Line array systems pose a unique set of challenges to you as a system operator. Prior experience and assumptions derived from traditional fan-shaped multi-box arrays do not translate directly to line array systems, regardless of manufacturer. A variety of factors contribute:

- The line array summation effect increases array directivity, especially at high frequencies, and it accentuates the highest frequencies at greater distances.
- The geometry of the combined enclosures' array baffle angle, determined by individual box splay angles, influences the array's polar pattern.

For more information, see "Vertical Technology Acoustical Principles", Chapter. 1.

System Equalization Issues

Acoustical measurements made in the field of articulated line arrays will typically show a rising frequency response curve. This is due in part to the line array summation effect, which is particularly influential at higher frequencies. This additional complexity makes it important to separate subjective adjustments like system timbre from system control adjustments such as crossover parameters and levels. Do this by providing a user-adjustable EQ device located ahead of the DSP signal controller. Once you've established the parameters for your system, use the digital controller's security features to prevent unauthorized modification.

The VERTEC system has certain specific frequency-dividing (crossover) and other filter parameters that have been carefully configured to maintain optimum array performance throughout the designed coverage area. These filters, signal delays and and gain adjustments reside in the individual passband sections of the system controller. It is recommended that system operators do not alter these control settings. The integrity of the array's ability to evenly cover the desired audience area depends on the interrelationship of the crossover parameters, the individual box splay angles, and the geometry of the entire array. Maintaining these crossover parameters despite changes in array configuration or listening environments should take precedence over random signal processing manipulation.

The VERTEC system uses precision frequency dividing networks and narrow band filtering to achieve its high level of performance in both the on-axis and off-axis planes. Altering any of the crossover parameters may cause undesirable changes in the polar characteristics (dispersion) of the array at different frequencies. When you need to alter the tonal characteristics of the array, use a separate equalizer connected ahead of the system controller (or the controller's input equalizer) to accomplish this.

Crossover Parameters and System Bandpass Issues

Any discussion of the frequency-dividing information for a properly-designed multi-way line array system such as the VT4889 requires a basic level of understanding of basic audio filter design.

In the VT4889, bandpass integration is achieved through the use of independent low and high frequency filters with slopes that are symmetrical, but having different - 6 dB electrical frequencies.

The basic system crossover parameters for the VT4889 are:

Bandpass Transition	Crossover Point	Electrical Filter Type
High Pass Filter	40 Hz 4th Order (40-80, varies w/application)	Bessel, 24 dB/octave
Low Freq. to Mid Freq.	202 Hz @ -6 dB	Linkwitz-Riley, 24 dB/octave
Mid Freq. to High Freq.	1.050 kHz @ - 6dB	Bessel, 18 dB/octave
Low Pass Filter	22 kHz	Linkwitz-Riley, 24 dB/octave

High Pass Filter and Low Frequency Issues

As with any high-powered multi-way system, you need to carefully and deliberately set the system's low-frequency limit via the system controller's high-pass filter.

The high pass filter frequency for DSP settings used to drive a VERTEC array is program dependent and user-selected. Will you use subwoofers, or rely on the VT4889 enclosures as a full-range system? Will you separate the VT4889 enclosures from the subwoofers, or will you locate them near, or perhaps even on top, of them? Are you using the system for vocal reinforcement only, or for musical program material? What type of program material will you reinforce, and with what sort of spectral balance expectations?

As with any high-powered multi-way system, it is important that the High Pass Filter be carefully set. System performance in the low frequency region should be monitored, to prevent driver over-excursion or failure of the 15" Low Frequency components due to excessive input voltage levels at lower frequencies, which can be damaging to loudspeaker components.

For more information on the 2255H and other components in the system, see "VT4889 Components", Chapter 3.

Low Frequency to Midrange Frequency Transition

The VT4889 enclosure includes exceptionally high-powered sound radiating devices that are tightly packed. Potential interaction between the low frequency and midrange frequency components (a function of the enclosure geometry) could cause noticeable beaming beginning at approximately 300 Hz in this type of physical design if not properly addressed.

