BUILD YOUR OWN DS-1 DISTORTION

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CREDITS

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Special thanks to the following who helped make this document possible:

1) Aron Nelson and everyone else on diystompboxes.com forum.
2) Robert Keeley for making information on his DS-1 "Seeing Eye" and "Ultra" mods available to the public.
3) Jack Orman for his "More Saturation Controls" article, along with the plethora of information he's shared with the DIY pedal community.
4) R.G. Keen for generously sharing his vast knowledge and patience with us all.

DISCLAIMER

The information in this document is accurate to the best of the authors' knowledge. While we've done our best to get all the details correct, there are no warranties or guarantees express or implied regarding its accuracy. This information is provided for reference purposes only, which essentially means that if you blow up your DS-1 while modifying it, burn yourself on a soldering iron while trying to build a pedal based upon these instructions or fall victim to some other misfortune after reading this information… it's your fault, not ours.

If you are having problems with your DS-1 mod or DS-1 replica build, please visit the diystompboxes.com forum and use the Search feature to see if the problem you're experiencing has been previously solved by others. If not, please read this page before posting for help in the forum. By doing this, you may solve the problem yourself before posting…and if not, you'll be communicating in a manner that will allow the other members of the forum to help you more readily.

CONTENTS

INTRODUCTION

Have you ever wanted to build your own DS-1 Distortion, but could only find work-a-likes, schematics for the pre-1994 “vintage” DS-1 or just plain inaccurate schematics on the Internet? If so, then this document is for you. We’ll give you the information you need to build a version of the DS-1 distortion that matches the exact circuit used by the large Japanese manufacturer of the original post-1994 DS-1 Distortion (with the exception of replacing the SIP-8 dual op amp layout with a DIP-8 dual op amp layout.)

Please be advised that both of the DS-1 layouts in this document are a bit more complicated than your average beginner-level project. Please consider the following factors and honestly assess your skill-level before you begin building this project:

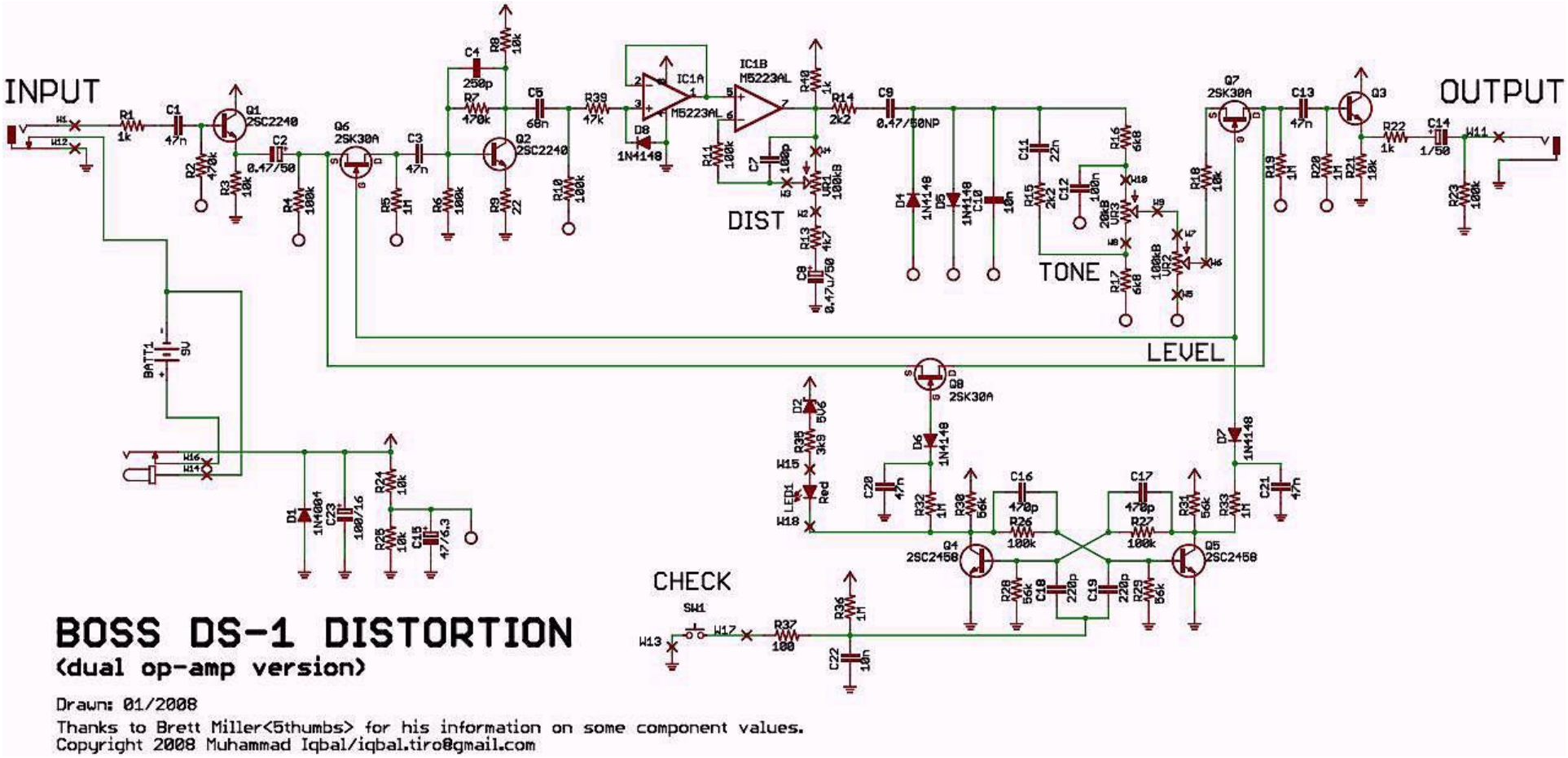
1. The component count is higher than a booster/overdrive/simple distortion (like the MXR Distortion+), which means more places to have to trouble-shoot in the event of a failure.
2. The component spacing is rather tight on both layouts, so you will need to solder with care to avoid creating short-circuits via solder bridges.
3. If you attempt to build the “Stock DS-1 Distortion”, you will be working with JFETs in the flip-flop switching circuitry. Multiple JFETs often need to be tested and grouped to get a set of individual JFETs that will work as desired in the circuit. The topic of JFET matching is beyond the scope of this document, but if you wish to learn more about this topic, please read more about it over at GEOFEX.

Given these factors, I’d rate the difficulty of this project as INTERMEDIATE. This means it is probably not a good idea for your first pedal build, but it will not be overly-difficult if you take your time and carefully assemble the pedal with the knowledge and skills you’ve developed in your previous pedal building experience.

BUILD A STOCK DS-1 DISTORTION

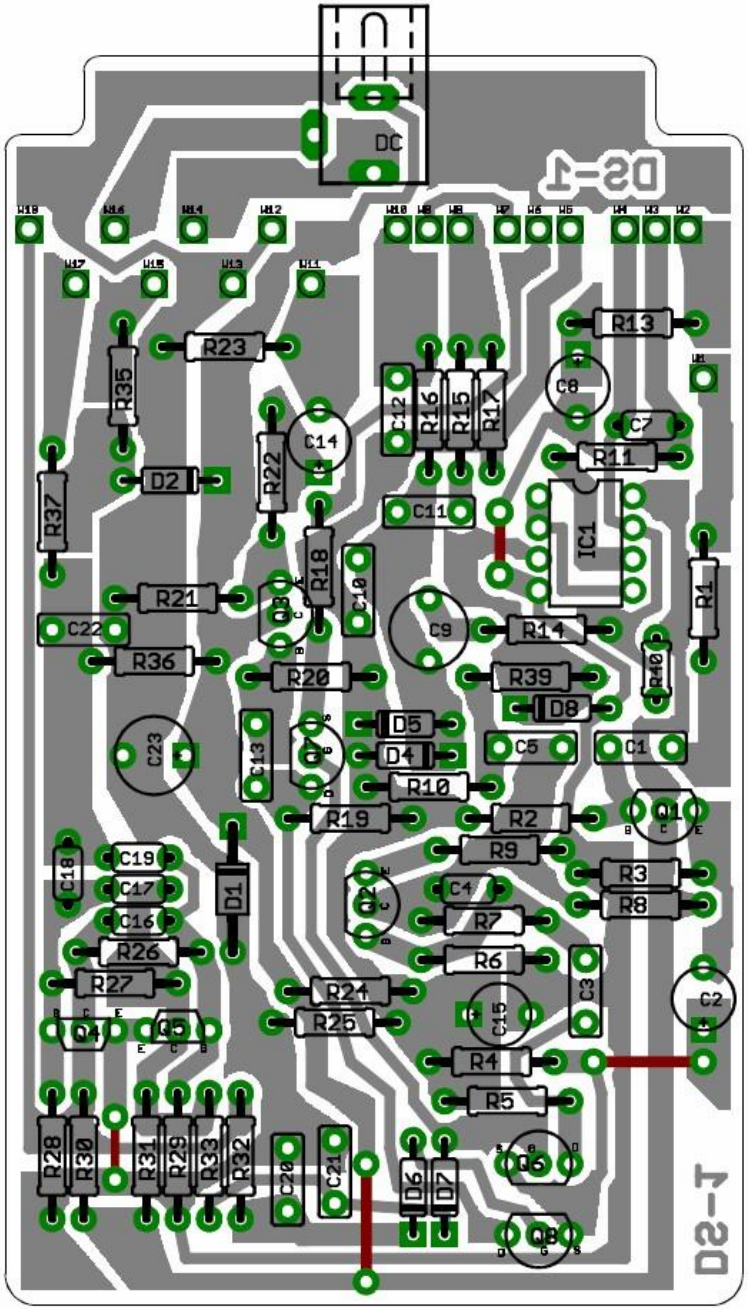
This schematic was reverse-engineered by Muhammad Iqbal from images of actual DS-1 circuit boards. All components in the schematic below are labeled with the same labels as the commercially-produced product, so if you find new DS-1 mods on the Internet that reference component numbers on the commercially-produced DS-1, they will be applicable to this circuit as well. This schematic includes all of the components from the original DS-1 board, including input and output buffers, as well as the switching circuitry.

