Technical Notes Volume 1, Number 27

Signal Processing Guidelines for VT4889 VERTEC™ Line Array Systems

Introduction:

VT4889 line array elements can be used in a wide variety of ways, offering system users a very flexible mechanical coupling and suspension system. This flexibility, while providing the system user with many array setup options, requires careful selection of DSP (Digital Signal Processing) system drive files to achieve optimum acoustical results.

This document describes various array shapes that will be encountered during system use, the low-frequency characteristics of these arrays, and considerations that must be taken into account when using JBL Professional's factory-recommended DSP templates on supported system controllers.

To achieve the best results when using VT4889's in arrays, knowledgeable system users will rely on careful system gain stage calibrations, and a thorough understanding of the chosen Digital System Controller and its user-configurable operating parameters. The VERTEC Line Array Calculator software application and practical experience gained from using the system will increase confidence.

The number of VT4889's used in an array, and the splay angles chosen between adjacent array elements, will determine which DSP template should be selected for use in the system controller(s).

Characteristics of Digital System Controllers used with VT4889 Line Arrays:

It is useful to understand the characteristics of contemporary digital system controllers, and how the design parameters vary between different models. This issue affects the acoustical performance of any multi-way sound reinforcement system, including VT4889 line arrays.

Line array systems require careful setup and adjustment of system drive files to achieve satisfactory coverage and tonal quality.

The VT4889's enclosure geometry, high density of sound-radiating components, and complex array summation effects (which vary with different mechanical array setups) require that close attention be given to the correct selection and implementation of JBL's recommended DSP templates.

An important pre-requisite for understanding the concepts discussed here will include careful reading of the following documents:

- VT4889 System User Manual
- Vertical Technology™ White Paper

The appropriate Digital System Controller manual will familiarize the system user with both general operating features, and with user-configurable options.

In the VT4889 System User Manual, carefully read Chapter 5, "Digital Signal Processing".

The VT4889 System User Manual provides important information related to overall system and array setup. Prior to using these arrays, the system user should understand how the chosen digital signal processors are set up to properly match the input sensitivities of the chosen power amplifiers, and how the limiter section of the controller is adjusted to properly protect system components.

Initial System Drive Path Setup:

Before selecting DSP templates for use with specific VT4889 arrays, it is assumed that the system operator will verify that the signal drive path through the system controller and power amplifier channels is correctly set up.

An appropriate way to do this includes the following sequence of activities:

1. <u>Amp Gain Calibration</u>: Be sure that the chosen system controller's bandpass gain settings are correct based on the specific power amplifiers that will be used with the system.

   (JBL's factory-supplied DSP templates have been created with the assumption that all power amplifier channels used in the system have identical gains and input sensitivities).

2. <u>Limiter Settings</u>: Prior to using the system controller to drive the loudspeaker system, properly set output bandpass limiter thresholds.

3. <u>Verify Controller Signal Paths</u>: Check all inputs/outputs for all channels, and ensure that each band's limiters are engaging properly.

4. Connect Controller to Amps: Complete connection of the system's drive electronics to the power amps, and visually check each channel for signal present, overload indication, and limiter threshold levels without speakers connected.

5. Low-Level Test: Connecting VT4889 arrays to the power amps, supply low-level audio program signals for testing purposes. Confirm proper signal present in all components.

6. High-Level Test: Verify proper system operation under full-load conditions only after above steps have been completed.

7. Custom Configurations: With growing familiarity, users can program additional custom memory settings in the system controller(s) for different VT4889 Line Array system applications using the factory-recommended templates as the baseline reference.

> *Certain parameters such as crossover points and bandpass signal delays must never be altered by the system user if optimum system performance and coverage characteristics are to be maintained.*

Controller Filter Topologies And Their Effect on JBL's DSP Templates for VT4889 Arrays:

Digital signal processors designed for use with multi-way sound reinforcement systems can have different characteristics, which affect the audio signal throughput. Differences are typically centered around group delay, latency, and user-selectable delay settings. Filter topology, frequency and slope directly influence group delay.

Due to these facts, it is seldom possible to merely match the specific settings on one brand of controller with another, by entering identical crossover/delay settings. An electrical transfer function must typically be mapped for each specific parameter (crossover points, filter slopes, bandpass delay, etc.) and then compared to the reference setting(s).

