DM NAX™ Audio-over-IP System

Design Guide

Crestron Electronics, Inc.

TOC

Original Instructions

The original language version of this document is U.S. English.
All other languages are a translation of the original document.

Introduction

The Crestron DM NAX Audio-over-IP (AoIP) digital audio distribution system routes and manages local analog and digital audio sources as well as cloud-based media streaming sources over standard 1-Gigabit Ethernet infrastructure. The DM NAX AoIP platform is based on AES67 standards, and is also interoperable with third-party AES67 devices for added flexibility and scalability.

The following DM NAX devices offer flexibility in endpoint selection.

- DM-NAX-4ZSP
- DM-NAX-8ZSA
- DM-NAX-16AIN

This guide aids in the design and installation of a DM NAX system and provides information about the following:

- System design, which includes endpoint and network design.
- System installation, which includes endpoint and network installation.

In addition, a glossary is provided at the end of the guide.

> **NOTE**: For mixed systems, refer to the DM NVX® AV-over-IP System Design Guide.

System Design

The following sections provide design information related to DM NAX endpoints and the network.

Endpoint Design

A DM NAX system is composed of two or more DM NAX-capable devices transmitting and receiving AoIP streams back and forth. Several DM NAX models can operate in standalone mode where local source switching and management can be performed within the unit without transmitting any AoIP traffic on the network, but once additional devices are added to the configuration and routes are made between devices it is considered a DM NAX system. Additional components of a DM NAX system can include DM NVX devices and compatible third-party AES67 capable devices.

The following sections provide information about DM NAX endpoints:

DM NAX Endpoints

DM NAX endpoints are available in three form factors:

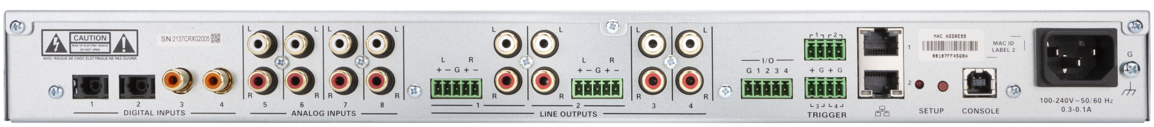
- Amplifiers (DM-NAX-8ZSA): operate as encoders to put local sources into the DM NAX AoIP environment, as well as decoders for local playback over speaker-level outputs.
- Preamplifiers (DM-NAX-4ZSP): operate as encoders to put local sources into the DM NAX AoIP environment, as well as decoders for local playback from line-level outputs.
- Edge Devices (DM-NAX-16AIN): peripherals that support additional I/O to the DM NAX environment, serving as on or off ramps for auxiliary inputs or niche use cases, such as ingesting audio from a traditional DM chassis onto the DM NAX AoIP network.

Rack-Mountable Endpoints

Rack-mountable endpoints consist of the following models:

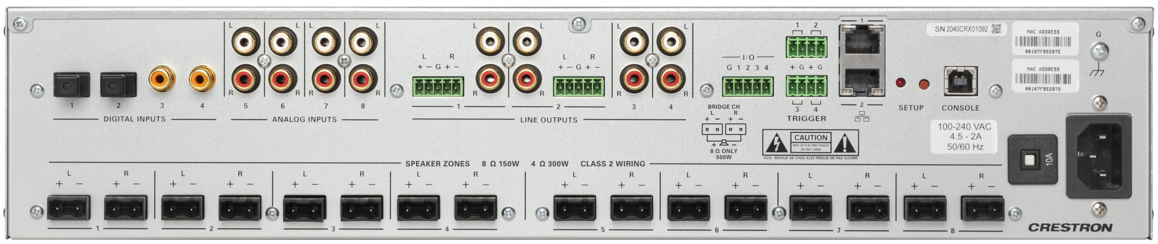
- DM-NAX-4ZSP
- DM-NAX-16AIN
- DM-NAX-8ZSA

DM-NAX-4ZSP- Front and Rear Views



DM-NAX-16AIN- Front and Rear Views

DM-NAX-8ZSA- Front and Rear Views



Endpoint Comparison

Feature	DM-NAX-4ZSP	DM-NAX-16AIN	DM-NAX-8ZSA
		Audio	
Input Signal Types	4 stereo analog (RCA); 4 digital S/PDIF (2 TOSLINK® and 2 Coaxial)	8 stereo unbalanced analog (RCA) includes (4) 5-pin phoenix balanced connectors; 8 digital SPDIF (4 TOSLINK® and 4 Coaxial)	4 stereo analog (RCA); 4 digital S/PDIF (2 TOSLINK and 2 Coaxial)
Output Signal Types	4 stereo analog outputs, Outputs 1 and 2 have a balanced 5-pin stereo Phoenix connection and an unbalanced RCA connection		4 stereo analog outputs (mirrors speaker zone outputs 1-4), Outputs 1 and 2 have a balanced 5-pin stereo Phoenix connection and an unbalanced RCA connection
Sampling Rates and Bit Depths	Digital Input (Coaxial): Up to 192 kHz, 24-bit; Digital Input (Optical): Up to 96 kHz, 24-bit; Media Players: Up to 192 kHz, 24-bit	Digital Input (Coaxial): Up to 192 kHz, 24-bit; Digital Input (Optical): Up to 192 kHz, 24-bit;	Digital Input (Coaxial): Up to 192 kHz, 24-bit; Digital Input (Optical): Up to 192 kHz, 24-bit
Source Compensation	±10.0 dB per input	±10.0 dB per input	±10.0 dB per input
Input Monitoring	Source Signal Detect	Source Signal Detect	Source Signal Detect
Frequency Response	20 Hz to 20 kHz ±0.2 dB	20 Hz to 20 kHz (±0.6 dB)	20 Hz to 20 kHz ±0.6 dB
THD	0.006%	0.002%	0.006%
Output Power			150 Watts per channel at 8 Ohms; 300 Watts per channel at 4 Ohms; 500 Watts per channel at 8 Ohms bridged
Amplifier Monitoring			Over Current, Over/Under Voltage, Over Temperature, DC Offset, Clipping

