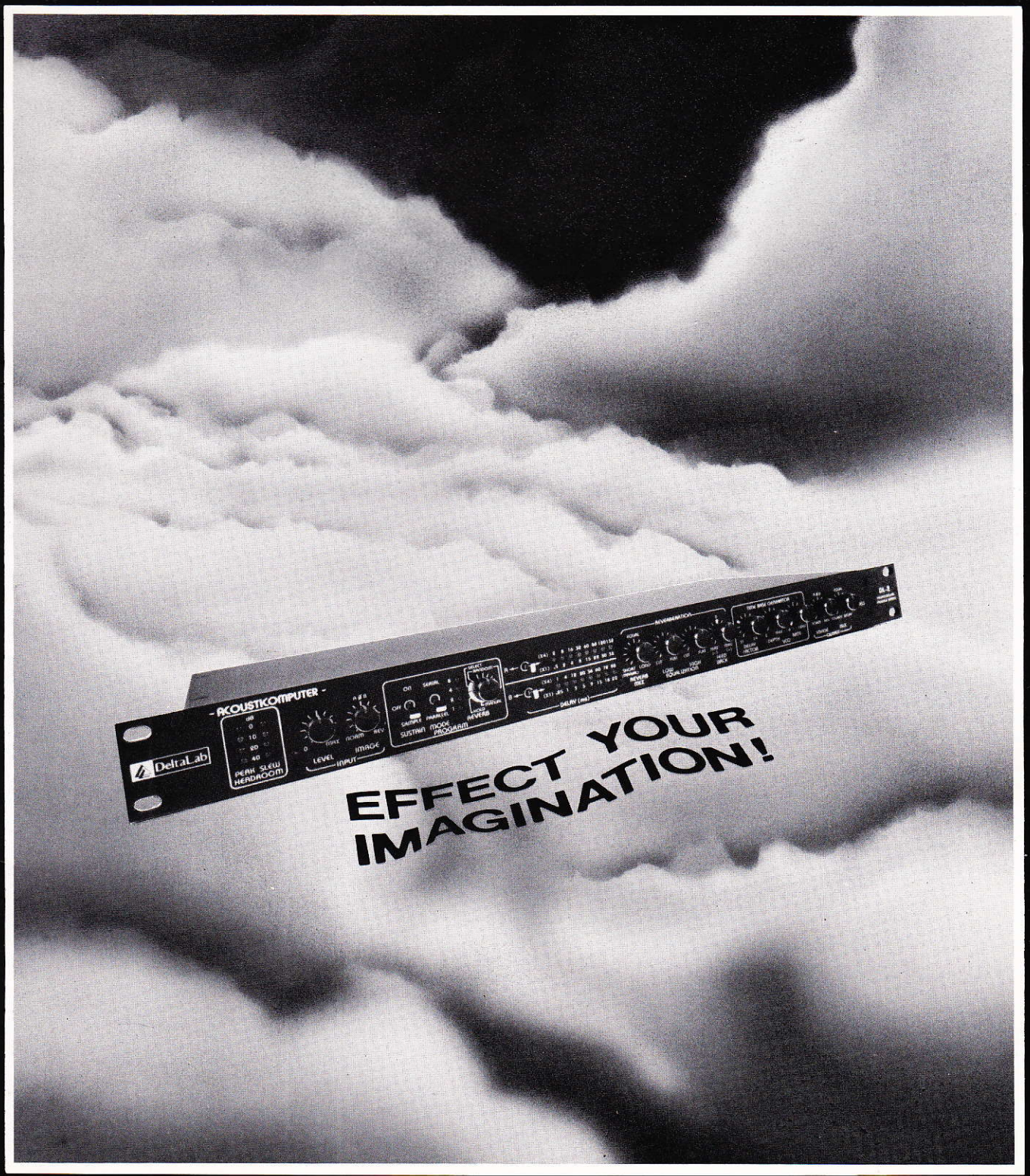
AUDIO signal processing



ACOUSTICOMPUTER®... a true stereo special effects processor

DeltaLab Research, Inc. 27 Industrial Ave., Chelmsford, MA 01824

Available at Quality Dealers

Your Next Musical Instrument Should be the ACOUSTICOMPUTER® by DeltaLab

Why wait any longer? Many of the leading groups in the U.S., England, and Europe already have theirs, as do the most advanced recording studios.

What is an ACOUSTICOMPUTER? Simply the cleanest sounding, most flexible, widest-range digital delay and special-effects processor.

ACOUSTICOMPUTER – designed and manufactured by DeltaLab, makers of the famous DL-1 Delay Line, whose sound was described by Modern Recording as "The best we have encountered in any digital delay unit."