For these reasons, JBL Engineering has provided DSP templates for various popular supported processing platforms. This allows system operators to confidently work with any of the supported DSP platforms while maintaining correct electro-acoustical performance from the system.

Explanation of Mechanical Array Configurations

The directional factor of an array of identical sources is the product of the directional factor of an array (with identical geometry but simple sources) and the directional factor of a single element of the array (Kinsler and Frey, 3rd edition).

Therefore a line array system made of identical elements (all enclosures with the same coverage characteristics) will offer certain benefits.

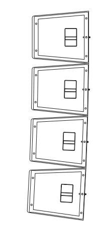
In addition to offering the advantages of a single-enclosure inventory, the VERTEC VT4889 system with its flexible coupling and suspension system allows the creation of a wide variety of array types.

The wide range of vertical baffle splay angles (from 0° to 10°) afforded by the VT4889's flexible rigging system enables the construction of arrays from a single type of enclosure that can be classified into several basic types.

These configurations can be viewed as 'building blocks' when building large or complex arrays. The four primary array shapes include:

I. Straight Arrays

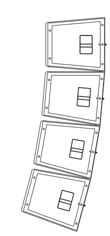
Arrays or array segments in which the splay angles between boxes are 1° or less (0°).



Example: Straight Array (4 boxes set at 1° baffle splay angle).

II. Constant Curvature (Far Coverage)

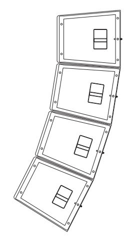
Arrays or array segments in which the splay angles between boxes are constant and from 2° to 6°.



Example: Constant Curvature Array, Far Coverage (4 boxes set at 5° baffle splay angles).

III. Constant Curvature (Near Coverage)

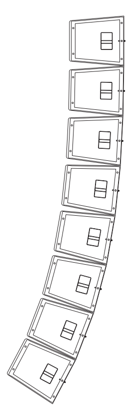
Arrays or array segments in which the splay angles between boxes are constant, and 7° or greater.



Example: Constant Curvature Array, Near Coverage (4 boxes set at 9° baffle splay angles).

IV. Progressive (Spiral)

Arrays or array segments in which the splay angles between boxes change incrementally, e.g. 1°, 2°, 3°, or 2°, 4°, 6°… etc.



Example: Progressive Array (8 boxes set to baffle splay angles of 1,2,3,4,5,6,7,8).

There is also a more complex array type. For example, a Constant Curvature (Far) array segment and a Progressive (Spiral) array segment, will often be combined into a single array. This results in a hybrid mechanical format we shall call the "J-Array".

V. J-Shape

Arrays made of a combination of two (or more) of the primary array types (I-IV).

Low Frequency Characteristics of Line Arrays: The Correlation Of Frequency and Array Length

With all line array systems, the directivity at any given frequency will be proportional to the length of the array. The array beamwidth will be inversely proportional to the product of the square of the array's length and the frequency of interest. It is particularly important for system users to have an awareness of how low frequencies behave differently in arrays of varying lengths that may be used in different setups.

There is a direct correlation between the height of the array and the wavelength of the frequency under consideration.

For example, as shown in the following chart, an 8-box array has a height of 13 feet (3.96 meters). At 87Hz, this array will have a directivity index of 3.5 dB. When that array size doubles to 16 boxes (a height of 26 feet or 7.92 meters), the larger array will have the same directivity at 43

Hz than the smaller array had at 87 Hz.

# of Boxes	Array Height	λ/4	λ/2	λ	3λ/2
4	6.5’	43 Hz	85 Hz	170 Hz	227 Hz
6	9/8’	28	57	113	170
8	13.0’	22	43	87	131
10	16.3’	17	35	69	104
12	19.5’	15	29	58	87
14	22.8’	13	25	50	87
16	26.0’	11	22	43	65
18	29.3’	10	19	39	59

Low Frequency Array Dimensions (Where λ= wavelength)

What this means for the system user is that in typical field conditions the power response will be the inverse of the directivity. For “flat” frequency response on-axis, the power response will be the inverse of the low-frequency array’s directivity factor. Directivity increases monotonically with increasing frequency; it decreases monotonically with decreasing frequency.

