



Model 5401 Dante® Master Clock

Key Features

- Dedicated master clock for Dante audio-over-Ethernet and AES67 applications
- High-performance IEEE® 1588 PTP v1 and v2 servers
- Internal temperature-stabilized frequency reference
- Compatible with external word clock, video sync, and 10 MHz sources
- Word clock sync output
- Eight configurable audio tones signals
- Dual Gigabit Ethernet interfaces allow switched, redundant, and split Dante operation
- Web-based management and FTP software updating
- AC mains and 12 volts DC powering
- Lightweight enclosure, single rack-space (1U) mounting

Overview

The Model 5401 Dante Master Clock provides precise timing signals for applications that utilize the Dante® audio-over-Ethernet media networking technology. The unit implements a high-performance IEEE 1588 precision time protocol (PTP) server, compatible with the requirements of Dante and capable of simultaneously supporting the timing needs of up to hundreds of Dante-compatible devices. As expected, the Model 5401 provides the PTP v1 (IEEE® 1588-2002) compatibility that's required by Dante. In addition, the unit supports PTP v2 (IEEE 1588-2008) for AES67 applications. A word clock sync output provides a timing reference to external devices. The Model 5401 also generates up to eight sine-wave audio tones on Dante transmit (output) channels, useful during audio network installation, maintenance, and operation. A clock input connection allows the Model 5401 to synchronize with a variety of timing reference signals.

The Model 5401 is suitable for use in fixed and mobile broadcast facilities, post-production studios, commercial and educa-

tional theater environments, and entertainment applications. Only power and one or two Ethernet network connections are required for full operation. Using Dante's inherent capabilities two Model 5401 units can serve in primary and secondary master clock roles for seamless, redundant operation.

An integral web server allows fast and flexible monitoring and configuration of the Model 5401's master clock, tone generation, and networking performance. Front-panel indicators, an LCD display, and pushbutton switches provide personnel with direct access to key operating parameters. Updating of the Model 5401's operating software can be easily performed using the unit's integrated FTP (file-transfer protocol) client. The unit's dual Gigabit Ethernet ("GigE") network interfaces allow support for redundant Dante operation. All program software files and configuration parameters are stored in non-volatile memory. The Model 5401 can be powered by 100-240 V, 50/60 Hz mains or a source of 12 volts DC. The lightweight enclosure mounts in one space (1U) of a standard 19-inch rack.



Model 5401 Front and Rear Views

Applications

Applications for the Model 5401 include fixed and mobile broadcast facilities, college and university audio networks, arenas, stadiums, and corporate installations — virtually any application where substantial numbers of Dante-compatible devices are utilized. The Model 5401 will serve as a stable and consistent master clock for the entire Dante “network.” And, as expected, the Model 5401 is compatible with all Dante devices, no matter what their primary function or manufacturer. Applications that utilize devices compatible with AES67 will also benefit from the Model 5401’s resources.

Why a Dedicated Dante Master Clock?

With Dante ubiquitous in fixed and mobile facilities of all sizes and types, the need arose for a cost-effective, purpose-designed, dedicated master clock. While an inherent strength of Dante networking is its carefully implemented use of IEEE 1588 to ensure that all connected devices maintain a common timing reference, the actual performance can vary widely depending on the specific Dante devices in use and the overall number of devices on a network. There are many Dante-compatible devices that can provide adequate basic performance as a master clock, but with the Model 5401 networked audio systems get the benefits of a high-performance “grand-master” PTP server, along with additional unique capabilities. The unit’s feature set, along with the associated internal hardware and software, was designed to provide optimum performance, flexibility, and system integrity.

Timing Sources

The Model 5401 can provide excellent master clock performance using its accurate and stable internal oscillator, which is temperature-controlled and exceeds the performance of standard Dante devices by at least an order of magnitude. While its standalone performance is excellent, the Model 5401 can also be “locked” to a variety of external signals for integration into facilities that include a master timing reference. Compatible signals include word clock, video reference, and 10 MHz.

A word clock signal, typically 48 or 96 kHz, is often used as a timing reference in audio-only facilities. Various word clock rates are compatible with the Model 5401’s sync input. Video reference (“sync”) signals are found in most broadcast and

post-production facilities. The Model 5401 supports the most-common video format/rate combinations including “black burst,” bi- and tri-level HD, and several that are specifically intended for 4K applications. Industrial and commercial facilities often utilize a GPS-disciplined source of 10 MHz as a timing reference. This sine-wave signal is directly compatible with the unit’s sync input.

