
lexicon 960L
DIGITAL EFFECTS SYSTEM
lexicon
Program Mode
THIS IS THE FUTURE

960L multi-channel digital effects system

The Lexicon Legacy: Welcome To The Future

In 1971, the audio industry was revolutionized with Lexicon's launch of the first commercially available digital audio product, the **Delta-T 101 Digital Time Delay**. During the three ensuing decades, Lexicon digital signal processing would become the world-recognized standard for quality and versatility in time-domain digital effects.

Lexicon's innovative reverberation and effects algorithms, developed by some of the foremost researchers and engineers in the industry, continued with the ground-breaking **Model 224 Digital Effects System**. Its successor, the flagship **480L**, has been a hallmark in the audio production industry for more than fifteen years – an unprecedented length of time in the rapidly changing world of professional audio. Lexicon processors have stood the test of time.

Lexicon continues its tradition of innovation and quality in world-class digital audio processing with the introduction of the **960L Multi-channel Digital Effects System**. This Is The Future.

The Sound of Today – and Tomorrow

Multi-channel sound is home ground for Lexicon. For almost as long as it has been a leader in professional digital audio technology, Lexicon has also been at the forefront of consumer audio – its line of digital controllers and processors have become the envy of the consumer electronics industry. With products like the award-winning **DC-2** and **MC-1 Digital Surround Sound Controllers**, Lexicon established itself as the leader in the home entertainment industry.

No wonder, then, that Lexicon is the foremost leader in surround effects systems for the new age of surround-sound digital audio production: with the **960L Multi-channel Digital Effects System**.

The *DC-2* and *MC-1 Digital Controllers* have won numerous industry awards as well as critical praise from home theater publications and experts – worldwide.

This is The Future

A look inside the 960L's 4-unit rack-mounting mainframe will show you Lexicon's platform for the new millennium. Everything about the 960L says "future expansion." The 960L you buy today is capable of being upgraded for years to come, adding new functions and features as they become available or desired.

The heart of the 960L is an upgradable DSP powerhouse with eight analog and digital inputs and outputs as standard. For users who work in all-digital environments, a "digital-only" I/O version (960L/D) is also available. The analog audio interface is fully-balanced with 24-bit, 96 kHz conversion, and there's AES/EBU digital I/O plus MIDI and word-clock in/out/thru. Plenty of room has been left to add interfacing options – for both additional I/O and control. A multiple D/A converter approach ensures that the noise floor is in line with the enviable performance of the DSP section. And it is here that the true capabilities of the 960L are hidden. A single DSP card carries a combination of the latest incarnation of Lexicon's proprietary LSI Lexichips™ and other industry standard DSP devices. These allow the 960L to be configured as a five-in/five-out plus two-in/five-out, 44.1/48 kHz surround reverb system or – four completely independent stereo machines or – a single 88.2/96 kHz system. When an optional, second DSP Reverb card is added to the system, the "DSP horsepower" doubles; this second card provides the potential of eight stereo or four surround

Inside the 960L mainframe there's room to grow: open motherboard DSP slots, a floppy disc drive for off-loading user sound registers and a convenient CD-ROM drive for software updates.

Working with the LARC2 Remote looks and feels familiar. The 960L retains a highly intuitive control interface with powerful new capabilities and a large display.

reverbs at 48 kHz, or four stereo and two surrounds at 96 kHz. Since each reverb card can be configured separately, various combinations of reverb configurations are available, such as four stereos and 2 surrounds at 48 kHz or two stereos and one surround at 96kHz. With the second DSP card added, a total of sixteen independent inputs are available. Because the I/O is "mappable," the engineer has the ability to mix and match inputs and outputs in numerous configurations. Any DSP card input (as well as DSP output) may be routed to any physical output. For example, eight channels may be dedicated to one reverb DSP card while the other eight channels dedicated to the second. In fact, the 960L could be set-up as a 16 in X 16 out digital-only processor. Perhaps the most important and powerful capability of two DSP cards is the ability to cascade from one to the other (see Page 7, LARC2 Configuration Screens). All inputs can be extensively panned and mixed – eliminating the absolute need to upgrade or invest in a new multi-channel console with dedicated surround panning. A CD-ROM drive allows for software upgrades to be added as easily as slipping in a disc.

Everything about the 960L says "future expansion," and the one you buy today is capable of being upgraded…

The 960L is designed to meet the demands of all recording professionals – including critical post-production audio applications.

