Dunlop CryBaby GCB-95 Cicuit Analysis

The Dunlop Crybaby is a Wah-Wah pedal released around 1982. The pedal is a copy of the original VOX model made by VOX/Thomas Organ Co in 1970. The effect is basically a band pass filter, it boosts the resonant frequency around 750Hz attenuating above and below harmonics. The rocketing action of the pedal shifts the resonant frequency up and down.

Due to the great success of the pedal, being maybe the most sold guitar pedal of all times, Dunlop produced several versions of the Wah-Wah and signature models adding enclosure customization and small circuit modifications. This study is focused in the first model, the Dunlop Crybaby GCB-95 which is considered to have the classic wah tone.

Table of Contents.

1. The Wah-Wah Effect.

The Wah-Wah pedal was invented in November 1966 by Lester Kushner and Brad Plunkett working at Warwick Electronics, a division of Whirlpool that owned Thomas Organ Company and Vox. Thomas Organ patented the Wah circuit design but by the time the patent was granted there were already dozens of copies of the pedal in the market. Enforcing the patent was too expensive so no attempt was made to stop the knockoffs.

Dunlop started manufacturing the Cry Baby GCB-95 in 1982, copying the original VOX design under license, becoming the most sold pedal of all times. Dunlop Wah-Wahs models are: GCB-95, GCB-95F Classic, GCB-95Q, GCB-535Q, EW-95V, 105Q Bass and 1999 Purple, White, Red or Gray Limited Edition.

Signature models include: JH-1 Jimi Hendrix, JH-1FW Jimi Hendrix Fuzz Wah, DB-01 Dimebag Darrel, ZW-45 Zakk Wylde, SC-95/SW-95 Slash Signature, EVH Signature, KH-95 Kirk Hammett, JC-95 Jerry Cantrell, etc...

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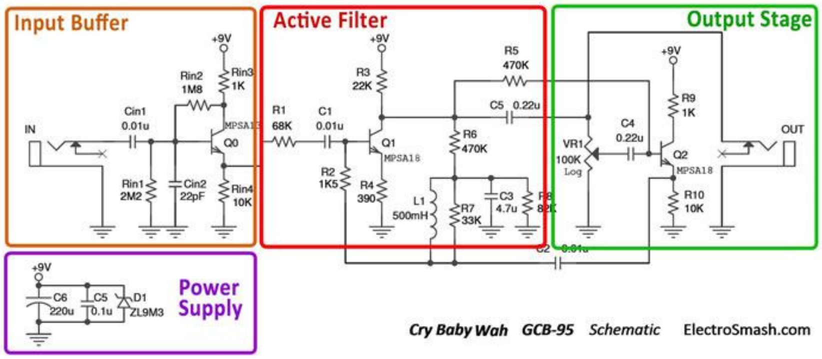
2. The Dunlop Cry Baby GCB-95 Circuit.

The Dunlop **Cry Baby GCB-95 schematic** can be broken down into four blocks: Power Supply, Input Buffer, Active Filter and Output Stage.



The circuit is undoubtedly inspired on the **VOX V847**. One of the mayor concerns of the original VOX design was the tone sucking due to the low input impedance of the Input Stage which was 69.5KΩ. Dunlop fixed this problem adding a buffer which raises the input impedance to 1MΩ preserving the guitar original tone. Besides the Input Buffer there are only two changes in the circuit:

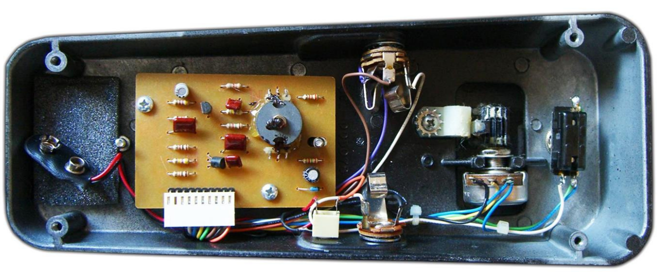
- R_4 size is reduced (from 510Ω to 390Ω): creating a slight higher voltage gain in the Q_1 stage.
- R_8 is also reduced (from 100KΩ to 82KΩ): this change just varies a bit the bias of Q_1, not affecting the tone at all. It is just a component resource change.

