PD-3 / PD-3-1000

PROFESSIONAL DELAY SYSTEM OWNERS MANUAL

ART

INTRODUCTION

The PD3 is a high performance multitapped digital delay system. Designed primarily for time synchronization in multiple sound distribution systems, the PD3's versatility offers a significant performance improvement in sound reinforcement, recording studio, television engineering, post production, and loudspeaker time alignment applications.

In developing the PD3 we applied our expertise in analog and digital signal processing design to create a digital delay with very high performance and versatility. Realizing the application, we paid close attention to reliability, ease of use, and flexibility of installation.

The PD3 is a 1 input, 3 output delay. Each output is individually adjustable in precise 1 millisecond increments to a maximum of 255 milliseconds via the front panel DIP switches. Recessed front panel level controls for input and output, as well as 4 LED indicators, accommodate a wide range of operating levels. All input and outputs are active balanced assuring hum and noise free interfacing with other equipment. Terminations are via both barrier strip and 1/4" phone jacks (tip-ring-sleeve) on the rear panel.

Internally the PD3 uses a new 16 bit linear D/A converter that meets the most stringent of audio performance demands. The audio signal is sampled at a 64kHz rate, much higher than is typical, allowing for a full 20kHz bandwidth while using maximally flat Butterworth filter alignments. A crystal controlled timebase assures delay accuracy and long term stability. The PD3 may be switched to a short delay mode where each output is individually adjustable in 31.25 microsecond increments, useful for time aligned loudspeaker applications.

The PD3 is designed for continuous unattended use. Its steel enclosure conforms to the EIA standard 19" 1U rack mounting requirements and a tamper proof security cover is provided. It generates very little heat (10 watts) and is very forgiving of its environment. Signal and chassis grounds are isolated to help minimize system ground loops. Only quality components are used and conservatively rated for reliable long term service. Couple the PD3's durability with its high performance and you have a system that will still be current years from now.

We recommend that you first read these instructions to learn more about the PD3 Digital Delay System and its operation. We have tried to cover some of the more common applications as a starting point.

PD3-1000

The PD3-1000 has the same operating characteristics as the PD-3. Differences in operation are in delay time and delay settings only. For all delay time references in this manual, multiply that time by four. The maximum delay time of the PD3-1000 is one thousand milliseconds (1000ms). Delay increments are 4ms or 125us.

Setting the DELAY TIME

The front panel DIP switches set the Delay Time of the PD3-1000. Multiply the front panel switch settings by 4 to compute the actual delay time. If the 128, 32, and 1 switches are in the up position, the delay time of that output would be 644ms [(128+32+1)4 = 644ms].

Short Delay Mode Switch

For the PD3-1000, the Short Delay Mode Switch sets the delay time to increment in 125 microsecond (us) intervals or 4ms. Set the switch right for increments of 4ms increments and left for 125us increments.

INSTALLATION

In this section we'll discuss some general considerations for setting up and installing the PD3 and cover what connections go where. Note that, throughout the rest of this manual, whenever we refer to actual labels on the product, we'll indicate them by using all upper case letters (e.g. the DELAY switches).

OPERATING ENVIRONMENT

The PD3 is an outboard device which may be used in a variety of setups including: fixed permanent rack installations directly before the power amplifier, mobile applications such as a portable sound system, and with a mixing console in post production applications. Your intended application will dictate the mounting requirements and which settings and connections discussed below are most appropriate.

The PD3 is designed for convenient mounting in a standard EIA nineteen inch rack and occupies one vertical rack position (1.75 inches high). As with any rack mount equipment, especially single high units, care should be taken to support the rear of the unit if the rack might be subjected to mechanical shock (in a touring case for example).

Mounting location is not critical, but for greater reliability we recommend that you not place the unit directly on top of high power amplifiers, power supplies, tube equipment or other sources of heat. Though the PD3 will operate over a wide temperature range, we recommend that it's normal operating ambient temperature be within the range of 0 to 50 degrees C for extended component life. Humidity should nominally be less than 95%, condensation free. In a permanent rack installation, if possible allow an inch above and below the rear of the unit for convection cooling.

CONNECTIONS

All connections to the PD3 are made at the rear of the unit via either screw terminal barrier strip of 1/4" phone jacks. Both types of terminations are paralleled internally. Hard wiring to the barrier strip is recommended for permanent installations as the connections are more secure and the long term effects of surface corrosion on the connections is minimized. For more temporary applications the 1/4" phone jacks provide a convenient interface and since they parallel the barrier strip they facilitate system setup, testing, and allow for "parallel" patch points.

