Eight Band Sub-Woofer Graphic Equaliser

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Introduction

Your sub is installed and set up as best you can, but you can't quite get it to sound right. Some frequencies are too prominent, while others seem subdued. If this sounds familiar, then this equaliser is what you need to fix it. It is not a panacea, and will not cure an impossible room, but the majority of lumps and bumps in the subwoofer response will respond very well to an equaliser as described here.

The unit is an 8 band variation on the expandable equaliser described in the Project Pages, and is dedicated to its task. Boards can be stacked to get more bands if desired, but the arrangement shown will be quite sufficient for most installations.

The equaliser is a constant Q design, so unlike most "ordinary" equalisers, it does not have a very low Q at low settings of boost and cut. This is a major problem with the standard (graphic) equaliser circuit, and is completely avoided by the constant Q version. Using the Multiple Feedback Bandpass design, these filters can be designed for any (reasonable) frequency and Q desired. As a 1/3 Octave equaliser, the filter Q should be 4.3, but I have deliberately lowered this to 4 for this design to allow a little overlap.

While there will always be "that" room which defies all attempts to make anything sound halfway decent, this EQ will dispose of the majority of problems likely to be encountered.

Description

The equaliser is 1/3 Octave band, with centre frequencies at 20, 25, 32, 40, 50, 63, 80 and 100 Hz. The circuit itself uses an opamp as an input buffer (U1A), ensuring a low impedance drive to the following inverting buffer. All filters are driven by an inverted signal from U2B, and the maximum amount of boost or cut is determined by the value of R18.

U1B is a summing amp, and it takes its input from the combination of the input, and the output signal from the CUT bus - this comes from the pots used as the level control for each frequency band. The combined signal is summed again by U2A, this time with the signal from the BOOST bus added. The signal drive to all filters is performed by U2B, the gain of which determines the maximum boost and cut allowed. As shown, The circuit will provide about +/-14dB, and the response is completely flat with all pots centred. Reduce the range by reducing the value of R18 - a value of 10k gives 6dB of boost and cut.

The actual operation of the circuit relies primarily on the amplitude and phase of the selected frequency, and it is beyond the scope of this article to cover it in great detail. The inverted signal drive is compensation for the fact that a standard multiple feedback filter is inverting at the resonant frequency - I shall leave it to the reader to work out exactly what happens (assuming you care, of course :-) For full details of the circuit topology, see Reference below.

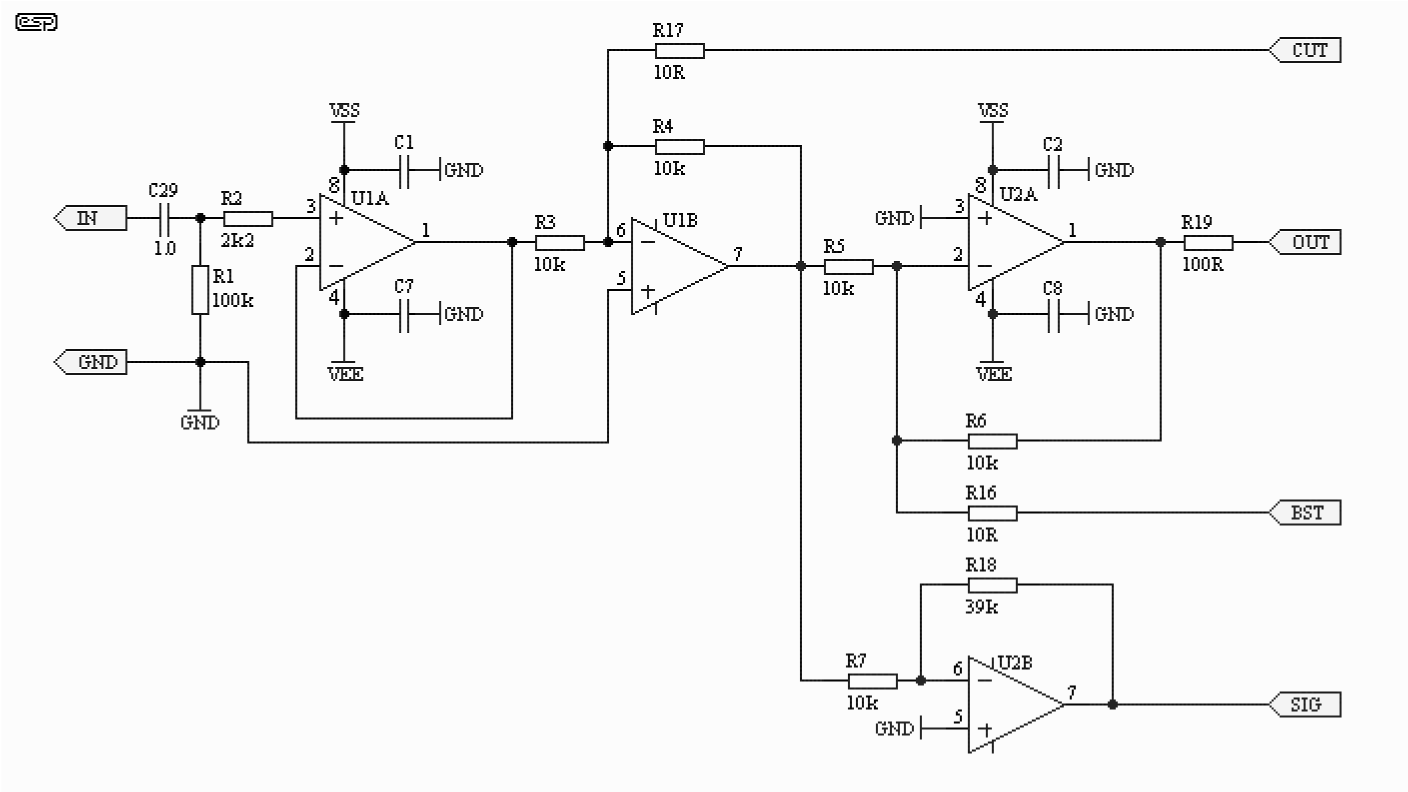
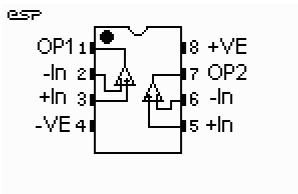