If you are serious about creative music-making, you need the ACOUSTICOMPUTER now:

- **Especially now** that the advent of digital recording demands clean, wide-range sound from every element in the signal path. Is a processor really good enough if it doesn't have the 90dB dynamic range and full 15kHz bandwidth of DeltaLab gear?
- **Especially now** when audiences increasingly expect every live performance to "sound as good as the record."
- **Especially now when money is tight.** It only makes sense to buy a device that does it all:
  - Doubling, tripling, chorus effect;
  - Slapback, multiple echoes, stereo reverberation;
  - Flanging, tuned resonance, R2D2 effects;
  - Vocal broadening and enhancement, spatial depth;
  - Vibrato, tremolo, pitch shifting;

  And many more . . .

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DeltaLab DL-2

- ACOUSTICOMPUTER® -

A true stereo (2 channel) delay and special effects unit with highly musical sound quality and extremely flexible versatility.

- *16 Reverb programs*
- *2 Independent pre-reverb delays*
- *VCO sinusoidal with 4:1 frequency range*
- *Sustain - non-deteriorating repeat with selectable updating*
- *Long delays - up to 252 ms (serial mode) for special effects*
- *Short delays - down to 0.25 ms for flanging effects*
- *Positive and negative reverb and flanging feedback*
- *Stereo imaging on input to extract hidden ambience*
- *Stereo imaging on output for left-right shifting*
- *Foot switch bypass control*
- *External memory expansion capability*

HIGH QUALITY DIGITAL DELAY PROCESSING IS NOW AVAILABLE

DeltaLab introduces the ACOUSTICOMPUTER,® a flexible and rugged all-electronic "space machine" with highly musical sound quality and a surprisingly modest price.

The ACOUSTICOMPUTER is a combination digital delay and special effects processor designed for use both on stage and in the studio, providing well-known functions (echo, doubling, vibrato, flanging, etc.) plus some new effects not available in any other device.

PERFORMANCE FEATURES

- 2 Independent delay channels
- Delay lengths from 0.25 ms to 252 ms
- Frequency response 20 to 15 kHz at all delay lengths
- Dynamic range greater than 90 dB
- No audible distortion (1 kHz THD $<$ 0.2%)
- 16 Inter-channel related reverb programs
- Foot pedal controlled bypass
- Variable time base with VCO
- Stereo imaging input and output controls

FOR STUDIO

The ACOUSTICOMPUTER is a compact, highly versatile true stereo delay line incorporating feedback and equalization circuitry. In one package, the DL-2 contains what would have previously required a rack full of outboard equipment. And the ACOUSTICOMPUTER maintains DeltaLab's no-compromise reputation -- full 20-15 kHz bandwidth, large dynamic range and virtually no audible distortion.

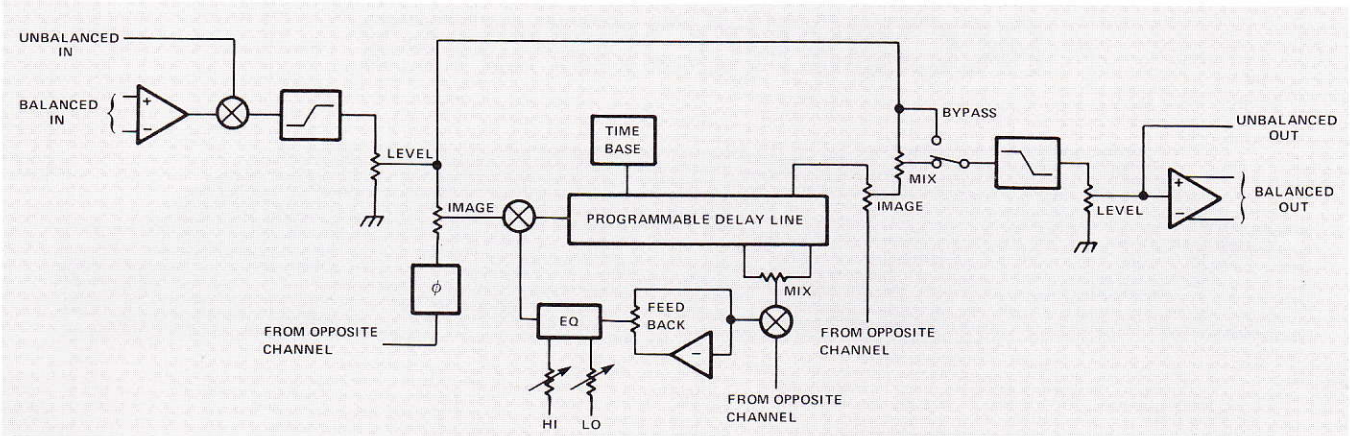
FOR THE PERFORMING MUSICIAN

Today's musician knows the problem of trying to recreate studio effects during a live performance. The DL-2 provides this versatility in one easy to understand, reliable unit. Footswitch bypass and external VCO inputs give musicians the option to "pre-select" an effect and also modulate the effect via the external input.