Sync Output

The Model 5401 generates a precise word clock sync output signal that can be used as a timing reference for related equipment. It’s specifically intended for “locking” audio equipment in applications that have Dante equipment whose timing reference signals are provided by a Model 5401. In this way all devices will share a common timing reference.

The word clock sync output rate can be selected to be 44.1, 48, 88.2, or 96 kHz. The underlying timing source for the sync output is derived from the Model 5401’s main timing source which, as previously reviewed, can be either an internal oscillator or an external source. The main timing source is divided and processed by the Model 5401’s logic circuitry to create the highly stable word clock sync signal. This ensures that the word clock sync output is synchronized with the unit’s PTP server functionality.

Audio Reference Signals

The Model 5401 generates eight sine-wave audio reference signals for general-purpose use. They are individually configurable in level and frequency. These audio “tones” are available on the Model 5401’s Dante transmitter (output) channels and can be connected, using the Dante Controller application, to Dante receivers (inputs) on related equipment. The flexibility of the available routes (Dante “subscriptions”) between all Dante devices on a network allows the reference signals to be used for a variety of purposes. Configuration choices allow the frequency and level of the sine-wave signals to be optimized for specific applications.

Master Clock Support for Dante Networks

A core part of the technology underlying Dante audio-over-Ethernet networking ensures that all connected devices follow a common timing reference. This is accomplished using the industry-standard IEEE 1588 precision time protocol (PTP).

Any connected Dante device can be used as a master clock; there is no requirement that a dedicated master clock device be utilized to realize adequate performance. However, the actual performance can range widely depending on the specific Dante devices available and the overall number of Dante devices on the network.

Many Dante devices utilize the 2- or 4-channel Ultimo™ integrated circuit to implement Dante connectivity. While Ultimo devices will fully support Dante audio transport they are not well suited to serve as a master clock. Ultimo's PTP performance is limited and does not have the ability to synchronize with an external timing reference. Other Dante devices use the Brooklyn II module to support Dante connectivity. In many cases these devices can provide good basic performance as a master clock including some that allow connection of an external source of word clock.

However, problems and limitations may arise when these devices are called upon to perform "double duty," serving both a primary function (such as analog-to-Dante interfacing or audio signal processing) and acting as a master clock. This is understandable as the main purpose of these devices is to serve a function other than as a master clock. For example, connection of a video bi- or tri-level sync signal is rarely, if ever, supported. And PTP performance can degrade when the computing power of a device is intended primarily for handling and manipulating digital audio signals. This can lead to the required PTP resources being in short supply when the number of Dante devices that need timing messages moves into the hundreds. Also, firmware updates, cabling changes, and other maintenance tasks typically associated with a general-purpose Dante audio device would impact the master clock functionality for an entire installation.

The Model 5401 was specifically designed to support a Dante-based audio system's master clock requirements. The unit's generation of audio tones and implementation of the sync output utilize hardware that is separate from that associated with PTP functionality. As such, this secondary functionality will not interfere with PTP operation. Unlike a general-purpose audio device, once mounted in an equipment rack and the required interconnections are made, the Model 5401 will perform its tasks without risk of interruption due to conflicting resource demands.

Overall Networking Capability

Using the Dante Controller application program the Model 5401's two Gigabit Ethernet ports can be selected to operate in one of three modes: switched, redundant, or split. In the switched mode a single Ethernet connection to either of the Model 5401's Ethernet ports will provide Dante master clock functionality as well as access to the Model 5401's management web pages. The remaining Model 5401 Ethernet port will provide network "loop-through" capability and can be used to interface with another piece of Ethernet-connected equipment. In the redundant mode two independent Ethernet connections are made to the Model 5401's Ethernet ports, enabling Dante's redundant network capability. In this mode the Model 5401's primary Ethernet port will provide access to the management web pages. In the split mode, called Pri Dante/Sec Mgmt, the Model 5401's primary Ethernet port will be used by the network associated with Dante while the secondary Ethernet port will be used to access the management web pages. This allows separate networks to be maintained for Dante and maintenance and configuration purposes.