The Sound of The Future: Lexicon 3DPM™

The concept behind the smooth new surround and stereo algorithms of the 960L lies at the very heart of the machine: in Lexicon's unique Three-Dimensional Perceptual Modeling – or **3DPM**™. This new approach to reverberation sets the 960L distinctly apart from conventional physical modeling techniques. The smoothest sounding surround-sound reverb must not only work effectively in a sophisticated 5.1 audio environment, but also in stereo and even mono, without artifacts.

...the operational logic of the 960L's LARC2 is identical to the 480L and retains all the familiar functionality for ease-of-use.

The secret: rather than simply model physical spaces, you model instead what the ear and brain hear, and expect to hear, about them – because in many cases, the modeling of real spaces compromises the quality of the listening experience. Reverberation energy within the first 300 milliseconds contains crucial auditory information. Proper utilization of psychoacoustic mechanisms during this time period are vital to creating spaciousness and depth without compromising the intelligibility and clarity of the sound source. The 960L's carefully-crafted 3DPM algorithms take these important factors into account and consistently out-perform traditional physical modeling techniques. For the first time the 960L's virtual surround spaces can sound even better than the real thing (see page 8, "*Behind the 3D Perceptual Modeling Experience*").

Thanks to a virtually complete de-correlation of reverb elements, the 960L's unique algorithms ensure those natural-sounding surround reverbs work equally well in stereo and mono – where, let's face it, much of your recordings will still be heard for years to come.

Control Outside the Box

What's outside the mainframe is equally as impressive as what's inside – because the 960L is controlled by the **LARC2** – a completely new remote with a vast array of new features.

At the center of the LARC2 are two elements: eight touch-sensitive motorized faders and a superb high-resolution color LCD display. Between these are eight soft keys associated with the display, a numeric keypad, cursor control, illuminated function keys, and a compact joystick. Above the bright

The *LARC2 Remote Controller* features a large color, fluorescent backlit LCD display; adjust the contrast easily from a rear panel knob. Eight "Soft Buttons" (directly below the display) give you direct access to all the internal controls.

Navigating through a plethora of useful options is easy with eight dedicated function buttons, eight "soft keys" and a numeric keypad.

screen are three LEDs for each channel which give you a quick and clear level indication.

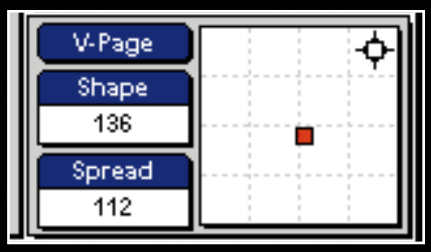
To get an impression of how the LARC2 places every aspect of the 960L at your fingertips, take a look at the main Program display (photo bottom, left page): a row of eight parameters (bottom of display screen), one for each fader, shows you what main features of the program can be controlled. Touch an associated fader and the parameter is highlighted. To navigate the program matrix, use a cursor key or "+/-" key to move up or down a row. When any program is loaded, the faders snap instantly into position, just like moving faders on an automated console.

The high-resolution LCD display is easy to read, colorful and large enough to display machine status plus all the parameters for a preset, making it simple to cursor to the specific parameter you need to change. While the shorthand labels above the faders will be familiar to existing 480L LARC users, the parameter is fully described when selected and there is a full description at the top of the display.

The 960L's basic set of controls enable you to access all the main features of setup quickly and easily. For rapid work when time is of the essence, and even if you've never used the unit before, an additional set of controls will appear on a "V-Page"; this allows you access to all of the key aspects of a program. You can assign favorite parameters to a "V-Page" for instant access – independently for each preset – with their names displayed over the faders. The Edit Page (see screen, page 6) gives the user the ability to wring out the finest detail of Lexicon's multi-faceted algorithmic possibilities. The eight faders also offer a "Fine" or vernier mode where they are set to the central position and you can use the whole length of a fader to make subtle value additions or subtractions to a parameter.