OPTIONAL MEMORY MODULE

Prior to the ACOUSTICOMPUTER, long delay times have been available only at the expense of dynamic range and/or bandwidth degradation. DeltaLab again chooses the no-compromise alternative by offering an external memory module with a maximum of two seconds of delay per module. Now delay lengths are limited only by the number of modules added; signal quality is not compromised at all!

DeltaLab ACOUSTICOMPUTER - DL-2



Block Diagram - ACOUSTICOMPUTER (One Channel Only)

SPECIFICATIONS

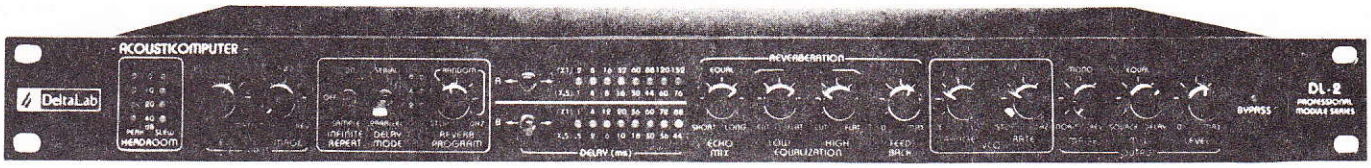
Delay Range	Parallel Mode 0.5 to 160 ms Ch A 0.25 to 92 ms Ch B	Serial Mode 0.5 to 160 ms Ch A 0.75 to 252 ms Ch A & B
Frequency Response[1] **(@ -14 dB) +1, -3 dB**	20 to 15k Hz	
Dynamic Range[1]	(X1 Delay factor)	(X4 Delay factor)
A-Weighted	90 dB min	85 dB min
C-Weighted (Broadband)	85 dB min	80 dB min
Headroom above 0 dB	6 dB	
Equivalent Pre-emphasis	50μs	
THD (Distortion Plus Noise)[1] [2]		
Ref 1 kHz	(X1 Delay factor)	(X4 Delay factor)
0 dB	0.2% max	0.4% max
-10 dB	0.2% max	0.4% max
-20 dB	0.3% max	0.6% max
-30 dB	0.5% max	0.8% max
-40 dB	0.8% max	1.0% max
Inputs		
Balanced (XLR)	0 to 18 dBm	
Unbalanced (Phone)	0 to 18 dBm	
Impedance	47K ohm	
Outputs		
Balanced (XLR)	Up to 24 dBm	
Unbalanced (Phone)	Up to 18 dBm	
Impedance	600 ohms	
Time Base Generator		
Delay Factor	Continuous from X1 to X4	
VCO Depth	0 to 100% of Delay Adjustment Range (4:1)	
VCO Rate	Sinusoidal from 0 to greater than 10 Hz	
Sustain	Repeats signal in memory indefinitely without degradation. Sample mode is used to update with new information at rate determined by the VCO.	
Reverberation	16 Programs displayed via binary weighted LED's. Most programs consist of high echo densities.	
Size	1¾ x 19 x 10 in. (4.45 x 48.3 x 25.4 cm)	
Shipping Weight	12 lbs (5.5 kg)	

[1] Straight Delay Mode [2] With C-Weighted Broadband Filter

Manufacturer reserves the right to make improvements without obligation.

DeltaLab Research, Inc.
27 Industrial Avenue, Chelmsford, Mass. 01824, Tel. (617)256-9034

Delta Lab DL2 Acousticomputer



by Dave Hastilow

The small studio operator or musician is hit by two facts of life. The first one is that producers often take their bands to well-equipped studios, and the second is that equipping a studio or PA rack costs a lot of money. Especially a rack full of what are fast becoming the 'obligatory ancillaries' such as digital delay, flanger, etc etc.

However, well-equipped studios have to update their hourly rates to cover costs so not-so-well-off operators can score a double direct hit if they find one piece of equipment which will do the work of a rack full and is moderately enough priced to justify keeping the hourly rate down. The other fact of life is that producers always have their eyes open for less expensive well-equipped studios, so you might score another hit if a producer looks in your direction after he's heard a few of your demos or happens to be at your gig.

Delta Lab, who have the interests of the small as well as the big wigs at heart, have had their thinking caps on and have produced what appears to be one of the best ideas in a long time – the *DL2 Acousticomputer*. Basically what it all boils down to is that they've taken a 19in × 1¾in × 8in box and filled it with enough electronics to give the user access to every type of effect from digital delay, ADT, flanging, reverberation, ambient reverberation, rear channel ambience extraction, digital sample flanging, digital random flanging, digital random sample flanging, echo, cardboard tube echo, slapback, rotating speaker, vibrato, chorus vibrato, simultaneous reverb phasing, simultaneous echo phasing and all of the effects in between the above knob settings (which can be pretty mind boggling), and they're all in stereo. How does it work? Read on – you might be able to afford it.