Precision filters are in place to reduce this effect. An amplitude filter is used to manipulate the relative phase response of the system in the 200-400 Hz region. This filter is engaged in the upper-skirt region of the low frequency bandpass, and its effect is to make the on- and off-axis frequency response more uniform in the low-mid frequency region of the system.

The acoustical crossover point is 202 Hz at the -6 dB point. The bandpass signals sum to unity because the low and mid frequency devices are phase-coherent at that point.

Midrange Frequency to High Frequency Transition

The 2250H 8" midrange loudspeakers cross over to the 2435H compression drivers in the region of 1.1 kHz. This crossover point is selected to maintain constant coverage characteristics across the midrange to high frequency transition region. The crossover point's electrical characteristics include a 3rd Order Butterworth filter with a low pass setting of 980 Hz, chosen to net a composite 4th Order electro-acoustical transition with a - 6 dB frequency of 1050 Hz.

High Frequency Drivers and Their Effect on Crossover Settings

The VT4889 is fitted with three compression drivers (instead of two, as in some similar products from other sources). They are the Model 2435H, a driver with exceptionally robust construction and high output capabilities. The three 2435H compression drivers can deliver 3.5 dB more displacement-limited output in each VT4889 than could be achieved with only two drivers.

This robust high frequency section is what allows these unique crossover parameters to be implemented so as to optimize the midrange to high frequency transition region of the system, while simultaneously providing increased electrical performance characteristics. The result is increased output capabilities along with lower distortion and smoother frequency response.

Traditional compression drivers have a mass break-point that is typically between 3-4 kHz with a 6 dB per octave rolloff. This usually requires the application of a rising electrical curve to restore extended high frequency response in most drivers.

By contrast, the 2435H's in the VT4889 system have a mass break-point that is nearly one octave higher than traditional high frequency drivers. In concert with JBL's proprietary Waveguides in the VERTEC system, these drivers offer a high frequency section that demands less mid-high frequency equalization to achieve overall superior system performance. A rising electrical curve is still employed as with traditional compression drivers, but it is set to begin at a higher frequency due to the higher mass break-point of the beryllium diaphragms.

For more information on compression driver construction including mass break-point effects, see JBL Technical Notes Volume 1, Number 8, "Characteristics of High-Frequency Compression Drivers".

Digital System Controllers

The VT4889 array elements used in VERTEC systems require digital signal processing files for use in system controllers. As a VERTEC user, these parameters are provided to you from JBL Professional in the form of software files on CD-ROM. These can be loaded into your system controller from a PC. Consult the User Manual for the specific system controller that you are using with your VERTEC system for information on file transfers.

The chosen system controller must be equipped with an appropriate number of variable-Q parametric filters to implement the specific crossover parameters previously discussed. Upon loading VERTEC system files you will notice that crossover settings are fixed regardless of system size or array configuration. Array-specific settings for adjusting the amplitude of various passbands, along with user-preference settings based on musical program material or subjective tonal quality choices, are implemented with filters and gain stages at the input and/or output side of the crossover section.

Choosing Your System Controllers

One of the most important parts of a sophisticated multi-way sound reinforcement system is the digital system controller, and the DSP files specific to your loudspeaker system. Your system needs will undoubtedly vary from other users. There are a number of fine products in this class available. JBL has chosen to support three specific DSP-based system controllers for use with the JBL VERTEC system. These controllers are:

dbx Drive Rack 480
BSS FDS-366
XTA DP226

Any of these processors fulfill the signal processing requirements of the VERTEC system. These requirements are:

- Enough outputs to create the system processor for a three-way mono system, with or without subwoofers. Additional inputs and/or outputs can be used to create stereo versions of the mono processor.
- Each output must have separate high-pass and low-pass filters, with individually adjustable frequency, slope, and filter characteristic.
- Each output must have its own parametric equalizer, time delay, limiter, and level adjustment.
- Each input must have its own highpass filter (for system VLF limit), level control, and parametric or graphic equalizer.
- Security features to protect output parameters from unauthorized user adjustment.
- The ability to download and upload settings.