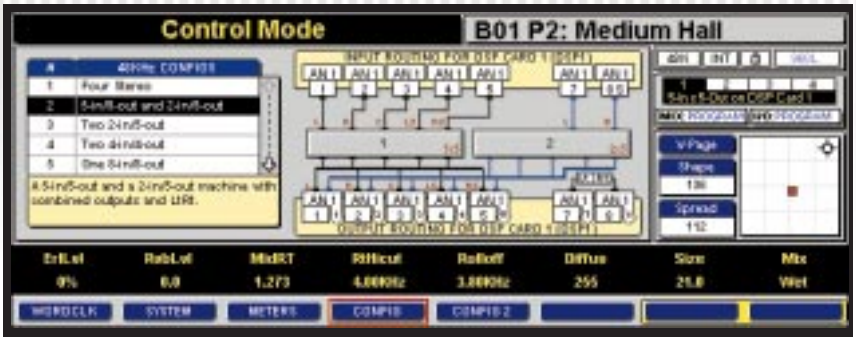
While the joystick is easy to use as a means of setting inputs to virtual source positions, it is fully assignable and can, for example, be used as a surround panner. Move a source smoothly and evenly around in a virtual room and you will immediately appreciate both the power and the subtlety of Lexicon's 3DPM system.

The joystick can assign inputs to virtual source positions, function as a surround panner and can be used as a two-axis program controller – assignable to actual parameters.

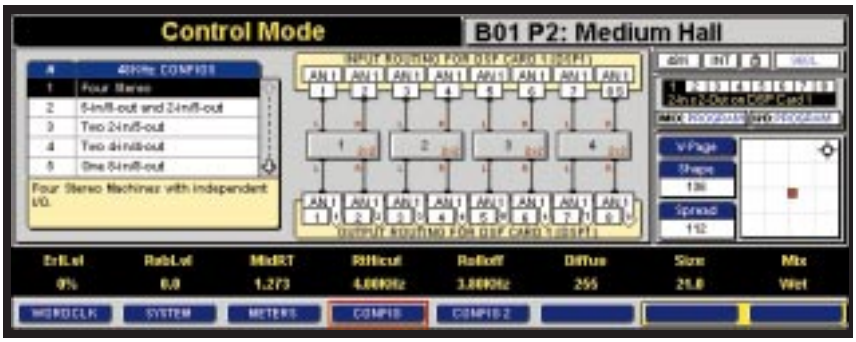


Eight touch-sensitive motorized faders snap instantly into position to represent new parameter settings – just like moving faders on an automated console. Push and hold the large, round button and all settings jump to their previous position.

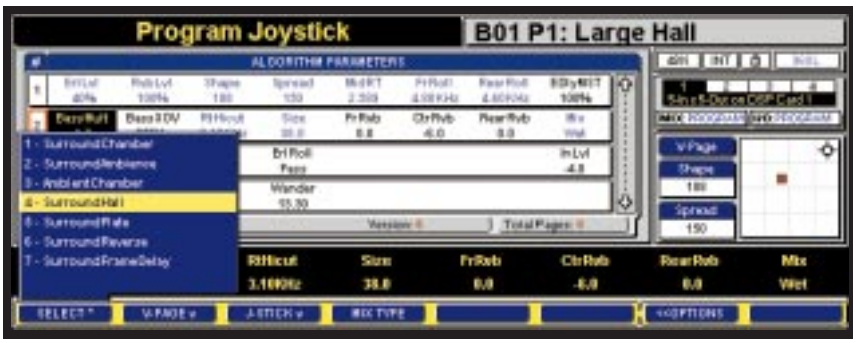
5X5 + 2X5 CONFIGURATION: Here, the 960L is configured as two independent machines. Machine #1 is a 5-input/5-output surround machine. The first five analog inputs feed surround machine#1, while analog inputs 7 and 8 feed surround machine#2. These two surround machines share the first five analog outputs.



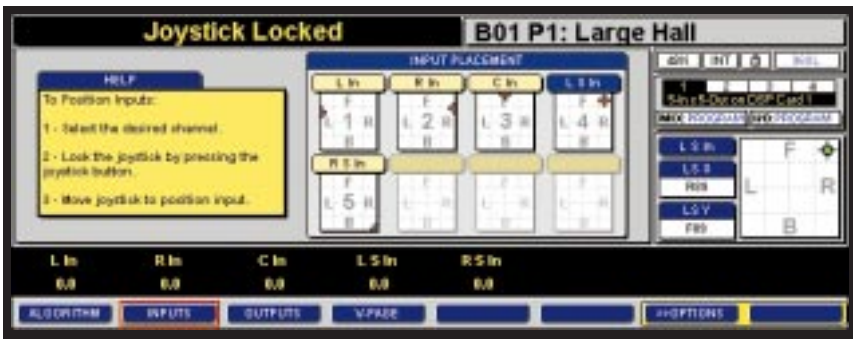
4X4 CONFIGURATION: At 44.1/48 kHz and utilizing all eight ins and outs, the 960L can be configured as four stereo machines. *Delete*: Notice all inputs are full AES/EBU digital.