Feature	DM-NAX-4ZSP	DM-NAX-16AIN	DM-NAX-8ZSA
		Audio	
S/N Ratio	110 dB digital in, 108 dB analog in	110 dB digital in, 108 dB analog in	110 dB digital in, 108 dB analog in
Zone Volume Level Control	-80.0 to +20.0 dB, adjustable from 0% to 100% plus mute		-80.0 to +20.0 dB, adjustable from 0% to 100% plus mute
Bass Control	±12.0 dB		±12.0 dB
Treble Control	±12.0 dB		±12.0 dB
Loudness Compensation	On/Off		On/Off
Dynamic Range Control	Off/Low/Medium/High		Off/Low/Medium/High
Balance Control	Left/right adjustable		Left/right adjustable
Tone Profiles	Flat, Classical, Jazz, Pop, Rock, Spoken Word		Flat, Classical, Jazz, Pop, Rock, Spoken Word
EQ Filter Types	EQ, High Pass, Low Pass, Treble Shelf, Bass Shelf, Notch		EQ, High Pass, Low Pass, Treble Shelf, Bass Shelf, Notch
EQ Center Frequency	10 to 20,000 Hz per band		10 to 20,000 Hz per band
EQ Gain	+20/-40 dB per band		+20/-40 dB per band
EQ Bandwidth	0.1 to 4.0 octaves per band		0.1 to 4.0 octaves per band
Bus Volume Offset	±12.0 dB per zone for output bussing		±12.0 dB per zone for output bussing
Stereo Separation			85 dB @ 1 kHz, 8 ohm; 80 dB @ 1 kHz, 4 ohm
Zone Separation			100 dB @ 1 kHz, 8 ohm; 95 dB @ 1 kHz, 4 ohm
Zone Volume Level Control			-80.0 to +20.0 dB, adjustable from 0% to 100% plus mute
Zone Configuration			Stereo Single Ended, Mono Single Ended, Stereo Bridged, Mono Bridged, Bridged 2.1, and Bridged 2.1 with Bridged Sub

Feature	DM-NAX-4ZSP	DM-NAX-16AIN	DM-NAX-8ZSA
		Audio	
Power Limiting			Configurable 5 to 150 Watts @ 8 Ohms; 5 to 300 Watts @ 4 Ohms; 5 to 500 Watts @ 8 Ohms bridged

Feature	DM-NAX-4ZSP	DM-NAX-16AIN	DM-NAX-8ZSA
		Communications	
Ethernet	For control, AoIP, and or console, 100/1000 Mbps, auto-switching, auto-negotiating, auto-discovery, full/half-duplex, DHCP	For control, AoIP, and or console, 100/1000 Mbps, auto-switching, auto-negotiating, auto-discovery, full/half-duplex, DHCP	For control, AoIP, and or console, 100/1000 Mbps, auto-switching, auto-negotiating, auto-discovery, full/half-duplex, DHCP
USB	For configuration management	For configuration management	For configuration management

Feature	DM-NAX-4ZSP	DM-NAX-16AIN	DM-NAX-8ZSA
		Connectors	
SPDIF TOSLINK	(2) JIS F05 female (TOSLINK) optical fiber connector;	(4) JIS F05 female (TOSLINK) optical fiber connector;	2) JIS F05 female (TOSLINK) optical fiber connector;
SPDIF Coaxial	S/PDIF coaxial digital audio inputs;	S/PDIF coaxial digital audio inputs;	S/PDIF coaxial digital audio inputs;
SPDIF Optical	S/PDIF optical digital audio input	S/PDIF optical digital audio input	S/PDIF optical digital audio input
RCA Female	2	4	2
Input Impedance	75 Ohms	75 Ohms	75 Ohms

Feature		DM-NAX-4ZSP	DM-NAX-16AIN	DM-NAX-8ZSA
		Connectors		
ANALOG SOURCES	Unbalanced	(8) RCA female comprising (4) unbalanced stereo line-level audio inputs;	(8) RCA female comprising (4) unbalanced stereo line-level audio inputs;	8) RCA female comprising (4) unbalanced stereo line-level audio inputs; Input Impedance: 10k Ohms; Maximum Input Level: 2 Vrms
	Balanced	(4) 5-pin phoenix balanced connector Input Impedance: 10k Ohms; Maximum Input Level: 2 Vrms	(4) 5-pin phoenix balanced connector Input Impedance: 10k Ohms; Maximum Input Level: 2 Vrms	
ANALOG OUT	Unbalanced	8) RCA connectors, female; Comprises (4) unbalanced line-level stereo audio outputs (mirror corresponding amplified output pairs 1 - 4); Output Impedance: 100 Ohms; Maximum Output Level: 2 Vrms		(8) RCA connectors, female; Comprises (4) unbalanced line-level stereo audio outputs (mirror corresponding amplified output pairs 1 - 4); Output Impedance: 100 Ohms; Maximum Output Level: 2 Vrms
	Balanced	(2) 5-pin 3.5 mm detachable terminal blocks; Balanced stereo line-level audio outputs (mirror corresponding unbalanced output pairs 1 - 2); Output Impedance: 150 Ohms; Maximum Output Level: 4 Vrms		

Feature	DM-NAX-4ZSP	DM-NAX-16AIN	DM-NAX-8ZSA
		Connectors	
LEDs	(8) LEDs. White indicates a signal present on the specified input/source. Red indicates there is a clipping on an analog input or a bitstream issue on a digital input. Off indicates that there is no signal detected on the specified input/source.	(16) LEDs. White indicates a signal present on the specified input/source. Red indicates there is a clipping on an analog input or a bitstream issue on a digital input. Off indicates that there is no signal detected on the specified input/source.	(8) LEDs. White indicates a signal present on the specified input/source. Red indicates there is a clipping on an analoginput or a bitstream issue on a digital input. Off indicates that there is no signal detected on the specified input/source.
Ethernet 1	(1) 8-wire RJ45 female; 100Base-T/1000Base-TX Ethernet port	(1) 8-wire RJ45 female; 100Base-T/1000Base-TX Ethernet port	(1) 8-wire RJ45 female; 100Base-T/1000Base-TX Ethernet port
Ethernet 2	(1) 8-wire RJ45 female; 100Base-T/1000Base-TX Ethernet port	(1) 8-wire RJ45 female; 100Base-T/1000Base-TX Ethernet port	(1) 8-wire RJ45 female; 100Base-T/1000Base-TX Ethernet port
USB	(1) USB Type B connector, female; USB computer console port (cable included); For setup only	(1) USB Type B connector, female; USB computer console port (cable included); For setup only	(1) USB Type B connector, female; USB computer console port (cable included); For setup only
100-240V~50/60Hz Universal AC	(1) IEC 60320 C14 main power inlet, mates with removable power cord (included)	(1) IEC 60320 C14 main power inlet, mates with removable power cord (included)	(1) IEC 60320 C14 main power inlet, mates with removable power cord (included)
G	6-32 screw, chassis ground lug	6-32 screw, chassis ground lug	6-32 screw, chassis ground lug
SPEAKER OUTPUTS L/R 1-8			(16) 2-pin 7.62 mm 15 A detachable terminal blocks; Power amplifier outputs; Wire Size: Terminals accept up to 12AWG