The design is built using 3 cascaded transistor stages with a couple of passive components and an inductor; the simple circuit makes the power consumption below 1mA.

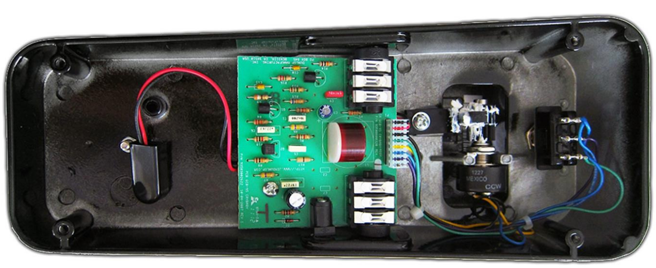
The gist of the design remains in how the resonant frequency of an LC filter made up of a fixed inductor L_1 and a fixed capacitor C_2 can be changed using a variable resistor VR_1.

2.1 Dunlop CryBaby Wah GCB-95 Guts / PCB Layout.

Before 1990 all Dunlop Wah pedals had wires between the jacks and the circuit board. In mid 1990 Dunlop changed the pcb design and started mounting the jacks directly on the PCB. Also, from mid 1991 onwards, a buffer circuit was added before the actual wah circuit (it is there if your pcb says "Rev F" or higher).

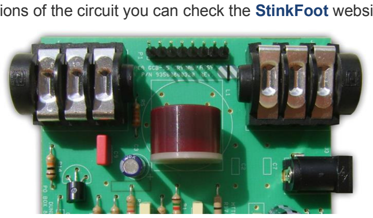
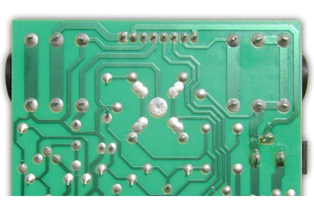


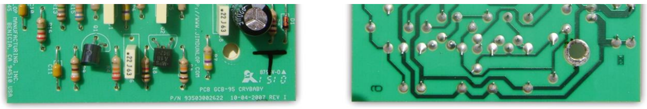
Before 1990 GCB-95 Design Image by Toxic Web



After 1990 GCB-95 Design Image by kelv_w

The current revision looks much like the models that have been running since mid 1992. For more detailed info about the different versions of the circuit you can check the **StinkFoot** website.

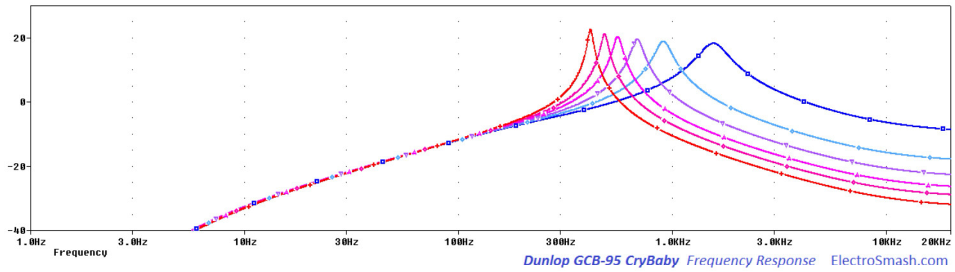


Dunlop Wah GCB-95 CryBaby PCB Image by Paciente8159's Lab

The single layer PCB fits without problems inside the big pedal enclosure using through hole components.