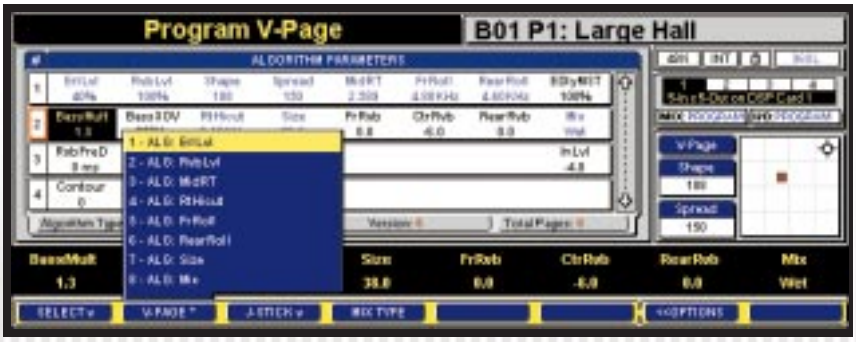
EDIT SCREEN: Touch a fader and the associated parameter is highlighted in the matrix for easy editing. Every program in the 960L can be modified. All parameters of a program can be easily accessed.



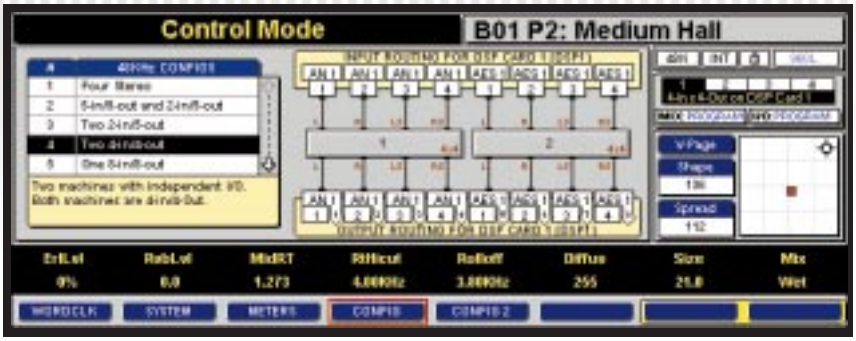
INPUT PLACEMENT: Here, each input to the multi-channel algorithm can be easily placed in a surround environment. The highlighted Left Surround channel parameter (blue) is currently locked to the joystick and informs the 960L from where the input to the reverb is coming.



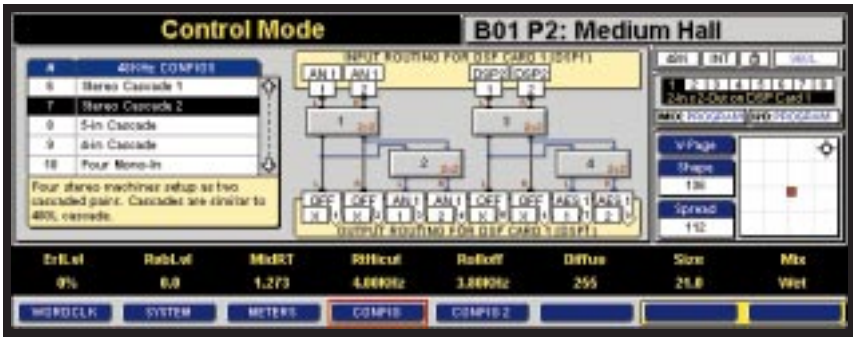
V-PAGE ASSIGNMENT: For instant access and rapid editing, you can assign up to eight parameters (plus the joystick) to the faders. A pop-up menu illustrates the current fader assignments. All fader and joystick assignments can be stored.