Figure 1 - Input and Output Circuitry

All unmarked capacitors (C1, C2, C7 and C8) are opamp supply bypass caps, and should be 100nF ceramic types for best performance. This is critical if high speed opamps are used, but still important if using the recommended TL072 opamps. There is little or nothing to be gained in using "audiophile" grade opamps for a subwoofer, since the TL072 has more than sufficient bandwidth for the job. Naturally if it makes you feel better, then OPA2134s or similar work beautifully.



The figure on the left (top view) shows the standard pinouts used for the vast majority or basically *all* dual opamps. If the PCB is used for this project (highly recommended, by the way), then only opamps with this pin configuration may be used. This is not a limitation :-) Correct insertion is (as always) essential, or the opamps will die ***!***

The filters are repeated - two are shown in Figure 2, and this functional block is then repeated 4 times to get the eight bands used. Again, unmarked caps C3 and C9 (and those for the additional 4 filter sections) should be 100nF ceramic bypass types.

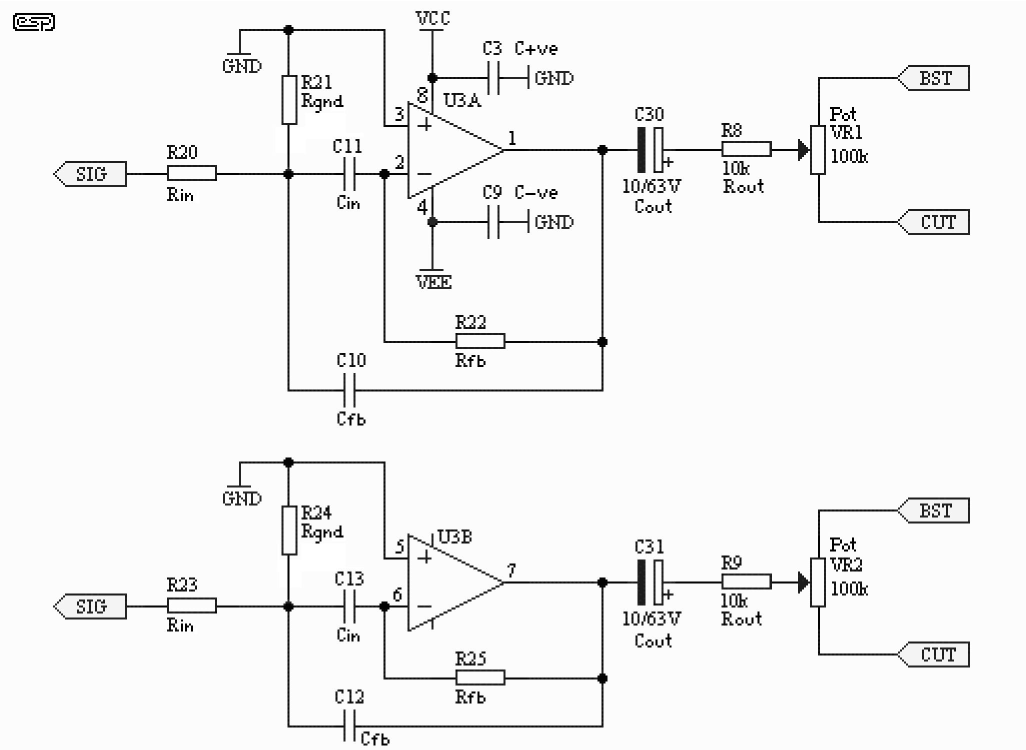


Figure 2 - Multiple Feedback Bandpass Filters

The table below shows the designations for all the filter sections. The output caps (10uF 63V as shown) may also be bipolar electrolytics - film caps would be nice, but are simply too large to fit on a decent sized board. The difference in performance is unlikely to be audible with any system, since the caps are very much bigger than they need to be at even the lowest frequency. The -3dB frequency for all output networks in this section is 1.6Hz worst case - well below anything we can hear.