Feature	DM-NAX-4ZSP	DM-NAX-16AIN	DM-NAX-8ZSA
Controls and Indicators			
PWR	(1) LED. White indicates that the device is switched on with audio passing. Red indicates that the device is in standby mode. Off indicates that there is no power from the power supply.	(1) LED. Amber indicates that the device is booting. White indicates that the device is switched on with audio passing. Red indicates that the device is in standby mode. Off indicates that there is no power from the power supply.	(1) LED. Amber indicates that the device is booting. White indicates that the device is switched on with audio passing. Red indicates that the device is in standby mode. Off indicates that there is no power from the power supply.
LAN	(1) LED. White indicates that the device is switched on and has a valid IP address. Off indicates that the device is not connected to a network or the IP address is invalid.	(1) LED. White indicates that the device is switched on and has a valid IP address. Off indicates that the device is not connected to a network or the IP address is invalid.	(1) LED. White indicates that the device is switched on and has a valid IP address. Off indicates that the device is not connected to a network or the IP address is invalid.
NAX	(1) LED. White indicates that any audio-over-IP traffic is passing in or out of the DM NAX unit (if any audio-over-IP streams are transmitting out of, or being received by the unit, then the NAX LED will illuminate white). Off indicates that no audio-over-IP traffic is passing in or out of the DM NAX unit.	(1) LED. White indicates that any audio-over-IP traffic is passing in or out of the DM NAX unit. (if any audio-over-IP streams are transmitting out of, or being received by the unit, then the NAX LED will illuminate white). Off indicates that no audio-over-IP traffic is passing in or out of the DM NAX unit.	(1) LED. White indicates that any audio-over-IP traffic is passing in or out of the DM NAX unit (if any audio-over-IP streams are transmitting out of, or being received by the unit, then the NAX LED will illuminate white). Off indicates that no audio-over-IP traffic is passing in or out of the DM NAX unit.
SOURCE	(8) LEDs. White indicates a signal present on the specified input/source. Red indicates there is a clipping on an analog input or a bitstream issue on a digital input. Off indicates that there is no signal detected on the specified input/source.	(16) LEDs. White indicates a signal present on the specified input/source. Red indicates there is a clipping on an analog input or a bitstream issue on a digital input. Off indicates that there is no signal detected on the specified input/source.	(8) LEDs. White indicates a signal present on the specified input/source. Red indicates there is a clipping on an analog input or a bitstream issue on a digital input. Off indicates that there is no signal detected on the specified input/source.

Feature	DM-NAX-4ZSP	DM-NAX-16AIN	DM-NAX-8ZSA
Controls and Indicators			
ZONE	(4) LEDs. White indicates there is audio output on the indicated zone. Red indicates clipping is detected on the output audio.		(8) LEDs. White indicates there is audio output on the indicated zone. Red indicates a fault due to clipping, over current, over temperature, or low voltage.
SETUP	(1) LED. Blinking red indicates that a network reset or factory restore has been initiated via the adjacent SETUP button.	(1) LED. Blinking red indicates that a network reset or factory restore has been initiated via the adjacent SETUP button.	(1) LED. Blinking red indicates that a network reset or factory restore has been initiated via the adjacent SETUP button.

Feature	DM-NAX-4ZSP	DM-NAX-16AIN	DM-NAX-8ZSA
Power			
Power Consumption	15.9 W	20 Watts	240 W (All channels driven at 1/8th power, 8 ohms)

Feature	DM-NAX-4ZSP	DM-NAX-16AIN	DM-NAX-8ZSA
Environmental			
Temperature	32° to 104°F (0° to 40°C)	32° to 104°F (0° to 40°C)	32° to 104°F (0° to 40°C)
Humidity	10% to 90% RH (non-condensing)	10% to 90% RH (non-condensing)	10% to 90% RH (non-condensing)
Heat Dissipation	57 BTU/hr	70 BTU/hr	450 BTU/hr

Feature	DM-NAX-4ZSP	DM-NAX-16AIN	DM-NAX-8ZSA
Construction			
Chassis	Metal, black and silver finish, vented sides	Metal, black and silver finish, vented sides	Metal, black and silver finish, vented sides
Mounting	1 RU rack-mountable	1 RU rack-mountable	2 RU rack-mountable

Feature	DM-NAX-4ZSP	DM-NAX-16AIN	DM-NAX-8ZSA
Dimensions			
Height	1.73 in. (44 mm)	1.25 in. (32 mm)	3.50 in. (89 mm)
Width	19 in. (482 mm) 17.28 in. (439 mm) without rack ears	19 in. (483 mm); 17.28 in. (439 mm) without rack ears	19 in. (482 mm) 17.28 in. (439 mm) without rack ears
Depth	14.50 in. (368 mm)	14.46 in. (368 mm)	14.52 in. (369 mm)

Feature	DM-NAX-4ZSP	DM-NAX-16AIN	DM-NAX-8ZSA
Weight			
	8.06 lb (3.65 kg)	7.39 lb (3.35 kg)	28 lb (12.70 kg)

Feature	DM-NAX-4ZSP	DM-NAX-16AIN	DM-NAX-8ZSA
Compliance			
Regulatory Model	FCC Part 15 Class B digital device, IC Class B, CE, ETL listed	FCC Part 15 Class B digital device, CE, ETL listed	FCC Part 15 Class B digital device, IC Class B, CE
		M201845005	M1845004

Endpoint Bandwidth Design and Management

A single DM NAX network link can carry the following data streams:

- **DM NAX™ (AES67) or Dante® Audio Stream:** An encoded audio stream that is sent for decoding independently of the primary audio/video stream.

  > **NOTE**: Each individual DM NAX stereo TX stream has a bandwidth of 6Mbps. A DM NAX device can have multiple transmitters. For example, the DM-NAX-16AIN can transmit 16 individual DM NAX stereo streams onto the network, and can output 96 Mbps of DM NAX stereo AoIP traffic with all streams transmitting.