Input and Outputs

The input impedance is 20k ohms, balanced using active circuitry. Common mode rejection ratio (CMRR) is 40 dB (typical) from DC to over 20kHz. Common mode range is greater than ±15 volts. The input may also be used with an unbalanced (single ended) line. The preferred method is to connect separate conductors from the sources ground to the PD3 (-) input and output ground. This allows the noise canceling benefits of the balanced input to be more fully realized. In less critical applications, the (-) input may be tied directly to the input ground on the barrier strip or use a two conductor (tip and sleeve) phone plug.

All outputs are balanced using active circuitry. Each output has a source impedance of 600 ohms balanced. 300 ohms unbalanced. When driving single ended inputs, use only the (+) output and ground. **Note:** all signal grounds are isolated from the chassis, which is connected to earth ground through the three wire power cord. This helps in minimizing system ground loop problems.

AC Mains

The PD3 operates from a power source of 105 to 125 volts AC (50-60 Hz). Models manufactured for use outside of the United States are modified to comply with the electrical standards for the country of destination. The PD3 is internally fused (1/2 amp slo-blo fuse) to protect against catastrophic failure.

SHORT DELAY MODE SWITCH

As shipped from the factory, the PD3s "normal mode" allows you to adjust each outputs delay in 1 millisecond increments to a maximum of 255 milliseconds via the front panel DIP switches. This is the normal mode for time synchronization in sound distribution systems. An internal switch allows the PD3 to provide 31.25 microsecond increments to a maximum of 8 milliseconds. This short delay mode is primarily useful for loudspeaker time alignment applications (aligning drivers within an array). The application will dictate which mode to use. We located the switch so as to prevent it from being inadvertently changed once installed.

The switch is located inside and requires the removal of the top panel for access. You'll find it, labeled SW4 on the printed circuit board, approximately 2" behind the front panel DIP switches. Position the slider to the left for 31.25 microsecond increments and to the right for 1 millisecond increments.

CONTROLS AND OPERATION

The main controls of the PD3 are divided into two primary sections, LEVEL and DELAY on the front panel. Each of the three delay outputs (labeled A,B,C) has a corresponding OUTPUT LEVEL attenuator and DELAY switch array (DIP switches) on the front panel. This section explains the function of each control.

LEVEL

The four LED indicators (-18, -12, -6, 0dB) display the actual signal level at the input of the A/D converter. To obtain maximum dynamic range the -18 LED should be on most of the time with average signal material and the 0dB LED should light on signal peaks. The 0dB LED lights at 3dB below clipping. The PD3 handles overloads gracefully so an even greater perceived dynamic range can be obtained if a slight amount of clipping is allowed. The INPUT LEVEL control permits adjustment of optimum signal level at the PD3. The OUTPUT LEVEL controls act as attenuators at each delay output, very useful when the system power amplifiers have no input level controls.

As shipped from the factory, the PD3's LEVEL controls are set to accommodate maximum system signal levels (+20dBm in and out) with a typical noise floor of -76 dBm over a 20kHz bandwidth. For most high signal level systems no input level adjustment is necessary. If the -18 LED is on infrequently with average signal material and noise is noticeable then the level controls should be used to optimize signals at the PD3.

DELAY

The front panel DIP switches are used to adjust each outputs delay. We chose this non-flashy method primarily because the 8 switches (arranged in binary format) in each array allow 256 different settings and they allow the entire system to be non-volatile (all settings are remembered on power down and there are no internal batteries for very long term service).

The numbers (128, 64, 32, 16, 8, 4, 2, 1) above the switches indicate the amount of delay in milliseconds that will be obtained when the switch directly below that number is on (up position). The delay obtained when multiple switches are on is additive (i.e. if the 128 and 64 switches are on then the delay will be 192 milliseconds (128+64=192).

With all switches off (down position) there is no delay, with all switches on (up position) the delay is 255 milliseconds (128+64+32+ 16+8+4+2+1=255). With a little practice this binary method of setting delay will become easy. Let's say, you want 73 milliseconds of delay, you would switch on the 64, 8, and 1 switches.

The above delay times apply to the normal mode (1 millisecond increments). If the PD3 is used in the short delay mode (31.25 microsecond increments) the same technique applies. I.E. if the 2, 4, and 8 switches are on (14 milliseconds in the normal mode) the delay will be 14*31.25 or 437.5 microseconds in the short delay mode.

Once you have set the appropriate delay for each output the provided tamper proof cover may be installed over the DELAY switch area.

APPLICATIONS

The PD3s high performance and versatility allows for a wide range of applications. In this section we will cover some of the more common audio delay applications as a starting point.

TIME SYNCHRONIZATION OF SOUND SYSTEMS

In any sound system the primary objective is to make music and speech more intelligible and natural while maintaining sufficient loudness at any point within the listening environment. To this end, high quality amplifiers and speakers are needed to provide an accurate rendition at each sound source. Delays are used to synchronize these sound sources so that localization of the performer (originating source) is maintained and reinforced by the distributed speakers without sacrificing intelligibility.

