About GEO Fex

GEO Fex DIY effects packages are designed with the musical effects experimenter in mind. GEO Fex offers the musical tinkerer the ability to work with and modify to his or her own liking circuits that accurately reproduce the technology of vintage effects.

GEO Fex packages reflect over two decades of research into effects technology and production techniques. The goal of the GEO Fex package is to make the sounds and circuits of a number of vintage effects available at a cost that is reasonable for the musical electronics enthusiast even when the enthusiast is making only one unit for himself.

As such, the emphasis is on achieving near-professional results in an at-home or in-garage setting. Modern toner-transfer technology allows the production of near-professional quality printed circuit boards one at a time by experimenters. Modern electronics mail-order suppliers can provide parts that were once very hard to find for the individual. The only missing part here is information - what was the circuit of a given vintage effect, and what special steps are needed to get the effect working right. This information is what GEO Fex all about.

GEO Fex packages reflect as closely as is known the original circuit of the vintage effect they are taken from. In some packages, the circuit was changed from the original in ways that make the GEO Fex package a better fit for modern musical effects practice - addition of true bypass switching, switch pop suppression resistors, and so forth. No changes are made that change the sound, which is, after all, the reason we do this.

GEO Fex packages have all been built and tested before you get them. They DO work, and they DO sound like the originals.

In some cases, detective work was needed to make the circuitry in GEO Fex packages available. Some of the vintage effects offered are so rare that none could be found for research, or the companies that provided them are no longer in existence. This meant quite a search for the underlying technical information in many cases.

GEO Fex packages refer to the original effect. This reference is for convenience in reference only, and does not imply that GEO Fex is in any way affiliated with the original maker, or the maker of any reissue effect, or the current owner of the trademark of the original effect. All trademarks are the property of their respective owners. GEO Fex artwork, packaging, layouts, and schematics are all new and original, and are not known or intended to infringe any copyright, trademark or patent.
The original Dallas Rangemaster has been little known in the USA, and under-appreciated. Many guitarists have experimented for a long time trying to emulate some sounds common in recordings from Europe, without notable success. It turns out that the Dallas Rangemaster may have been the secret weapon. Network research and personal email have indicated that the Dallas Rangemaster was a key item in the sound Eric Clapton achieved in the Bluesbreakers album, Rory Gallagher’s tone, and later Brian May. In the US, Tony Iommi noted in an interview that he used one for his work on the first Black Sabbath album.

What does this secret weapon do?

First and foremost, it’s a treble booster. It provides gain of up to 24db at frequencies above about one to two kHz. It has about unity gain at the lowest normal guitar notes, and the gain about doubles with each octave. Since a doubling of level is a just-perceptible change in loudness, not a perceived doubling of loudness, this amounts to a fairly mild increase in level for higher notes, enough to make the guitar more “present”. It shares this characteristic with other treble booster effects. If that was all that happened, there wouldn’t be much excitement.

However, the Dallas Rangemaster has some other tricks. As a result of the use of germanium devices and careful biasing, there is a subtle distortion added, as well as a changeover to harder distortion on loud notes, and the built-in ability to overdrive a tube amp input for some more serious distortion. These effects get more prominent as frequency goes up, so there is a very characteristic note added by the Dallas Rangemaster.

So – how does it work?

The Austin Treble Blaster uses the same circuit as the original Dallas Rangemaster, so the comments apply to both circuits.

The Dallas Rangemaster/Austin Treble Blaster couldn’t be simpler. Referring to the original schematic, there is only one transistor, biased by four resistors. The 470K/68K series resistor string provides a bias voltage to the base of the device, helping to set the static current in the collector. Since germanium transistors are used, the collector-base leakage also “helps” set the bias point as well. The 4.7K resistor, in conjunction with the input divider helps set and stabilize the bias point against drift and temperature variations. Its value and that of the nominal 68K base resistor are key to setting the bias point, so the exact values of these resistors should be set upon testing with the actual transistor to be used.
the output cap leakage, so there was no [clik] when it was switched. In modern setups, we cannot rely on those assumptions, so for my use I have added 2.2M "pulldown" resistors at both ends for maximum flexibility. The pulldown resistor have no audible effect, by actual test, other than keeping [clik]s from happening. If you are a stickler for originality, you can simply leave these resistors off. The pulldown resistors are a practical necessity for use in a modern context with true bypass, which the original did not have.

