

# AQUABOY DELUXE (ABDX)

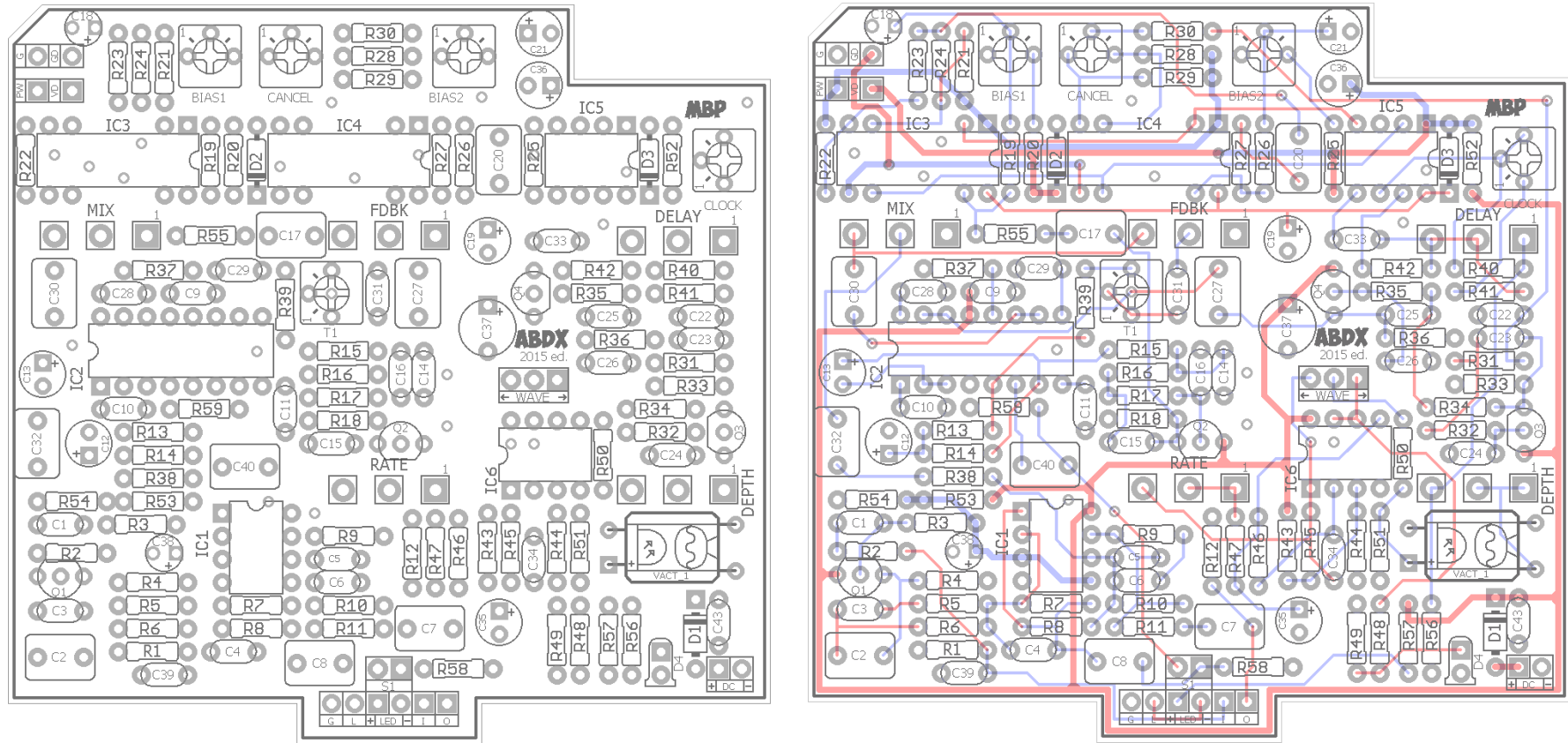
2015 edition

FX TYPE: Analog Delay

Based on the Boss® DM-2™

Download the previous (2013) version of the Aquaboy documentation here: <http://www.madbeanpedals.com/projects/Aquaboy/docs/ABDX2013.zip>

3.3" W x 3.2" H



**Licensing:** You are free to use Aquaboy Deluxe PCBs for DIY and small commercial building. You may not sell Aquaboy Deluxe PCBs on your own (selling to fellow DIY'ers through the forums is fine, of course) or re-package them as part of a "kit".