This layout has been built and verified as successful by Muhammad Iqbal.



The layout below is designed to fit into a BOSS-style pedal enclosure, but may also be fit into a 1790-style enclosure.

Component Layout (enlarged):



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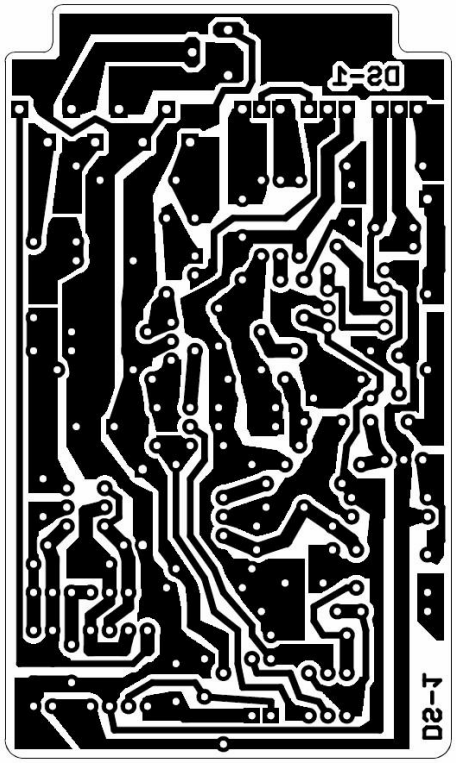


Stock DS-1 Layouts by: Muhammad Iqbal

Stock DS-1 Connections:

W1	– Input	W13	– Effect Switch, SPST Momentary
W2, W3, W4 (VR1)	– DIST Control, 100KΩ Linear Potentiometer	W14	– Board to Input Jack Ring, then Battery Negative (-)
W5, W6, W7 (VR2)	– LEVEL Control, 100KΩ Linear Potentiometer	W15	– +9V to LED (+)
W8, W9, W10 (VR3)	– TONE Control, 20KΩ Linear Potentiometer	W16	– Battery Positive (+)
W11	– Output	W17	– Effect Switch, SPST Momentary
W12	– Ground to Input Sleeve	W18	– Power return from LED Negative (-) to flip-flop switching circuit

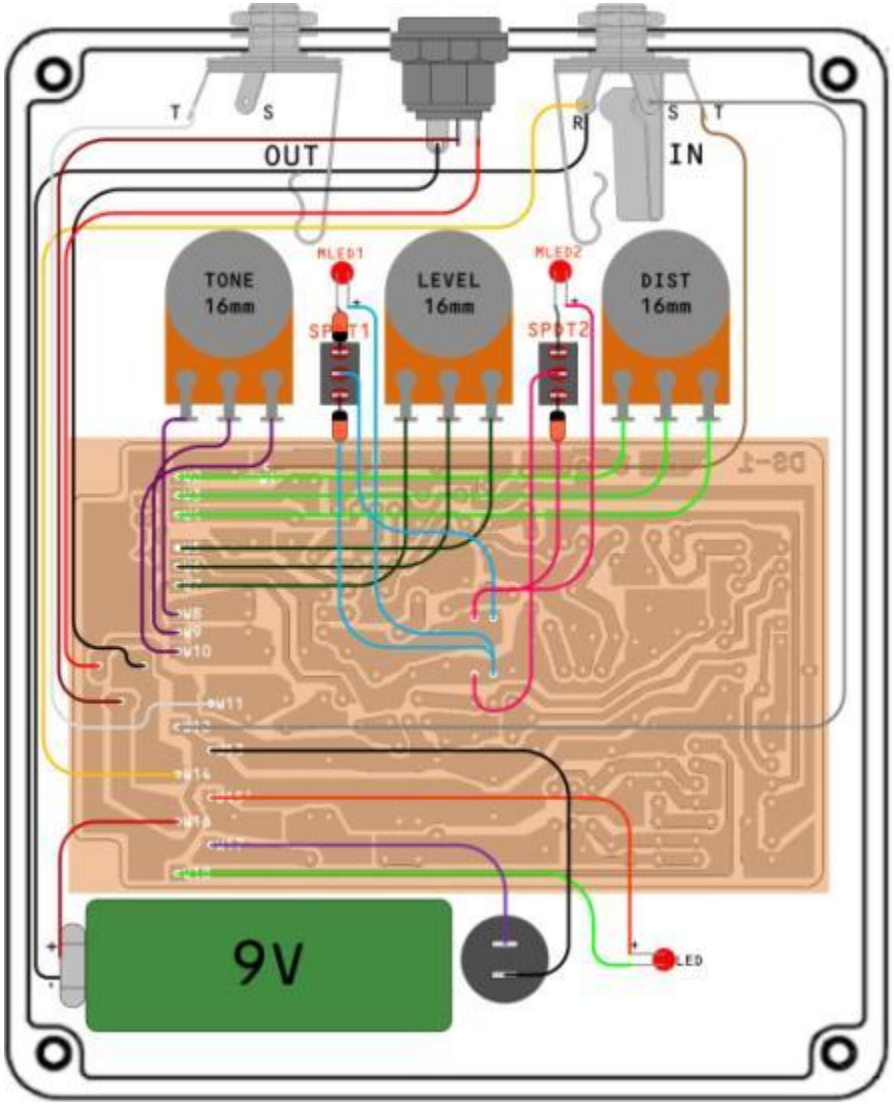
Stock DS-1 Parts List:

C1 – 0.047µF	R1 – 1KΩ	R25 – 10KΩ	Q1 – 2SC2240*	*2N5088 transistors may be used in place of 2SC2240 transistors. You will need to orient the pins differently, as the 2SC2240 are B-C-E and 2N5088 are C-B-E.
C2 – 0.47µF/50V	R2 – 470KΩ	R26 – 100KΩ	Q2 – 2SC2240	
C3 – 0.047µF	R3 – 10KΩ	R27 – 100KΩ	Q3 – 2SC2240	
C4 – 250pF	R4 – 100KΩ	R28 – 56KΩ	Q4 – 2SC2458**	
C5 – 0.068µF	R5 – 1MΩ	R29 – 56KΩ	Q5 – 2SC2458	
C6 – *omitted in original*	R6 – 100KΩ	R30 – 56KΩ	Q6 – 2SK30A***	
C7 – 100pF	R7 – 470KΩ	R31 – 56KΩ	Q7 – 2SK30A	
C8 – 1µF/50V	R8 – 10KΩ	R32 – 1MΩ	Q8 – 2SK30A	** BC549 or BC559 transistors may be used in place of 2SC2458 transistors. You will need to orient the pins differently, as the 2SC2458 are B-C-E and BC549/BC559 are C-B-E.
C9 – 0.47µF/50V NP	R9 – 22Ω	R33 – 1MΩ		
C10 – 0.01µF	R10 – 100KΩ	R34 – *omitted in original*	LED1 – 3mm Red LED	
C11 – 0.022uF	R11 – 100KΩ	R35 – 3K9Ω	SW1 – SPST momentary	
C12 – 0.1µF	R12 – *omitted in original*	R36 – 1MΩ	VR1 – 100KΩ Linear Pot	
C13 – 0.047µF	R13 – 4K7Ω	R37 – 100Ω	VR2 – 100KΩ Linear Pot	
C14 – 1µF/50V	R14 – 2K2Ω	R38 – *omitted in original*	VR3 – 20KΩ Linear Pot	
C15 – 47µF/6.3V	R15 – 2K2Ω	R39 – 47KΩ		
C16 – 470pF	R16 – 6K8Ω	R40 – 1KΩ	IC1 – OPA2134PA (recommended) –or– LM358	***2N5457 transistors are somewhat close to 2SK30A transistors. You will need to orient the pins differently, as the 2SK30A are S-G-D and 2N5457 are G-S-D. If you want to purchase 2SK30A transistors, Small Bear Electronics has them.
C17 – 470pF	R17 – 6K8Ω	D1 – 1N4004		
C18 – 220pF	R18 – 10KΩ	D2 – 5.6V Zener		
C19 – 220pF	R19 – 1MΩ	D3 – *omitted in original*	NOTE:	
C20 – 0.047µF	R20 – 1MΩ	D4 – 1N4148	Mitsubishi's M5223AL SIP-8 dual op amp is used in the post-1994 DS-1 pedals. This chip is not available in DIP-8 format, so I recommend using the Burr Brown OPA2134PA or LM358 in this layout. You may try any other DIP-8 dual op amp that has the same pin-out.	
C21 – 0.047µF	R21 – 10KΩ	D5 – 1N4148		
C22 – 0.01µF	R22 – 1KΩ	D6 – 1N4148		
C23 – 100µF/16V	R23 – 100KΩ	D7 – 1N4148		
	R24 – 10KΩ	D8 – 1N4148		