The amount of processing required makes anything but a DSP implemented processor impractical (size, rack space, cost).

dbx Drive Rack 480

dbx Drive Rack 480

The Drive Rack 480 is a 2U 4-in 8-out complete equalization and loudspeaker management system with integral crossovers, equalizers, delays, and protection compressor/limiters. The unit can be operated from a remote PC via a RS232 link. RS485 and MIDI protocols are also provided. The 480 can also be controlled from its front panel.

The 480 has built in dual-channel Real Time Analyzers. A useful accessory is the model 480R System Remote Control which can replace a computer for controlling a network of Drive Racks.

The factory supplied VERTEC configuration program sets the unit for stereo four-way operation. The outputs are (1-8) high, high, mid, mid, low, low, sub, sub. If desired you can reconfigure this via the unit's user interface. You can set the Drive Rack with lowest frequencies on the left and highest frequencies on the right, the setup typically used by most sound reinforcement system operators.

FDS 366 Omnidrive Compact Plus

BSS Omnidrive Compact Plus FDS 366

The BSS Audio FDS 366 system controller is a compact 1U, 3-in, 6-out loudspeaker management system with integral crossovers, delays, dynamic EQ and protection limiters. The unit can be operated from a remote PC via RS-232, RS-485, or MIDI. It can also be controlled from its front panel.

The FDS366 has a built-in advanced loudspeaker measurement function called the Alignment Assistant. Using a measurement microphone, the Alignment Assistant can directly measure the delay and phase relationship between drivers and to automatically adjust settings to accommodate the measured results. You can also use it for distance correction delay measurements.

The factory supplied VERTEC configuration program sets the unit for stereo three-way operation. The outputs are (1-6) low, mid, high, low, mid, high.

XTA DP226 Speaker Management System

XTA DP226

The XTA DP226 speaker management system is a compact 1U 2-in, 6-out processor having integral crossovers, delays, parametric equalization, delays, and limiters. The unit can be operated via a remote PC via RS-232, RS-485, or MIDI. It can also be controlled from its front panel.

The factory supplied VERTEC configuration program sets the unit for stereo three-way operation. The outputs are (1-6) Low, Mid, High, Low, Mid, High.

System Controller Manufacturer Contact Information

Here is contact information for each of the processor manufacturers.

Company	dbx Professional Products	BSS Audio USA	XTA Electronics Ltd.
Model No.	Drive Rack 480	FDS 366 Omnidrive Compact Plus	DP 226
Website	www.driverack.com/	www.bssaudio.co.uk/	www.xta.co.uk
Email	support@dbxpro.com	BSSAudioUSA@harman.com Support@bssaudio.co.uk	tech@xta.co.uk
Address	8760 S. Sandy Pkwy Riverside Business Sandy, Utah 84070	1449 Donelson Pike Nashville, TN, 37217	Airpark Business Ctr 12 Worcester Road Stourport-on-Severn Worcs. DY11 9BZ UK
Voice Phone	(801) 568-7660	(615) 360-0277	+44 (0) 1299 879977
Fax	(801) 568-7662	(615) 360-0480	+44 (0) 1299 879969

General Comments, System Controllers

Each of the three system controllers listed above is quite different. Although they all perform more or less the same task, they each get results for you in their own unique way. Whichever controller you decide is best for your VERTEC system, you should do the following 'homework':

- Glance through the user documentation. At a minimum, look at the table of contents.
- Learn how the unit stores its settings.
- Learn how to recall settings (on the unit as well as on the PC).
- Learn how to get around via the front panel of the unit as well as on the PC.
- Learn how to get around via the unit's PC control software.
- Spend enough time so you are comfortable with changing settings and reconfiguring the unit.
- Learn the security system.

Ready-to-use multi-output system configuration files that will be useful in configuring your VERTEC system are available from each manufacturer's website. Get them; they are your starting point. You will want to work with setting the relative passband gains to tailor the tonal quality of the system to the type of program material and field applications you are involved with.