2.2 Dunlop Cry Baby GCB-95 Frequency Response.

The frequency response is characterized by a resonant peak centered in 750 Hz (with the variable resistor VR_1 at mid position). The peak sweeps up and down from 450 Hz to 1.6 KHz. The selected frequencies are amplified up to 18dB while the surrounding ones are attenuated:

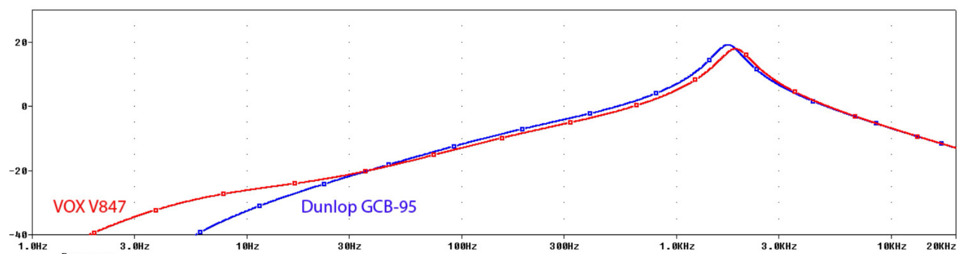


Dunlop GCB-95 CryBaby *Frequency Response* ElectroSmash.com

2.3 Dunlop CryBaby GCB-95 VS. VOX V847 Differences.

The circuit of these 2 pedals is pretty similar; the Dunlop design includes the Input Buffer to preserve the signal integrity but the price (Dunlop slightly cheaper), quality construction and sound are really similar. People often decides between the two of them because of the look

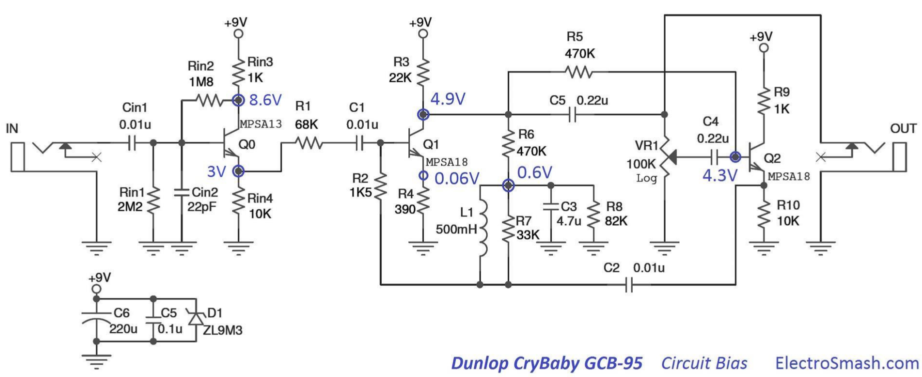
Dunlop CryBaby GCB-95 Vs VOX V847 Frequency Response: The crybaby has slightly less bass content. You can check in the graph below how the low freq harmonics are more present in the VOX than in the Dunlop due to the Input Buffer which filters part of this bass content.



VOX V847 vs. Dunlop GCB-95 *Frequency Response Comparison* ElectroSmash.com

2.4 Dunlop CryBaby GCB-95 Circuit Bias

The most important DC bias points are shown in the image below. It is useful for circuit failure troubleshooting:



Dunlop CryBaby GCB-95 *Circuit Bias* ElectroSmash.com

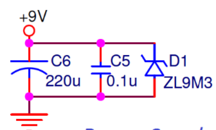
2.5 Dunlop Cry Baby GCB-95 Components Part List / Bill of Materials.

Q_0 MPSA18
Q_1 MPSA18
Q_2 MPSA18
C_{in1} 0.01uF
C_{in2} 22pF
C_1 0.01uF
C_2 0.01uF

C_3 4.7uF
C_4 0.22uF
C_5 0.22uF
C_6 220uF
L_1 500mH
R_{in1} 2.2MΩ
R_{in2} 1.8MΩ
R_{in3} 1KΩ
R_{in4} 10KΩ
R_1 68KΩ
R_2 1K5Ω
R_3 22KΩ
R_4 390Ω
R_5 470KΩ
R_6 470KΩ
R_7 33KΩ
R_8 82KΩ
R_9 1KΩ
R_{10} 10KΩ
VR_1 100KΩ
Input/Output Jack Connector.
True Bypass Switch.

3. Power Supply.

The simple Power Supply Stage provides an stable energy supply to the circuit.