Simply stated, the longer the array, the greater directivity will be at lower frequencies. Because of the line array summation effect, longer arrays can produce surprisingly large quantities of low-frequency energy.

Compensation for this phenomenon has been factored into DSP templates provided by JBL Professional for use with VT4889 arrays.

File Naming Convention for VT4889 DSP Templates

We have discussed the primary mechanical array segment types. We have also looked at the importance of understanding low frequency directivity in systems of this type, due to the line array summation effect. JBL Professional has developed a suite of DSP templates specifically designed to provide system users with the necessary tools for achieving optimum system performance under varying array setup conditions.

Each DSP template consists of an 8-character alphanumeric name. Knowing the naming convention is key to correct selection of DSP templates for use with various VT4889 arrays. The eight characters in each DSP template name designate size, shape, and signal processing drive configuration of the array that file has been created for

The first two (numeric) characters are reserved for the number of boxes in an array. This ranges from 4 to 18.

The next three (alphabetical) characters describe the shape of the array. These described shapes follow the primary mechanical array types previously discussed. The next characters (#6, #7) describe the number of signal processors used for a given array, and where in the array (top or bottom) the processor is assigned if multiple processors (split-processing) are used.

For example, a DSP template with the name “XXXXX2XT” describes 2 processors used for a single array (top and bottom split), and that this DSP template is for use on the top (“T”) portion of the array.

The seventh character at the end of the file name (“B”, for instance) refers to the specific batch file code that has been developed from rigorous array measurement sessions under controlled conditions.

Following is the VT4889 file-naming format.

Format for VT4889 DSP file naming. The first five places describe the array:

1	2	S	C	P	2	B	T
Number of Boxes in Array		**Top or Overall Array Shape**	**Second Array Shape (If Used)**	**Bottom Array Shape (If Used)**	**Number of Process. Channels**	**Source Code for DSP File**	**T = Top B = Bottom (If Split Processed)**

Legend, Array Types / Shapes:

S = Straight Array, 0-1 degrees
C = Constant Curvature, Near Coverage, 7 degrees or greater
F = Constant Curvature, Far Coverage, 2-6 degrees
P = Progressive Spiral, e.g., 1,2,3,4,5…degrees

As can be seen in the above sample, the name of each DSP template includes a specific array characterization, a guide as to whether it is best used as a “split-processed” array, a marker noting which part of a split-processed array this DSP template is meant for, and an archival note detailing what source code (based on rigorous array measurement sessions) was used to develop this DSP template.

The suite of DSP templates for VT4889 arrays includes a variety of files for arrays of different sizes, shapes and types. A total of 26 separate DSP templates are available on the VERTEC CDROM Version 2.0 (September 2001), “VT4889 System User Information”. It is prudent to carefully study the master list of templates (provided as a spreadsheet at the end of this document).

Selecting the Correct DSP Template:

We have discussed various array types and the suite of DSP templates for arrays of different sizes and shapes. Each DSP template serves as a general guideline for the different array setups that will be encountered.

A DSP template in the family of files is a starting point; it is not intended to replace final system optimization or creative program equalization. It should also be noted that a thorough examination of the DSP templates would show that files for general array sizes are provided. For instance, files are provided for array sizes of 4, 8, 12, or 18 VT4889 array elements.

A DSP template with the “4” prefix is not intended for use only with 4-box arrays. It is applicable to arrays or array segments that range from 4 to 6 boxes. A DSP template with the “8” prefix is applicable to arrays or array segments that range from 7 to 10 boxes. A DSP template with the “12” prefix will serve arrays or array segments ranging in size from 11 to 16.

When preparing to select DSP templates for use with a VT4889 array, the system user will first want to review predictive coverage information for potential array sizes and shapes intended to cover a specific audience area. There is a particular sequence of events that, when followed, will prepare the system user to successfully evaluate anticipated coverage characteristics.

Once array size and shape has been selected, system users will be equipped with knowledge that can be reliably applied to selection of correct DSP templates to use as guidelines with chosen array formats.

The appropriate steps to follow include:

I. Use the Line Array Calculator software to determine an acceptable array size and shape for the venue, based on seating area geometry.