Basically, and in the simplest words available at this time on Sunday evening, the two input channels A and B enter the device and are each routed through two independent side chains which may remain independent or may interact with each other depending upon which mode of operation is selected. Channel A may be delayed from .5 to 152 ms and Channel B from .25 to 88 ms with the *DL-2* in the parallel mode. However, in the 'serial' mode the inputs are mixed and processed first through Channel A and then Channel B. The output of Channel B is delayed by the sum of Channel A and Channel B indicators. Also the Channel B data is twice processed. I told you it was simple.

In practical terms imagine the situation where you are trying to get an ambient guitar sound from a dry miked guitar track. Had the guitar amp been in the middle of the empty studio or room and had the mic been stereo the sound waves hitting the mic would have consisted of the direct sound from the amp mixed with multiphase delayed sound waves arriving a short time later after being reflected off the walls, floor and ceiling. This is essentially what the *DL-2* is doing in its most basic mode. Channel A delay and Channel B delay are in effect the walls around the amp, the reflections from the walls are mixing together somewhere in the middle of the room, and is the case with the *DL-2* when the Image control is in the A/B position and the resultant blend of dry plus delayed information gives the ambient effect. The reason Delta Lab have labelled the *DL-2* the *Acousticomputer* is that every delay tap within the device has a binary address code or number between 0 and 15, and the *DL-2* can select any number and regenerate it or it can scan the whole series of fifteen addresses and select randomly at a given sample rate determined by the position of the reverb knob. This is a brief description of what the *DL-2 Acousticomputer* does in its simplest mode and it is possibly the closest electronic approach to artificial ambience creation short of playing the guitar track back through a speaker in the studio and recording it.

To complete the picture the *Acousticomputer* can not only regenerate random selected short and long delayed signals but also feed back or sustain them to simulate the build-up of what is described in books on acoustics as 'equilibrium intensity', where the direct and indirect sounds from a sound source have built up to their highest level. Sound waves bounce around a room until the energy within them has been dissipated. While they've been bouncing they will have had their frequency content altered considerably by the acoustic properties of the materials lining the walls of the studio. This effect is simulated in the *Acousticomputer* by adjusting the equalisation of the signals which are being fed back to the input for regeneration. The equalisation controls consist of high and low pass filters.

The front panel can be divided into six sections which are further sectionalised by the nature of the controls under these headings. Now that I have described what the *Acousticomputer* does I hope that these individual controls will make more sense.

▷▷

Dave Hastilow is a recording engineer at Eel Pie Recording, Twickenham

INPUT SECTION

Headroom indicator: Two columns of LEDs indicating peak and slew level between –40db and 0db.

Level Control: Adjusts input level of Channel A and B simultaneously.

Image: Three settings – *Norm:* Signals pass straight through to their respective channels. *A Ø B:* Each channel is mixed with a multiphase signal from the other channel to extract ambience. *Rev:* Signals are directed to opposite channel (Stereo reverse).

PROGRAM

Sustain: In essence an infinite repeat control. When *on* the input is diconnected and data is recirculated indefinitely with no degration. In the *sample* mode the on/off function switches at a rate set by the VCO. New data is loaded into the register in the 'off' function and circulated in the 'on' function. This facility makes possible a new effect – 'Digital Step Flanging'. The sustain function may be switched on by a foot pedal.

Mode: Serial – Inputs are mixed through Channel A and then B. The output of Channel A is delayed by the Channel A indication. The output of Channel B is delayed by the sum of the channel A and B indications. Also the Channel B indications are twice processed.

Parallel – Each channel is mixed via the input image control and processed independently. The reverberation will be interrelated.

Reverb: As already mentioned, there are sixteen reverberation programs stored in the *DL 2* which create effects varying between sensations of spaciousness, flutter, and tubey effects depending upon the settings of the Time Base Generator, Reverberation, and Mix controls. The programs are selected by the reverb control.

Manual – Allows user to select delay time settings in each channel.

Hold – Locks in program displayed

Select – Program changes in a slow counting manner until the knob is rotated to the hold position

Random – Program changes at a rate determined by position of knob

DELAY

Moving the switches forward or backward respectively increase or decrease the initial delays in each channel by the amount indicated in figures above and below the Light Emitting Diodes. Short delays are used for flanging and long delays for spatial or echo effects. In the parallel mode channel B behaves in the same manner as channel A but in the serial mode the initial delay of channel B output will be the sum of the delays indicated by both the Channel A LED and Channel B LED. This means that Channel B becomes Channel A + B.

REVERBERATION

The reverb mix control mixes the long and short reflections to create reverberation. In the 'short' position only short reflections will be regenerated. In the 'long' position only long-delayed reflections are regenerated. In the 'equal' position equal amounts of short and long are fed back. In practical terms the 'short' position corresponds to the reverberation of a small room and so on.