Another quirk of the original is that there is a DC voltage across the volume control, which also serves as the collector load resistor. This means that it will inevitably scratch and crackle whenever the control is moved even if you use high-collar conductive plastic pots. This was OK in the time of the original unit, as the designer assumed that a player would set up this thing and leave it, not twiddling the control during a number. There are ways to "correct" this, but they complicate the design unduly, so I have chosen to leave them out, going with the original circuit. It will crackle when you twist the "boost set" control.

Digging deeper

The magic in the effect is all buried in the details of the biasing, the transistor characteristics, and what it does to a following tube amplifier.

It’s not widely understood, but all transistor gain decreases at low collector currents. Normally transistors are biased as close to the middle of their linear swing area as possible to get the biggest possible non-distorted signal out. If you bias a bipolar transistor near cutoff, the gain of the transistor is heavily dependent on the instantaneous signal in a way that compresses the signal more the closer to cutoff it gets. Even for signals that do not fully cut the transistor off, the signal is softly compressed more on one side than the other, which amounts to asymmetric distortion of the waveform since the compression is instantaneous.

This asymmetric distortion adds a sweet, liquid quality that gets more noticeable as notes are hit harder. Hit a note hard enough (or just use a high output pickup) and you can actually drive the transistor fully into cutoff, and get a changeover into harder distortion.

Germanium devices have more of this change of gain near cutoff than silicon ones do – bad for mainstream electronics, great for guitars. While silicon does this as well, and I have used the silicon device 2N3906 with moderately pleasing results, but germanium has more oompf.

Finally, the amplifier following the Dallas Rangemaster has a part to play in the tone. A vacuum tube input is usually biased with the grid more negative than the cathode, and in the case of the common 12AX7 preamp tube in most guitar amps, this is usually about 1 to 1.5 Volts negative. Whenever the grid is driven positive with respect to the cathode, the grid still affects the plate current, but since electrons can now be absorbed by the now-positive grid, a grid current flows. The grid voltage, which controls the plate current, depends on whether the impedance driving the grid has a low enough impedance to supply the grid current. A high impedance source will be unable to drive the grid current, so the grid voltage will remain fixed at only slightly over zero volts, and the plate current will appear clipped for that part of the signal cycle where the grid is driven positive.

This leads to the curious fact that a low impedance source driving a tube grid will have a less distorted and more softly distorted plate signal than will a higher impedance source.

The Dallas Rangemaster has an output impedance no higher than the output pot resistance of 10K, and lower than that over most of the pot travel. This is substantially lower than the equivalent forward biased grid resistance of a 12AX7, so it can drive an input grid somewhat positive. The resulting distortion is smoother than a high impedance source would be. Note that amps that have series 68K resistors for “mixing” two inputs may not show the full benefit of this effect.

In terms of frequency response, I ran some measurements on the original unit. I had to measure the gain with an input of 10mv peak to keep the signal undistorted. The gain versus frequency is as follows:

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>~ 1</td>
</tr>
<tr>
<td>100</td>
<td>1.2</td>
</tr>
<tr>
<td>200</td>
<td>2.4</td>
</tr>
<tr>
<td>500</td>
<td>6</td>
</tr>
<tr>
<td>1000</td>
<td>10</td>
</tr>
<tr>
<td>2000</td>
<td>17</td>
</tr>
<tr>
<td>5000</td>
<td>29</td>
</tr>
<tr>
<td>10K</td>
<td>32</td>
</tr>
<tr>
<td>20K</td>
<td>30</td>
</tr>
</tbody>
</table>

This response is clearly just a simple RC high pass filter, and can be computed fairly closely with the approximation that the input capacitor works into the parallel equivalent of the 470K and 68K input resistors and the input resistance of the transistor. The transistor input resistance dominates this combination, being roughly 12K at the nominal DC bias current.
If the collector is too high (the transistor is too "off") decrease the RB1 value. If you go too low near the highest resistance before you get to –7V, then increase the RB1 value again. If you go near the low end of the RB1 resistor before you get to –7V, then try turning the RB1 value down.

5. If you go too low near the low end of the RB1 resistor before you get to –7V, then try turning the RB1 value down again.

6. If you go too near the lowest resistance before you get to –7V, then increase the RB1 value carefully, not to turn the shafts. Measure the resistance and solder in the nearest standard value fixed resistors.