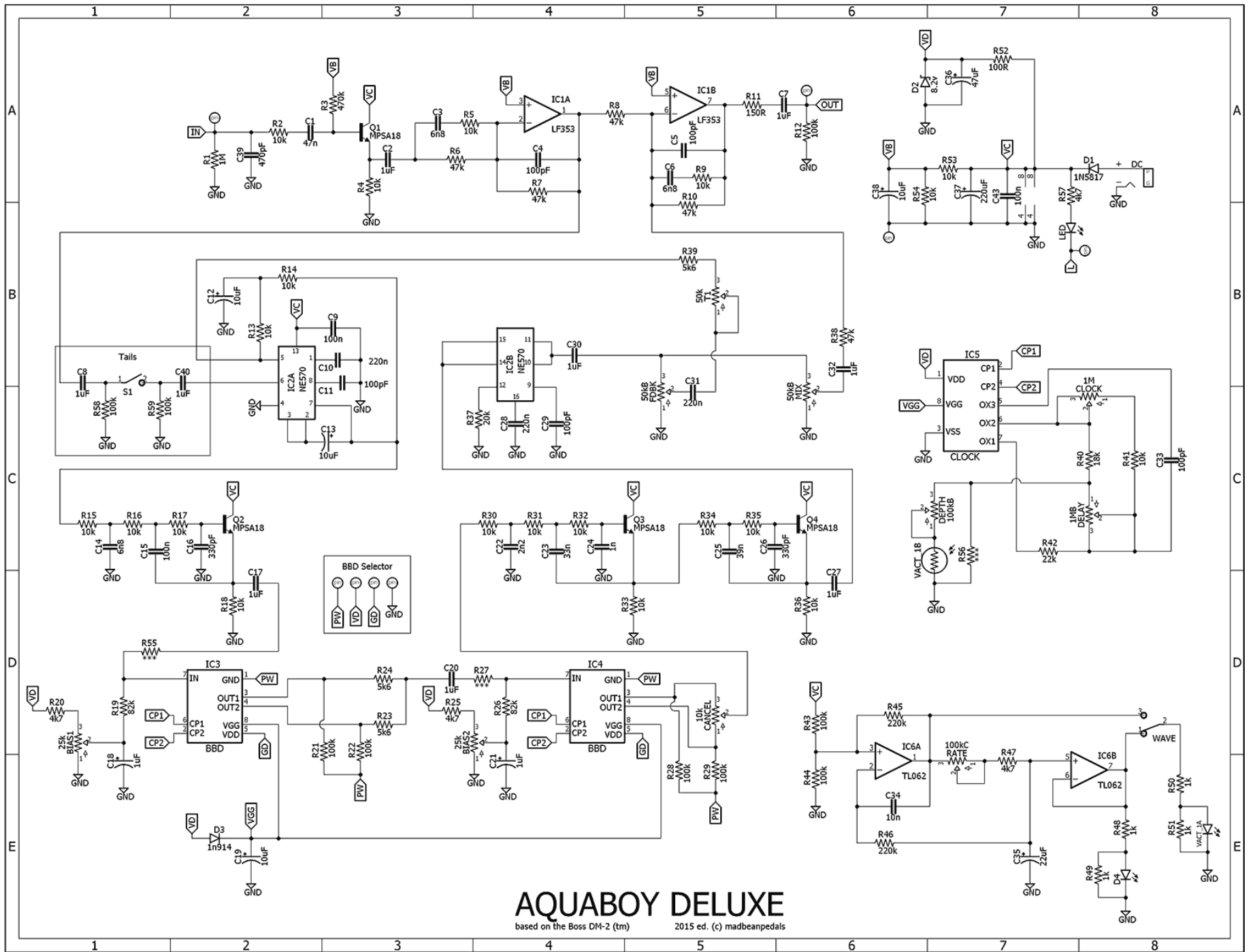
## B.O.M.

Resistors		Resistors		Caps		Caps		Vactrol	
R1	1M	R31	10k	C1	47n	C31	220n	VACT_1	VTL5C/3
R2	10k	R32	10k	C2	1uF	C32	1uF	<b>Switch</b>	
R3	470k	R33	10k	C3	6n8	C33	100pF	WAVE	On/Off/On
R4	10k	R34	10k	C4	100pF	C34	10n	<b>Pots</b>	
R5	10k	R35	10k	C5	100pF	C35	22uF	DELAY	1MB
R6	47k	R36	10k	C6	6n8	C36	47uF	DEPTH	100kB
R7	47k	R37	20k	C7	1uF	C37	220uF	FDBK	50kB
R8	47k	R38	47k	C8	1uF	C38	10uF	MIX	50kB
R9	10k	R39	5k1	C9	100n	C39	470pF	RATE	100kC
R10	47k	R40	18k	C10	220n	C40	1uF		
R11	150R	R41	10k	C11	100pF	C43	100n		
R12	100k	R42	22k	C12	10uF	<b>Diodes</b>			
R13	10k	R43	100k	C13	10uF	D1	1N5817		
R14	10k	R44	100k	C14	6n8	D2	8.2v Zener		
R15	10k	R45	220k	C15	100n	D3	1n914		
R16	10k	R46	220k	C16	330pF	D4	LED		
R17	10k	R47	4k7	C17	1uF	<b>Transistors</b>			
R18	10k	R48	1k	C18	1uF	Q1 – Q4	MPSA18		
R19	82k	R49	1k	C19	10uF	<b>I.C.</b>			
R20	4k7	R50	1k	C20	1uF	IC1	LF353		
R21	100k	R51	1k	C21	1uF	IC2	NE570		
R22	100k	R52	100R	C22	2n2	IC3, IC4	BBD		
R23	5k6	R53	10k	C23	33n	IC5	CLOCK		
R24	5k6	R54	10k	C24	1n	IC6	TL062		
R25	4k7	R55	***	C25	39n	<b>Timmers</b>			
R26	82k	R56	***	C26	330pF	CANCEL	10k		
R27	***	R57	4k7	C27	1uF	CLOCK	1M		
R28	100k	R58	100k	C28	220n	BIAS1	25k		
R29	100k	R59	100k	C29	100pF	BIAS2	25k		
R30	10k			C30	1uF	T1	50k		