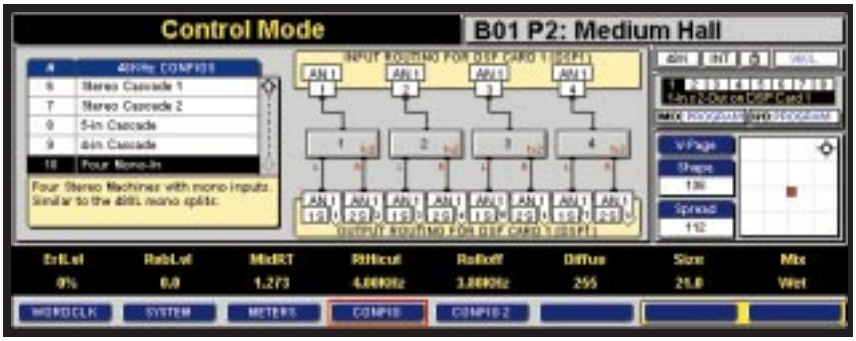
All configurations shown above can be obtained from a single DSP processing board.



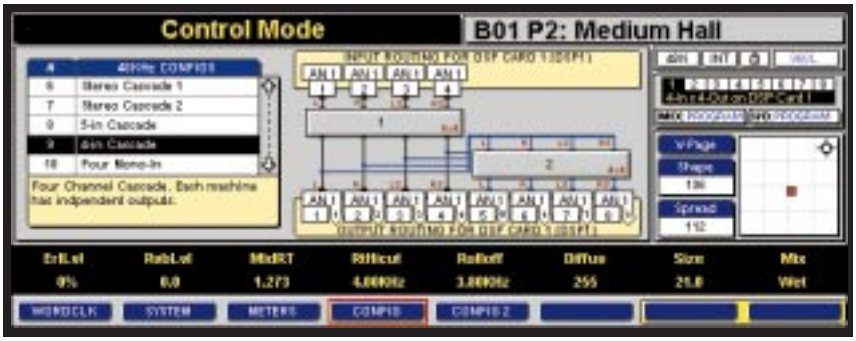
4-IN / 4-OUT CONFIGURATION: At 44.1/48 kHz and utilizing all eight ins and outs, the 960L can be configured as four stereo machines. Notice inputs 1-4 are analog and digital while outputs are also analog and full AES/EBU digital.



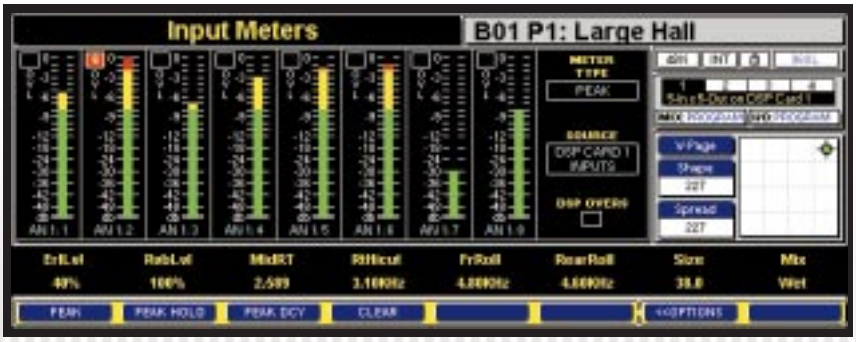
48K Stereo Cascade CONFIGURATION: Analog inputs 1 & 2 are routed to Outputs 1 & 2 ("OFF") and cascaded to the second DSP on analog outputs 3 & 4. A total of four stereo machines are setup as two cascaded pairs.



4-Mono In/Stereo Out CONFIGURATION: Here, physical inputs 1-4 are individually sent as mono inputs to 4 independent stereo machines each running its own stereo effect.



4-In Cascade CONFIGURATION: Four analog inputs are cascaded to dual DSP cards for a total of eight analog Stereo outputs.



Input Metering: High-resolution input display for the selected machine's DSP may be displayed. Three different meter modes are available: *Peak*, *Peak Hold* (shown) and *Peak Decay*. Each input channel includes a Peak Overload counter and an overall DSP Overload Counter.

Cascade configurations shown above can only be obtained with an optional DSP processing board.

The 960L mainframe will support up to two LARC2 Remotes.

The 960L is a powerful and sophisticated digital effects system, and we recognize the need to give you as much feedback as possible. As a result, we have implemented the most comprehensive context-sensitive help system you'll find on any digital effects processor to date. Help is easily accessed and visible thanks to the LARC2's large screen. You can also label your own bank and register creations and describe what they do and even how to use them. In addition to more than 200 factory-programmed presets, you can store up to 1,000 user Registers of your own (in Banks of 10). If you feel the need to write an extensive description, simply plug in a standard PS/2 computer keyboard. The 960L Mainframe will support up to two independent LARC2's for added flexibility and control.

