NETWORK
TECHNOLOGIES
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Video Matrix Switches and Bandwidth

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What is a Video Matrix Switch?

Video matrix switches are designed to simplify the task of routing video inputs from multiple input sources, such as computers, surveillance cameras, and DVD players, to one or more display devices, such as monitors, projectors, and TVs. These electronic switches create a matrix pattern of interconnections, with models accommodating a variety of possible input and output configurations. Video matrix switches are commonly used in applications such as command centers, conference rooms, and entertainment venues. The benefits of deploying video matrix switches include reducing equipment costs and space needs, while giving video system designers more control and flexibility.

Video matrix switch models vary in the types of signals they route, including composite video, S-video, HDTV/component video, VGA/SVGA/XGA, and DVI. A single unit may accommodate multiple types of signals, but the individual signal types are managed separately within the switcher. Therefore, S-video inputs, for instance, may only be routed to S-video outputs.

Video matrix switches are housed in a single enclosure and controlled by many types of user interfaces, including front panel buttons, a remote control, or application software running on a PC. Internally, the video matrix switch consists of a series of distribution amplifiers and switchers, which properly connect and terminate all inputs and buffer each output.

Bandwidth specifications and performance vary among video matrix switches on the market. Additionally, bandwidth performance can vary for a specific video matrix switch, given the different input/output routing configurations possible for that switcher. Therefore, the most demanding input/output configuration—typically one input connected to all possible outputs—should be measured by the video matrix switch manufacturer, and noted in the product specifications. This “fully loaded” configuration establishes that regardless of how a switcher is ultimately configured, actual performance will meet or exceed the specified bandwidth of the switch.

A video system, no matter how sophisticated the various input and output devices are, relies heavily on the performance of the video matrix switch managing it. Adequate bandwidth is a necessity, and video system designers must be equipped to choose a video matrix switch that meets the bandwidth needs for their particular application.

Bandwidth in Video Matrix Switches

In analog applications, bandwidth is defined as the difference between the lowest and highest frequencies that a communications system can pass, and is measured in Hertz (Hz), or cycles per second. The higher the bandwidth, the higher the capacity is to transfer information in that system.

In electronics, bandwidth is used to specify the performance of analog electronic circuits. Adequate bandwidth in a video matrix switch is critical to the integrity of the video signal. Without sufficient bandwidth, signal degradation can result, with serious effects on the resulting video image, including smearing, a lack of sharpness, and a loss of brightness. Therefore, manufacturers must accurately specify the bandwidth of a video matrix switch through optimal, reliable testing methods. For video system designers in search of a video matrix switch, several considerations are especially important. They need to know how to design a video system with adequate bandwidth, and know what to look for in video matrix switch bandwidth specifications.

Bandwidth Variations in Video Systems

To maintain the quality of the original signal, video systems must maintain sufficient signal frequency and amplitude as the video signal travels throughout the system. Yet, every component that comprises the finished video system can contribute to bandwidth loss. Video matrix switch manufacturers need to allow for enough bandwidth to accommodate all of the frequencies passing through a system. Additionally, they must keep in mind that bandwidth loss is cumulative from one circuit to the next. Therefore, rigorous and comprehensive testing and measurement of how a video matrix switch manages, and responds to, one or more video signals is critical. The outcome of the testing should be an accurate and meaningful bandwidth specification for the product.

Measuring Video Matrix Switch Bandwidth

Electronic technicians can use various testing methods to measure video matrix switch bandwidth. The time domain characterization using an oscilloscope for measurement has been proven to be highly effective.