Operating Power

The Model 5401 allows an AC mains source of 100-240 V, 50/60 Hz to be directly connected. It can also be DC powered using a 10-18 volt source that is connected via a broadcast-standard 4-pin XLR connector. If both AC and DC power sources are connected the unit will be powered by the AC mains supply. Only if the AC mains source fails will a load be placed on the DC source. This allows a source of DC, typically an external power supply or broadcast-style battery, to serve in a backup capacity. With this arrangement normal operation can continue even if AC mains power is lost.

Future Capabilities

The Model 5401's main and logic (FPGA) embedded software (firmware) can be updated by way of its Ethernet network connection and the internet. Multiple versions of firmware are used to support the Dante interface hardware, user management menus, and audio generation capabilities. Each can be independently updated as required.

Model 5401 Specifications

Applications:

High-performance master clock for Dante audio-over-Ethernet applications. Also supports AES67-2013 applications. In addition provides audio reference signals (tones) for general-purpose use and a precision word clock sync output.

Precision Time Protocol (PTP) Support: IEEE® 1588-2002 Version 1 (v1) for Dante; IEEE 1588-2008 Version 2 (v2) for AES67-2013

Timing Reference:

Source: internal time-base, external sync input, or via an existing Dante network, selectable

Internal Time Base:

Type: 24.576 MHz temperature-stabilized crystal oscillator
Initial Accuracy: 2 ppm (parts-per-million)
Long-Term Accuracy: 1 ppm (parts-per-million) per year
Temperature Stability: ± 280 ppb (parts-per-billion), 0-50 degrees C

Sync Input:

Compatible Sources: word clock, bi-level video, tri-level video, 10 MHz
Termination: 50 ohms, 75 ohms, or high Z (unterminated), selectable
10 MHz Characteristics: sine wave, 1 V_{rms} with 50 ohm load

Sync Output:

Type: word clock
Rate: 44.1, 48, 88.2, or 96 kHz, selectable
Impedance: 75 ohms
Amplitude: 5 V_{pp}, measured unterminated
Jitter: measurement pending

Network Audio Technology:

Compatibility: Dante audio-over-Ethernet with Dante Domain Manager (DDM) support; AES67-2013, selectable enabled/disabled
Ethernet Interface Configuration: switched, redundant, or split
Clock Source: follows overall Model 5401 configuration
Bit Depth: 24
Sample Rate: 44.1, 48, 88.2, or 96 kHz, selectable
Number of Dante Transmitter (Output) Channels: 8
Number of Dante Flows: 32

Audio Reference Signals:

Type: continuous sine-wave signals on Dante transmitter (output) channels
Number of Channels: 8
Frequency: 1 Hz to 22 kHz, individually configurable in 1-Hz steps
Amplitude: 0 to -99 dBFS, individually configurable in 1-dB steps
Distortion (THD+N): <0.0001% (<-121 dB), measured at 1 kHz, -1 dBFS

Network Interfaces:

2, primary and secondary
Type: 1000BASE-T (Gigabit Ethernet ("GigE")) per IEEE 802.3ab (100 Mb/s also supported but not recommended for optimal performance)
NIC Status LEDs: one link and one activity for each Ethernet interface

Software Updating: internal FTP client supports updating of application, main FPGA, and sync FPGA software; process requires unrestricted access to the internet or a local FTP server

Front-Panel Display: LCD with LED backlighting

Front-Panel LEDs: 6, dual-color

Functions: provides indication of condition of incoming AC and DC power, status of Dante connections on Ethernet interfaces, and status of Dante connectivity

Power Sources:

AC Mains: 100 to 240 V, 50/60 Hz, 5 W maximum
DC: 10 to 18 V, 0.5 A max

Connectors:

Sync Input, Sync Output: BNC, per IEC 61169-8 Annex A
Ethernet: 2, RJ45
AC Mains Input: 3-blade, IEC 320 C14-compatible (mates with C13)
DC Input: 4-pin male XLR (pin 1 negative, pin 4 positive)

Dimensions (Overall):

19.00 inches wide (48.3 cm)
1.72 inches high (4.4 cm)
7.9 inches deep (20.1 cm)

Mounting: one space (1U) in a standard 19-inch rack

Weight: 3.0 pounds (1.4 kg)

Specifications subject to change without notice.

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