Combining the specific VT4889 crossover settings from JBL with your preferred spectral balance levels for Lows, Mids and Highs will give you an excellent signal processing foundation that you will want to tailor to meet your specific needs.

Subwoofers and Other Issues

The setup files mentioned previously configure the system controller for stereo three-way operation without subwoofers. The dbx Drive Rack has 8 outputs, so it can be configured for subwoofers by default. If you are using the BSS or XTA processors, the most common solution is to use two separate system controllers, each running in mono. This would provide the four outputs (Sub, Low, Mid, High) with two added outputs that could be used for delay arrays, near fill speakers, or audience side-fills.

Each system controller has its own method for mapping the crossover outputs to the rear panel. You may also have your own preferences about this. If you intend to reconfigure the device to suit your own preferences, spend enough time with the factory-supplied configuration to learn it, then learn how to transfer those settings to other channels or outputs. Once you've mastered this, be sure to save your new configuration using a unique name.

Protection Limiters

The JBL VERTEC system can be used with a variety of professional power amplifiers and it is not possible to know in advance which amplifiers you may choose for your system. You will need to adjust your limiter functions to match the sensitivity of your chosen power amplifiers.

The system controller's limiter engages when the output signal of a given bandpass reaches the set limit, preventing additional amplifier output. Chose a limiter threshold that allows the maximum amount of power allowed for that frequency band's transducers. This sets the limiters for the rigorous demands of contemporary live music while providing maximizing system protection.

For example, if the total desired maximum output of the high-frequency amps is to be no more than 6 x 75 watts, or 450 watts at 8 ohms, and the HF amp being used is rated for 520 watts at 8 ohms, then the HF limiter (band D) should be set to limit the HF amp at 450 watts. For precision adjustments, you may elect to use an oscilloscope or digital multimeter, a sine-wave source, and a dummy amplifier load to correctly set the limiters.

System Bandpass	VERTEC System Component	System (Bandpass) Minimum Impedance	Maximum Input Voltage Recommended
LF	2255H	5.5 ohm	60 volts RMS, 120v Peak
MF	2250H	7.2 ohm	38 volts RMS, 76v Peak
HF	2435H	16.5 ohm	40 volts RMS,100v Peak

You'll also need to consider limiter time constants. This is a system-design philosophy decision. It is something that should not be left to the discretion of the operator (balance engineer, or music soundmixer). Each passband in the system has different requirements, so the limiter settings for each band are different. The supplied configuration files for each system controller are your starting points.

Acoustic Analysis

In addition to your ears, it's a good idea to have some sort of impartial analysis capability. This takes the form of a computer-driven analysis package such as Smaart, or at least a Real Time Analyzer (RTA). You'll also need a medium-priced measurement microphone such as the Crown CM-150.

If you're using Smaart, then in addition to frequency response, you also get phase and time measurements. Smaart can also operate using your pre-show music or whatever is going through the system at any instant in time. This can be useful for spotting problems during the performance and zeroing in on them in real time.

Use measurement and analysis tools, even if they are relatively simple ones, to monitor both sound levels and frequency response during system use. You'll thank yourself the next time you have to handle a loud music festival of many hours' duration.

Summary

The digital signal processing presets have been carefully chosen to maintain optimum array performance throughout the coverage area of the system, both on-axis and off-axis. Regardless of the system controller platform you choose, you will find that factory-recommended presets combined with your subjective system equalization tunings can adapt the VERTEC system for use with a diverse range of program styles and venue sites.

As you work with the system's spectral balance and subjective E.Q., use the Line Array Calculator to investigate predicted coverage patterns. Acoustical performance measurements of various array sizes and configurations have been undertaken to confirm the predictive accuracy of this useful tool.

For more information on using this application tool, see Chapter 9, "Line Array Calculator Software".