- **Other Ethernet Traffic:** Control data from DM NAX network ports connected to third-party devices such as displays or cameras. Ethernet traffic also includes network protocol traffic such as DHCP, DNS, and RADIUS for 802.1X.
- **Streaming Service Traffic:** Media streams from streaming providers that are passing up to the maximum number of Media Players on a given DM NAX device. For example, the 8ZSA can have up to 8 simultaneous Media Player streams active at once.

DM NAX bandwidth (6 Mbps per stereo DM NAX stream) cannot be adjusted, since the sample rate/bit depth is fixed at the NAX transmitters. An individual DM NAX device cannot output enough traffic to saturate its network uplink (for example, 1Gbps traffic), but several DM NAX and DM NVX devices on a single switch can easily saturate switch uplinks if total traffic throughput is not accounted for.

Network Design

DM NAX systems require a designed and provisioned Ethernet network to function correctly. Be sure to gather requirements and documentation, coordinate with IT staff, and complete the network design before site work.

Minimum Network Requirements

Minimum network requirements must be met for a successful installation. Minimum requirements consist of the following:

- Network Switch
  - 1-Gigabit port for every connected DM NAX endpoint
  - Nonblocking backplane
  - Layer 3
  - IGMPv2 implementation
- Required network switch settings
  - IGMPv2 snooping enabled
  - IGMPv2 querier enabled
  - Fast-leave enabled (also known as immediate-leave)

- Recommended network switch settings
    - Layer 3 packet prioritization (DSCP) for QoS
- Inter-switch uplinks (if required)
    - The uplinks must have sufficient bandwidth for all encoders and decoders connected to the network switch. Allocate 1 Gigabit per encoder or decoder connected to the switch.
    - Uplinks must be configured properly to support multicast traffic.

Network Design Overview

DM NAX networks should be designed to isolate traffic on network segments specifically designed for DM NAX devices and DM NVX A/V over IP traffic. This can be accomplished by using separate infrastructure or Virtual Local Area Networks (VLANs). DM NAX network segments carry DM NAX multicast streams, DM NAX control, and ancillary traffic.

The dual Ethernet ports on a DM NAX device can be set to isolate traffic so one port is designated the Control and Media Player port (to be connected to the Control LAN, which will have Internet access), and the other is designated as the AoIP port, with all DM NAX/AES67 streams managed there. Connecting the AoIP port to a separate switch or VLAN will isolate the traffic away from the Control LAN.

The location of other Crestron network devices relative to network infrastructure must be determined. A decision must be made as to whether the devices will coexist on the same network segment as the DM NAX segment, or on another segment that has traversal capabilities to the DM NAX segment but is not multicast enabled.

Networked AV devices other than DM NAX devices can be placed on the DM NAX network segment if their bandwidth requirements are relative to the DM NAX endpoint bandwidth requirements.

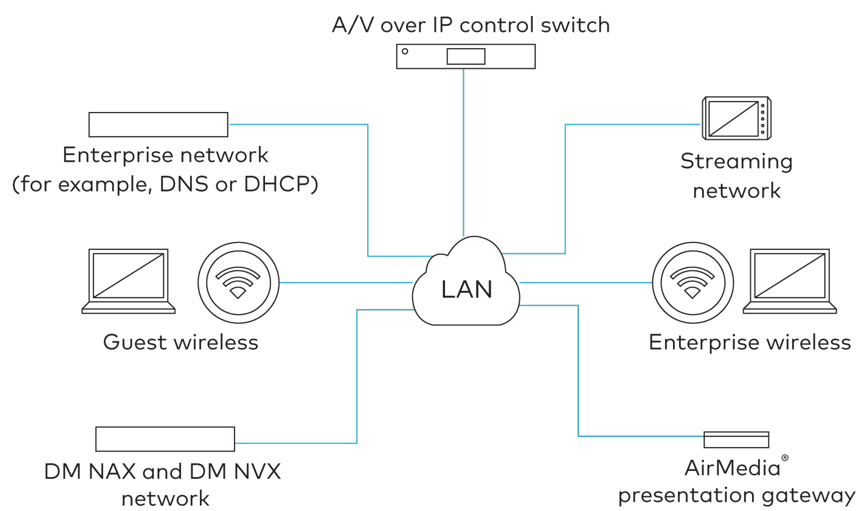
A DM NAX device can have several addresses:

- An IP address is required for control, web configuration access, and console.
- Multicast addresses are required for multicast streams:
    - One multicast address is required per each multicast DM NAX transmitter within a device. A general rule is that there should be a multicast NAX transmitter for each local source and each local media player on a device.

During device configuration, the Commissioning function can be used in the device's web configuration to automatically assign multicast addresses in a specified range. Alternatively, each transmitter can be assigned a multicast address manually or through custom programming. Having duplicate multicast transmit addresses on the same network is not permissible. Reusing addresses will cause collisions and unpredictable behavior when a stream receiver attempts to subscribe to an address that has been used more than once. Using the Commissioning function will prevent multicast addresses from being used more than once on the same DM NAX device, and Crestron Home® will also manage multicast addresses for DM NAX and DM NVX devices to prevent reuse of addresses.

The DM NAX network segment must receive network services, including DNS, DHCP, Active Directory, PTP, mDNS, and RADIUS services. Coordinate with IT staff to provide access to these services and to create the proper traversal rules for the DM NAX network segment.

Network Segmentation along Logical Boundaries



Consideration must be given to blocking at both the switch level and the network design level. DM NAX network switches must have enough switch fabric bandwidth to support full nonblocking bidirectional gigabit bandwidth on all ports simultaneously.

This is a common feature in enterprise-grade gigabit network switches, but it should not be assumed that a switch is non-blocking or is configured as non-blocking.

Due to system size or physical layout, many DM NAX installations require multiple network switches. The network switches must connect to each other via a high-bandwidth uplink port.

Network Topologies

Connect devices such as control processors, touch screens, servers, personal computing devices, and DM NAX endpoints directly to network switches. In a large network with multiple layers of switch hierarchy, situate these devices at the network's edge.

The network edge switches are often connected via uplinks to other switches and routers. This aggregates traffic from the network edge and forms the network's core. The relationships between network switches and their interconnection to each other define the network's topology.