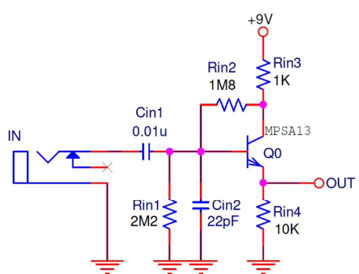
Power Supply

The 9V supply will feed the transistors. The ZL9M3 is a 9.1 zener diode which helps to regulate the power line (protecting the circuit from voltage peaks over 9.1V) and also prevents reverse polarity connections.

- Capacitors C_5 and C_6 between 9V and ground remove noise from the power line.

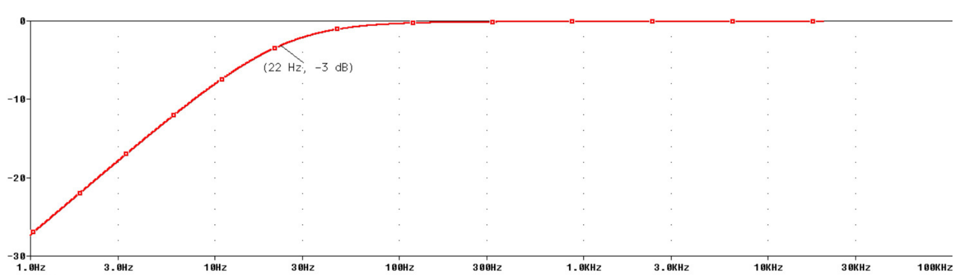
4. Input Buffer.

The first stage is an Emitter Follower / Common Collector NPN amplifier, with unity voltage gain, high input impedance and low output impedance which makes it very suitable for buffering the signal, avoiding high frequency signal loss:



Cry Baby Wah GCB-95 Input Buffer

- The 0.01uF input capacitor Cin_1 isolates the guitar from any pedal DC potential, protecting the pickups in case of circuit failure and removing hum.
- The resistors Rin_1 and Rin_2 form a voltage divider in order to bias the transistor Q_0.
- Resistor Rin3 in the collector is included to suppress the oscillation tendency.



Dunlop GCB-95 CryBaby Input Buffer Frequency Response ElectroSmash.com

Dunlop Cry Baby GCB-95 Input Impedance:

or simplification we can ignore $_{in3}$ the input impe ance is in1 in parallel with in2 an the input impe ance of the emitter follower. t can be calculate following the formula:

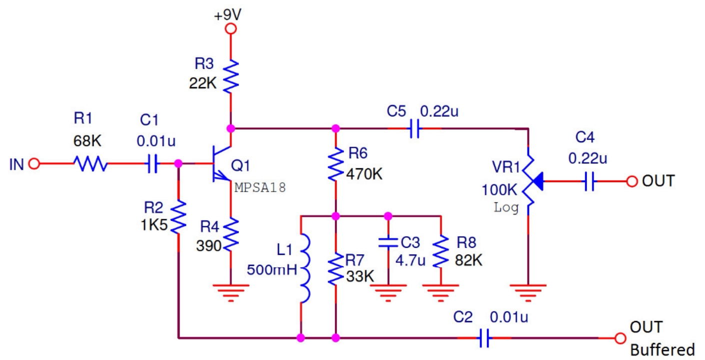
$$Z_{in} = R2//Rin2//Zin_{BJT} = 2M2//1M8//(5000 \cdot 10K) = 1M$$

1 can be consi ere a goo input impe ance to a oi signal egra ation. he effect of the resistor $_{in3}$ re uces this alue to 50 which is still a goo input resistance alue.

<u>note:</u> he hybri pi mo el an mathematics behin the oltage Gain an nput mpe ance calculation are similar as in ube Screamer input buffer **check it for further details.**

5. Active Filter.

he Acti e ilter stage is a Common Emitter Amplifier with oltage Shunt ee bac networ :



Cry Baby Wah GCB-95 Active Filter ElectroSmash.com

he C_1 is a bypass capacitor that isolates the nput Buffer from the Acti e filter.

he resistor $_1$ is almost all the input impe ance of this Acti e ilter stage an helps to rise the input impe ance of this stage preser ing signal integrity.

esistors an $_8$ form a oltage i i er for etermining the bias applie to the base of $_1$ through the in uctor $_1$ an resistor $_2$.

Active Filter Voltage Gain.