	Band 1	**Band 2**	**Band 3**	**Band 4**	**Band 5**	**Band 6**	**Band 7**	**Band 8**
Pot	VR1	VR2	VR3	VR4	VR5	VR6	VR7	VR8
IC	U3A	U3B	U4A	U4B	U5A	U5B	U6A	U6B
Rin	R20	R23	R26	R29	R32	R35	R38	R41
Rgnd	R21	R24	R27	R30	R33	R36	R39	R42
Rfb	R22	R25	R28	R31	R34	R37	R40	R43
Rout	R8	R9	R10	R11	R12	R13	R14	R15
Cin	C11	C13	C16	C18	C21	C23	C26	C28
Cfb	C10	C12	C15	C17	C20	C22	C25	C27
C+ve	C3	-	C4	-	C5	-	C6	-
C-ve	C9	-	C14	-	C19	-	C24	-
Cout	C30	C31	C32	C33	C34	C35	C36	C37

The frequency selection components are shown in the following table - these are quite accurate, and will generally be suitable for all applications. I have included the 125Hz band for those who may want to move the range up slightly - only eight of the frequencies are used for the unit.

Freq Band	Rin	Rgnd	Rfb	Cin, Cfb
20	330k	10k	680k	100nF
25	270k	8k2	510k	100nF
31	270k	8k2	510k	82nF
40	330k	10k	680k	47nF
50	330k	10k	680k	39nF
63	270k	8k2	510k	39nF
80	82k	2k7	160k	100nF
100	82k	2k7	160k	82nF
125	150k	4k7	330k	33nF

Arrrgh! The values are all over the place - this was done to avoid having to use caps in parallel (there is no room on the board), and I have tried to maintain at least passably sensible values. Unfortunately, maintaining the Q and frequency for such closely spaced filters is not easy, and the table above is the result. Feel free to use the MFB Filter calculator program to see if you can do any better - it is available from the Download page.

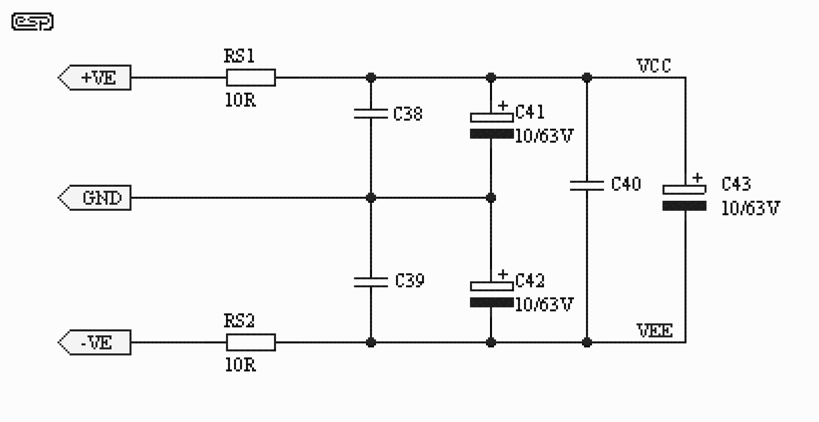


Figure 3 - Supply Conditioning Circuit

Finally, the DC input conditioning section. The 10 ohm series resistors can be omitted, but they do no harm, and help to isolate the supply from other circuitry that shares the same supply module (the P05 Power Supply is recommended for this unit). Small inductors can also be used if interference is a major problem, but these are unlikely to be needed in 99% of cases.

Although C41 and C42 are shown as 10uF 63V caps, I suggest that they be 100uF 25V - this is provided for on the PCB, which is now available.

Note
If you use the PCB for this project, it is designed to use miniature (9mm square) rotary pots, so the term "graphic" equaliser is something of a misnomer. If desired, slide pots may be used, but will have to be wired to the board. This is not as arduous as may first be thought, since there are only 10 wires needed. If required, the 9mm pots can be obtained from ESP.

Using The Equaliser

Connect the equaliser into the signal path (usually between the source and the subwoofer equalisation and/or power amplifier). Make sure that all pots are centred for an initial flat response. Verify that the sub sounds the same as before, then preferably with a test CD (known music will work too, but is not as predictable), run a frequency sweep (or burst signals) and adjust the equaliser for the smoothest response in the low frequencies. You should be in your normal listening position for this - the sound quality will be different in different parts of the room, and this is part of the problem in the first place.

Make adjustments sparingly - over use of an equaliser is a guaranteed way to ruin the sound, so make adjustments in small increments, one band at a time. It may take a while before you are completely happy, but careful listening and perseverance are the key to getting ot right. Generally, you are more likely to need a reasonable amount of cut than boost, and although possible, it is not really practical to make the circuit asymmetrical.

Once set, the EQ settings will not need to be changed, so the unit should be placed where it is not readily accessible - you ***know*** what will happen if others know that it's there, and what it does.

The settings will need to be changed if the subwoofer is moved, or if furniture is moved, added or removed from the listening area. Large soft furnishings will make the biggest difference, while small (open) shelves will usually make little or no change at all. Book cases are highly unpredictable animals, and only careful evaluation will determine if the settings remain accurate if a bookcase is added or removed.