The following general rules apply for sizing network switches in terms of switch fabric nonblocking bandwidth:

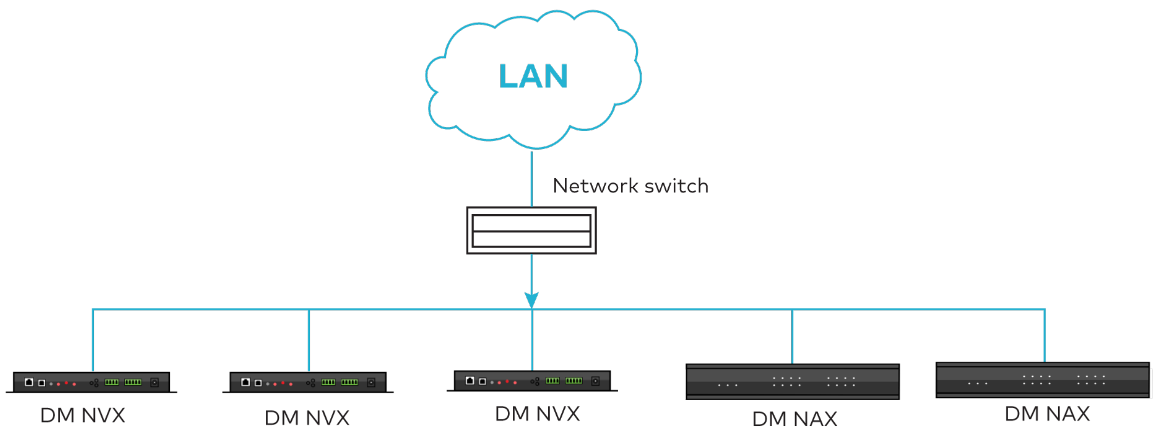
- The network core must support a non-blocking bandwidth and port speed equal to 1 gigabit multiplied by the lesser of the total number of anticipated encoder endpoints or the total number of anticipated decoder endpoints.
- The network edge must support a non-blocking bandwidth and uplink speed equal to 1 gigabit multiplied by the greater of the total number of anticipated encoder endpoints or the total number of anticipated decoder endpoints.

Star

The default recommended network topology is a star. Using a fully nonblocking switch, the star topology allows any combination of one or more endpoints to connect to any other combination of endpoints. It also easily allows the network to grow beyond a single switch if the uplink in the switch supports the maximum specified bandwidth.

For small DM NAX systems that employ only one network switch, use a nonblocking switch to prevent a bottleneck. Star topologies can accommodate very large DM NAX installations by using large modular switch frames.

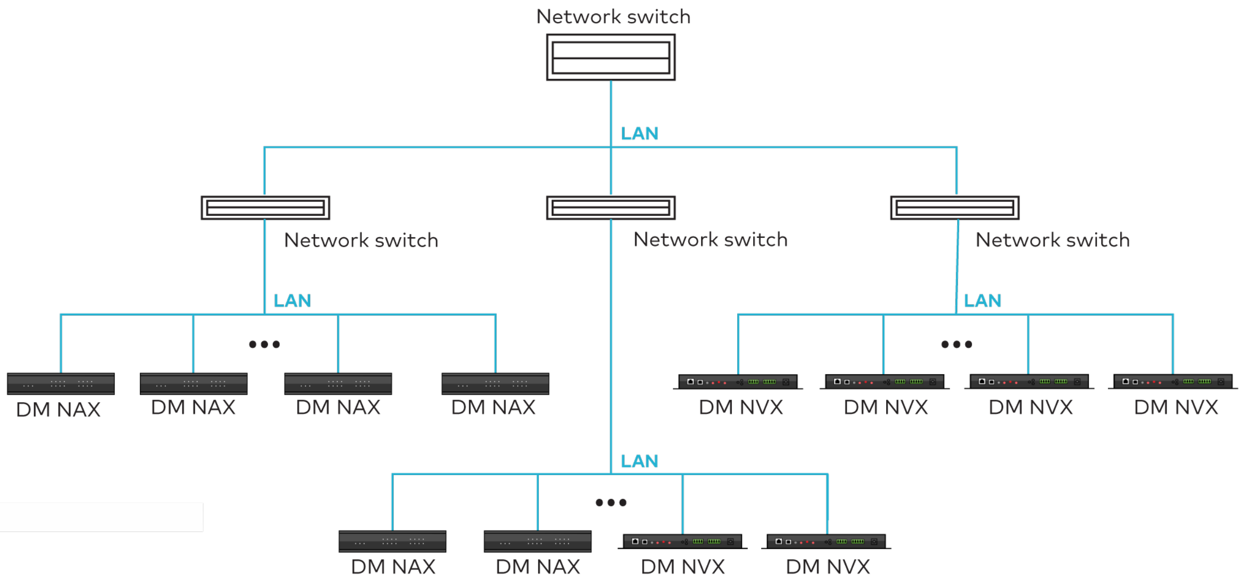
Star Network Using a Nonblocking Switch



Tree

A tree network is a combination of more than one star network existing on a core-switching infrastructure. The tree network allows failure in one part of the attached star network without widely affecting the other star networks. Configure the core network, which is the larger network switch, for redundancy and scalability.

Tree Topology Using Nonblocking Switches on a Core Network



Network Multicast Functionality

DM NAX networks rely on multicast functionality to send and receive audio. Internet Group Management Protocol (IGMP) multicast in the Ethernet context replaces a fixed switching architecture in audio distribution.

Segregation of DM NAX (not necessarily separate from DM NVX or a dedicated AV over IP VLAN, but separate from customer-facing networks with wireless access points or Internet access) traffic by using a VLAN is usually the first step in enabling multicast. A VLAN ensures that DM NAX traffic stays on the DM NAX network and does not route to other network segments and interfere with their operation. A VLAN also ensures that traffic from other network segments does not interfere with DM NAX operation. Within that segment, all ports can be flooded by IGMP traffic, regardless of whether that traffic was intended to be sent or received by a network device at any time. This will result in interference with network operation and can be a means of implementing a denial-of-service attack on a network if done maliciously.

To ensure that only traffic between intended multicast senders and multicast receivers appears at a given port, IGMP snooping must be enabled. IGMP snooping refers to the ability of the network switch to limit multicast traffic only to ports between intended senders and receivers. The DM NAX network supports both versions of IGMP snooping: IGMPv2 and IGMPv3.