***...a** total of 1,000 user-programmable locations, in addition to more than 200 factory-programmed presets...*

Hearing Is Believing

There are new and challenging requirements for multi-channel content creation. Whether you make records, create feature film soundtracks, or mix high-quality live sound, today's producer and engineer needs, expects and demands the best and most useful technology. When it comes to the 960L's multichannel effects processing, hearing is believing.

Set the unit up in your studio, select one of the 960L's superb surround reverb algorithms and turn off the lights. You'll hear Lexicon's proprietary 3DPM modeling create a new acoustic environment. Move about inside the speaker array – or even beyond – and hear for yourself how large and enveloping the sweet spot is, how stable the imaging, and how realistic the sound. You'll immediately hear how the 960L redefines the digital effects standard for a new generation of surround-sound professionals and listeners alike – just as the ubiquitous Lexicon 480L is the standard by which reverbs have been judged for nearly two decades.

The Lexicon 960L. This Is The Future. Hear it today.

Behind 3D Perceptual Modeling™

There is magic in acoustics – magic that can give recording both depth and life. Without added reverberation, studio recordings and recordings made in halls with modern multi-microphone techniques can sound dull and lifeless. But capturing the acoustics of the recording venue can be tricky, and adding realistic acoustics electronically can be just as difficult. Modern surround reproduction systems give engineers the opportunity to create much more effective acoustic fields than two channel systems, but it is difficult to realize the acoustic potential of this medium with simple two-channel reverberators.

It might seem ideal to model the reflection pattern of a real or imaginary room, and then reproduce this reflection pattern using a 5-channel surround system. Alternately, one could measure the reflection pattern from a particular source position to a particular listener position, and then reproduce that pattern electronically.

Alas, the illusion of reality is not so easily achieved. First, real rooms are themselves a compromise. Small rooms can provide blend, but their reverberation gives you muddiness, and no real depth or envelopment. Large rooms easily provide envelopment, but individual voices can be isolated and up-front, stuck in the loudspeakers.

Second, every instrument in a real acoustic space will have a completely different reflection pattern from every other instrument, and every listener will have a completely different pattern from every other listener (and the instruments are often not stationary).

Third, it is electronically possible to recreate a particular sound pattern only at a single listening position – the fabled "sweet-spot." If we are trying to create a believable acoustic impression over a wide listening area – and this is a primary goal of a good surround recording – we better do something else.

The solution is to use the properties of human hearing to optimize the useful properties of reverberation over a wide listening area, without incurring the penalties of muddiness or coloration. We do this through "perceptual modeling" – looking at how acoustics are perceived with speech or music signals, and not at how acoustics are typically measured and described.

For example, the illustration below shows the sound pressure resulting from a 200ms "note" after it is modified by the acoustics of the room. Note that for the first 20ms the note is completely unchanged by the acoustics. Our brains can use inter-aural time and level differences to determine the horizontal direction of the sound source if the sound has a rise-time shorter than the arrival time of the first reflections.

Once the reflections arrive, the amplitude (and the interaural phase) of the sound is greatly altered. The amplitude and interaural phase seems to fluctuate; the degree of fluctuation depends on the strength and direction of the reflections. Our brains use the amplitude of the fluctuation in interaural phase as a cue to the distance of the sound source. Notice that for a distance effect the strength and direction of early reflections is important, but the actual direction is not detectable. We only detect their combined effect on interaural fluctuations. We can also notice that for good localization these reflections should not come earlier than about 15ms.

When the sound ends, the perceived sound pattern depends on the duration of the sound. If the sound was long (as in our 200ms example) we see a staircase decrease in sound energy. First the direct sound ends, then the sound from the first reflection, then from the second, etc. Due to interference effects, the actual amplitude will fluctuate as the various reflections end, but the energy content is continually decreasing.

If the sound is short, perhaps around 50ms, the energy might not steadily decrease. A discrete reflection could cause a sudden increase in level after the direct sound ended. This increase is caused by the delayed *onset* of the original sound. Some speech sounds are this short, and discrete reflections with greater than 50ms of delay are easily heard as disturbing echoes.