R27, 55 and 56: see notes

## Shopping List

Value	QTY	Type	Rating	Value	QTY	Type	Rating
100R	1	Metal / Carbon Film	1/4W	1N5817	1		
150R	1	Metal / Carbon Film	1/4W	8.2v Zener	1	(for MN/v 3205 BBD)	1W
1k	4	Metal / Carbon Film	1/4W	1n914	1		
4k7	4	Metal / Carbon Film	1/4W	LED	1	diffused, any color	3 or 5mm
5k6	3	Metal / Carbon Film	1/4W	MPSA18	4	or, 2N5088, 2N3904	
10k	20	Metal / Carbon Film	1/4W	LF353	1	or, TL072	
18k	1	Metal / Carbon Film	1/4W	NE570	1	or, SA571	
20k	1	Metal / Carbon Film	1/4W	BBD	2	* see notes on BBD	
22k	1	Metal / Carbon Film	1/4W	CLOCK	1	* see notes on Clock	
47k	5	Metal / Carbon Film	1/4W	TL062	1	or, TL072	
82k	2	Metal / Carbon Film	1/4W	10k	1	Bourns 3362P	
100k	9	Metal / Carbon Film	1/4W	1M	1	Bourns 3362P	
220k	2	Metal / Carbon Film	1/4W	25k	2	Bourns 3362P	
470k	1	Metal / Carbon Film	1/4W	50k	1	Bourns 3362P	
1M	1	Metal / Carbon Film	1/4W	VTL5C/3	1	* see notes on modulation	
100pF	5	Ceramic	25v min.	On/Off/On	1	Solder Lug	
330pF	2	Ceramic	25v min.	1MB	1	PCB Right Angle	16mm
470pF	1	Ceramic	25v min.	100kB	1	PCB Right Angle	16mm
1n	1	Film	25v min.	50kB	2	PCB Right Angle	16mm
2n2	1	Film	25v min.	100kC	1	PCB Right Angle	16mm
6n8	3	Film	25v min.				
10n	1	Film	25v min.				
33n	1	Film	25v min.				
39n	1	Film	25v min.				
47n	1	Film	25v min.				
100n	3	Film	25v min.				
220n	3	Film	25v min.				
1uF	9	Film	25v min.				
1uF	2	Electrolytic	25v min.				
10uF	4	Electrolytic	25v min.				
22uF	1	Electrolytic	25v min.				
47uF	1	Electrolytic	25v min.				
220uF	1	Electrolytic	25v min.				