VERTEC VT4889 Controller Settings

All amplifier gains assumed equal for each bandpass

	BSS FDS366 OmniCompact Plus	dbx 480 Drive Rack	XTA DP226 Audiocore
LF (2x15")	***Outputs 1&4***	***Outputs 5&6***	***Outputs 1&4***
High Pass Freq	39.8Hz	40Hz	40.1Hz
High Pass Shape	Bessel 24dB/Oct	Bessel 24dB/Oct	Bessel 24dB/Oct
Low Pass Freq	183Hz	140Hz	191Hz
Low Pass Shape	Bessel 24dB/Oct	Bessel 24dB/Oct	L-R 24dB/Oct
Output Gain	+2dB	+2dB	+2dB
Output Delay	0.542ms	0.55ms	0.546ms
Filter Type	Bell	Adaptive Q	PEQ
Filter Freq	42.7Hz	42.5Hz	46.8Hz
Filter Bandwidth	0.7 Oct	Q=3.41	Q=2
Filter Gain	+6dB	+4dB	+4dB
MF (4x8")	***Outputs 2&5***	***Outputs 3&4***	***Outputs 2&5***
High Pass Freq	203Hz	265Hz	202Hz
High Pass Shape	L-R 24dB/Oct	Bessel 24dB/Oct	L-R 24dB/Oct
Low Pass Freq	1kHz	950Hz	981Hz
Low Pass Shape	Butterworth 18dB/Oct	Bessel 18dB/Oct	Bessel 18dB/Oct
Output Gain	0dB	+2dB	+2dB
Output Delay	1.094ms	1.09ms	1.088ms
Filter Type	Bell	Adaptive Q	PEQ
Filter Freq	297.3Hz	300Hz	297Hz
Filter Bandwidth	0.3 Oct	Q=5.71	Q=4.5
Filter Gain	+3dB	+4dB	+3dB
Filter Type	Bell	Adaptive Q	PEQ
Filter Freq	450.6Hz	450Hz	454Hz
Filter Bandwidth	0.7 Oct	Q=2.03	Q=2
Filter Gain	-5dB	-5dB	-5dB
Filter Type	-	Adaptive Q	-
Filter Freq	-	850Hz	-
Filter Bandwidth	-	Q=3.41	-
Filter Gain	-	+1.5dB	-
Filter Type	Bell	Adaptive Q	PEQ
Filter Freq	1.31kHz	1.32kHz	1.31kHz
Filter Bandwidth	0.25 Oct	Q=5.71	Q=5.3
Filter Gain	-3dB	-6dB	-6dB
HF (3x1")	***Outputs 3&6***	***Outputs 1&2***	***Outputs 3&6***
High Pass Freq	1kHz	1.12kHz	1.02kHz
High Pass Shape	Butterworth 18dB/Oct	Bessel 18dB/Oct	Bessel 18dB/Oct
Low Pass Freq	Out	Out	22kHz
Low Pass Shape	-	-	Bessel 12dB/Oct
Output Gain	-11dB	-7dB	-9dB
Output Delay	0ms	0ms	0ms
Filter Type	-	Adaptive Q	-
Filter Freq	-	2kHz	-
Filter Bandwidth	-	Q=0.94	-
Filter Gain	-	-2dB	-
Filter Type	Bell	Adaptive Q	PEQ
Filter Freq	4.59kHz	4.5kHz	4.58kHz
Filter Bandwidth	0.7 Oct	Q=4.41	Q=2
Filter Gain	-2dB	-2.5dB	-3dB
Filter Type	Bell	Adaptive Q	PEQ
Filter Freq	7.99kHz	8kHz	8kHz
Filter Bandwidth	0.5 Oct	Q=4.41	Q=3
Filter Gain	-6dB	-5dB	-7.5dB
Filter Type	Bell	Adaptive Q	PEQ
Filter Freq	16kHz	16kHz	16kHz
Filter Bandwidth	0.7 Oct	Q=1.22	Q=2
Filter Gain	+15dB	+12dB	+15dB

Note: These settings are provided by JBL Professional to obtain even Power and Frequency response. Users may wish to adjust these parameters to suit particular program material or personal preference.