Stock DS-1 Wiring:

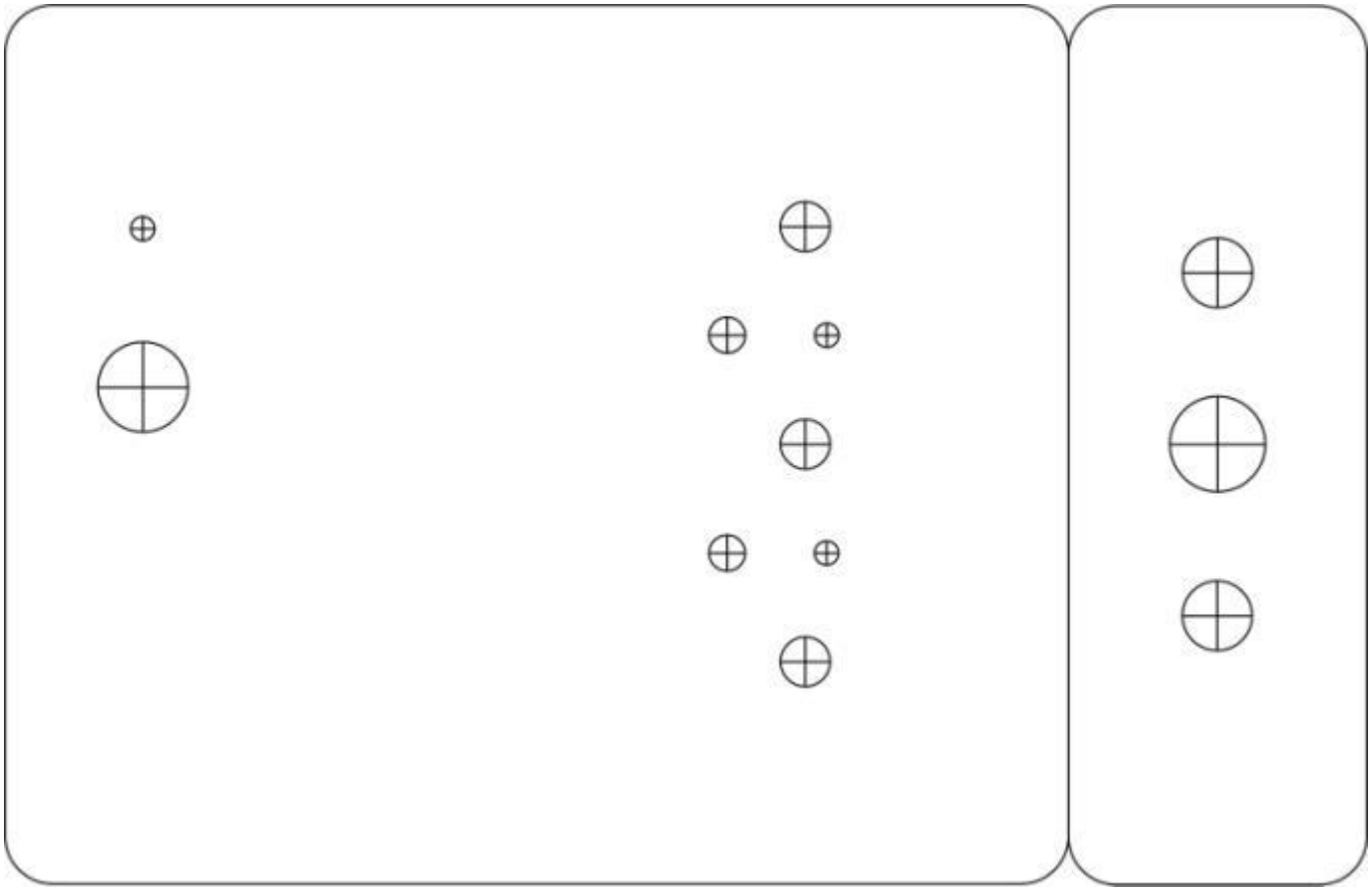
The diagram below is a 1:1 scale image of an installation of the Stock DS-1 in a 1790-style enclosure.

1:1



Stock DS-1 Enclosure Drilling Template:

Print out this page, cut out the diagram below and place it on top of your 1790-style enclosure, folding the smaller rounded rectangle over the edge and tape everything down securely. All holes are sized according manufacturer specifications. Since there are variances between hole sizes required by different manufacturers, you may need to reduce/enlarge some of the holes to fit your components. It is a good practice to purchase a dial caliper and measure the exact parts you plan to use before drilling any enclosure, but this template should work for most components available.

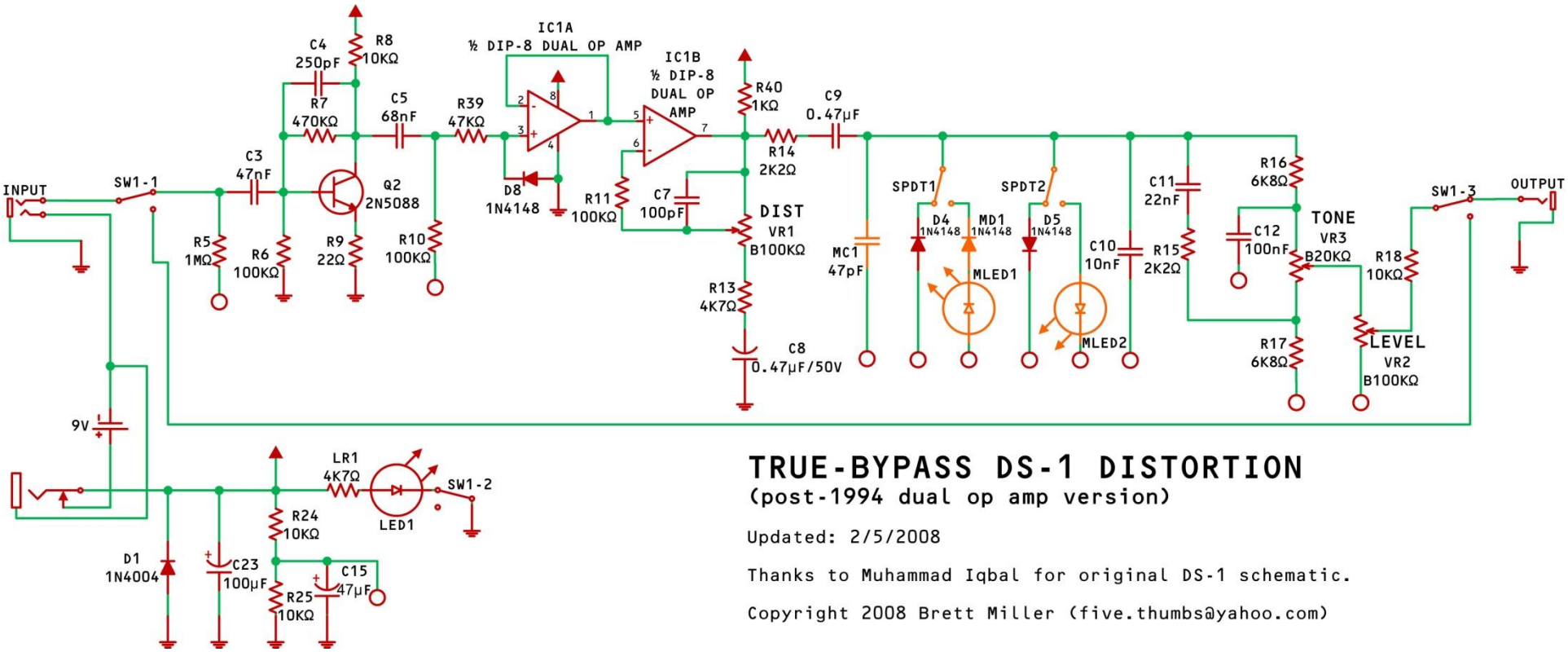


BUILD A TRUE-BYPASS DS-1 DISTORTION

This schematic was developed by Brett Miller from Muhammad Iqbal's "BOSS DS-1 Distortion" schematic. All components in the schematic below are labeled with the same labels as the commercially-produced product, so if you find new DS-1 mods on the Internet that reference component numbers on the commercially-produced DS-1, they will be applicable to this circuit as well. This schematic *does not include* all of the components from the original DS-1 board, as it removes the input/output buffers and the switching circuitry.