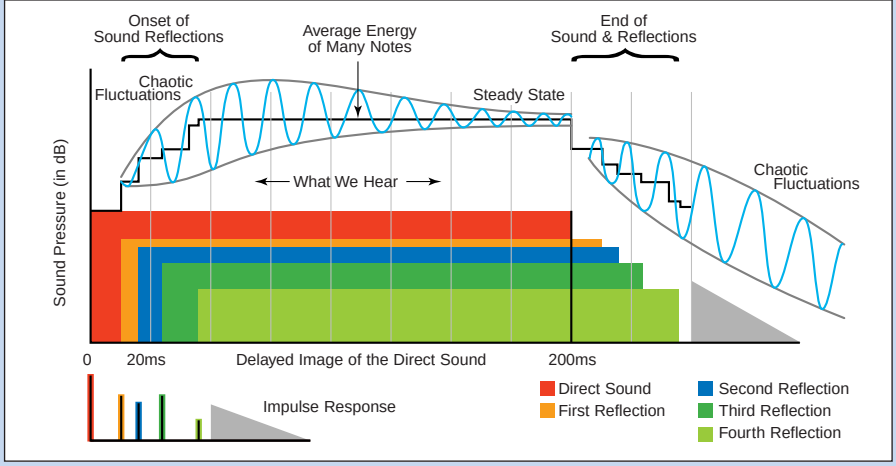
This perception comes in part from neural circuitry designed to separate sound events one from another. To separate the phones, (elementary parts of speech) from the incoming sound, the brain looks for probable endings of a particular sound, and then waits about 50ms to be sure the sound has actually stopped. If there is no sudden increase in level during this period, the sound is assumed to have stopped and we prepare for the start of the next sound. It is during this period – more than 50ms after a phone has stopped, and before the next one has begun – that we perceive reverberation, spaciousness, and envelopment.

Thus, it is very highly delayed sound (late reverberation) that contributes to spaciousness and envelopment, and early reflections that contribute to the sense of distance. If the early reflections occur within 50ms, they are perceived as part of the note itself; for notes longer than 50ms, they *are* part of the note itself. Their effects on the end of the note are difficult to hear because these effects occur during the period that the neural mechanism is waiting to be sure the note has ended.

The result of this "perceptual modeling" is the ability to generate reverberation that precisely matches the needs of a particular recording. We can manipulate the apparent distance of sound sources by adding de-correlated early reflections into all our surround speakers. Closely-mic'd voices magically move back into the space behind the loudspeakers, but the reflections themselves are inaudible. By controlling the level of the late reverberation separately, and by not emphasizing the time range between 50 and 150ms, we can create a strong sense of space and envelopment without compromising clarity. This is what the 3DPM algorithms are designed to do. They give your recordings both space and depth, in precisely controllable amounts.

Written by Dr. David Griesinger, Spring, 2000

SOUND PRESSURE AT ONE EAR FROM A SINGLE 200 MILLISECOND NOTE



Mainframe shown with standard configuration; optional digital-only version omits Analog I/O panels (two bottom rows)

Rear View - 960L Mainframe

960L MULTI-CHANNEL DIGITAL EFFECTS SYSTEM — SPECIFICATIONS

960L Mainframe Specifications

Analog Input	Connectors:	Eight, Female XLR
	Impedance:	50kΩ, balanced
	Level (for 0 dbFS):	+24dBu
	Frequency Response @ 48kHz:	20Hz-20kHz, ±1dB
	Frequency Response @ 96kHz:	20Hz-40kHz, ±1dB
	A/D Conversion:	24 bits, 128x oversampled
	A/D Dynamic Range:	›110dB (20Hz-20kHz)
	THD:	‹ .002%
	CMRR:	›50dB
	Crosstalk @ 1kHz:	‹ -100dB
Analog Output	Connectors:	Eight, Male XLR
	Impedance:	50Ω, balanced
	Level (for 0 dbFS):	+24dBu
	Frequency Response @ 48kHz:	20Hz-20kHz, ±1dB
	Frequency Response @ 96kHz:	20Hz-40kHz, ±1dB
	D/A Conversion:	24 bits 8x oversampled @ 44.1/48kHz 4x oversampled @ 88.2/96kHz
	D/A Dynamic Range:	›110dB (20Hz-20kHz)
	THD:	‹ .002%
	Crosstalk @ 1kHz:	‹ -100dB
A/A Performance		
	Frequency Response @ 48kHz:	20Hz-20kHz, ±1dB
	Frequency Response @ 96kHz:	20Hz-40kHz, ±1dB
	Dynamic Range:	›107dB (20Hz-20kHz)
	THD:	‹ .002%
Digital Audio I/O	Connectors:	Four Male XLR Outputs; Four Female XLR Inputs
	Format:	AES/EBU
	Word Size:	24-bits
Sample Rates	Internal:	44.1/48/88.2/96kHz
	Accuracy:	Within ±10ppm Meets AES 11, Grade 2
	External:	44.1/48/88.2/96kHz
	Lock Range:	±1.5%
Synchronization		
	TTL Word Clock Input:	75Ω, BNC self-terminating loopthru
	TTL Word Clock Output:	BNC
	Clock Jitter:	Intrinsic Jitter and Jitter Gain: Exceeds AES3, Amendment 1