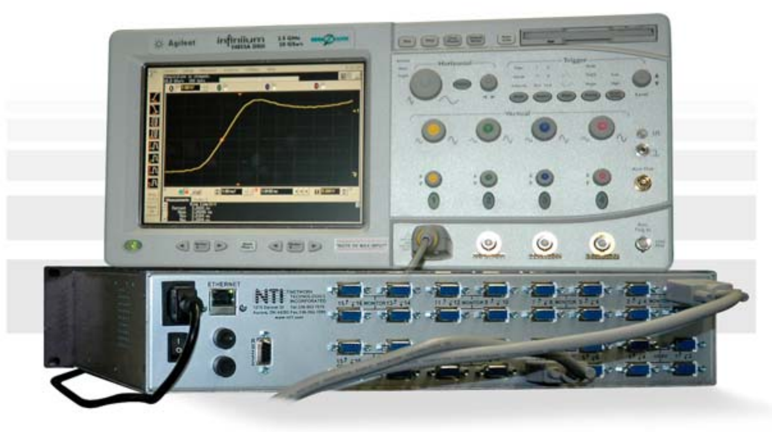

Figure 1 - Oscilloscope measures the bandwidth of an NTI video matrix switch

In time domain measurement, square waves are used to determine bandwidth by measuring the rise time of the signal. The rise time is the time required for the signal amplitude to change from 10 to 90 percent of the total square-wave amplitude. In Figure 1, the rise time of the signal shown is approximately 0.22 seconds.

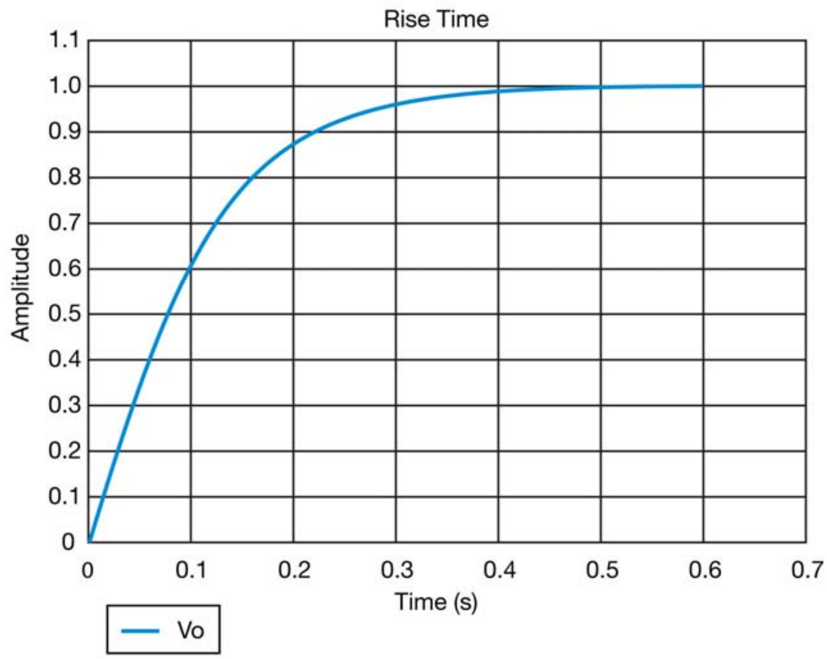

Figure 2 - Signal rise time.

Signal bandwidth can be calculated from rise time as follows:

$$-3\text{dB bandwidth} = \frac{0.35}{T_r} \quad \text{(measured in Hertz (Hz), or cycles per second)}$$

where T_r is the rise time.

(Equation 1)

Note that electronics manufacturers typically specify bandwidth at half the power, or –3dB point. The –3dB point is the frequency at which the product will output only half the power of the signal that is connected to its input.

Thus, for the signal shown in Figure 1, –3dB bandwidth can be calculated as follows:

$$-3\text{dB bandwidth} = \frac{0.35}{0.22} = 1.6\text{Hz}$$

(Example 1)

Video Signal Bandwidth vs. Video Matrix Switch Bandwidth

As previously stated, video signals are impacted and altered as they travel through a video system. Signals are modified or filtered depending on the combined response of the video signal and video matrix switch. Using the 10 to 90% rise time calculation, the system response can be stated in Equation 2:

$$T_{r\,sys} = \sqrt{T_{r\,sig}^{2} + T_{r\,sw}^{2}}$$

where $T_{r\,sys}$, $T_{r\,sig}$, and $T_{r\,sw}$ are the rise times of the system, signal, and switch, respectively.