In a well designed natural sounding installation, sound from all sources including the original source should arrive at the listener within 30 milliseconds of each other. This will assure that the sound sources reinforce or augment each other. When two sounds of equal loudness arrive at a listener separated by more than 30 milliseconds they will be perceived as two distinct and different sounds and will tend to conflict with each other, decreasing intelligibility.

Localization of the performer is obtained by making sure that the performers direct signal arrives 15 to 20 milliseconds before any reinforced sound is heard. This slight delay (commonly referred to as the "precedence effect") provides auditory cues to the listener that establish the performer as being the original sound source. While this entails delaying signal to the main cluster or speaker array, a side benefit is obtained in that audio feedback to the performers microphone from the main speakers is delayed. Thereby greatly reducing the possibility of system feedback or howling and allowing an increase in system acoustic gain or level.

Sound energy travels through air at approximately 1130 feet per second at room temperature and normal humidity. This converts to 1.13 feet per millisecond or .885 milliseconds per foot. The PD3s maximum delay of 255 milliseconds would therefore allow you to synchronize sound reinforcement speakers up to 288 feet from the original source. The PD3 provides 1 millisecond resolution in its normal delay mode, allowing you to fine tune delay to within approximately 1 foot. The PD3s maximum delay and fine resolution are more than adequate for more than 90% of today's fixed installations.

Signal levels of any reinforcement speakers should be trimmed as the precedence effect is negated if the signal from a nearby speaker is over 10 dB higher than the primary sound source. Each delays level should be trimmed after all appropriate delays are set. The three independent output attenuators on the PD3 provide a convenient central location for this trimming.

The above general discussion covers most of the basics. The specific type of installation will usually dictate the manner in which a delay may be implemented.

Central Cluster

A central overhead speaker cluster provides reasonable sound coverage in many applications. To be effective it must be high enough to allow sound from the original source to arrive at the audience before the sound from the cluster. This is not always practical due to the structure. In these cases, by delaying the signal to the cluster a much more natural sound will be obtained and the localization of the performer can still be maintained.

Supplemental Speakers

In larger auditoriums and theatres, once the main speakers are properly delayed for proper coverage of the primary audience area, there is often a need for supplemental speakers in balcony and secondary seating areas. These secondary reinforcement areas gain much from the application of delay as their

distance from the main speakers is great enough to cause audible echo if no delay were used. The appropriate delay in these applications is usually derived by taking the distance from the main speakers to the listeners in this area and subtracting the distance from the supplemental speakers to these listeners. This difference in feet is then coverted into milliseconds.

Distributed Speaker Systems

Simple distributed loudspeaker systems use 8 inch ceiling mount speakers with a broad enough coverage to allow placement every 12 to 15 feet. This technique provides reasonable coverage at all points in the listening area, however, the audio signal should still be delayed if naturalness is to be maintained. Typically in this case you would apply delay to "zones" of speakers, with each zone covering about 30 feet.

The delay time for a zone would be set to the zones average distance from the original source or performer. Intelligibility and naturalness would be maintained and someone seated directly between two zones would still hear signals within 30 milliseconds of each other.

There are numerous other sound system applications where the PD3 can help improve the overall quality and naturalness. Keep in mind that delay alone cannot fix all of the problems in a system. Coverage, frequency response, and operating level of the system should all be adequate before a delay is added.

LOUDSPEAKER TIME ALIGNMENT

Although the PD3s primary applications are for sound system time synchronization, its short delay mode allows it to offer a cost effective solution in loudspeaker time alignment applications. By switching an internal switch (see installation section) the delay increments are changed to 31.25 microseconds per increment. Equating this to the speed of sound we get .42375 inches per increment. In this mode the maximum delay is approximately 8 milliseconds (255*31.25=7968.75 microseconds).

What is loudspeaker time alignment and when do I need it? With any multiple driver loudspeaker array or cluster, there is usually a slight difference in the distance between one driver and the listener and another driver even when the drivers are within the same enclosure. This slight difference is not perceived as a time delay error, but rather as an anomaly in the frequency response due to a frequency dependent phase error.

When using small or medium linear arrays, where all drivers are the same and the distance from the array to the listener is substantially greater than the distance between drivers in the array, this effect is minimal and usually not a problem. This effect becomes significant in two and three way systems where horn loaded drivers and separate enclosures are used.

Even though a high quality crossover in such a system can separate the frequency components to each section and provide reasonably flat response in the crossover region at the driver, the driver in a horn loaded loudspeaker can be a couple feet from the horns mouth. At lower frequencies the apparent acoustical source from the horn is its mouth, while at high frequencies the apparent source is at the throat.