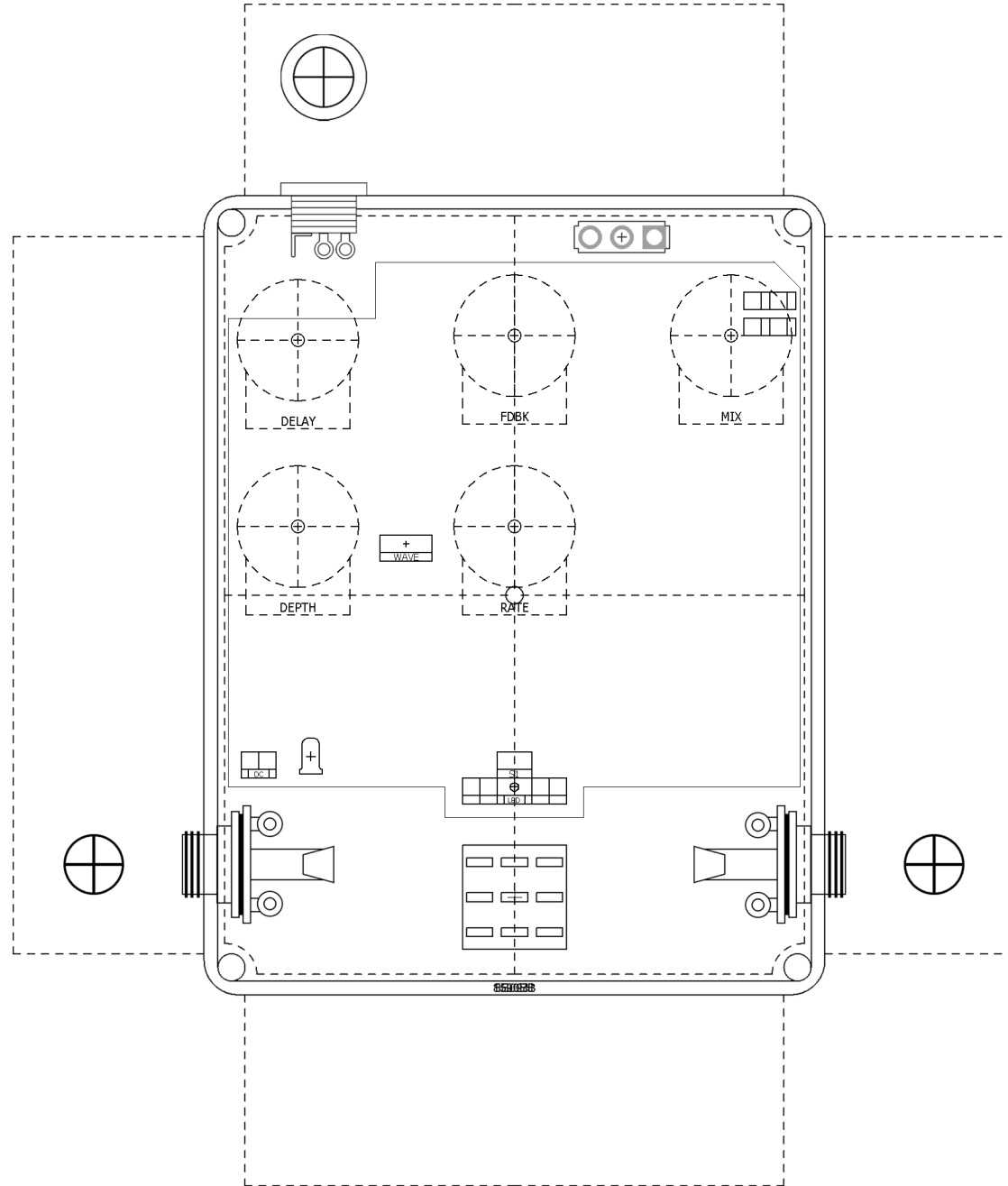


# AQUABOY DELUXE

based on the Boss DM-2 (tm) 2015 ed. (c) madbeanpedals

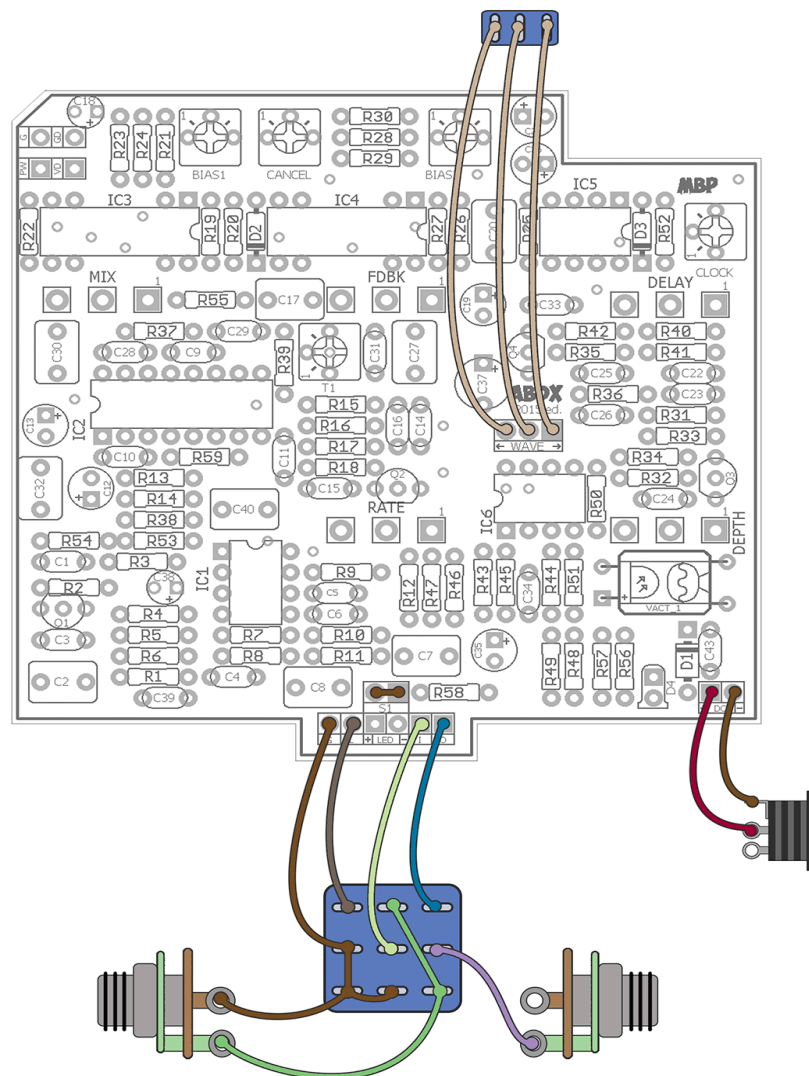
# 1590BB Drill Guide – 5.8" W x 6.83" H

Download the Photoshop template here: [http://www.madbeanpedals.com/projects/Aquaboy/docs/ABDX2015\\_DRILL.zip](http://www.madbeanpedals.com/projects/Aquaboy/docs/ABDX2015_DRILL.zip)



## True Bypass Wiring

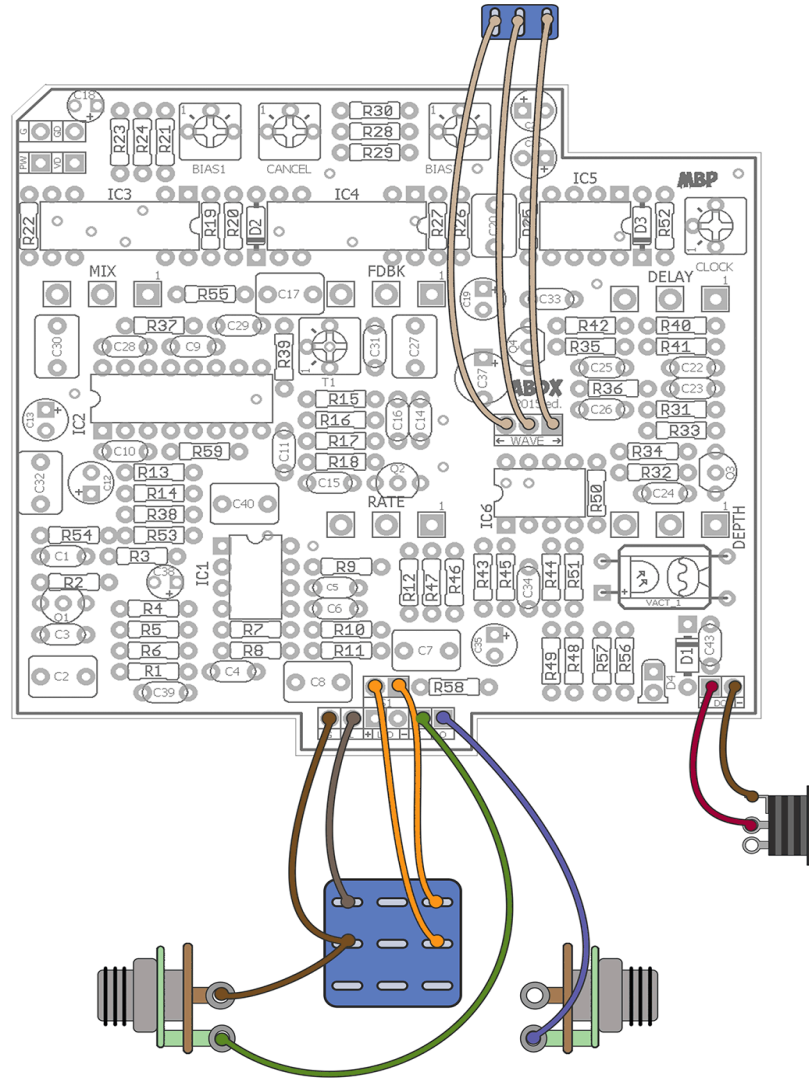
Jumper the two "S1" pads. Omit R58, R59 and jumper C40 instead of using the 1uF cap listed.