(Equation 2)

With this equation, technicians can measure signal rise time and system rise time, and then calculate the switch rise time.

$$T_{r\,sys} = \sqrt{T_{r\,sig}^{2} + T_{r\,sw}^{2}}$$

$$T_{r\,sys}^{2} = T_{r\,sig}^{2} + T_{r\,sw}^{2}$$

$$T_{r\,sys}^{2} - T_{r\,sig}^{2} = T_{r\,sw}^{2}$$

$$T_{r\,sw} = \sqrt{T_{r\,sys}^{2} - T_{r\,sig}^{2}}$$

(Equation 3)

This calculation for switch rise time is illustrated in Example 2, where measured signal rise time equals 0.1 seconds and measured system rise time equals 0.2 seconds.

$$T_{r\,sw} = \sqrt{0.2^{2} - 0.1^{2}} = 0.17$$

(Example 2)

The switch rise time calculated in Equation 3 can then be used to calculate switch bandwidth (Equation 1), where the switch rise time equals 0.17 seconds (calculated in Example 2):

$$\text{Bandwidth} = \frac{0.35}{0.17} = 2\text{Hz}$$

(Example 3)

Therefore, to assure that the effect of the video matrix switch on the signal is minimal and inconsequential, the switch bandwidth should be considerably higher (that is, have a shorter rise time) than the signal bandwidth.

Using the rise time measurement, technicians can quickly and thoroughly test each video matrix switch output before the product ships. Potential device defects can be easily detected in a rise time measurement by reviewing graph data produced by an oscilloscope. For example, excessive overshoot (shown in Figure 2), which can be seen as peaking or excess phase shifts in the high-frequency response of the device being tested, can be identified. Rise time measurement can also check a product for ringing (see Figure 3), which is seen as an oscillation on the peaks. Overshoot and ringing can appear as ghosting or fuzzy edges on a display.

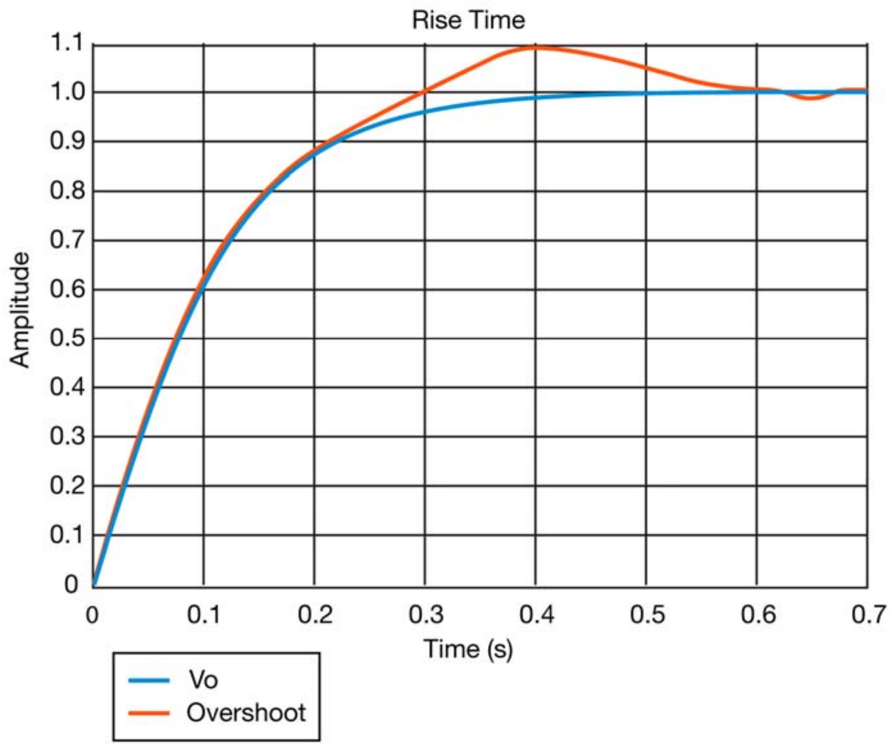

Figure 3 - Excessive signal overshoot.