II. Match the shape of the chosen array with the DSP template that most closely matches the array.

III. Perform a preliminary listening evaluation of audience coverage and system tonality to validate DSP template selection and system bandpass levels.

IV. With the selected DSP template as a starting point, the system user can now begin to further adjust bandpass levels and system program e.q. to suit taste.

To preserve system predictability, the user is cautioned not to alter internal DSP parameters.

Considerations for Amplitude Shading and Split-Processing of VT4889 Line Arrays

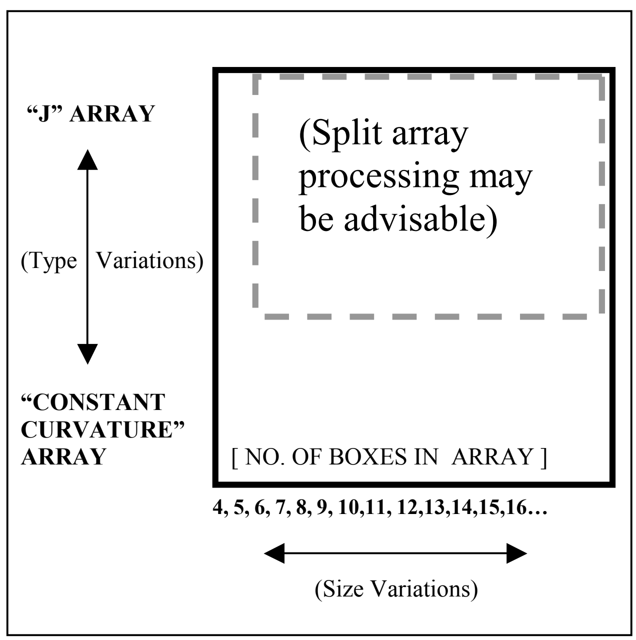
The DSP templates include accommodations for split-processing of arrays. In some instances, this means system users may energize different parts of the system (for example, the upper 8 boxes and the lower 4 boxes in the same 12-box array) using more than one processor. However, the issue of amplitude shading should first be understood, and considered, prior to implementing a more complex system drive scheme.

When working with large arrays, or speaker arrays that cover distinctly different seating planes, it is often necessary to use amplitude shading to ensure uniform sound pressure level throughout the audience area. Simple amplitude shading can be done by turning specific amplifier channels down to taper the sound level of an array. It is also possible to change the frequency response of the array by turning down specific bandpass amplifier channels down in the front rows.

An example of this is turning the high frequency amplifiers of the bottom enclosures down to balance the sound levels. A more advanced method of frequency and amplitude shading involves using split processing. Split processing is defined as using more than one DSP system processor to control the amplitude and frequency response of an array. The use of split processing (amplitude or frequency shading) of any system enables more even coverage of the audience area.

One specific reason for utilizing split processing with VT4889 arrays is to be able to use more than one family of vertical splays within an array. JBL Engineering research has shown that for optimum results, adjacent boxes set at “straight” splay angles (0°-1°) will require a different DSP template than a group of constant-curvature boxes set for “far” coverage” (2°-7°).

Because of the overall system design, including the VT4889’s unique rigging system that allows splay angles greater than 5°, users have the ability to set up a broad range of array designs. To fully take advantage of the design features of the VT4889 system, JBL recommends that users employ split-processing in complex (non-constant curvature) arrays larger than 8 boxes, or those having two different families of baffle splay angles.



Realizing that split processing is often not possible or desirable, JBL has provided single-processor settings for 8, 12 and 18 box arrays.

Considerations When Ground-Stacking VT4889 Arrays:

DSP Templates that are supplied also work well with ground-stacked arrays. However, boundary-surface effects should be taken into account. When ground-stacking a 4-box array, for example, users may benefit from selecting the next larger DSP template (8-box array files) due to the reflected groundplane image at longer wavelengths.

Technical Note Summary:

The information contained herein has been compiled with the benefit of measurements taken of a wide variety of VERTEC arrays, set up under controlled conditions, and actual-use field observations by JBL Applications Engineers.