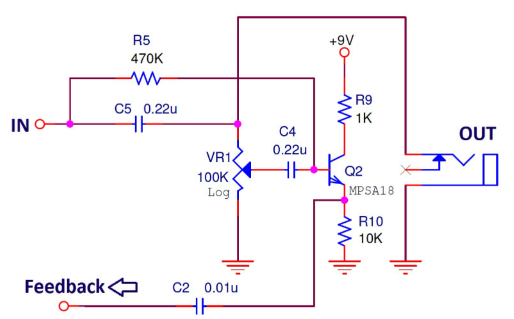
n Common Emitter amps the oltage gain is calculate as G $_C$/ $_E$ 22 /390 5 . 35 B. he effect of the fee bac networ has to be ta en into consi eration re ucing in practice the gain to 19 B. he fee bac networ from collector to base is compose by the resistance 0 an $_8$ 82 to groun he in uctor in parallel with the resistor 33 can be consi ere as a shortcut .

Applying negati e fee bac in the transistor amplifier results in a o erall re uce oltage gain an transistor input impe ance with some impro ements li e stabili e fre uency response an immunity against transistor ariations.

he output of the $_2$ is connecte to the 100 $_1$ oltage i i er with the roc eting foot action the oltage gain eli ere by the Acti e ilter Stage is regulate from 19 B to 1 B.

6. Output Stage.

he last stage is an Emitter ollower connecte as a low output impe ance amplifier with appro imately unity gain. he topology is almost the same as in the nput Buffer.



Cry Baby Wah GCB-95 Output Stage ElectroSmash.com

his bloc will buffer the signal ta en from the wiper of the 1 potentiometer.

he $_2$ transistor is biase through the resistor 5.

esistor $_{10}$ is a DC return for the Emitter ollower.

- Resistor R_9 in the collector is included to suppress the tendency to oscillation.

The output jack of the pedal is taken before the variable resistor VR_1 and is not affected by the position of the foot pedal. The position of the potentiometer does not affect the output volume level.

6.1 Dunlop Cry Baby GCB-95 Output impedance.

Once again the output impedance can be estimated using the hybrid pi model, but in this case the formula is complex and does not give any intuitive idea. Alternatively, the value can be calculated using pspice accurate simulation giving a value of 5KΩ. The real value is between 630Ω and 8.6KΩ (The position of the VR1 potentiometer effects the value of the output impedance) which can be considered as good output impedance. For more details check the **V847 output impedance calculation** which is the same circuit as the GCB95.

7. How the Dunlop Cry Baby GCB-95 works.

The core of the wah design remains in the cap C_2 which close the feedback loop between the output (Q_2 emitter) and input stage of the circuit:

The Acrive Filter Stage amplifies the feedbacked signal coming from the Q_2 emitter through C_2 and R_2. Because of this amplification of the signal applied across the C_2 capacitor, the apparent reactance seen by the input signal looking into the capacitor is different from the real one.

This apparent magnitude of the cap C_2 reactance magnitude depends on the gain of the signal of the first stage which is fixed by the position of the rocket pedal potentiometer VR1:

- If the pedal is in the lower position, Gain = min, Current through feedback cap C_2 = min, Apparent reactance = max, Apparent capacitance = min.
- If the pedal is in the upper position, Gain = max, Current through feedback cap C_2 = max, Apparent reactance = min, Apparent capacitance = max.

Connecting a complementary reactance (inductor L_1) will produce a resonant circuit which is adjusted by tuning the apparent capacitance of C_2.

Note: The impedance of an element can be expressed as Z = R + jX

- In ideal resistors Z = R (impedance = resistance [O])
- In ideal capacitor Z = jX (impedance = reactance [O])

Capacitor Reactance: It is the opposition of the Capacitor to the change of voltage through it. The built-up electric field resists the change of voltage between the capacitor pins. (reactance)XC = -1/wC(capacitance). Reactance is measured in Ohms, not Farads. The Farads is the measure of the the capacitance, an inherit property of the capacitor element.

8. Dunlop Cry Baby GCB-95 Wah Modifications.

The Dunlop CryBaby GCB-95 can be modified in the same way as the VOX V847.