*The bypass LED and D4 (LFO rate indicator) can be mounted directly to the PCB.*

## Tails Wiring

*This option has been added but is not yet tested on this project. I have used this bypass on similar projects so it should work fine.  
Note that Tails wiring is not true-bypass.*



*The bypass LED and D4 (LFO rate indicator) can be mounted directly to the PCB.*

The **Aquaboy Deluxe** (ABDX) is a “feature expansion” version of the original madbeanpedals Aquaboy project. The ABDX is based on the classic DM-2 analog delay with the addition of dual delay BBDs (for twice the delay of a DM-2), delay modulation and the ability to use several different types of bucket brigade devices.

Improvements to the original Aquaboy design have been made in the area of power supply filtering and layout. Even though the PCB is densely packed, it should be a relatively easy build for the experienced stompbox maker. The PCB will fit comfortably in a 1590BB enclosure.

This is complex project that should not be under-taken by novice builders. It requires considerable effort in biasing and at least some tinkering to tailor it to the builder’s needs. It is also a costly project to realize. Aside from the cost of the PCB itself, the BBD chips can run anywhere from \$7 to \$80 for a pair (depending on what type of BBD technology you use). However, this is also the type of project where money spent will go a long way toward making a unique and professional delay AND still be cheaper than most commercially available analog delays out there. Indeed, there are very few true analog delays with 500ms of delay and modulation that are under \$200.

### Controls

**DELAY** – The total amount of signal delay from slapback to approximately 500ms.

**FDBK** – The number and intensity of delay repeats from one to infinity/self oscillation.

**MIX** – The level of delay signal relative to the dry path of the guitar signal.

**RATE** – The speed of the delay modulation from slowest to very fast.

**DEPTH** – The intensity of modulation from moderate to extreme.

**WAVE** – This On/Off/On SPDT allows you to choose between triangle wave, none and square wave modulation.

### Trimmers

**T1** – Sets the maximum amount of feedback possible in order to control the total range of the FDBK control.

**BIAS1, BIAS2** – Used to set the biasing point on the input of each BBD.

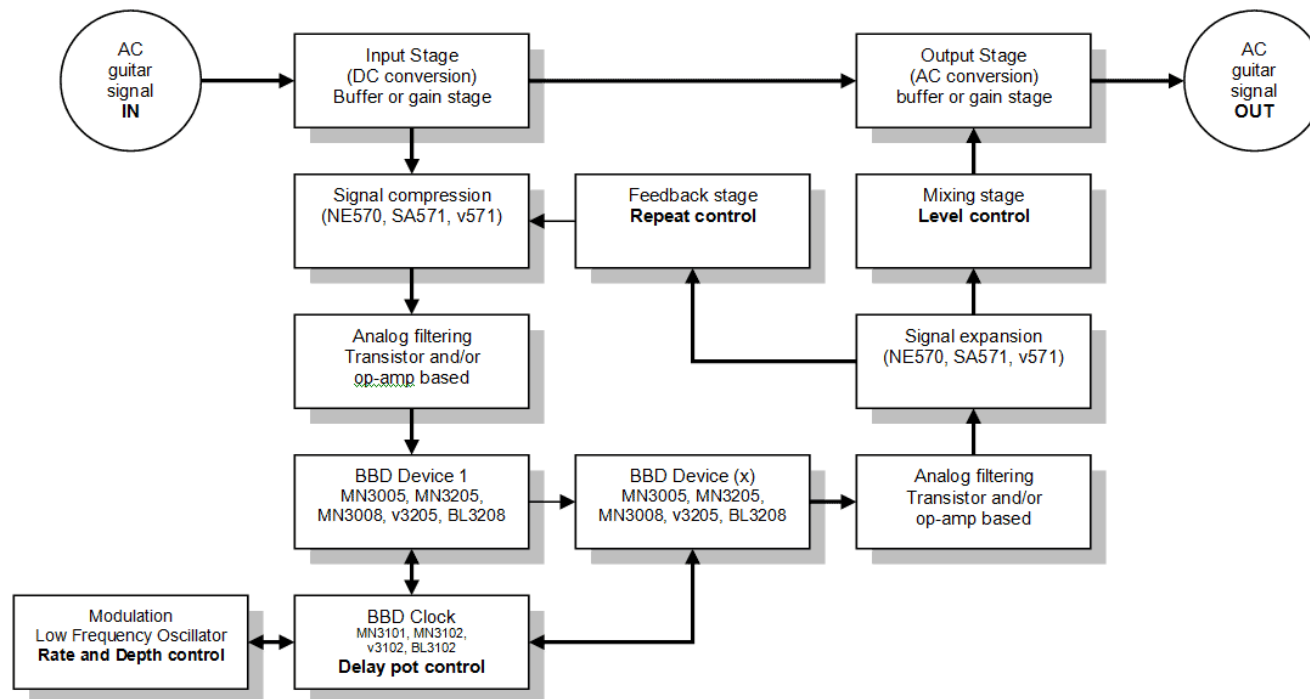
**CANCEL** – Sets the mix of the two outputs on BBD2.