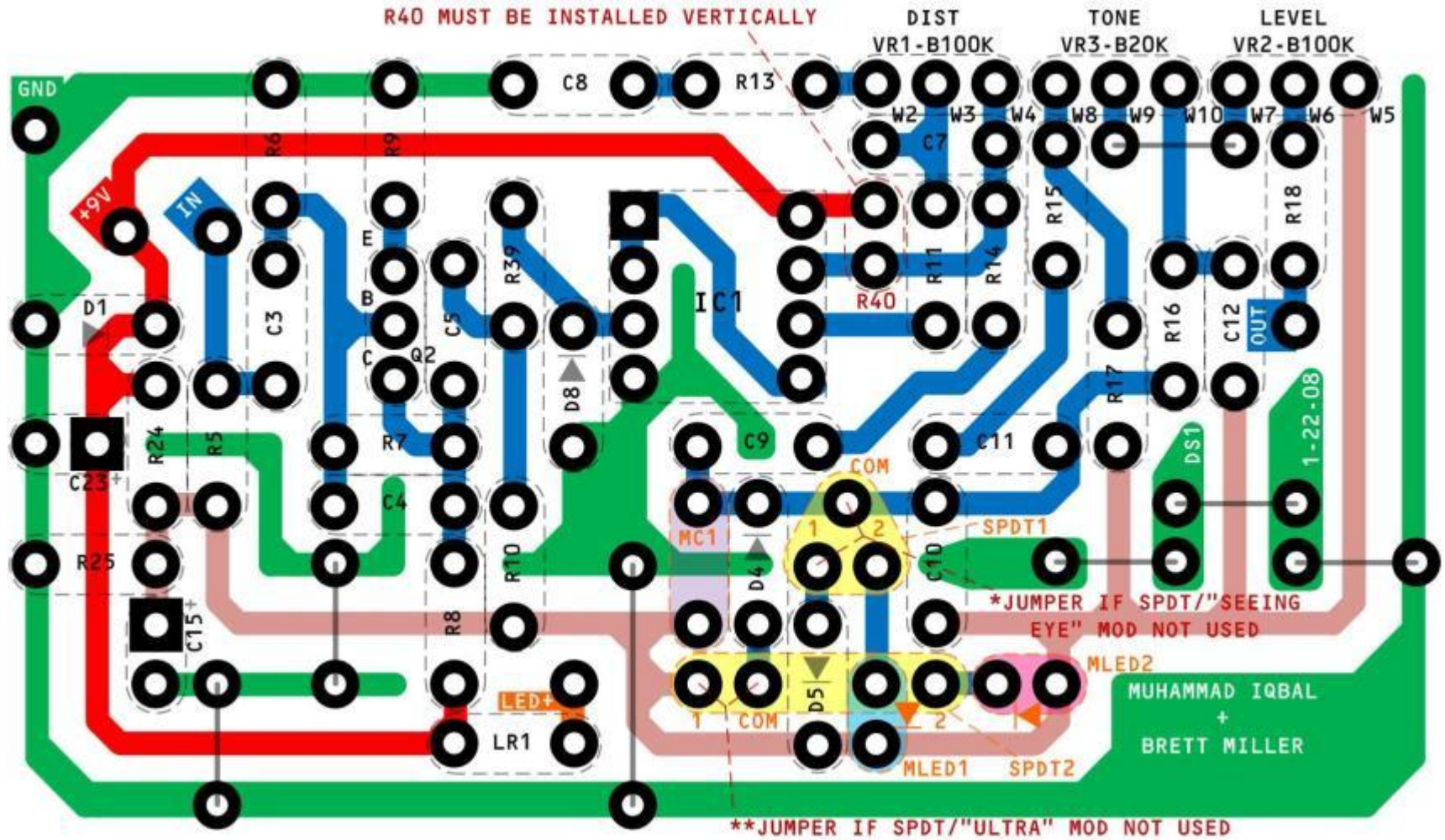
This schematic also includes Robert Keeley's "Seeing Eye" and "Ultra" mods, which are described in-depth in the "Robert Keeley DS-1 "Seeing Eye" / "Ultra" Mods" section at the end of this document. Please note that circuit components that map to the original DS-1 circuit have red lines, whereas the Keeley mods have orange lines. You can build this design with or without the Keeley mods, but if you do not include the mods, please be sure to install jumpers between the pads marked 'COM' and '1' on the SPDT1 and SPDT2, as indicated on the Component Layout. I would recommend installing the Keeley mods, as I have designed it to allow switching between either Keeley diode mod individually, or you can switch the clipping diode mods off altogether and have a nearly-stock DS-1 sound.

This layout is unverified at this time, as I've got five DS-1 pedals of various vintages and mods…and I really don't want one more. If you build this successfully, please let me know and I'll credit you as the initial build verifier in this doc.

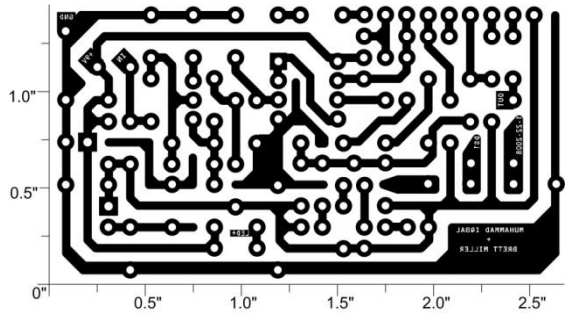


The layout below is designed to fit into a Hammond 1590BB-style enclosure.

Component Layout (enlarged):



Ready-To-Transfer:



True-Bypass DS-1 Layouts by: Brett Miller

True-Bypass DS-1 Connections:

IN	– Input	OUT	– Output
W2, W3, W4 (VR1)	– DIST Control, 100KΩ Linear Potentiometer	GND	– Ground
W5, W6, W7 (VR2)	– LEVEL Control, 100KΩ Linear Potentiometer	+9V	– +9V Input
W8, W9, W10 (VR3)	– TONE Control, 20KΩ Linear Potentiometer	LED+	– Current-limited + 9V power to status LED (LED1)

True-Bypass DS-1 Parts List:

C3 – 47nF
C4 – 250pF
C5 – 68nF
C7 – 100pF
C8 – 0.47µF
C9 – 0.47µF
C10 – 10nF
C11 – 22nF
C12 – 100nF
C15 – 47µF/6.3V
C16 – 470pF
C23 – 100µF/16V

MC1 – 47pF

R5 – 1MΩ
R6 – 100KΩ
R7 – 470KΩ
R8 – 10KΩ
R9 – 22Ω
R10 – 100KΩ
R11 – 100KΩ
R13 – 4K7Ω
R14 – 2K2Ω
R15 – 2K2Ω
R16 – 6K8Ω
R17 – 6K8Ω
R18 – 10KΩ
R24 – 10KΩ
R25 – 10KΩ
R39 – 47KΩ
R40 – 1KΩ
LR1 – 4K7Ω

D1 – 1N4004
D4 – 1N4148
D5 – 1N4148
D8 – 1N4148

LED1 – 3mm Red LED

MD1 – 1N4148
MLED1 – 3mm Red LED
MLED2 – 3mm Red LED

SW1 – 3PDT latching
SPDT1 – SPDT toggle, ON-ON
SPDT2 – SPDT toggle, ON-ON

Q2 – 2N5088*

VR1 – 100KΩ Linear Pot
VR2 – 100KΩ Linear Pot
VR3 – 20KΩ Linear Pot

IC1 – OPA2134PA (recommended) –or– LM358

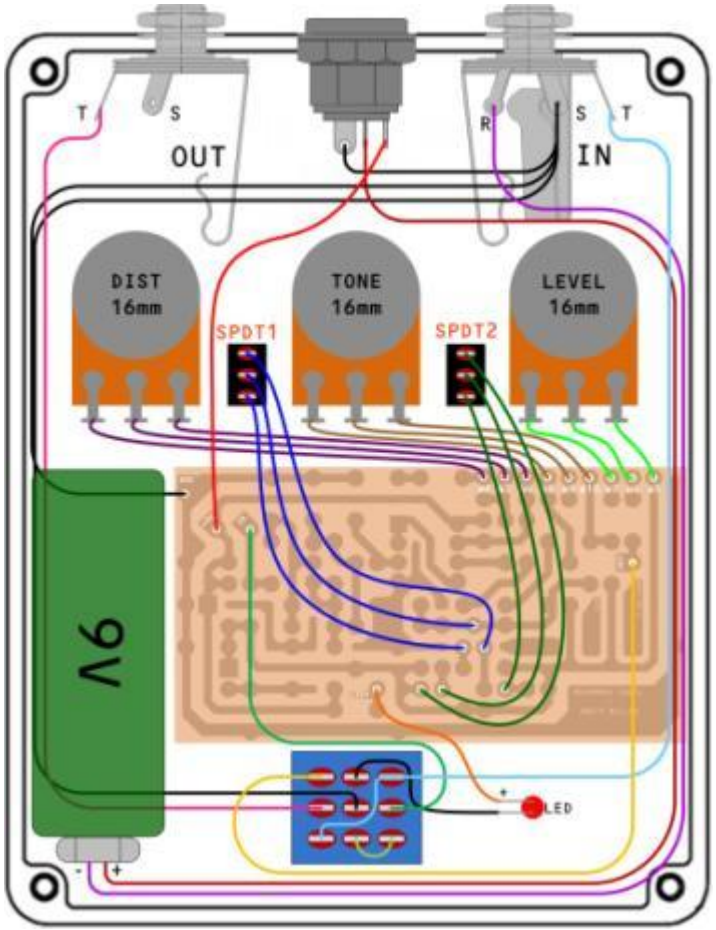
NOTE:
Mitsubishi's M5223AL SIP-8 dual op amp is used in the post-1994 DS-1 pedals. This chip is not available in DIP-8 format, so I recommend using the Burr Brown OPA2134PA in this layout. You may try any other DIP-8 dual operational amplifier that has the same pin-out as the OPA2134PA/JRC4558/TL072/ etc. In my experience modifying DS-1 pedals, the OPA2134PA sounds best and the M5223AL sounds second-best in the DS-1. The LM358 is rumored to be quite good in the DS-1 as well. The TL072/JRC4558/RC4558P all sounded dreadful to me, but let your ears be your guide!

*2SC2240 transistors may be used in place of 2N5088 transistors. I have designed this layout around the 2N5088, so if you want to use 2SC2240 as in the original, you will need to orient the pins differently, as the 2SC2240 are B-C-E and 2N5088 are C-B-E.