Control Interfaces		
	Remote Control:	LARC2 ports (2)
	MIDI:	In/Out/Thru 5-Pin DIN
Reverb Types	Ambience:	48K Stereo and Surround
	Chamber:	48K Stereo and Surround
	Plate:	48K Stereo and Surround
	Reverse:	48K Stereo and Surround
	Random Hall:	48/96K Stereo and Surround
	Ambient Chamber:	48K Surround
Reverb Card Configurations		
	44.1/48K Performance:	Stereo Machines (4) 2 In x 5 Out Machines (2) 5 In + 2 In x 5 Out Machines
	88.2/96K Performance:	Stereo Machines (2) 2 In x 5 Out Machines (1) 5 In x 5 Out Machines (1)
Internal Hard Disk Storage		
	Factory Programs:	›200
	User Registers:	1,000
Removable 3.5" Floppy Disk Storage		
	User Programs:	100
Power	Requirements:	100-120/220-240 VAC, 50-60Hz, 300W max,
	Connector:	3-pin IEC
Physical Specifications	Size:	19.0"W x 17.4"D x 7.0"H (483mm x 442mm x 178mm) (4 rack units)
	Weight:	35 lbs.
Regulatory Approvals		FCC: Class A; CE: EN55103-1, EN55103-2; UL: UL1419; C-UL: C22.2; TUV: EN60065
Environment	Operating:	10° to 40° C
	Storage:	-30° to 70° C
	Humidity:	95% max, non-condensing

LARC2 Specifications

Display	Type:	Passive Matrix LCD
	Resolution:	640 x 240 pixels
	Colors:	256
	Backlight:	CCFL (Fluorescent)
	Brightness:	Software controlled
	Contrast:	rear panel knob
LED Meter Bridge		
	Configuration:	8 channels x 3 levels
	Levels:	-60dB, -6dB, -0.5dB (overload)
Control Surface	Faders:	Eight, 60mm throw, motorized, touch sensitive
	Joystick:	Two-axis
	Dedicated Function Keys:	29 (12 backlit)
	Soft Function Keys:	8
Connectors	960L:	9-pin D-sub
	Auxiliary PS/2 Keyboard:	6-pin Mini-DIN
	External Power:	Concentric, 2.5mm
Power		
	Requirements:	12 VDC, 2 Amps (max)
Physical Specifications	Size:	12.7"L x 8.25"W x 5.0"H (323mm x 210mm x 127mm)
	Weight:	4 lbs.
Regulatory Approvals		FCC: Class A; CE: EN55103-1, EN55103-2; TUV: EN60065
Environment	Operating:	5° to 40° C
	Storage:	-30° to 70° C
	Humidity:	95% max, non-condensing
Operating Distance		
	Powered from 960 Mainframe:	Up to 100 feet
	With External Power:	Up to 1,000 feet

All specifications subject to change without notice. Digital-only version, 960L/D retains pertinent specifications.

Lexicon wishes to thank the following organizations for their cooperation. Cover Photo: Middle Tennessee State University, Dept. of Music Recording, Murfreesboro, TN;
Inside Front Cover: Sound Stage, Nashville, TN; Page 3 (bottom): Larson Audio, Burbank, CA (Courtesy of Otari Corporation). All photography: Ron Neilson

Lexicon

THIS IS THE FUTURE

Printed in U.S.A.
Part #072-13366 rev. 1
960Lv2/1200/15M

3 Oak Park Bedford, MA 01730-1441 • Tel: 781/280-0300 • Fax: 781/280-0490 • E-Mail: info@lexicon.com • www.lexicon.com