**CLOCK** – Sets the lower limit of the clock frequency used to drive the BBD chips.

### Changes to the 2015 edition

1. Layout tweaks. Relocated I/O pads to the bottom center of the PCB.
2. Added an optional “Tails” bypass which allows delay repeats to spillover when the delay is bypassed.
3. Relocated R55 and R27 before the two 82k biasing resistors rather than after.
4. Relocated BBD jumper pads where they can more easily be changed after-the-fact.
5. Updated PCB to 2015 Eagle library.





**All analog delays have two essential ingredients: the bucket brigade device and the clock**

The BBD is made up of hundreds or thousands of tiny mosfet transistors (called steps) that delay the input signal via capacitive charging (each step may also be referred to as a clock cycle). The more steps in the device the longer the signal can be delayed. This delay is measured in milliseconds.

The clock outputs a continuous square wave at a specific frequency. This frequency instructs the BBD as to the rate at which its steps “catch and release” the signal. The clock (which actually outputs two frequencies 180° out of phase) can also be altered over a range to change the rate at which the BBD processes the signal. It is this range that changes the delay signal from short to long.

This type of design has two major caveats: the clock generally operates on a frequency that is within the human range of hearing and the signal processing of the delay degrades the input signal continuously. The lower the clock frequency, the more delay you get, but the further it creeps into the audio range.

Analog delays attempt to optimize the balance between signal degradation and clock bleed by a series of additional signal processing chains. These are compression, filtering and expansion. The compressor portion “beefs up” the incoming signal to minimize its degradation while traversing the BBD. The filtering removes some of the high end content so that the clock does not bleed into it (which would create a high pitch whine). Finally the expander portion “de-compresses” the processed signal and gets it ready for the output mixer.

This entire process is also responsible for creating the “magic” and “mojo” of the analog delay. That magic is warmth. The continuous filtering of the guitar signal removes more and more high end frequencies with each repeat which the ear perceives as warmth in the resulting guitar signal. This is why people like analog delays so much---they create a very pleasing “bed of sound” that is neither too piercing nor distracting. Each analog repeat fits neatly under the preceding one to create a very natural and musical sound.

### There are several types of BBDs and Clocks that work with the ABDX

The ABDX accepts different types of BBDs and their clock counterparts. The following chart illustrates the advantages and disadvantages of each. Note that the Clock type does not contribute to the pros/cons. They are simply the appropriate chips to use in each circumstance.

<b>BBD</b>	<b>Clock</b>	<b>Steps</b>	<b>Pros</b>	<b>Cons</b>
MN3005	MN3101	4096	Best sounding. Can run at up to 15v for added headroom	Out of production, rare, hard to find (up to \$80 for a pair)
MN3205	MN3102	4096	Also great sounding. Lower current consumption than the MN3005	Out of production, rare, hard to find. Requires lower voltage to operate.
MN3008	MN3101 or MN3102	2048	Sounds every bit as good as the MN3005. Can be run up to 15v (MN3101 only).	Out of production, rare, hard to find. Half the delay time of the MN3005.
BL3208B	BL3102	2048	Very good alternative that is currently in production. Low current consumption. Used by EHX for some of the modern DMM.	Half the delay time of the MN3005, MN3205 and v3205.
V3205	V3102	4096	Cheap. Same delay time as the MN3005.	Worst sounding. Lower headroom than the BL3208B even when operated at nearly the same voltages.

This chart pretty much explains the order in which you should choose your BBD type from top to bottom. If you can find the MN3005 and afford it, then use it. If you are limited to current production chips, then choose between the superior sounding BL3208B with half the delay time or the inferior v3205 that will give you a full 500ms of delay from the ABDX.

Please keep in mind that these evaluations are in degrees, not absolutes. IOW, it is entirely possible to build the ABDX with the v3205 to get the max delay and still get a very acceptable amount of fidelity (the design has mods to help with this). It's just never going to sound as good as the MN3005 running at 15v, period.

The great thing about the ABDX is that you can change the chips out at will simply by changing two jumpers on the board. So, you might build it with a BL3208B or v3205 now, and then replace them with the MN3205 or MN3005 later if you are able to source them. It's that simple (you will have to re-calibrate the delay when doing so).

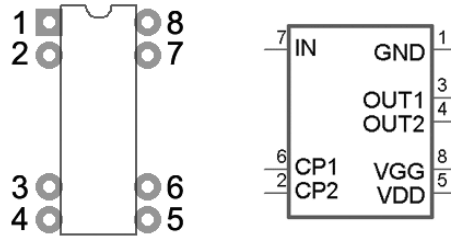
Note: I have not personally tested the MN3205 with the Aquaboy for the simple reason that I have never found any legitimate chips. I have tested all other configurations.

### A word about sourcing BBD chips

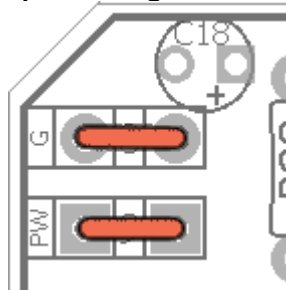
Whenever you try to locate and purchase out of production chips like the MN3005 and MN3205 you are running the risk of getting ripped off, either through malice or ignorance on the seller's part. There are a lot of fake chips out there and quite a few sellers that make a living by selling counterfeits to hapless gear geeks like us. So, use caution. Don't just throw money down the toilet at whatever Asian eBay seller claims to have a true MN3005 because most likely it is a fake. Rather, if you want to get these chips, ask around on trusted forums. There are some fellow DIY'ers that may be willing to part with some of their stash from time to time or point you toward a reliable source. It takes time but it's also worth the effort.