True-Bypass DS-1 Wiring:

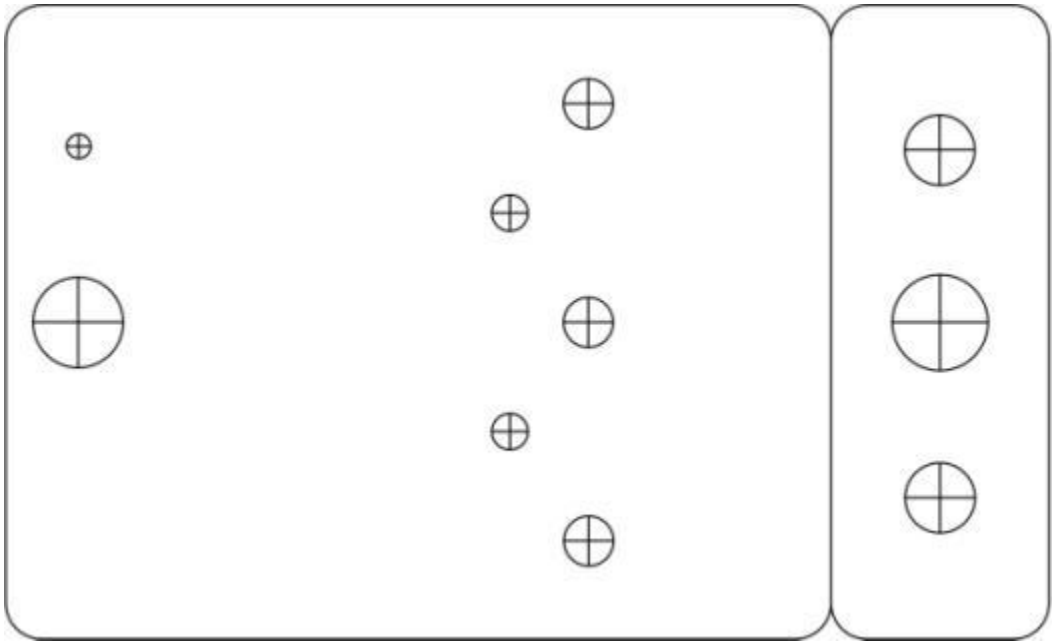
The diagram below is a 1:1 scale image of an installation of the True-Bypass DS-1 in a Hammond 1590BB-style enclosure.

1:1



True-Bypass DS-1 Enclosure Drilling Template:

Print out this page, cut out the diagram below and place it on top of your Hammond 1590BB enclosure, folding the smaller rounded rectangle over the edge and tape everything down securely. All holes are sized according manufacturer specifications. Since there are variances between hole sizes required by different manufacturers, you may need to reduce/enlarge some of the holes to fit your components. It is a good practice to purchase a dial caliper and measure the exact parts you plan to use before drilling any enclosure, but this template should work for most components available.



ROBERT KEELEY DS-1 "SEEING EYE" / "ULTRA" MODS

Robert Keeley has public information on his site about his DS-1 "Seeing Eye" and "Ultra" mods here: http://www.robertkeeley.com/audio6l6/dstech.html, which is why his mod information is included in this document.

There are other modifications you can make to your DS-1 that are too numerous to list here. Please visit the diystompboxes.com forum and search for "DS-1 mods" to find more mods for your DS-1.

Robert Keeley's DS-1 "Seeing Eye" / "Ultra" Mod:

1) Replace C1, C3, C5, C12 and C13 with 0.1µF metal film capacitors.
2) Replace C2, C8, C9 and C14 with 1µF metal film capacitors.
3) Replace C11 with 0.047µF metal film capacitor.
4) Replace C7 with a 220pF silver mica capacitor.
5) Replace R13 with a 2.4KΩ metal film resistor.
6) Replace R39 with a 20KΩ metal film resistor.
7) Replace R14 with a 1.5KΩ metal film resistor.
8) Add a 47pF silver mica capacitor in parallel to the D4/D5 clipping diodes (as illustrated below.)

This mod is soldered on the trace-side of the board, not on the component-side.

NOTE: On the "True-Bypass DS-1 Distortion" build instructions above, you do not need to solder the 47pF cap across the D4/D5 diodes as illustrated immediately above, as I have added holes/pads to the left of D4/D5 for you to add this cap as part of the "Ultra" mod.

9) *"ULTRA" Diode Mod:*

Add a 3mm red LED in series with D4. To make this mod switchable so you can choose to have the LED/D4 diode combination or just the D4 diode, you can wire an On-On SPDT toggle switch as follows:

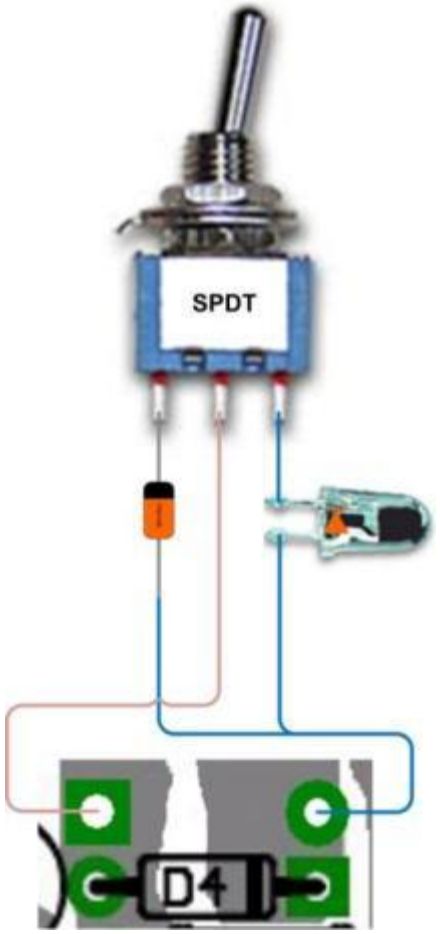
You will need one additional 1N4148 (or other diode matching the one in D4) to construct this mod as illustrated below.

NOTE: On the "True-Bypass DS-1 Distortion" build instructions above, you do not need to remove D4 and off-board wire the switch with diodes/LED as illustrated immediately above, as I have added holes/pads near D4/D5 for you to add the SPDT switch and LED as part of the "Ultra" mod.

10) *"Seeing Eye" Diode Mod:*

Replace D5 with a 3mm red LED. To make this mod switchable so you can choose to have the LED or just the D5 diode, you can wire an On-On SPDT toggle switch as follows:

You may use the original D5 diode as illustrated below.



NOTE: On the "True-Bypass DS-1 Distortion" build instructions above, you do not need to remove D5 and off-board wire the switch with diode/LED as illustrated immediately above, as I have added holes/pads near D4/D5 for you to add the SPDT switch and LED as part of the "Seeing Eye" mod.

BRETT MILLER DS-1 "MIJ" MOD

In Appendix B, I describe the major differences between the vintage, pre-1994 DS-1 and the post-1994 pedal. If you would like to understand why the components in the MIJ-Mod were selected and changed to the values below, please read that section.

The intent of this mod is to alter the post-1994 DS-1 to make it sound like the vintage DS-1. I've tested a stock DS-1 modified with the MIJ-Mod side-by-side with a genuine pre-1994, MIJ DS-1 and found the similarity in sound characteristics to be remarkable.

Mod Steps:

1. Change C7 from 100pF ceramic disc capacitor to a 250pF ceramic disc capacitor.

2. Change C8 from 0.47µF/50V aluminum electrolytic capacitor to 1uF/50V aluminum electrolytic capacitor; save the 0.47µF/50V cap for the next step.

3. Remove the 0.068µF film capacitor from C5 and replace it with the 0.47µF/50V aluminum electrolytic capacitor previously removed from C8 in Step 2.

NOTE: Tantalum capacitors are not recommended for C5 and C8. BOSS used aluminum electrolytic capacitors in these positions originally, so since we're trying to recapture the sound of the pre-1994 DS-1, I used aluminum electrolytic caps in these positions as well. Despite their somewhat bad reputation, aluminum electrolytic caps sound pretty good in these positions. I tried tantalum caps in these positions and they made the distortion sound trebly and harsh. Tantalum caps can be used in some locations in the DS-1 with positive effect (like Monte Allums does in his DS-1 mods), but they do not sound good in this mod.

Metal film caps may be used in C5 and C8, but please bear in mind that BOSS didn't use film caps for C5 and C8 in the original, so you'll be making a hybrid-of-a-hybrid and might not sound as true to the pre-1994 DS-1 sound as I have tried to achieve in this mod. I did try film caps in C5 and C8 and they did sound good, but not as close to the original as the aluminum electrolytic caps.

The same goes for using a silver mica cap in C7. Try it if you want to, but BOSS used ceramic caps in C7 in both pre-1994 and post-1994, which is why they are used in this mod.

I would strongly advise you to try this mod without mixing in any other mods first. A post-1994 DS-1 with the MIJ-Mod has a sound that is less-compressed sounding than the stock post-1994 DS-1. The note articulation is vastly improved as well. You can crank the DIST control with this mod and it still sounds good, unlike the post-1994, where cranking the DIST control results in a bit of a fuzzy mess (in my opinion, of course.)

If you are fortunate enough to own both a vintage DS-1 and a post-1994 DS-1 modified with the MIJ-Mod, if you carefully listen to them side-by-side, you'll notice that the vintage pedal has slightly less bass and sounds slightly more compressed than the post-1994 DS-1 with the MIJ-Mod. Personally, I like the post-1994 with the MIJ-Mod best, as it has almost identical tone characteristics to the vintage DS-1, but has a less-compressed, higher-fidelity sound that compares favorably with some of the best DS-1 mods out there. (And yes, I *am* biased. ☺) But don't take my word for it, let your ears be your guide to which one is best for you.