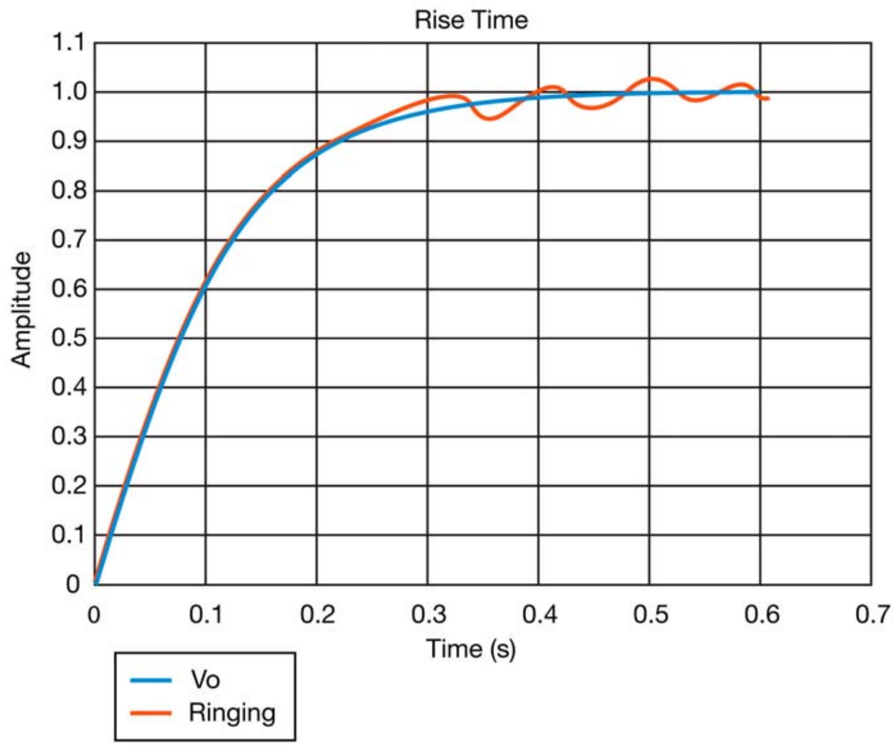

Figure 4 - Signal ringing.

Determining System Bandwidth Requirements

Achieving the desired video resolution is a critical factor in designing video systems. Video resolution, which pertains to the amount of detail that can be seen, is specified in terms of TV lines comprised of horizontal and vertical pixels. If the bandwidth of a video system limits the video signal bandwidth excessively, the video resolution is reduced, and the smaller details of the video image are eliminated. Thus, the more the signal is band-limited, the less detail information is visible.

System bandwidth requirements can be determined based on the signal resolution of a video source and its destination. Given that a full fundamental cycle covers two pixels, the calculation of the fundamental frequency for a monitor, for example, is the pixel rate divided by two. A commonly used method of calculation is as follows:

$$\text{fundamental frequency} = \frac{W \times H \times R_R}{2}$$

where W is the width (horizontal scan of pixels), H is the height (vertical scan of pixels), and R_R is the refresh rate (or scan rate).

(Equation 4)

An important consideration here, however, is that Equation 4 assumes that there is visible video during the entire scan time and does not account for the retrace times, which is when no pixels are being lit. The horizontal retrace time refers to the time found between the last pixel of one line and the beginning of the next. The vertical retrace time is that found between the last line of one frame or field and the beginning of the next.