Input has also been incorporated from sound system operators who have used JBL VERTEC line array systems under a variety of conditions for musical concerts, playback events, public-address, and other sound reinforcement applications for various special events. This information will be most useful to VT4889 line array system users who become thoroughly familiar with initial system setup procedures, and who take care to calibrate their overall system signal drive paths in accordance with User Manual instructions.

Upon ensuring that electronic system drive configurations fully match all factory recommendations, system operators may then choose to carefully “optimize” the system bandpass level parameters and program equalization of their VERTEC system to match the unique needs of varying musical program styles, specific venue setups and regional tastes.

The factory pre-programmed controller settings for VT4889 system array configurations, found on VERTEC System User Information CDROM’s dated from September 2001, should be used as the default settings when these systems are set up and deployed. Any modifications or additional equalization should be evaluated by system users through the use of critical listening skills, in accordance with professional audio industry best practices, and particular customer preferences.

System users will also benefit from the correct application of software test and measurement tools like SmaartLive™.

For additional technical information and helpful tips, it is suggested that system users investigate the VERTEC section of the JBL Pro Website, accessible electronically over the World Wide Web at < www.jblpro.com >.

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VT4889 DSP Templates (August 2001)
Source Code B
dbx / BSS / XTA

DSP Filename	FILE DESCRIPTION
4S1B	4 BOX, STRAIGHT, 1 DSP
4F1B	4 BOX, CONSTANT FAR, 1 DSP
4C1B	4 BOX, CONSTANT NEAR, 1 DSP
4P1B	4 BOX, PROGRESSIVE, 1 DSP
8S1B	8 BOX, STRAIGHT, 1 DSP
8F1B	8 BOX, CONSTANT FAR, 1 DSP
8C1B	8 BOX, CONSTANT NEAR, 1 DSP
8P1B	8 BOX, PROGRESSIVE, 1 DSP
8S2BT	8 BOX, STRAIGHT, 2 DSP, TOP 4 BOXES
8S2BB	8 BOX, STRAIGHT, 2 DSP, BOTTOM 4 BOXES
8F2BT	8 BOX, CONSTANT FAR, 2 DSP, TOP 4 BOXES
8F2BB	8 BOX, CONSTANT FAR, 2 DSP, BOTTOM 4 BOXES
8C2BT	8 BOX, CONSTANT NEAR, 2 DSP, TOP 4 BOXES
8C2BB	8 BOX, CONSTANT NEAR, 2 DSP, BOTTOM 4 BOXES
8P2BT	8 BOX, PROGRESSIVE, 2 DSP, TOP 4 BOXES
8P2BB	8 BOX, PROGRESSIVE, 2 DSP, BOTTOM 4 BOXES
12S2BT	12 BOX, STRAIGHT, 2 DSP, TOP 4-8 BOXES
12S2BB	12 BOX, STRAIGHT, 2 DSP, BOTTOM REMAINING BOXES
12SFP2BT	12 BOX, STRAIGHT/CONSTANT-FAR/PROGRESSIVE, 2 DSP, TOP 8 BOXES
12SFP2BB	12 BOX, STRAIGHT/CONSTANT-FAR/PROGRESSIVE, 2 DSP, BOTTOM 4 BOXES
12FC2BT	12 BOX, CONSTANT-FAR/CONSTANT-NEAR, 2 DSP, TOP 8 BOXES
12FC2BB	12 BOX, CONSTANT-FAR/CONSTANT-NEAR, 2 DSP, BOTTOM 4 BOXES
12FCP2BT	12 BOX, CONSTANT-FAR/CONSTANT-NEAR/PROGRESSIVE/ 2 DSP, TOP 4 BOXES
12FCP2BB	12 BOX, CONSTANT-FAR/CONSTANT-NEAR/PROGRESSIVE/ 2 DSP, BOTTOM 8 BOXES
12FP1B	12 BOX, CONSTANT FAR/PROGRESSIVE, 1 DSP
18FP1B	18 BOX, CONSTANT FAR/PROGRESSIVE, 1 DSP
Legend:	
S = Straight Array, 0-1 degrees	
C = Constant Curvature, Near Coverage, 7 degrees or greater	
F = Constant Curvature, Far Coverage, 2-6 degrees	
P = Progressive Spiral, e.g., 1,2,3,4,5…degrees	

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