### Setting the jumpers

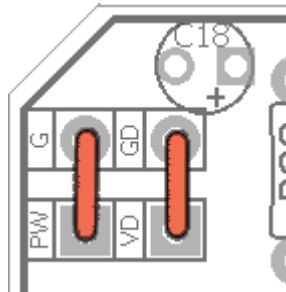
You need to set two jumpers on the ABDX PCB in order to deliver the correct power and ground. The different BBD types require these on specific pins and they are different between devices.



**The MN3005 and MN3008 require power on pin 1 and ground on pin 5. Set the jumpers on the PCB like this:**



**The MN3205, v3205 and BL3208B require power on pin 5 and ground on pin 1.**



*Setting these jumpers also changes whether the output resistors on the BBD (pins 3 and 4) are pull-up or pull-down. Again, these will be different between the two groups of devices.*

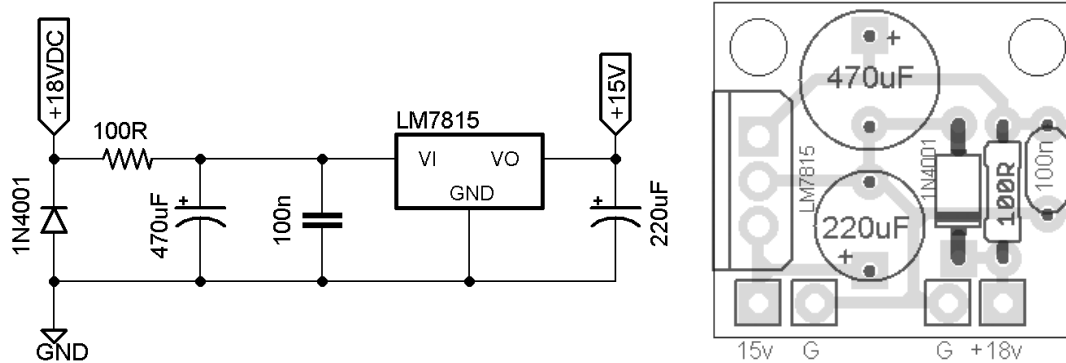
**NOTE:** If you build the ABDX for one type of device and then later put in a different type you may have to switch the jumpers and/or the voltage supply depending on which group they fall under. You will also need to re-bias the BBDs if they are switched.

## MN3005 / 3008 Power Supplies

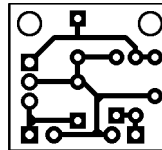
MN3005 and MN3008 can be run at 9v, 12 or 15v DC. 15v operation is recommended however it must be regulated as this is max power supply these devices can handle. When running 12 or 15vDC, you must use the MN3101 clock. For 9v operation, use the MN3101 for the MN3005 and MN3102 for the MN3008.

If you are running the ABDX at 15v regulated, then you should plan ahead how you will accomplish this. You can use a Road Rage PCB to use a 9v supply to generate 15v regulated (using the LT1054 chip) or use an 18v adaptor then run it through a 15v regulator (220 type). Consult the Road Rage documentation for more info on using a charge pump.

To regulate an 18v supply, this method is suggested.



85"W x .78" H



When using this board or a charge pump supply, you should jumper D1 on the ABDX PCB.

### MN3205 / BL3208B / v3205 Power supplies

The power requirements for the MN3205, BL3208 and v3205 are slightly different. The MN3205 and v3205 are usually run at about 8.2v whereas the BL3208 can run up to 10v. I recommend using a 9v power supply for these devices. For the MN3205 and v3205, use an 8.2v Zener for D2. This will limit the BBD power (VD) to about 8v or so. For the BL3208, omit D2. D2 should also be omitted for the MN3005 and MN3008.

### Clocks

MN3101 - This clock can be used with the MN3005, MN3008 and v3205 (not recommended). It allows you to run the ABDX at 15v with the MN3005 and MN3008. While you can use it with the v3205, there is no advantage to it since you must run the ABDX at 9v in this case. **NOTE: if you are using the MN3101 with the v3205, you must use D3 to approximate the correct Vgg voltage for pin8 of the clock (14/15 of Vdd). In all other cases (including when using an MN3102, BL3102 or v3102) you should omit D3.** The 3102 clocks automatically generate the correct Vgg voltage needed in each case.

MN3102, BL3102, v3102 – Any of these should work with the MN3008, BL3208 and v3205. *I do recommend using the one that matches the device you are using.* IOW, with the MN3008, use the MN3102 (remember you cannot run the ABDX at 15v with this option), the BL3208B uses the BL3102 and the v3205 uses the v3102.

BBD	Recommended Clock	Recommended Compaander
MN3005, MN3008	MN3101	NE570, SA571
BL3208B	BL3102	NE570, SA571
V3205	V3102	NE570, SA571, v571

### Modulation

The modulation section is a tweaked version of the Mod board for the original Aquaboy project. It uses an LFO to generate either triangle or square wave modulation which drives an LED/LDR combo. The LDR combines with the Depth pot to create a variable resistance to ground from lug 1 of the Delay control. As the LED brightness fluctuates, the resistance on the photocell goes up and down which creates an oscillating change on the overall delay time. This can go up to fairly extreme settings. **To tweak the overall range/intensity of the LFO further, you can use a large resistor (R56) in parallel with the LDR/Depth control.** You should socket this component and try different values ranging from 220k – 1M5 for experimentation. 470k is a good starting point.