Equalisation: Low control rolls off low frequencies in the regenerated delayed signals. At full cut passes frequencies above 800 Hertz only. High control rolls off everything above 1.5kHz.

Feedback: Determines the amplitude of signals being fed back. At max +, signals are fed back in phase with input. At zero, output has no reverberation. At max –, reflections are fed back out of phase with input.

TIME BASE GENERATOR

Delay Factor: Varies the basic clock frequency which determines the delay; thus acting as a variable delay multiplier. Variable between ×1 and ×4.

VCO Rate and Depth: Rate variable between 0 and 10 Hz. Depth control varies amplitude of VCO frequency thus making deep flange and pitch bending possible.

OUTPUT

Image: As with the input image control allowing subtle stereo effects to be created.

Mix: Allows the source (bypass) or the delayed signals only to appear at the outputs or a mix of both when the knob is set in the equal position.

The *DL 2* can be bypassed by using a footpedal which plugs into the back of the unit.

In the Program section ot the front panel are set four LEDs which are numbered 1 2 4 8 upwards. These indicate the binary address codes for the Channel A and Channel B short and long initial reflections which are recirculated to create reverberation. LEDs 8 and 4 indicate the short and long initial reflections of Channel A and LEDs 2 and 1 the short and long initial reflections of Channel B.

The precise amount of short and long initial reflections recirculated to create the final reverberation pattern is determined by the position of the Reverb Mix control.

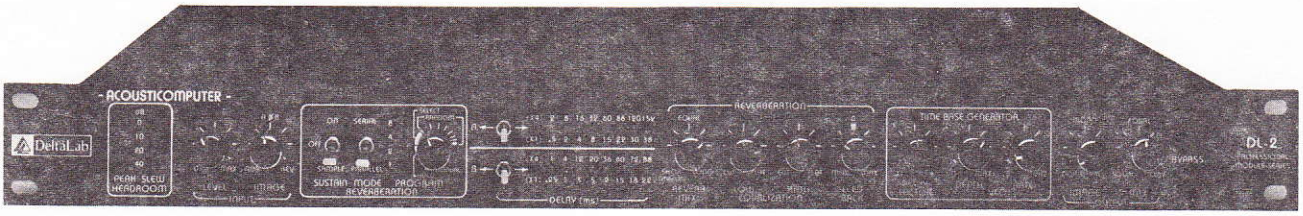
In operation the *Acousticomputer* does everything it says it can and more. It is not possible to describe in words the effects created when the knobs are in the intermediate settings and it is advisable to make slight rather than large adjustments to the knobs when looking for effects to prevent overloading other equipment which may be interfaced with it. It is possible to set up quite a simple program and flick the parallel/series and sustain switches only to be knocked out by something else, so beware of Acousticomputeritis, or sidetracking! The chorus effect is quite astounding; so is the rotating speaker, and the reverberation is similar in texture to that provided by a reasonably-priced spring. The input and output connections are balanced and unbalanced which makes for good mobility between studio and stage and three sockets allow for the sustain and bypass modes to be switched by footpedal or for insertion of an external control voltage of between 0 and 10v. Provision is also made for an optional memory module, which increases the *DL 2* memory capability to 2 seconds, to be inserted via a 5 pin Switchcraft connector. The increased delay time will not degrade any of the *DL 2 Acousticomputer* functions.■

DeltaLab DL-2 Acousticomputer

By John Murphy and Jim Ford

The DL-2 Acousticomputer from DeltaLab Research, Inc. utilizes a stereo pair of programmable digital delay lines to produce a wide variety of special effects including echo, flanging and reverberation. It can provide up to 240 milliseconds of delay while maintaining a high level of audio quality, and has control features which make it attractive for use on the stage as well as in the studio. With more than a dozen front panel controls of operating parameters, the DL-2 has a very strong "toy appeal" and encourages creative experimentation with its wide variety of delay effects. The DL-2 currently sells for $1,750.

General Description: The DL-2 is not a simple piece of equipment either in its functions or in the control of those functions. In general it is appropriate for novice users of complex signal processing equipment (such as the DL-2) to first carefully learn the operation of the unit. Studying a block diagram showing signal flow through the unit (see *Figure 1* for a block diagram of one channel of the DL-2) is usually the quickest way to learn how it operates. Knowing the operation, it then becomes easier to use it to maximum advantage.



The operation of the DL-2 can probably be best understood by viewing it as a pair of digital delay lines that can be used in many different configurations. Each of these delay lines has one input and three separate outputs corresponding to three different time delays along the line. Of these three outputs, the middle one is used as the main output of the delay line while the other two outputs are made available to be fed back to the delay line input for reverberation and repeating echo effects. The feedback network incorporates high and low frequency attenuation controls for coloring the reverberation as well as a "mix" control for adjusting the balance between the short and long delays fed back to the input. In addition, the feedback signal can be either phase inverted or not.