BRETT MILLER DS-1 "MIJ-PLUS" MOD

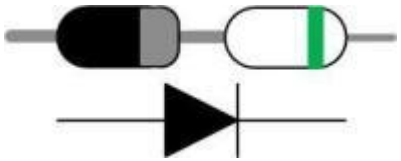
After developing the MIJ-Mod, it has become my favorite DS-1 pedal. Unfortunately, I found that, with the increased fidelity of the M5223AL chip over the TA7136P chip, the distortion was a little bit fizzy with the DIST knob cranked for maximum gain. Gain is good, fizz is bad (at least with how I commonly use the DS-1), so I wanted to smooth out the distortion a bit further. So in essence, the "MIJ-Mod PLUS" is the MIJ-Mod with additional changes to diodes D4/D5 to smooth out the distortion.

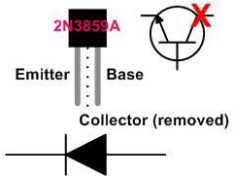
I started by focusing on the clipping diodes. Many folks like switching to LEDs for the clipping diodes, but I prefer a more saturated sound than LEDs provide. I wanted to raise the clipping threshold from the 1N4148/1N914 levels in the stock DS-1, which led me to examine the following clipping thresholds for common devices used in the clipping circuits of overdrive/distortion pedals:

- LEDs ~1000-1200mV (and higher for some of the super-bright varieties)
- 1N34A Germanium diodes ~300-350mV
- 1N4002 silicon power diodes ~450-500mV
- 1N914/1N4148 silicon diodes ~550-600mV
- NPN silicon transistors (Base->Emitter –or– Base->Collector) ~650-700mV.

In the past, I've typically preferred asymmetrical over symmetrical clipping, so I wanted to replace D4 and D5 with components that clip at different levels. I didn't want to go as high as LEDs (1000-1200mV) and I didn't want the fuzzy saturation/volume-loss from going as low as 300-350mV with Germanium diodes. I wanted to have one side clip between 800 and 900mV and the other side clip between 600 and 700mV, so I ended up using a 1N4002 diode and 1N34A diode in series to replace D4 and a 2N3895A silicon transistor (Base->Emitter, with the Collector pin removed) in D5. This resulted in a less fizzy distortion that was more pleasing to my ear and, in fact, another baby-step closer to the sound of the vintage DS-1. My gut feeling as to why the post-1994 DS-1 with the MIJ-Mod sounds slightly fizzier at full DIST is due to the increased fidelity of the M5223AL dual op amp. The slightly-decreased fidelity of the TA7136P seems to mask this fizz better, whereas the M5223AL allows this fizz to be heard a little bit more clearly.

When installing the diodes in D4, make sure you've got the components oriented correctly. On the 1N4002/1N34A pair, make sure the lines on the diodes are both facing the same direction, as pictured below on the left. I used a 2N3859A NPN transistor in D5 because the Base and Emitter are the outside pins, as pictured below on the right. You can use any common NPN silicon transistor that has a forward voltage of 650mV-700mV between Base->Emitter or Base->Collector (verified via diode test on a digital multi-meter), but make sure to read the datasheet so you can locate the Base/Emitter or Base/Collector pins correctly. With the NPN silicon transistors, remember that the current flows from the Base to either the Emitter or Collector, so the "diode arrow" printed on the board should always point towards the Emitter or Collector and away from the Base.





BRETT MILLER DS-1 "MONDO-MIJ" MOD

OK, now that we're at the third of the "MIJ"-type mods, let's recap a little. The original "MIJ" mod was designed to replace only the minimal number of components necessary to make the post-1994 DS-1 sound like the pre-1994 MIJ vintage DS-1. The "MIJ-Plus" mod was designed to remove some of the "fizz" from the "MIJ" mod by increasing the proximity to clip in the D4/D5 clipping diodes. The "Mondo-MIJ" mod is designed to bring a higher fidelity sound to the "MIJ"-type mods through the use of film capacitors, an upgraded op amp and a more sophisticated clipping circuit.

Admittedly, this is probably the last of the "MIJ"-type mod series. To extend the mod much further than the "Mondo-MIJ" will take the pedal in a direction that will likely be inconsistent with the tone shape and note articulation that endear the original MIJ DS-1 (and hopefully "MIJ" modded) pedals to guitarists worldwide. Having said all that, let's get on with the "Mondo-MIJ" details.

I've broken the "Mondo-MIJ" mod instructions into three parts. You could apply any of these sections to a DS-1 separately, but to complete the "Mondo-MIJ", you really need to apply all three parts to your post-1994 DS-1. These instructions do not require you to perform any other mods previously to complete the "Mondo-MIJ." These instructions assume you are starting with a stock post-1994 DS-1.

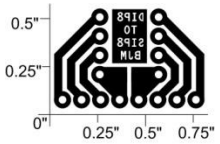
"Mondo-MIJ" Part 1:

1. Replace C1 and C13 with 0.1µF metal film capacitors.
2. Replace C2 with a 0.47µF metal film capacitor.
3. Replace C5 with a 0.47µF metal film capacitor.
4. Replace C7 with a 250pF ceramic disc capacitor.
5. Replace C8 with a 1µF metal film capacitor.
6. Replace C9 with a 0.47µF metal film capacitor.
7. Replace C14 with a 1µF metal film capacitor.
8. Replace R13 with a 2.4KΩ metal film resistor.

“Mondo-MIJ” Part 2:

The M5223AL dual op amp sounds pretty good in the DS-1 circuit, but it can also sound a bit harsh at times, depending upon your guitar and/or the level of DIST control. To smooth out the distortion, I chose to replace the M5223AL in-line dual op amp with a Burr Brown OPA2134PA dual op amp.

The OPA2134PA is a DIP8 package, so you will need to either purchase a SIP8 to DIP8 adapter board or make one yourself. If you wish to buy one, you can buy them from Cimarron Technology: http://cimarrontechnology.com/index.asp?PageAction=VIEWPROD&ProdID=34. If you wish to etch and drill your own adapter board, you can use the ready-to-transfer image below.



The vertically-aligned holes are for the DIP8 op amp, with Pin 1 being at the upper-left. It is recommended that you install a DIP8 socket in this position. The horizontally-aligned holes are for the pin connectors. You can use 22-gauge tinned bus wire to make these pins by soldering the wire into the hole, bending the wire 90-degrees and clipping to desired length. NOTE: You should install the OPA2134PA op amp *after* you’ve soldered the DIP8 socket and pins; this will reduce the heat the op amp IC is exposed to.

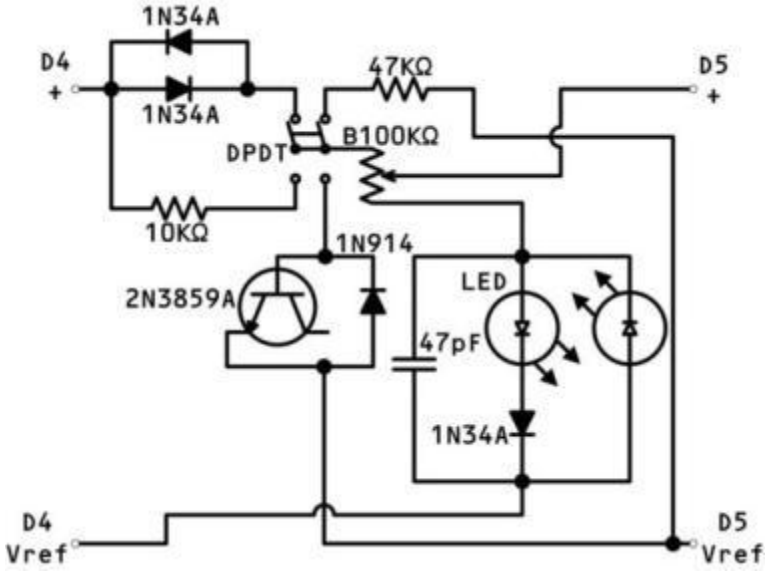
Once you’ve got your SIP8 to DIP8 adapter board, de-solder the M5223AL op amp and remove it. Install Mill-Max in-line sockets in place of the removed M5223AL. Install the OPA2134PA into the DIP8 socket, then install the entire adapter assembly into the in-line sockets on the main PCB. NOTE: You may need to gently bend the pins on the adapter board one direction or the other to get the necessary clearance to fit everything back into the case.

“Mondo-MIJ” Part 3:

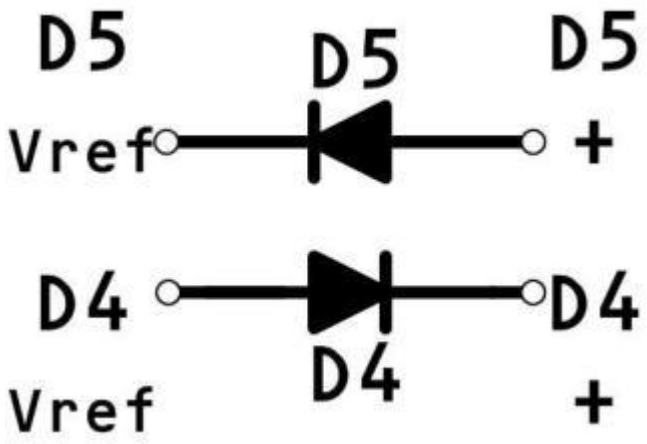
This part of the “Mondo-MIJ” mod is perhaps the most complicated, yet also potentially the most unique. The inspiration for this part of the “Mondo-MIJ” mod came from an article by Jack Orman where he described alternative distortion saturation and blending configurations.

