally, Dante equipped audio expanders can be added to a Dante enabled Allen & Heath mixing system for additional analogue I/O.

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Dante 128x128

Dante 128x128 provides any dLive or Avantis mixer with a full 128×128 channel, 96kHz or 48kHz interface to a Dante network.

Dante 64x64

Dante 64x64 provides any dLive or Avantis mixer with a full 64×64 channel, 96kHz or 48kHz interface to a Dante network.

SQ Dante V2

SQ Dante V2 provides any SQ or AHM mixer with a full 64×64 channel, 96kHz or 48kHz interface to a Dante network.

M-DANTE

M-DANTE provides a ME-U with a full 64×64 channel, 48kHz interface to a Dante network.

DT168

The DT168 provides 16 microphone preamps and 8 line outputs in a stagebox form factor. Up to 16 units can be added to an AHM, SQ, Avantis or dLive system when equipped with a 96kHz Dante card.

DT164-W

The DT164-W provides 16 microphone preamps and 4 line outputs in a wall-mount design for permanent installation. Up to 16 units can be added to an AHM, SQ, Avantis or dLive system when equipped with a 96kHz Dante card.

For further information, application guides, and recommended products please visit

https://www.allen-heath.com/installation/

Don't hesitate to contact our Install team at installedsolutions@allen-heath.com if you need assistance on which products to specify or if you have questions about an application.

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