Because of the R56 mod, a variety of LED/LDR combinations can be used. A VTL5C3 is pretty standard for this type of modulation control, but is also quite expensive. If you want to make your own vactrol, a photocell ranging from 1M to 5M dark resistance should work fine. The LED can be a 3mm or 5mm red diffused. You should shield the LED/LDR combo with some heat shrink or at least block external light from it when testing your build. *When building the 15v/MN3005 version of the ABDX, use 8k2 resistors for R50 and R51. This will help reduce the added brightness of the vactrol's internal LED due to the higher voltage supply.*

D4 is meant to be an external indicator of the rate of the LFO and should be mounted to the enclosure like any LED indicator. It is optional and not necessary to the function of the modulation.

2019 Note: If you run the ABDX at 15v for the MN3005 configuration, changing R43 and R44 to either 220k or 470k will increase the overall depth of modulation.

## Reducing Distortion

R55 and R27: These are two series resistors at the input of each BBD. Their purpose is to provide some signal limiting when using the v3205 BBD. This should help reduce distortion on the delay repeats which is a common problem with this particular device. You should definitely socket both of these components. I suggest a value of 100k for R55 and 470k for R27.

R55 and R27 are not needed when using the MN3005, MN3008 and BL3208. You can either jumper them or just stick a 1k in each spot.

R13 and R14: This resistor pair sets the output level of the compressor portion of IC2. Larger values result in a larger bias value on pin7 (the output). When using a 9v supply, they should be 10k. When using a 15v supply, use either 36k or 39k. Larger values here tend to have a positive effect on the overall headroom, but if they are too large and it will cause unwanted distortion on the signal.

## Calibrating the Delay

### *Make the following adjustments before beginning*

- Delay, Mix controls to their center position.
- FDBK at about 1/3 up.
- Rate and Depth controls all the way down.
- Wave switch to the center (off) position.
- BIAS1, BIAS2 and Cancel trimpots to their center position.
- If you have frequency measurement on your DMM, adjust the Clock trimmer to about 6.5kHz while probing either pin2 or pin4 of IC5. If you don't have this feature set the Clock trim half-way up.

Remove IC4 temporarily. Audio probe pin3 of IC3 while either strumming the guitar or send some audio through the input of the circuit. Adjust the BIAS1 trimmer until you get delay passing. The range over which the trimmer will result in delay is usually about 1/4 to 1/6 of its entire rotation. Continue refining the position of BIAS1 until you get the lowest amount of distortion on the delay signal. Now probe pin4 of IC3 to confirm it is also passing delay. If it does not, make sure that you have clock frequency on both pins 2 and 6.

Replace IC4. Repeat the same procedure above by audio probing pin3 and adjusting BIAS2 for the lowest amount of distortion on the repeats. Confirm that pin4 is also passing delay.

Set the Delay pot to Max. Now finely adjust the CLOCK trimmer until just before you hear any high pitch whine in the audio path. This is the maximum delay setting. The clock frequency should land somewhere between 6 and 7 kHz.

Leave the Cancel trim in the center position. Set T1 fully counter-clockwise. Now set FDBK fully clockwise. Adjust T1 until you get self-oscillation with the repeats.

If you do have a scope, you can use it instead of an audio probe to make the proper adjustments to BIAS1, BIAS2, Clock and the Cancel trimpots. When using a scope, set the Cancel trimpot so that the two output waveforms from pins 3 and 4 of IC4 converge.

## Troubleshooting

Problem	Solution
No delay, no dry audio	Check your wiring and make sure the ADBX is receiving power. Audio probe pins 1 and 7 of IC1 to see where the dry audio drops out.
Dry audio, but no delay	Audio probe pin7 of IC2 to confirm that the compander is working.  Probe pin7 of IC3 to confirm that the first BBD is receiving signal.  Confirm that you have set the jumpers properly for the BBD set you are using and that pins 1 and 5 of each BBD are receiving power/ground appropriate to that device.
Max delay is too short	Using your DMM, measure the resistance across lugs 1 and 3 of the Delay pot. If it reads under 1M, considering replacing it with a pot closer to spec.  Confirm that C33 is actually 100pF ( <b>note ceramics can vary widely so a Mica might be a good choice</b> ). Replace with a slightly larger cap like 120pF to increase max delay. This may require re-calibration of the delay, however.

### Final notes

- You can use 16mm short pin PCB mounted pots mounted underneath the PCB. However, I recommend against this unless you plan on building quite a few of these. You may find that you need to remove a component or do some work underneath the PCB after you build it to troubleshoot. Having wired pots instead of PCB mounted ones will make this MUCH easier.

**The trim pots are spaced for Bourns 3362P, which are about .25" on a side.**

- 10k: <http://www.mouser.com/ProductDetail/Bourns/3362P-1-103LF/?qs=sGAEpiMZZMvygUB3GLcD7k%252bod3ZqvEIQboRRPdOKB6M%3d>
- 50k: <http://www.mouser.com/ProductDetail/Bourns/3362P-1-503LF/?qs=sGAEpiMZZMvygUB3GLcD7vRbQqL9uMLMZgtO2Ks3Q%2f4%3d>
- 1M: <http://www.mouser.com/ProductDetail/Bourns/3362P-1-105LF/?qs=sGAEpiMZZMvygUB3GLcD7kddhVJPyV2kST8Lo8GI%252b%2f8%3d>
- 25k: <http://www.mouser.com/ProductDetail/Bourns/3362P-1-253LF/?qs=sGAEpiMZZMvygUB3GLcD7vRbQqL9uMLMqIpepdvvyRc%3d>

Last but not least: **DON'T BOX IT UNTIL IT'S READY!** Seriously! Don't even dream of trying to put this in an enclosure until you fully calibrate, test and debug your build. This is a very complicated build and chances are you may run into one small problem or another.