This part of the mod replaces the hard clipping diodes in D4 and D5 with a network of diodes that are blended together to create a mixed distortion sound.

Mondo-MIJ



Stock



NOTE: The wire between the center (common) lugs of the DPDT and B100KΩ pot *does* connect to both center lugs. Strip the wire about ½” and feed it through both lugs before soldering.

The DPDT toggle switch allows you to switch between crossover distortion and the hard-clipping distortion found in the MIJ-Plus mod. The B100KΩ pot is used to blend the mixture with either more clipping from the LED hard-clipping diodes or the diode pairs controlled by the DPDT. NOTE: Once you’ve built this part of the mod into your “Mondo-MIJ”, you will notice that, other than the diodes controlled by the DPDT, you cannot really turn off any of the diodes in this circuit. This is due to the fact that the DPDT-controlled diodes always have a path between signal and Vref, no matter what the blender pot is set at –and– the fact that the positive (signal) side of D4 and D5 are connected directly outside of this clipping circuit. The effect of the LED/1N34A clipping diodes can be reduced significantly (due to the 100KΩ series resistance presented by the B100KΩ pot), but due to the higher output level of that part of the circuit, their effect cannot be eliminated entirely.

The result of all this blending is a fairly complex distortion with increased headroom, with the ability to “nudge” the signal towards smoother or more aggressive/edgy, depending upon how you set the DPDT and the blender pot. Touch-sensitivity is *vastly* improved, allowing your picking dynamics to determine the amount of distortion the circuit produces. (Meaning: pick softly and it cleans up…dig in hard with the pick and it distorts, akin to similar behavior in tube distortion circuits.)

So now that I'm done with my basic discussion of the theory and design behind Part 3 of the "Mondo-MIJ", let's talk about actually building it.

On all DS-1 variants, B100KΩ pots are used for both the LEVEL and DIST controls. Part 3 of the "Mondo-MIJ" also uses a B100KΩ pot as its blender control. You might think, "Two B100KΩ pots in a pedal already tight on interior space?!" My mind immediately thought "dual B100KΩ pot", which is a good idea…with some caution. Since you will want either the LEVEL or DIST control to operate independently of the Blender control, you will need a dual *concentric* B100KΩ pot. These can be hard to come by, but at the time of this revision, GuitarFetish has some snazzy miniature B100KΩ dual concentric pots and knob sets that work very well for this mod (pictured below on the left.) You might be able to find these pots and knobs elsewhere, but finding them in the B100KΩ variety is tough. If you can locate linear mini dual concentric pots in a larger resistance, you can solder resistors between lugs 1 and 2 plus lugs 2 and 3 (on both pots) to create a 100K pot. (Visit Joe Davisson's EMH page and click on 'Linear Pot' on the left side for help picking the resistor sizes to make a B100KΩ pot out of your pot.)

On my DS-1, I chose to put the DPDT toggle switch below the TONE control (with the chassis hole approximately centered on the 'O' in TONE.) I replaced the DIST control with the dual concentric B100KΩ pot. I enlarged the hole slightly with a step drill bit and installed the pot. The GuitarFetish pot come pre-terminated with plastic connectors, which I decided to leave on, as they make for easier assembly/disassembly. To make pin connectors for the wiring and BOSS pot PCB mini-boards, use 22-gauge bus wire. Once you've assembled the connections for both the "Mondo-MIJ" clipping circuit and the DIST control, a piece of electrical tape around the connection will keep them from separating due to vibrations that normal handling and use produce. (If you want to skip dealing with the connectors, just cut off the terminals, strip the wires, tin the ends and solder them up directly.) Below in the center is an exterior shot of my finished "Mondo-MIJ" DS-1.

If you don't want to use (or can't find) a dual concentric B100KΩ pot, there is still hope. Get an Alpha 12mm B100KΩ pot from Mouser.com (Mouser part number 313-1210F-100K) and a small knob for it. Leave the LEVEL and DIST pots as-is and find some empty space on the upper-right side of the right vertical face of the pedal (with pedal sitting on its rubber base and knobs on top.) Space will be tight, but you should be able to drill that side and squeeze the pot in there, having the knob protrude out of the right side of the pedal. In the above-right picture, I have marked the alternate location for the Blender pot with a red 'X'.

Once you've done all that, test it, *carefully* box it up and revel in the satisfaction that you have created a great, new sound for your DS-1 –and– just fit 20 pounds of "fertilizer" into a 5-pound bag by fitting all that stuff inside the DS-1 chassis. ☺

BRETT MILLER DS-1 "PHLAT" MOD

This mod is an alteration to the low-pass and high-pass filters that feed the TONE control of the DS-1. The intent of this mod is to give the user the option to switch between the stock, scooped-mids tone and a flatter tone shape that will help keep the tone full-sounding at lower DIST settings.

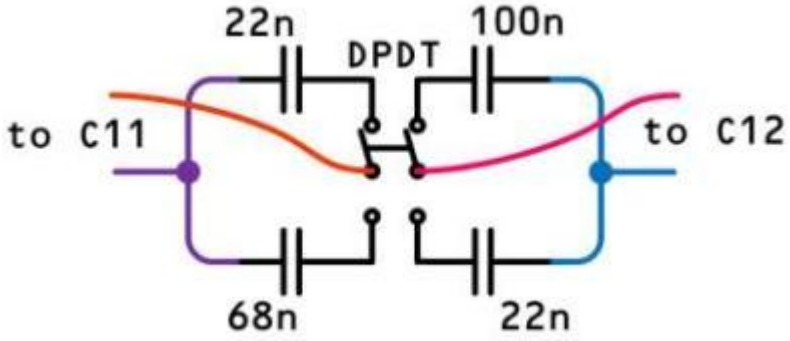
The stock DS-1 TONE control has a low-pass filter with a corner frequency of 234 Hz and a high-pass filter with a corner frequency of 3290 Hz. This produces the classic DS-1 scooped mids tone that allows the harmonics produced by the clipping diodes to be more prominent, giving it a heavily-distorted sound. The PHLAT Mod moves the corner frequencies of both the TONE low-pass and high-pass filters to 1064Hz. This change results in the mid frequencies to jump out more, resulting in a noticeable volume increase, as well as boost in sustain. The resulting distortion is less harmonically rich than the scooped tone, but has a more vintage amp tone that works well with blues and country riffs at lower DIST settings.

To perform the PHLAT Mod, you'll need a DPDT On-On toggle switch, insulated wire, one 68nF film capacitor and one 22nF film capacitor. Once you've obtained those parts, do the following to install it:

1) De-solder the 22nF capacitor from C11 and the 100nF capacitor from C12; save these for Step 3.

2) Cut and strip two wires and solder them to the common (middle) lugs on DPDT switch.

3) Solder the capacitors to the DPDT switch as indicated below:



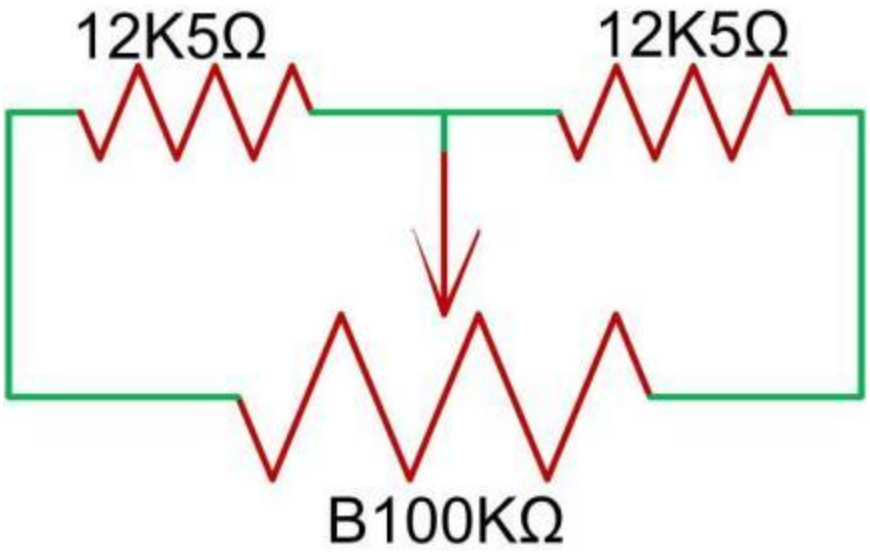
4) Cut and strip four wires and solder one each to the leg of the capacitor not soldered to the DPDT switch, then solder the free ends of these wires together as indicated above. Make sure to solder the ends together so that a single-thickness of wire remains to fit through the PCB.

5) Drill a hole in the enclosure below the DIST knob and install the DPDT.

6) Solder the wires marked 'to C11' above to the holes for the C11 capacitor; do the same for the wires marked 'to C12' above to the holes for the C12 capacitor.

APPENDIX A: WHERE CAN I FIND B20K POTS?

Small Bear Electronics has a G-taper, 20K pot that is designed for Tube Screamer circuits, but you can also make your own B20K pot by taking a B100K pot and adding two 12K5Ω resistors between the lugs as illustrated below:



12K5Ω resistors are rather rare in themselves, but 12K4Ω resistors are much more common. If you use 12K4Ω resistors in place of 12K5Ω resistors, you'll end up with 19K9Ω on the pot, which is close enough for our purposes here.