8.1 GCB-95 True Bypass Mod.

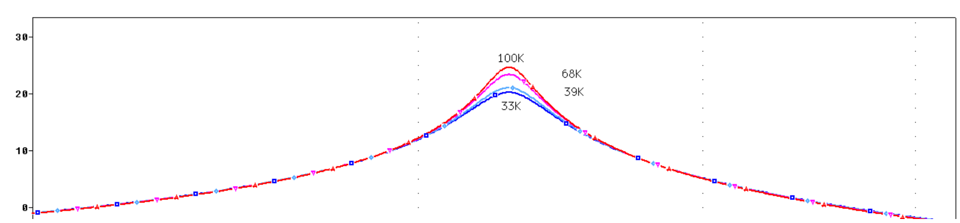
This mod uses a 3PDT switch to bypass the whole circuit in the typical boutique pedal arrangement. Removing the standard switch and installing the 3PDT, it can be done before or after the Input Buffer stage, most of the people do it before the Input Buffer because is easiest to do and to reverse.

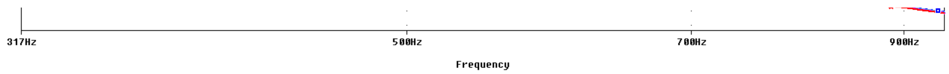
In the StinkFoot site there is great article about **how to do True Bypass for the GCB-95.**

8.2 Modifying the Wah-Wah Q factor or "Vocal Mod".

The Quality Factor is a parameter that characterizes how narrow or spread is the selected frequency band.

The 33KΩ resistor R_7 adjusts this sharpness of the resonant peak. This modification is also known as “Vocal Mod”, some users replace the 33K for a bigger one like 39KΩ, 68KΩ or even 100KΩ to have more vocal sounding.

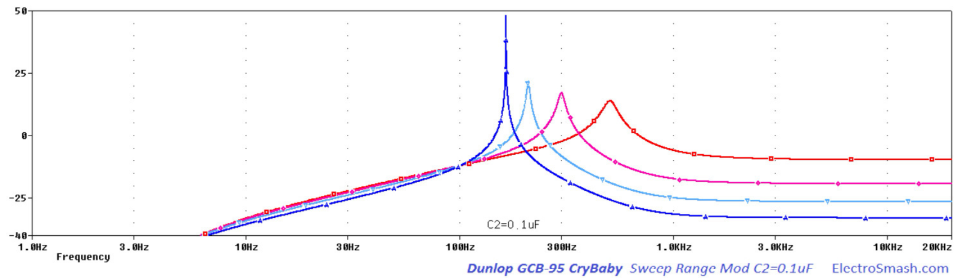


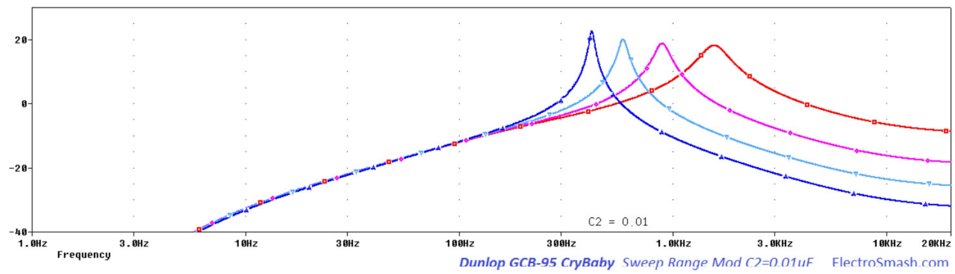


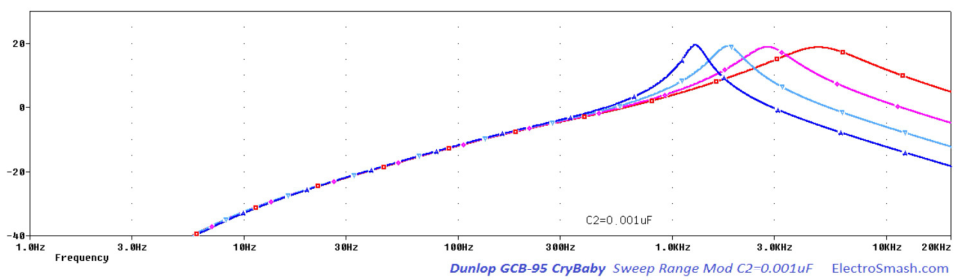
In the above graph the effect of the R_7 is shown, reducing its value, the Q factor is reduced, and the filter bell is spread.