For the network switch to know where route limiting is implemented in the network for multicast traffic, an IGMP querier must be enabled. In most instances, a single network switch is selected by address to act as the IGMP querier; however, if multiple switches are configured as queriers, the switch with the lowest numerical IP address on the network is typically the default. The default leave time for the querier (typically about 125 seconds) is sufficient for a DM NAX network.

Precision Time Protocol (PTP)

The PTP clock synchronization protocol keeps clocking aligned throughout a network. This is crucial to audio-over-IP since it keeps audio in-sync and transmitting properly between DM NAX or other AES67 devices. Many interactions that are part of PTP negotiation are extremely time-critical, and allow the protocol to achieve sub-microsecond accuracy between networked clocks. This also makes it extremely sensitive to high-bandwidth network traffic if not managed properly.

PTP is multicast, and needs to be able to reach all DM NAX or AES67-capable devices on a network in order to maintain clock synchronization. To keep units synchronized, a single clock in the system will be assigned as a Master clock device, and all other clocks in the system will synchronize to that device's clock. This can be a DM NAX or AES67 device, or it can be a dedicated clock on the network. The Master clock assignment is typically decided by the priority of the clocks on the network. Most DM NAX devices have a priority of 254, and would be assigned Master clock over devices with a higher priority of 255. However, any device with a priority value less than 254 will be assigned Master clock status over the DM NAX device (unless you have set this priority to a custom value). If the Master clock assigment cannot be decided just on priority, for example, multiple devices share a priority, it will be decided by the device with the lowest MAC address.

Once the clock Master is elected, all other clocks will be synchronized to that device. If network bandwidth becomes saturated and the clock synchronization cannot occur, noticeable drops in audio quality, broken routes, or audible distortions will occur. Enabling Quality of Service settings on your network switch is needed to preserve consistent clock synchronization and good audio.

Enabling Network Quality of Service (QoS)

QoS will ensure that certain types of traffic are prioritized by your network switch in the event of high bandwidth usage. This can ensure that time-critical events like Precision Time Protocol (PTP) clock synchronization between audio devices never fail, even as your network bandwidth handles high utilization from surges in traffic. This becomes very necessary in mixed DM NAX/DM NVX VLANs, where high-bandwidth traffic is the standard for most ports on your switch.

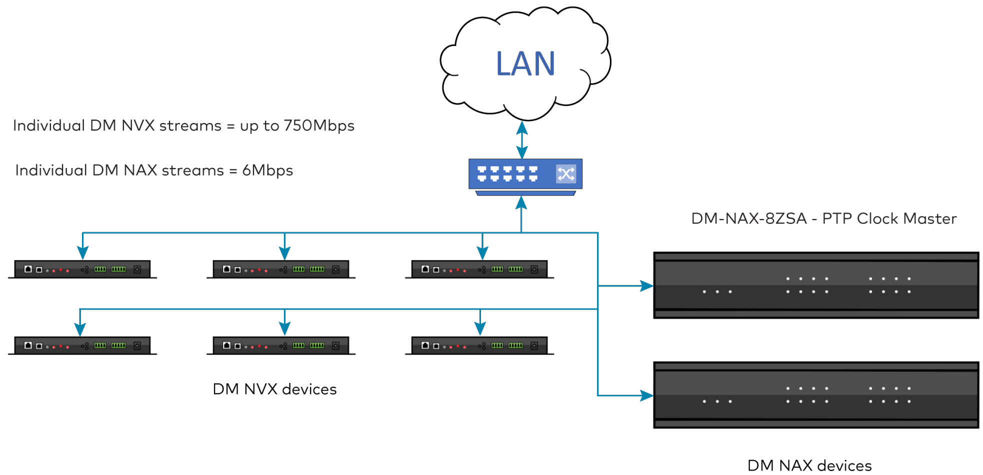
> **NOTE**: Switches supporting QoS to this level should be considered necessary for any mixed DM NAX/DM NVX mixed AVoIP network with more than two DM NVX transmitters.

DM NAX devices tag their outgoing traffic with DSCP headers that can be used to divvy up the outgoing communications into the following classes that should be prioritized on your switch as shown:

Prioritization	Traffic Type	DSCP
Highest	Time critical PTP events	CS7 (56)
↓	PTP	CS6 (48)
	Audio	EF (46)
Lowest	Other traffic	BestEffort (0)

> **NOTE**: DM NAX traffic is tagged with DSCP values, not 802.1P IP Precedence values. VLAN tagging is not yet supported locally on DM NAX devices.

Quality of Service



NOTE: With the potential for DM NVX, AES67, control, and USB traffic to be passing on individual DM NVX switch connections, any given port may approach or exceed 80% utilization (assuming 1Gbps connections), at which point QoS can prioritize time-critical PTP negotiations. This prevents master clock status or synchronization from being interrupted during near network saturation. Without QoS configuration, as port utilization approaches the point of saturation, PTP may no longer remain synchronized and audio signals throughout the network may begin to falter, distort, or cut out completely.

Network Security

Security requires the support of particular capabilities within all devices on the network. DM NAX networks employ the following security features:

- 802.1X authentication is used to ensure that devices on the network have been authorized by the network administration team. Unauthorized devices are prevented from being added to the network and from having access to sensitive content.
- Active Directory services for endpoint administration can be used to ensure that administrative privileges for DM NAX devices can be centrally managed, granted, and revoked when necessary.
- SSL-based secure Cresnet over IP (CIP) for DM NAX control ensures that control processors and DM NAX devices communicate with the intended party device and that any unauthorized device on the network cannot monitor commands and status.
- SSH-based command-line console access for device configuration and status protects the device console from access by unauthorized users.

SSL-based Cresnet over IP and SSH-based command-line console access are automatically configured within DM NAX devices and support software. The designer should focus on 802.1X and Active Directory services within the design.

For additional information about deploying security with Crestron products, refer to the IP Considerations Guidelines for the IT Professional Design Guide (Doc. 4579) at www.crestron.com/manuals and to Answer ID 5571 in the Online Help section of the Crestron website (www.crestron.com/onlinehelp).