APPENDIX B: HOW DO I MODIFY MY POST-1994 DS-1 TO MATCH THE ORIGINAL DS-1?

First things first, let's set some expectations. Unless you use the TA7136P single op amp (SIP-7) and scour the earth for all of the old transistors/diodes listed in red below, you can't exactly replicate the "vintage" DS-1 Distortion. (You'd also need a PCB layout for the old circuit.) If your intent is to exactly replicate the vintage, Made-In-Japan DS-1, it would certainly be easier (and possibly cheaper) to just save up and buy a MIJ DS-1 on eBay.

It is worth pointing out that many of the transistors and diodes listed in red below are functionally-equivalent to the post-1994 component listed in green next to it. In fact, BOSS often changed the transistors and diodes within the same PCB version of the DS-1. Having the exact component isn't as important as having one that is functionally-equivalent. One should consider that fact before you spend your weekends scavenging 2SC732 diodes from old clock radios in order to build your vintage DS-1 replica.

The intent of this section is not to convert a post-1994 DS-1 to exactly match the pre-1994 circuitry. This section will walk you through the general differences between the circuits and point out likely candidates to modify to make a post-1994 DS-1 more closely match the sound of the vintage DS-1.

Now that's out of the way, if you're like me, believing that you're probably only a few components away from modifying your post-1994 DS-1 to sound like the vintage DS-1, please read on.

From reviewing the schematic for the vintage DS-1, below are the component differences between vintage and post-1994 DS-1 pedals. Values appearing in the vintage DS-1 are in red text, whereas values appearing in the post-1994 DS-1 are in green:

C5 – 0.47µF/50V, 0.068µF	D1 – RD11EB (11V Zener)*, 1N4004	Transistor info for folks building DIY replicas:
C6 – 150pF, *not present*	D2 – RD5.1EB (5.1V Zener), 5.6V Zener	
C7 – 250pF, 100pF	D3 – 1S2473, *not present*	[1]2N5088 transistors may be used in place of 2SC2240 and 2SC732 transistors. You will need to orient the pins differently, as the 2SC2240 and 2SC732 are B-C-E and 2N5088 are C-B-E.
C8 – 1µF/50V, 0.47µF/50V	D4 – 1S2473, 1N4148	
	D5 – 1S2473, 1N4148	
R12 – 27KΩ, *not present*	D6 – 1S2473, 1N4148	
R21 – 100KΩ, 10KΩ	D7 – 1S2473, 1N4148	[2] BC549 or BC559 transistors may be used in place of 2SC2458 transistors. You will need to orient the pins differently, as the 2SC2458 are B-C-E and BC549/BC559 are C-B-E.
R34 – 1MΩ, *not present*	D8 – 1S2473, 1N4148	
R38 – 470Ω, *not present*	D9 – 1S2473, *not present*	
R39 – *not present*, 47KΩ	Q1 – 2SC732, 2SC2240[1]	
R40 – *not present*,1KΩ	Q2 – 2SC732, 2SC2240	[3]NTE85 transistors may also be used in place of 2SC945/2SC2458 transistors. The pin-out of NTE85 transistors matches that of 2SC945/2SC2458 transistors, so no adjustment of the pin-out is necessary.
IC – TA7136P, M5223AL	Q3 – 2SC732, 2SC2240	
	Q4 – 2SC945[3], 2SC2458[2]	
	Q5 – 2SC945, 2SC2458	
	Q9 – 2SC945, *not present*	

So now that we know what components are different between the two, what do those components actually do in the two circuits? OK, let me step through them by functional grouping:

1. D3 and R38 are two components that are connected between battery lug on the DC adapter jack and the Ring terminal on the Input Jack. Going from Input Ring to DC Jack, D3 is connected in series with R38 (with D3 forward current flow going towards the DC Jack); R38 then connects to the battery lug on the DC Jack. I am surmising that this is to prevent DC current from leaking back into the grounding network. If true, that would make these components are essentially noise-prevention devices and would likely have little effect on tone.

   Random Rambling: Since we're dealing with potential myths and legends when talking about the vintage DS-1, one might wish to include the D3/R38 hookup in a "vintage DS-1" mod, as some will be quick to point out that those components were in the original DS-1 and are, like the TA7136P op amp IC, "the reason the OLD ones sound better." I'm not in agreement with that sentiment, as my ears tell me that the TA7136P has a slightly compressed sound when compared side-by-side with the M5233AL, but it is not the primary driver of the altered sound characteristics anyway…the capacitor differences make the biggest impact on tone by far. But I digress…wiring a small signal diode and 470Ω resistor in series between the DC jack and Input Jack Ring is a simple mod if you wish to try it yourself.

2. D4 through D8 are silicon signal diodes in the same positions as the 1N4148/1N914-type silicon signal diodes found on the post-1994 DS-1 pedals. Unless you have a rainy Saturday afternoon with nothing better to do, I wouldn't recommend replacing these with 1S2473 diodes (even if you can find some) because the net effect will be negligible.

3. R34, D9 and Q9 are part of the old flip-flop switching circuit design, so unless you're going to revert the entire switching flip-flop circuit from post-1994 to vintage design, ignore these three component differences. If the post-1994 switching circuit flips and flops as you expect, then don't mess with it.

4. *This one could be a bit controversial, as the PCB v.ET-28E BOSS service sheet for the vintage DS-1 has a RD11EB (11V, 0.5W Zener Diode) acting as the reverse-protection diode. BOSS then used 1N4004 diodes in D1 in every PCB version after that PCB v.ET-28E. (My vintage DS-1, PCB v.ET-28F, has a 1N4004 in it.) Since even BOSS couldn't make up their mind which diode was better in the pre-1994 DS-1, I'd recommend sticking with the 1N4004 that BOSS has used in both pre- and post-1994 DS-1 pedals.

   As for D2, this Zener diode appears to be part of a "check battery" circuit (along with R35) that will prevent the LED from illuminating when the battery voltage drops below a certain voltage. So changing this Zener diode from a 5.6V Zener to a 5.1V Zener just means your battery will be allowed to drop 0.5 volts lower before the LED stops illuminating, which indicates it's time to change the battery.

   Final conclusion on this component change? Minimal, if any, effect on the tone of the circuit. Change 'em if you want, but the effect will be negligible, if noticeable at all.

5. R12 is a biasing resistor. This is not needed on the common dual-op amps that are functional equivalents to the M5223AL/JRC4558/OPA2134PA/etc. C6 is a compensation capacitor not needed with the dual op amps in use on the post-1994 DS-1. I'd recommend ignoring these components as candidates for a vintage mod, as they do not apply to the op amps we can use for this pedal. (Dual op amps like those previously mentioned do not have an external compensation loop.)

6. The vintage transistors are functionally-equivalent to the post-1994 parts. I'm not saying you can't replace them if you want, but I really don't think it's worth the effort.

7. R39 and R40 are not in the pre-1994 DS-1. I did an experiment where I removed these resistors and replaced them one-at-a-time with a linear 100K pot. I will now explain my findings from this experiment below.

   R39 Result: With a B100KΩ pot wired in for R39 and set to around 47KΩ (stock value), I found it to smooth out the upper mids a bit. When zeroed out, there was a noticeable "yang"-ey characteristic to chords, particular A-chords played in X-0-2-2-2-0 position. Turning the pot up to 100KΩ smoothed out these mids too much, causing a loss of articulation. It was about half-travel on the pot (just about the 47KΩ BOSS picked for the R39 resistor) that the balance of note articulation versus smoothness seemed to have the best balance. To my ears, BOSS got that resistor value right on the money...47KΩ in R39 sounded best to me.

   R40 Result: I did the same procedure with R40 after installing R39 in its original configuration. At anything below 1KΩ, the whole circuit would become inaudible. (Not surprising, because you would have essentially opened a direct connection between +9V and your audio path.) Turning up the resistance above 1KΩ didn't have much audible difference. The biggest difference with R40 came with removing it completely. With R40 removed, there was a drop in the midrange gain, or to put it differently, the clarity and midrange "fatness" dropped off considerably. So once again, I think BOSS made the right call having R40 at 1KΩ with the M5223AL chip.

   Final Opinion: R39 and R40 are not in the pre-1994 DS-1, but they do smooth and "fatten" the sound of the post-1994 DS-1. Removing these resistors (and jumpering R39) results in a thinner-sounding, somewhat harsh sound with less sustain. R39 and R40 should be left in place on the post-1994 DS-1 as long as the stock M5223AL dual op amp is used. If other op amps are used, I would suggest installing a 250KΩ trimpot in place of R39 and a 10KΩ trimpot in place of R40. By adding the trim pots, you could dial in the smoothness/midrange character desired with the replacement dual op amp.

8. OK, time for some more controversy. R21 is 100KΩ on pre-1994 DS-1 PCB version ET-28E and earlier. R21 is 10KΩ on pre-1994 DS-1 PCB version ET-28F and later. My personal, vintage DS-1 has 10KΩ in R21.

   So this leaves the modifier with a conundrum. Both 100KΩ and 10KΩ were used in R21 on vintage, MIJ DS-1 pedals. From my research, it appears that the majority of vintage DS-1 pedals were shipped with 10KΩ in R21, which is why I recommend not changing R21 from the 10KΩ value held in common with the post-1994 DS-1.

So now that we've eliminated most of the differences as potential mod components, what does that leave us? Why, that gives us the "MIJ-Mod."