The delay time of the delay line is adjusted in two steps. First, a pair of momentary toggle switches are used to set the coarse delay time with horizontal rows of LEDs indicating the range of delay selected. Then the delay time of the pair of delay lines is fine adjusted over a four-to-one range using the "delay factor" control. A VCO (Voltage Controlled Oscillator) in the time base generator section of the DL-2 can be used to vary the delay time. Both the depth and rate of the VCO are adjustable. Mixing the direct and delayed sound while using very short delays (0.1 to about 1 milliseconds) and a slow sweep rate provides the familiar swept comb filter sound of "flanging." A vibrato effect can be created by using a short delay and selecting only the delayed signal in the output mix. The depth and rate controls of the VCO then control the depth and rate of the vibrato.

Reverberation is synthesized in the DL-2 by recirculating (or feeding back to the input) the long and short delays of the two channels. The fraction of the output signal fed back to the input determines the decay characteristics of the reverb. The greater the feedback percentage the longer it will take for the reverberation to decay. When either the highs or lows are attenuated in the feedback loop the decay time for the attenuated

frequencies is reduced in comparison to the other frequencies. With the DL-2 the best sounding reverberation is typically obtained by using a fair bit of low frequency attenuation and near maximum feedback.

The reverberation output for channel A is made up of recirculated delays from both channels A and B. Likewise for channel B. There is one long and one short delay from each of the two channels available for feedback to the input. This gives a total of four discrete delays that can be fed back in various combinations. Which of these delays is used for feedback depends on the setting of the DL-2's program indicator. The program indicator is composed of four LEDs that are either on or off. The four LEDs indicate the presence (or absence) of each of the four available delays in the reverberation. DeltaLab has a novel way of allowing the user to select any of sixteen possible combinations of these four delays. When the reverb program control is placed in the select position the LEDs cycle on and off in a binary counting sequence thus stepping through the sixteen combinations of discrete delays corresponding to sixteen different reverb "programs." When the desired program is reached the reverb program knob is set to the "Hold" position and the program sequencing stops where it is. If desired, the reverb program knob can be left in the sequence position and the reverb character will change continually as the unit sequences through its sixteen reverb programs. Rotating the reverb program control further clockwise to its "Random" setting increases the rate at which the DL-2 steps through the program cycle.

The input controls for the DL-2 are located at the left side of the front panel. First there are signal headroom indicators which indicate slewing headroom as well as peak level (amplitude) headroom. Each display consists of four LEDs labeled 0, 10, 20 and 40 dB. Input level and image controls are located just to the right of the headroom indicators. The input level control simultaneously adjusts the input signal level for both channels. The input image control directs the signals to the opposite channel as the control is rotated from normal to reverse.

Located at the right of the input controls are the reverb program controls. The first control in this group is a three-position toggle switch labeled "Sustain." In the "On" position of this switch the input to the delay line is disconnected and the signal currently in memory is recirculated indefinitely with no degradation. Returning the switch to the center or "Off" position returns normal operation of the unit. The third position of the switch is labeled "Sample" and with the switch in this position the sustain function alternates between on and off at a rate set by the VCO. DeltaLab recommends using the "Sample" feature with the DL-2 set up for flanging to obtain a "digital step flanging" effect. The sustain function can be switched on and off via a footswitch jack located on the rear of the unit.

Next to the sustain switch is a two-position toggle switch labeled "Mode" with the positions labeled "Parallel" and "Serial." In the serial mode the two channel inputs are mixed and processed through channel A and then through channel B. The output of A is then delayed by the amount indicated for channel A. However, the output of channel B is now delayed by the sum of the delays indicated for A and B. Switching to the parallel mode, the two input signals are mixed (through the image control) and then processed independently. However, the reverberation for the two channels will be interrelated.

The final control in this group is the reverb program control previously discussed. The program indicator is located between the mode switch and the reverb program control.

Delay times for the two delay lines are adjusted by way of two momentary-type toggle switches located one above the other. The LED displays to the right of the switches indicate the 4 to 1 range of delay times selected for each channel. The range of delay times available is 0.5 ms (milliseconds) to 152 ms for channel A and 0.25 ms to 88 ms for channel B. When used for reverb these initial delays become pre-reverb delays.