Network Design Considerations

The following are the network design best practices:

- Use QoS to ensure prioritization of time-critical clock traffic. PTP events are tagged with DSCP values at DM NAX devices so that (with QoS enabled and relevant DSCP queues prioritized) PTP events can always pass on the network even at high traffic saturation, and clock sync is never interrupted between audio devices.
- Use nonblocking Layer 3 switches with port-based QoS at all stages of the design. Use sufficient switch bandwidth and port speeds. Less expensive switches cause a loss of capability in the network.
- Choose switches with sufficient bandwidth at each segment from edge to core to accommodate a nonblocking architecture for DM NAX endpoints and any additional needs.
- Choose an appropriate network topology. Consider the network, including basic functionality and redundancy, and whether additional DM NVX features such as video walls or repetitive display signage is necessary. When planning a topology for the network, ensure that network IT staff and network architects are involved in the decisions.
- Enable an IGMP querier on at least one switch in the DM NAX network. The IGMP querier ensures that all switches know which multicast transmitters and receivers are connected to which switches in the network. Enabling an IGMP querier on multiple switches causes the switch with the lowest value of IP source address to take priority and act as the querier.
- Consult the network switch manufacturer's documentation to ensure that the uplinks are properly configured to support multicast traffic.
- Use switches that support 802.1X for endpoint authentication by implementing 802.1X endpoint authentication through TLS or MS-CHAP v2. Only authorized endpoints can communicate with the network.
- Ensure that VLANs are implemented correctly. Leveraging existing switch infrastructure with VLANs can cause conflicts with network provisioning needs. If a dedicated DM NAX network is not going to be used, VLANs must be implemented correctly with their IP subnet.

  In this case, set DM NAX network ports to isolate their control and Audio-over-IP traffic onto separate connections, then use those connections for interfacing with their respective VLANs.

- Use the Active Directory service for administration security:
    - Create an Active Directory group responsible for device administration.
    - Add device administrators to the group.
    - Add the group to the DM NAX device on the Device page of the web interface.

      Use of the Active Directory service with DM NAX endpoint logins allows for easy, seamless, and better-controlled access from a central directory authority with fewer risks.
- Use a DHCP server with link-layer filtering, and configure the IP addresses of endpoints using DHCP rather than static IP addresses. Using a DHCP server with short lease times, MAC address filtering, and sufficient address space for future needs makes network management easier.
- Enable IGMPv2 (DM NAX default) or IGMPv3 multicast snooping on all switches in the DM NAX network. This is a requirement for all designs to enable multicast delivery to multiple endpoints. Without IGMP snooping enabled, switches that receive a multicast stream will transmit that stream to all ports simultaneously and saturate all network links.
- Use the Rapid Spanning Tree Protocol (RSTP) on the network to ensure that network loops are discoverable and to prevent deployment issues. Network management should account for RSTP discovery downtime when the network changes.
- Disable IGMP proxy functionality on Crestron control processors with routers to ensure that DM NAX multicast traffic does not interfere with the control processor. The CP3N, Pro3, and AV3 control processors as well as DMPS3 presentation systems should have IGMP proxy functionality disabled when connected to the DM NAX network.
- Ensure that multicast IP addresses do not overlap and do not share multicast MAC addresses. Sharing MAC addresses can cause network collisions and prevent normal operation of the DM NAX network.

System Installation

The installation phase should ensure that the interaction between the designer, installer, programmer, and the end-user is considered in all installation decisions.

Endpoint Installation

Each DM NAX endpoint has unique installation requirements that depend on the following:

- RJ-45 connectors for the connectivity of the endpoint.
- Configuration of NAX devices as either encoder/decoder or encoder only or decoder only.
- Additional audio sources that require encoding.
- Amplification, form factor limitations, proximity of external amplification devices, channel count requirements.
- Versiports on the DM-NAX-4ZSP and DM-NAX-8ZSA.

A Crestron touch screen can be linked through a spare LAN port on an endpoint (if Port Selection is not enabled).

The endpoint features and attached devices can be configured through programming or the web interface.

For a maintenance-free installation, follow these guidelines:

- Avoid direct access to the endpoint by the end-users. End users can induce failures or create a security risk due to unauthorized network access.
- Use properly terminated shielded or unshielded Cat 5e or higher copper network cable that is terminated with an RJ-45 connector.
- Observe the minimum bend radiuses and pull forces of cables to maintain cable integrity and prevent failures.
- Use plenum-rated cables in plenum spaces. Cables such as Crestron DigitalMedia™ plenum-rated cables are suitable. Fire-rated conduit for any fiber or copper cabling used in plenum spaces is also suitable.
- Practice good cable dressing.
- Use descriptive names for endpoints either through the DM NAX web interface or by replacing the default name in the Crestron Toolbox™ software. Do not rely on the default name or the Crestron IP ID.
- Physically secure the endpoint to a fixed point or rack to prevent movement over time.
- Thoroughly document the installation of endpoints including drawings, lists, and descriptions to provide detailed information for those who will maintain or upgrade the DM NAX network.

Network Installation

The installation of a DM NAX network varies greatly depending on many factors, including the following:

- Whether existing network infrastructure such as switches and cabling is to be reused.
- Location of closets, racks, Intermediate Distribution Frames (IDFs), and Main Distribution Frame/Combined Distribution Frame (MDF/CDF) relative to the endpoints.

For optimal installation and maintenance of the DM NAX network, follow these best practices:

- Use or repurpose existing infrastructure in DM NAX network installation cases.
- Use physical security for the network. Secure all network locations (MDF/CDF and IDF down to individual closets) from unauthorized access.
- Disable any unused ports on the network switches.
- Use a structured cabling approach such as those described in the TIA/EIA-568 standard. Include keystones in jacks and patch panels, shielded or unshielded solid copper conductor cable not exceeding 295 ft (90 m), and patch cables not exceeding 33 ft (10 m) to connect between patch panels. Use cable testers to verify the integrity of the installation and capacity for future expansion and backup.
- Use Crestron-recommended switch configuration files.
- Configure the routing of external servers. If nondedicated DHCP, RADIUS, Active Directory, or other servers are used, ensure that the servers access the DM NAX network.
- Thoroughly document all DM NAX network hardware and configurations.

Crestron Service Provider Handoff

Consult Crestron Service Providers (CSPs) once the DM NAX network and endpoints are installed and interconnected. Typical activities of a CSP in a DM NAX installation may include the following:

- Writing appropriate control programs for controllers on the network.
- Configuring output DSP settings to tune zones for acoustic environments and video walls.
- Configuring external analog and digital audio source input and output.
- Designing button and UI features for control surfaces such as touch screens and switches.
- Managing delay settings for synchronization of audio zones with video.