8.3. Modifying the Sweep Range or "Bass Players Mod".

The C_2 cap determines the center frequency of the wah sweep. Changing C2 the whole wah sweep range moves up or down. In the images below the shift of the sweep range can be appreciated, using 0.1uF, 0.01uF (default) and 0.001uF.



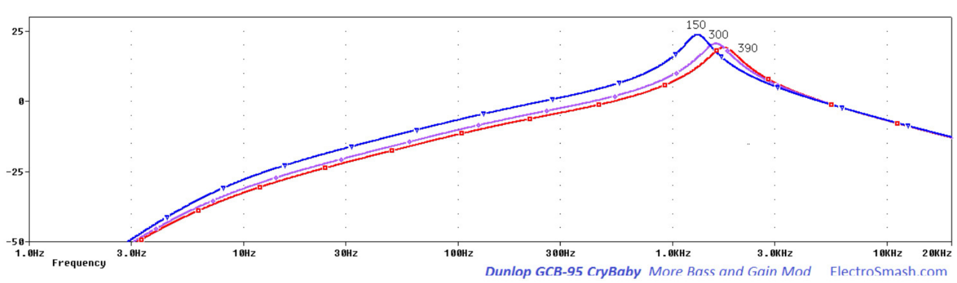




Bigger values move it down towards bass, smaller values move it up. Bass players like to increase the value (typically 0.068μF) for a better bass wah response.

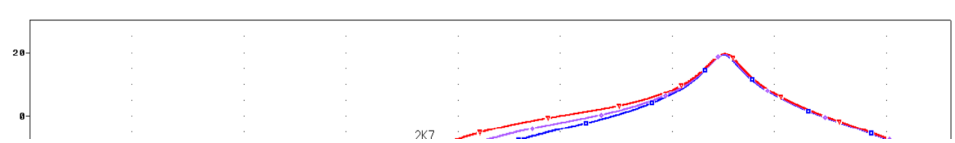
8.4. More Bass and Gain Modification.

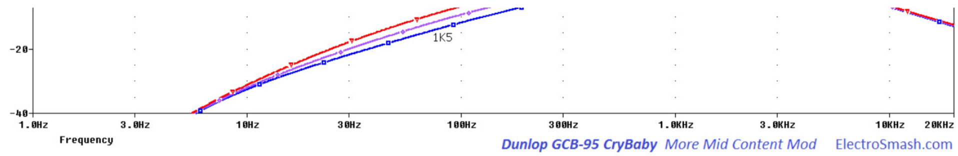
The emitter resistor R_4 controls the gain level of the effected signal. Reducing it will result in s light addition of gain and bass content. In the figure below you can see how smaller R_4 values modify the frequency response:



8.5 More Mid Content Modification.

This mod subtle sets the midrange content. Increasing the value of the R_2 resistor the heel-down position will sound slightly more strong and emphasized. Typical values for this mod are 2KΩ and 2.7KΩ (default R_2 resistor is 1.5KΩ).





8.6 The V847 Wah-Wah Inductor.

n all intage pe als there is some component which is often impossible-to-fin /e pensi e which somehow a s the best soun or the legen ary original tone. n this case the asel in uctor from the first series is consi ere the holy grial.

here are se eral options in the mar et to play with e erything with a DC resistance between 10 to 100 15 typ. an in uctance between 200m to 1 500m typ. can be use : he Dunlop ellow/ e asel D Sabba ius Soul n uctor Coloursoun n uctor ipple in uctor S D in uctors miniature au io transformers an coils from in ustrial filters.

9. Resources.

The Technology of Wah Pedals by Geofe .
Stinkfoot Wah mods.

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