Next, and just to the right of the center of the front panel is a group of four rotary controls labeled "Rever-

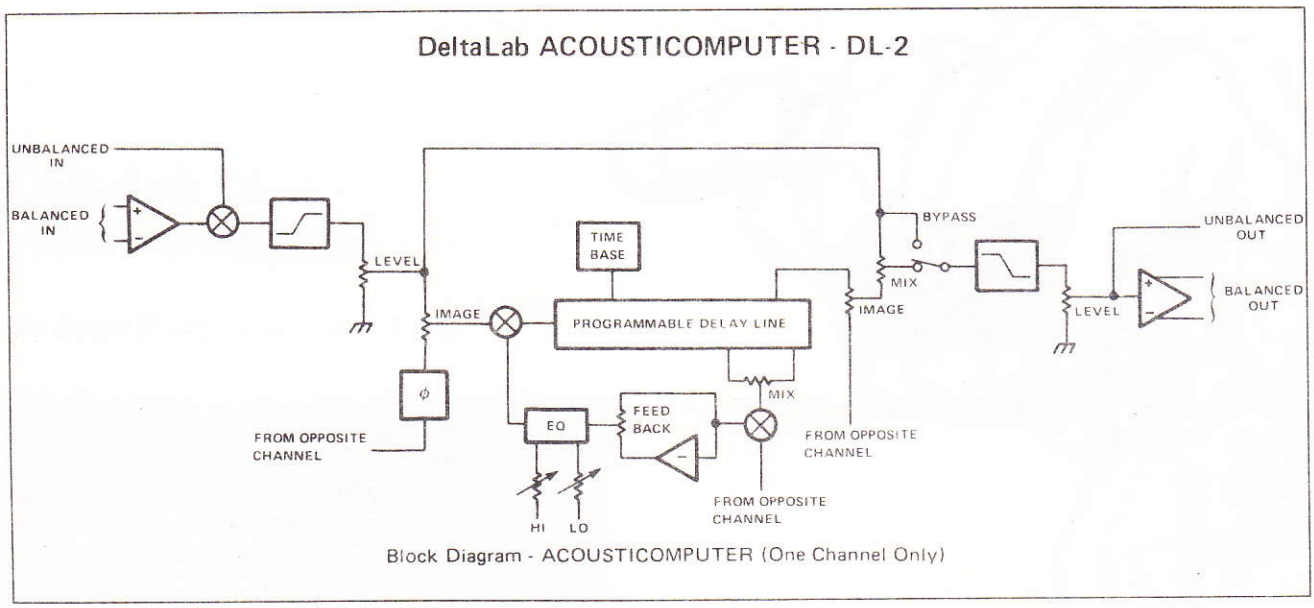


Fig. 1: DeltaLab DL-2: Block diagram of the unit (one channel only).

beration." The first control, "Reverb Mix," sets the mix of long and short delays fed back to the delay line input. This control simultaneously adjusts the relative levels of the four long and short delays available for feedback. The next two controls are labeled "Equalization" and provide high and low frequency cuts when backed off from their full clockwise "Flat" settings. The last reverberation control is the feedback control. With this control in the twelve o'clock position none of the delayed signals are fed back to the inputs. Rotating the control clockwise provides increasingly more feedback signal to the inputs. Counterclockwise rotation results in increasingly more of the delayed outputs being fed back to the inputs except that the outputs are first phase inverted.

The "Time Base Generator" is next and employs three rotary controls labeled "Delay Factor," "Depth" and "Rate." The delay factor is adjustable from 1 to 4 and provides fine delay time adjustment in conjunction with the coarse delay adjustment already discussed. The other two controls adjust the depth and rate of the VCO. The VCO can be externally controlled via a phone jack on the rear panel.

The final controls on the front panel are the output image and mix controls. The image control interchanges the channels as it is rotated clockwise from the normal to the reverse setting. The output mix control allows the direct and processed (delayed) signals to be mixed in the desired proportions. At the right of the output mix control is a bypass indicator. This LED lights to indicate that the system is bypassed through use of a rear panel foorswitch jack.

The input connectors for the DL-2 are located on the rear panel. The unit accepts balanced inputs by way of XLR-type connectors and accepts unbalanced inputs via ¼-inch phone plugs. Likewise, both balanced and unbalanced outputs are provided employing XLR and ¼-inch phone connectors, respectively. A single screwdriver-adjustable control simultaneously adjusts the output levels of the two channels.

The rear panel houses three ¼-inch phone jacks for interfacing the bypass, VCO and repeat foot controls. There is also a five pin XLR-type connector for interfacing optional memory modules. Next to this connector is a slide switch labeled "Memory" with internal and external switch positions. Unless external memory is used, this switch should be left in the "Internal" position.

The DL-2 is packaged in a single space rack mount chassis and provides quite a lot of signal processing capability in very little space.

Field Test: We tried out the DL-2 during a leisurely four-track recording session and were quite pleased with the wide variety of effects that we could obtain. DeltaLab has provided diagrams which indicate control settings for some nineteen different effects and we experimented with nearly all of them. In addition there are blank control diagrams which allow the user to record control settings for additional effects. We tried the suggested "guitar reverb" control settings and were pleased with the results. The effect combined some audibly discrete echos along with more diffuse reverberation to provide a rather tasty combination of echo and reverb. The effect identified as "ambient reverb" provided what seemed to be the most natural sounding reverb for the unit. Even though this was a good reverb effect it lacked the quality of lush diffusion that is generally demanded of the finest [and costlier] reverberators. However, in many applications the DL-2 will provide quite satisfactory reverb.