As CSPs implement and deploy the program, installers and designers should test and review the functionality. The programmer must document the program functionality to avoid future issues.

Troubleshooting

This topic provides troubleshooting procedures for various issues that may occur when using DM NAX devices.

Issue	Solution
Loss of control or sluggish control over connected devices	Isolate the AV-over-IP traffic from the control traffic to avoid loss of control or sluggish control over connected devices.
Inability to reach web configuration interfaces	Isolate the AV-over-IP traffic from the control traffic to reach web configuration interfaces.
Dropped routes between AV-over-IP endpoints	Make sure there is enough bandwidth and a Master PTP clock.
Distorted audio, or clicks and pops in audio	Make sure PTP synchronization is uninterrupted and prioritize QoS during bandwidth saturation.
Audio routes have unexpected signals, such as mismatched left and right channels or a signal from an unexpected source	Ensure that there are no duplicate multicast transmitter addresses on the network.

Glossary

802.1Q:
A network protocol that allows for VLANs and tagging of VLAN traffic and enables 802.1P to provide quality of service features; defined in IEEE 802.1Q-2014.

802.1X:
A network control protocol to authenticate devices connected to an Ethernet network on a port-by-port basis by encapsulating the Extensible Authentication Protocol; defined in IEEE 802.1X-2010.

Active Directory:
An application protocol developed for Microsoft® Windows® networks that authenticate and authorizes users and devices using login mechanisms and also stores and controls additional information on the network regarding users and resources.

Audio Engineering Society (AES67):
An audio-over-IP standard put forth by the Audio Engineering Society to allow for interoperability between a broad range of proprietary audio-over-IP systems.

Closet:
The distribution point for networking infrastructure localized to a floor or group of rooms.

Core:
The central point of a network from which all network devices and intermediate infrastructure are normally accessible.

Differentiated Services (DiffServ):
A method of Ethernet traffic tagging used for QoS that relies on a 8-bit header containing a 6-bit value called the DiffServ Code Point (DSCP). This DSCP determines the queue of a specific packet, which is then prioritized based on the network switch's priority level for that queue.

Differentiated Services Code Point (DSCP):
A 6-bit value in the Differentiated Services IP header that determines the queue/priority of a packet as determined by a network switch's QoS configuration.

Domain Name System (DNS):
A system of naming computers on a network that have numerical IP addresses; defined across multiple IETF RFCs starting with IETF RFC 1034.

Dynamic Host Configuration Protocol (DHCP):
A network protocol that distributes network parameters such as IP addresses through a server to clients requesting them; defined in IETF RFC 2131.

Edge:
The endpoint of a network connection that allows end device interconnection with the network.

Extensible Authentication Protocol (EAP):
A protocol for authentication of point-to-point network connections using multiple methods

including TLS and Design Guide – DOC. 9268A DM NAX Audio-over-IP System • 29 MS-CHAP v2; defined in IETF RFC 3748 and IETF RFC 5247.

Institute for Electrical and Electronics Engineers (IEEE):
A nonprofit organization that publishes electrical and electronics standards particularly for network communication through the IEEE 802 family of standards.

Intermediate Distribution Frame (IDF):
The signal distribution frame that allows interconnection between the main distribution frame and premises closets.

International Electrotechnical Commission (IEC):
A nonprofit organization that publishes standards regarding electrical and electronic standards.

Internet Engineering Task Force (IETF):
A standards organization that establishes and maintains voluntary standards for Internet networking globally.

Internet Group Management Protocol (IGMP):
A network protocol that allows multicast traffic to pass over adjacent routers on an IPv4 network; defined in IETF RFC 2236 for v2, IETF RFC 3376, and IETF RFC 4604 for v3

Internet Protocol (IP): A communications protocol that relays information across network boundaries between addresses; defined in IETF RFC 791 for IP version 4.

Main Distribution Frame (MDF):
The signal distribution frame for networking that connects premises physical plant equipment to outside physical plant equipment.

Media Access Control (MAC):
A 48-bit address in the Ethernet protocol that establishes the unique physical device in a network that is routed to or from that physical device.

Microsoft Challenge-Handshake Authentication Protocol (MS-CHAP):
A network authentication protocol that is used for network devices by RADIUS servers. MS-CHAP is defined in IETF RFC 2433 for MS-CHAP v1 and IETF RFC 2759 for MS-CHAP v2.

Multicast:
One-to-many data transfer that allows scalable distribution of audio and video in an efficient manner.

Network Topology:
The layout of a network as it would appear visually in a simplified form.

Plenum:
Part of a building where heating, ventilation, and air conditioning are provided.

Precision Time Protocol (PTP):
A multicast networking protocol used for the synchronization of networked clocks. As this applies to AES67, this is the protocol that keeps the audio clocks in an AoIP network synchronized to a master device so audio arrives on time and in sync.

Quality of Service (QoS):
A performance improvement feature that prioritizes more important network traffic over less important traffic in a network switch.

Rapid Spanning Tree Protocol (RSTP):
A network control protocol for discovering and accounting for network loops and redundancies; defined in IEEE 802. 1d-2004.

Remote Authentication Dial-in User Service (RADIUS):
A network protocol that provides authentication, authorization, and accounting for network devices and users securely, especially for IEEE 802. 1x protocol, and deployed in a client-server model; defined in IETF RFC 2865 and IETF RFC 2866.

Request For Comments (RFC):
A standards publication from the IETF.

Secure Shell (SSH):
A protocol utilizing cryptography that secures network services such as a command-line shell; defined across several IETF RFCs beginning with IETF RFC 4250 by the IETF SECSH working group.

Structured Cabling:
A standard for developing network and cable infrastructure; defined in TIA/EIA-568.

Symmetric Encryption:
An algorithm or method of using cryptography such that a single key is used for both the encryption and decryption of information to be protected.

Transport Layer Security (TLS):
A protocol implementing cryptographic security on a computer network; defined in IETF RFC 5246 and IETF RFC 6176.

Virtual Local Area Network (VLAN):
A nonphysical sequestered broadcast domain or partition isolated at the data link layer, effectively sequestering switch ports and network traffic across one or more switches from all other ports and traffic.

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Crestron Electronics, Inc.
15 Volvo Drive, Rockleigh, NJ 07647
Tel: 888.CRESTRON
Fax: 201.767.7656
www.crestron.com

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