Taking this into consideration, the scan rate will now include the visible video plus the retrace time, meaning there is more information to be displayed in less time. As a result, the fundamental frequency will be increased by approximately 35%. Revising the previous formula, the maximum frequency requirement of a system can be calculated as:

$$\text{fundamental frequency} = \frac{W \times H \times R_R}{2} \times 1.35$$

(Equation 5)

Meeting Bandwidth Needs in a Video Matrix Switch

Using Equation 5 to calculate the maximum frequency required of a switch allows system designers to verify if a video matrix switch has ample bandwidth. This is exemplified in Example 4, below.

NTI's SM-nXm-15V-LCD video matrix switch supports 1920x1200 video resolution at a refresh rate of 85 Hz with video bandwidth of 200 MHz, fully loaded.

$$\text{fundamental frequency} = \frac{1920\text{x}1200\text{x}60}{2} \times 1.35 = 132{,}192{,}000\text{Hz} = 132.192 \text{ MHz}$$

(Example 4)

Using the equations described above to determine adequate bandwidth is a reliable method for selecting a switcher. System designers should also keep in mind the importance of "fully loaded" bandwidth specifications to ensure realistic performance regardless of how the video matrix switch is configured.

Applications for Video Matrix Switches

Video matrix switches are used to manage the task of routing video signals in environments where multiple inputs and outputs are needed. Among the more common applications for video matrix switches are:

- Command and control centers
- Boardrooms
- Entertainment facilities
- Conferences and trade shows
- Courtrooms
- Classrooms
- Home theater

Command and Control Centers

Command and control centers use video matrix switches to route multiple audio/video inputs (computers, cameras and specialized equipment) to individual monitors or to a common display wall. Controllers can monitor data, alternate between different sources and, if needed, drive the signal to different viewing stations or send information through public address systems.

Boardrooms

Corporate boardrooms often require both fixed and portable video sources for business presentations. Video matrix switches allow the inputs from participants' laptops to feed into the facility's projector. Additionally, videoconferencing can be incorporated with the use of video matrix switches.

Entertainment Facilities

Food and beverage outlets, such as restaurants and sports bars, often use video to bring entertainment programming to their customers. These establishments use a video matrix switch to route video and audio inputs from DVD players, cable boxes, and satellite feeds to multiple displays and speakers. In addition, surveillance camera inputs can be managed from a single security station using a video matrix switch to monitor activities at cash registers, exits, and parking lots.

Conferences and Trade Shows

At conferences and trade shows, presenters need the ability to display video material from different sources on demand. By using a video matrix switch, presenters can easily manage their video feeds to address the particular needs of audience members by switching from one video source to another as needed.

Courtrooms

Courtrooms often need the ability to present video content to different locations around the room for viewing by a judge and jury members, among others. Video matrix switches enable the quick and efficient presentation of key evidence, such as graphic reenactments of accidents or crime scenes, as well as video depositions. Courtroom security and confidentiality can be maintained in special instances, such as limited viewing by a single witness, or previewing by a judge. Video matrix switches also enable entire arraignments and bench trials to be conducted virtually.

Classrooms

Utilizing video matrix switches in educational environments lets multiple classrooms to use centrally located sources like VCRs or DVD players, which reduces space needs and equipment costs. Within individual classrooms, video matrix switches allow instructors to easily alternate between video sources during lessons. Even specialized equipment such as electronic whiteboards can be incorporated into the system.

Home Theater

A video matrix switch implemented in a home theater allows routing of audio and video signals from many sources (DVD player, satellite set top box, game system, etc) to multiple displays in the same room or throughout a home from a centralized location. This lets a user to eliminate multiple remote controls and monitor display content more easily, while increasing the number of sources available to each display.

NTI Video Matrix Switches

Network Technologies Inc (NTI) manufacturers a variety of video-only and audio/video matrix switches to improve presentation efficiency, reduce equipment and energy costs, and maximize space utilization. In order to provide innovative video matrix switch solutions, NTI invests in research and development, and performs rigorous testing on all products to ensure long-lasting and proper operation.