In this application, the apparent acoustical source from the driver at frequencies near the crossover point is used. Determination of the specific delay time needed becomes fairly complex, as it is dependent on each driver, the crossover, and the physical positioning of the drivers. Usually once the theoretical delay is determined, an interactive process of testing and trimming is employed. Therefore we will not attempt to cover an entire example here.

MISCELLANEOUS APPLICATIONS

The PD3s precise and very stable delay increments allow for a wide range of general audio signal processing applications. In television broadcast and post production work there is often the need for a very short delay to help "sync" the audio with the processed video. Whenever audio and video are transmitted over different media (i.e. video via satellite and audio via land link) delays are needed. In audio post production work high quality delays are used to compensate for the distance between two heads on analog tape decks and azimuth misalignment as well as stereo imaging, and a wide variety of special effects. High tech theme parks and amusement centers use multiple audio delays to simulate an acoustical environment that matches the visual, thereby adding more realism to the illusion. In these and other applications, the PD3s performance specifications are never the limitation.

ARCHITECT'S AND ENGINEER'S SPECIFICATIONS

The delay shall be all electronic with no moving parts other than controls for setting signal levels and delay time intervals. The delay shall provide three outputs with each output individually adjustable in 1 millisecond increments from 0 to 255 milliseconds via front panel switches. The performance specifications shall be met for all possible delay settings allowed by the controls. An input level control shall be provided and 4 LED indicators shall indicate when the input signal is within the preferred operating level range. Individual output level controls shall be provided for each delay output. All controls shall be recessed and a tamper proof security cover shall be provided that is removable to permit selection of delay settings without removal of the chassis in a relay rack. The delay shall meet or exceed the following specifications: distortion shall be less than .03% at 1kHz, +4dBm; frequency response shall be better than +0.5, -1dB from 10Hz to 18.5kHz; dynamic range shall be greater than 90dB. Signal and chassis grounds shall be isolated. Signal input and output connections shall be provided by screw terminal type barrier strip and 1/4" phone connections on the rear. Input shall be electronically balanced with an impedance of 20k ohms. Each output shall be balanced electronically with an impedance of 600 ohms. The unit shall operate from 110V +10% 50/60Hz AC power source. The chassis shall mount in a standard 19" rack using 1-3/4" panel height and 10" behind the panel. The delay shall be the ART model PD3 manufactured by Applied Research and Technology, Incorporated.

SPECIFICATIONS

Maximum Input Level	+20 dBm, 7.75 volts rms
Maximum Output Level	+20 dBm into 10k ohms +14 dBm into 600 ohms
Input Impedance	20K ohms balanced
Output Impedance	600 ohms balanced
Frequency Response	+0, -3 dB 5Hz to 20kHz +0.5, -1 dB 10Hz to 18.5kHz
Operating Level	+4 dBm nominal, input level adjustable from -6 to +18 dBm for 0 dB indication on front
Level Indication	4 LEDs (-18, -12, -6, 0 dB), 0 dB LED on 3 dB below clipping equalized to indicate true A/D signal level
Dynamic Range	90 dB, 20Hz to 20kHz unweighted
THD & Noise	Less than .03% at 1kHz, +4 dBm
D-A Conversion	16 bit linear A/D - D/A
Sampling Rate	64kHz, crystal controlled timebase
Filtering	7 pole in, 5 pole out, maximally flat Butterworth filter alignment
Delay Range	0 to 255 milliseconds in 1 ms steps 0 to 8 milliseconds in 31.25 us steps in short delay mode
Power Requirements	100-125 volts AC, 50/60 Hz, 10 watts, fused internally, (export units configured for destination country)
Dimensions	1.75" high, 19" wide, 10" deep
Terminations	Screw terminal barrier strip and 1/4" phone (tip-ring-sleeve) jacks
Weight	9 lbs.

ART retains a policy of constant product improvement. Specifications are subject to change without notice.

Designed and manufactured in the United States of America.

Applied Research & Technology
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(716) 436-2720
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DIP Switch Settings

0=off (down) 1=on (up)

0=00000000
1=00000001
2=00000010
3=00000011
4=00000100
5=00000101
6=00000110
7=00000111
8=00001000
9=00001001
10=00001010
11=00001011
12=00001100
13=00001101
14=00001110
15=00001111
16=00010000
17=00010001
18=00010010
19=00010011
20=00010100
21=00010101
22=00010110
23=00010111
24=00011000
25=00011001
26=00011010
27=00011011
28=00011100
29=00011101
30=00011110
31=00011111
32=00100000
33=00100001
34=00100010
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37=00100101
38=00100110
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255=11111111