7. Once you have tuned the bias point, you can have to tweak the input capacitor, C1. This is normally 0.002uF in the original Dallas Rangemaster. This capacitor and the input resistance of the transistor, in parallel with the two biasing resistors, tends to be about 1k, so a 0.005uF capacitor makes this gain about 80 Hertz. The frequency response of this circuit depends primarily on the value of this capacitor and the input resistance of the transistor. The exact frequency of the lowest note (the passband of the Dallas Rangemaster) moves away from 1kHz as the frequency response of the transistor is moved down. If you make the capacitance bigger, the passband moved down, so progressively lower frequencies are boosted. If you make the transistor capacitor much larger, say as much as 0.15uF, then almost all notes are boosted to full gain, and the result is NOT the original Dallas Rangemaster sound, but you may prefer it for your purposes. For the original Dallas Rangemaster sound, stay within about 0.4 – 0.5% of 0.005uF.

8. I recommend you do the actual tuning this way:

1. Build up your circuit by one of the methods shown later. Leave the RB1 and RB2 resistors out, attaching a 100k and a 10k pot respectively on long wires and make a temporary mark on the pot and shaft to note the pot rotation at 0.

2. Use an A.D.M. and set these marks on the nominal 68k and 3.9k respectively, and make a temporary mark on the pot and shaft to note the pot rotation at 0.

3. Attach your battery voltage and measure the collector voltage to ground. You would like to see –6.5 to –7.2V with a fresh battery (6.0 to 9.3V).

Leaky devices can be a problem. Most modern D.M.'s don't really measure leakage, and the I.C. leakage shows up as a falsely high gain on a gain test. If you have tweaked your unit in and I still do not sound right, you may have a leaky transistor. If you show a gain of more than 150 upon testing, that transistor is probably either really too high or too leaky to work well.
Austin Treble Blaster

very original, but you'll also induce hiss. Metal film is much better for this one. The transistor may also be hissy, in which case, use another one.

Terminal strip method. This is most like the original construction of the Dallas Rangemaster. Procure six-lug terminal strip, such as a Mouser part number 158-1006. The lugs on either end of this strip serve as mounting and ground points, since they each have a foot that can be screwed into the chassis.

Choose one end and number the lugs one to six from that end, the starting lug being “1”. Lug 1 will be the ground point for the circuit. In this order, insert components, dress and clip their leads, and finally once all components are in, solder:

Note: if only one lug is specified, only one end of the component is connected.
1. 47uF (+ to L1): L1 - L4
2. 47uF (+ to L1): L1 – L5
3. 470K: L3 – L5
4. Two ground wires: L1
5. Collector wire: L2
6. Input capacitor: L3
7. Power wire: L5
8. Solder the wires at the lugs.
9. Add the transistor, collector to L2, base to L3, emitter to L4. Use a heat sink between the solder joint and body of the transistor when you solder the device or you may ruin it! Note that you must heatsink the transistor lead each time you solder or unsolder a joint that connects to the transistor in the following two steps. This is important!!
10. Temporarily tack-solder the 100K tuning pot with wires from L1 to L3 and the 10K from L1 to L4, then perform the tuning process.
11. With the resistor values determined in the tuning process, insert the Re resistor from L1 to L4 and the Rb1 resistor from L1 to L3 and solder them in.
12. Position the terminal strip assembly in the box you’re going to use and connect up the wires:
   • solder the ground wires to input and output jacks ground lugs
   • power wire to the “cold” lug of the boost set pot (the one that the wiper connects to when fully counterclockwise)
   • collector wire to the “hot” lug of the boost set pot
   • base capacitor to the bypass switch
13. Solder the output capacitor from the wiper of the boost set pot to the bypass switch
14. Battery connector (-, black) wire to the bypass switch
15. Battery connector (+, red) wire to the input jack stereo signal lug

Austin Treble Blaster

16. Bypass switch output wire to the output jack

If you like the idea of building the whole thing on a PCB instead of a terminal strip (musical legends aside, there is no advantage or disadvantage of point to point terminal strip versus PCB construction for this device) then you can make one either of two different ways.
**Terminal Strip Method**

Insert wires into terminal lug and wrap until the wire will stay in the lug without solder.

Insert multiple wires before soldering lug.

Filling the lug with solder is not necessary.

Heat sink transistor leads with needle nosed pliers or hemostats when soldering!!!!!