NTI Video Matrix Switch Features

NTI's products are hardware-based solutions, and are known for their ease of use, reliability, high performance, and crisp and clear video resolution. Common features found in NTI's video matrix switches include:

- Crisp and clear video resolution up to 1900x1200.
- Amplification/buffering to isolate the signal source from the load, ensuring signal integrity throughout the system.
- Overshoot and undershoot kept to less than 10% to prevent signal distortion such as "ghosting".
- Audio breakaway—allows audio signals to be routed independent of video signals.
- Memory function—stores up to 100 connection configurations.
- Front panel keypad and LCD—allows the user to view and change the current audio and video connections, adjust audio volume and configure the RS232 control interface.
- Ethernet control—configuration and control can be done over the Internet via Web Server or Telnet.
- RS232 control—configuration and control can be done through the serial port.
- Matrix control software with graphical user interface—an easy and powerful graphical program that controls NTI's video matrix switches through an RS232 connection.
- Compliance with CE standards.

NTI Video Matrix Switch Product Offerings

NTI video matrix switches are manufactured at NTI's company headquarters in Aurora, Ohio, and are sold worldwide through an extensive network of international distributors and resellers. NTI's VEEMUX® Video Matrix Switches meet all industry standards and offer users flexible functionality with video-only matrix switches, audio/video matrix switches, and audio/video matrix switches via CAT5.

Video Matrix Switch

The VEEMUX SM-nXm-15V-LCD video matrix switch routes video from many computers to multiple displays. This switch can drive standard VGA cables, and is capable of connecting to as many as 32 video sources and 16 video displays. A single computer video output can be routed to one or more monitors. Each video output is buffered from each input, ensuring signal integrity throughout the system. The switch supports crisp and clear 1900x1200 video resolution with video bandwidth of 200 MHz, fully loaded.

Audio/Video Matrix Switch

The VEEMUX SM-nXm-AV-LCD audio/video matrix switch routes audio and video inputs from many computers to multiple displays and speakers. This switch can drive standard VGA cables, and is capable of connecting to as many as 32 inputs and 16 outputs.

Users can independently connect each input to any or all outputs. The switch supports 1900x1200 video resolution and stereo audio. Audio inputs accept any standard line level audio, and audio outputs are capable of driving 8-Ohm speakers. Video bandwidth is 200 MHz, fully loaded.

HDTV Audio/Video Matrix Switch

The VEEMUX SM-8X4-HDA HDTV audio/video matrix switch independently switches eight sets of YPbPr component video and analog/digital audio signals to any or all of the four outputs. Each input and output has YPbPr component video, L/ R analog audio (balanced/unbalanced), and digital audio on coax (S/PDIF).

The SM-8X4-HDA supports High Definition and Standard Definition component YPbPr video, S-Video or composite video signals; and unbalanced analog stereo, balanced analog stereo or digital S/PDIF audio signals. The switch supports 480i (interlaced), 480p (progressive), 720i, 720p, 1080i, and 1080p formats. Video bandwidth is 150 MHz, fully loaded.

Audio/Video Matrix Switch via CAT5

The VEEMUX SM-nXm-C5AV-LCD CAT5 audio/video matrix switch works with NTI's ST-C5x-600 CAT5 transmitters and receivers to create a high-performance audio/video signal routing system with a maximum extension of 600 feet between the local and remote units. The switch uses CAT5/5e/6 cable instead of bulky coax cables to route and distribute audio/video up to 600 feet. Crisp and clear 1024x768 resolution is supported at 600 feet; higher resolutions are supported at shorter distances up to 1920x1440. Video bandwidth is 175 MHz, fully loaded.

The VEEMUX audio/video matrix switch via CAT5 is capable of connecting to as many as 32 video sources and 16 video displays. VGA and S-Video transmitters and receivers can be supported on the same switch.

Trademarks

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