Other classifications of effects that we found useful, besides reverberation, include varieties of flanging (DeltaLab provides five control recipes for flanging

effects), echo (four recipes provided), vibrato and doubling/chorusing. We used the DL-2 to flange the output of an electric piano with excellent results. We were especially pleased with the consistently high level of audio quality when we processed signals through the unit. There was never any loss of highs and the unit's noise was never heard. The Acousticomputer is really quite a high-quality device!

We performed our usual listening test by incorporating the DL-2 into a tape loop on our preamplifier. The DL-2 was set for 15 ms delay in each channel with no feedback or VCO employed. The output mix control was set to full delay so that we could listen through the delay chain with no other effects. When we played a disc back through our reference system we heard virtually no degradation when we introduced the DL-2 into the chain. I must say though that we allowed the DL-2 a healthy amount of headroom and were careful not to press the signal levels. In any event it was quite transparent and introduced no sound of its own.

Lab Test: We performed the usual variety of tests on the DL-2 and the specific results are provided in the "Lab Test Summary." We noted that the input section does not have a lot of gain as an input signal level of -2.2 dBV is required for a 0 dB headroom indication. Even though this appears to be the equivalent of a nominal "0 VU," some caution is necessary in setting levels through the DL-2 as there is only about 5 dB of headroom before clipping above the "0 dB headroom" indication. However, because of the low noise level of the unit (about 88 dB below 0 dB headroom) it shouldn't be necessary to push the input level. The output level at 0 dB indication was +15.0 dBV with the output level control at maximum, so there is plenty of output level.

The THD distortion at 0 dB headroom indication was about 0.1% in the midrange with the delay factor control at the X1 setting. Increasing the delay factor to X4 increased the mid-frequency distortion to 0.36%. Distortion also increases at the low and especially the high frequency extremes. The bandwidth through the delay line is better than 15 kHz, which is excellent. This wide bandwidth was not degraded with any control settings.

The slew rate limit through the delay lines was measured as 0.4 volts per microsecond. At a 0 dB headroom level (+15 dBV output level) this provides a slew rate ratio of 0.065 volts per microsecond. A couple of simple calculations reveal that in order to maintain a slew rate ratio of 0.5 (the recommended minimum) or higher, signal levels through the delay line must be no higher than 17.7 dB below the 0 dB headroom indication. With the output level control at maximum this would restrict the output signal level to less than -2.7 dBV. Slewing performance for the direct signal path is better. The direct output could not be driven into slew limiting because the small signal bandwidth (18.7 kHz) is less than the power bandwidth through the "direct" signal chain. If the power bandwidth were just equal to the small signal bandwidth then the slew rate limit would be (from calculations) 1.3 volts per microsecond. Therefore the actual slew rate limit through the direct path is *at least* 1.3 volts per microsecond. Calculating the slew rate ratio based on this slew rate limit it was determined that the slew rate ratio will be *at least* 0.21 for 0 dB dB headroom signal levels. Keeping signal levels below -7.5 dB headroom (+7.5 dBV output) will insure that the slew rate ratio never drops below 0.5 for the direct signal path.

The preliminary owner's manual that we received with the DL-2 provided good explanations of the operation of the front panel controls and should allow users to get good results quickly.

Conclusion: The DL-2 Acousticomputer by DeltaLab proved to be a highly versatile digital delay sound effects unit. It provides high quality flanging and doubling effects with many subtle variations. Although its reverberation is not in the same class as the best reverberators available, it does provide a good reverb sound that will be satisfactory in many applications. In our listening tests we were impressed with the consistently high level of audio quality when listening through the unit. The DeltaLab Acousticomputer is an excellent delay effects processor.

LAB TEST SUMMARY

(Note: 0 dBV is referenced to .775 Vrms, all tests made with output level control at maximum)

Input/Output Levels

Minimum input level required for 0 VU indication (unbalanced input):	– 2.2 dBV
Maximum input signal before clipping:	+ 19.2 dBV
Maximum output level at 0 VU (unbalanced output)	+ 15.0 dBV
Output clips at:	+ 20.1 dBV

Noise Performance

(20 kHz filter, unweighted)

With no input signal, noise at the output is:	– 73.3 dBV or – 88.3 VU

Distortion

(THD plus noise at 0 dB headroom indication, delay output)

Frequency	X1 delay	X4 delay
10 kHz	1.95 %	9.4 %
1 kHz	.113%	.36%
100 Hz	1.05%	1.25%

Bandwidth

(– 3 dB points)

24 Hz to 15.7 kHz (delay out)

17 Hz to 18.7 kHz (direct out)

Slewing Performance

Slew Rate limit: 0.4 volts per microsecond (delay output)

at least 1.3 volts per microsecond (direct out)