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**Trace-your-own PCB method.** Clean a suitable sized board blank of all traces of oil, dirt, and oxidation with a scouring cleanser and dry. Tape a bit of carbon paper over the board blank and over that tape the Trace Your Own board layout. Trace the layout onto the copper with a ball point pen. Then, remove the layout and tracing paper, and using a suitable etch-resist pen (Radio Shack sells them) ink in the pattern directly on the copper, trying to make it match the original layout. You can touch up any goofs by scraping the marker off with a sharp pointed knife for small mistakes or by wiping the board blank clean with a solvent and starting over for big errors. Once you’re satisfied with the layout pattern, etch with your favorite etchant. Note that the Trace-Your-Own pattern is intended for top side soldering; you will solder parts on the copper side of the board. Note that using this method you will have to use the miniature 16mm control for the boost set pot to have enough room inside the recommended cast aluminum box, as the parts sit slightly higher than in ordinary pin-in-hole boards.

**Standard drilled PCB method.** Using the Toner Transfer Pattern, copy the layout to your favorite toner transfer medium (I prefer Techniks Press-N-Peel Blue) and iron it onto a board blank cleaned as above. Drill the holes in the pads and stuff the board as indicated.

The wiring diagrams and assembly diagrams for the PCB approaches apply to both PCB methods.

[Note: 11/24/98 PCB layouts will be added shortly]
## Parts List and Suppliers

<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
<th>Mouser PN</th>
<th>M $</th>
<th>Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>OC44 [1]</td>
<td>PNP Germanium transistor</td>
<td>N/A- alternates available from GEO</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>47µF</td>
<td>Al Electro Cap</td>
<td>140-XAL16V47 (axial)</td>
<td>0.25</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OR-</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>0.005 to 0.01µF</td>
<td>Capacitor, film, see text</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>0.01µF (10nF)</td>
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<td>140-PF2A103K</td>
<td>0.14</td>
<td>1</td>
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<tr>
<td>0.47K nominal</td>
<td>1/4W resistor – see text</td>
<td></td>
<td>0.07</td>
<td>1</td>
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<tr>
<td>0.68K nominal</td>
<td>1/4W resistor – see text</td>
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<td>1</td>
</tr>
<tr>
<td>470K</td>
<td>1/4W resistor</td>
<td>29SJ250-470K</td>
<td>0.07</td>
<td>1</td>
</tr>
<tr>
<td>2.2M optional</td>
<td>1/4W resistor</td>
<td>29SJ250-2.2M</td>
<td>0.07</td>
<td>2</td>
</tr>
<tr>
<td>10K “B”</td>
<td>Audio Taper Pot</td>
<td>313-4000-10K</td>
<td>1.74</td>
<td>1</td>
</tr>
<tr>
<td>DPDT [4]</td>
<td>DPDT stomp switch [4]</td>
<td>N/A, alternates available from GEO</td>
<td>10.00 to 16.00</td>
<td>1</td>
</tr>
<tr>
<td>¼” jack 1-ckt</td>
<td>Mono phone jack</td>
<td>16PJ023</td>
<td>1.22</td>
<td>1</td>
</tr>
<tr>
<td>¼” jack 2-ckt</td>
<td>Stereo phone jack</td>
<td>16PJ081</td>
<td>1.31</td>
<td>1</td>
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<tr>
<td>Terminal strip [5]</td>
<td>Terminal strip, six lugs</td>
<td>158-1006</td>
<td>0.57</td>
<td>1</td>
</tr>
<tr>
<td>9v battery clip</td>
<td></td>
<td>12BC092</td>
<td>0.38</td>
<td>1</td>
</tr>
<tr>
<td>#22 - #24 AWG</td>
<td>stranded hookup wire</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>knobs</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:

[1] OC44 was the original part number. This part is available only by the sheerest chance anymore. You can use most PNP germanium types if you can find one with a gain between 65 and 100, adjusting as noted in the text. Actual prototypes with type number NKT275, 2N527, 2N508, 2N404, and 2SB75 have worked very well. The replacement part ECG158 works well sometimes if you can get the right one. See if you can get the guy at the service counter to let you poke the leads through the plastic bag and test the gain at the counter before buying.

[2] These values are determined by experiment in the tuning of the pedal. You will need a 100K and a 10K pot temporarily for the tuning process.

[3] The Hammond 1590B is a comfortable fit for this effect. You can also use the Eagle equivalent, the Mouser part number 400-4591, which is a bit cheaper at $7.35.

[4] Mouser does not have suitable stomp switches. The Carling 317P is the old standard, and is available through Stewart Macdonald Luthier supply for about $17. Another usable one is the “Arrow” DPDT available through GEO for $8.50 at the time of this writing.

[5] The terminal strip should only be bought if you are doing the hand-wired version. It is not needed for the PCB versions.