JBL M2 active crossover settings

Author: Thomas Drugeon ([pos](#))
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This document presents the crossover settings used in the original Crown DSP amplifier for the JBL M2 loudspeaker, as well as alternatives for different crossover solutions.

The intent of this document is to let the user choose a different crossover unit and replicate as closely as possible the original settings.

EQ and shelving handling tend to vary from one unit to another, even when advertising the same EQ or shelving type, so it is recommended to measure the actual output of the crossover and compare it to the reference one (cf appendix 1).

See here for some comparisons of textbook vs BSS implementation of the parameters described in this document:

http://www.audioheritage.org/vbulletin/showthread.php?33972-JBL-Master-Reference-Monitor&p=393277&viewfull=1#post393277

http://www.audioheritage.org/vbulletin/showthread.php?33972-JBL-Master-Reference-Monitor&p=393453&viewfull=1#post393453

Due to these variations, it is recommended that you use either a BSS/Crown unit of the same generation as the one used for the M2, or a FIR crossover using the parameters described in appendix 2.

The original crossover settings were published by member 4313B on the audioheritage forum in this post. Please note that the summary table presented in the post that follows it is not complete as the input EQs are only reflected in the upper channel.

These active parameters assume that the stock passive network is inserted between the amplifier and compression driver (lpad and 1st order filter, see appendix 3 for reference) and that both the LF and HF amplifier channels have the same gain.

Colored table cells represent alternative variations to obtain the same result with various crossover units (eg proportional Q for miniDSP units).

Disclaimer: The information presented in this document are presented without guarantee. Use with caution :)

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Gain

The complete correction (EQ+Shelving) presents a maximum of 8.4dB of gain at high frequencies, so depending on your gain structure it might be necessary to lower the gain inside or in front of your crossover unit to avoid digital clipping.
Of course the important thing to note is the 0.6dB difference between the lower and upper channels.

- First column is the factory Crown preset.
- Second column is an alternative version that avoid clipping by attenuating the input and then only keeping the difference on the outputs.
- Third column is another equivalent alternative version that handle all gain settings on the outputs. This is the one implemented in the rePhase FIR presets published in appendix 2.

Input

Gain (dB)	Gain Alternative 1 (dB)	Gain Alternative 2 (dB)
User controlled (should not exceed -6.6 to avoid clipping at 0 dBFS)	-7.8	0

Upper channel

| Gain (dB)	Gain Alternative 1 (dB)	Gain Alternative 2 (dB)
-1.8	-0.6	-8.4

Lower channel

Gain (dB)	Gain Alternative 1 (dB)	Gain Alternative 2 (dB)
-1.2	0	-7.8

Parametric EQ

The Crown DSP amplifier uses Symmetrical Constant Q EQs, as most other DSP units on the market do.
The tables also show in the last column the Proportional Q equivalent, as used for example in the miniDSP units.

To help you find what type of EQ your crossover unit is using, here is a graphical representation of the two types of EQ with the Q parameter set to 1 and a +10dB gain:

+10dB, Q=1, constant Q vs proportional Q
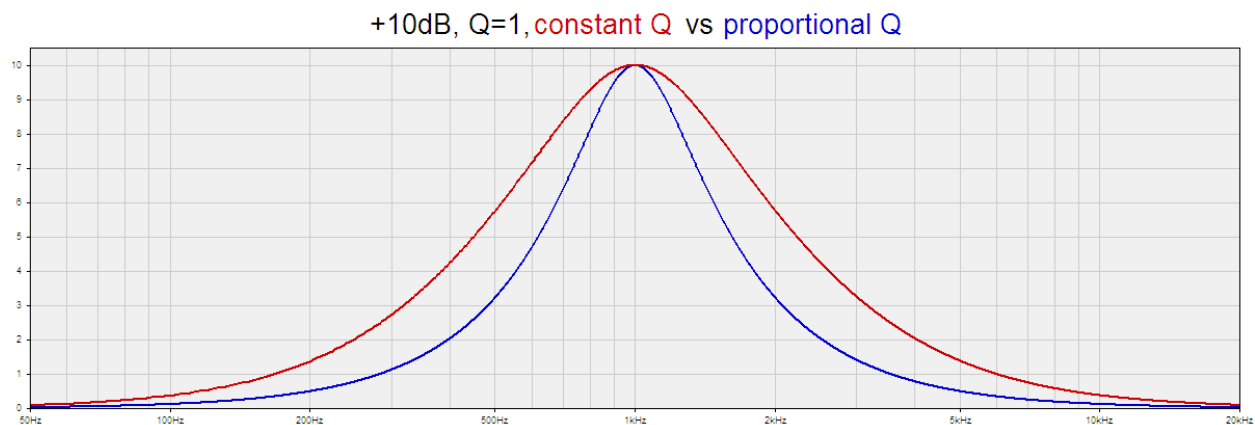
In addition to EQ types, it is important to note that implementation differences from one unit to another can cause variations in the resulting curve.
This is for example typically the case in the UHF with 48kHz DSP units.
It is recommended to measure the output and compare it to a reference (see appendix 1).

Input

These EQs are common to both the lower and upper channel and are intended to be applied before the actual filters.
Depending on your crossover unit you might have to replicate these EQs in both channels. This is what is done in the rePhase FIR presets published in appendix 2.
Depending on the number of available EQ points the highest EQs (1600Hz and up) can safely be ignored for the lower channel.

Frequency (Hz)	Gain (dB)	Symmetrical Constant Q	Proportional Q alternative equivalent
500	1.1	5.26	4.94
900	1.6	4.38	4
1150	1.4	7.43	6.85
1600	-0.9	3.13	2.97

2540	-1.1	9.72	9.12
3250	1.3	7.07	6.56

Upper channel

Frequency (Hz)	Gain (dB)	Symmetrical Constant Q	Proportional Q alternative equivalent
760	-4.3	2.5	1.95
1000	1.5	3	2.75
3100	-5.6	3.5	2.536
4000	-1	6.56	6.19
9370	2	10.16	9.06
11200	2	13.25	11.81
16000	2	5.26	4.69

Lower channel

Frequency (Hz)	Gain (dB)	Symmetrical Constant Q	Proportional Q alternative equivalent
21.5	4.7	1.77	1.35
61.5	-0.8	5.32	5.08
197.5	0.9	6.31	5.99
236	0.4	6.56	6.41
254	2.6	10	8.61
340	-0.5	3	2.91
400	-0.5	7.43	7.22

Shelving

There are even more variations in shelving implementation among DSP units than there are for EQs.

The Crown DSP amplifier specifies the shape of the shelving using a slope parameter. These tables also show in the last column the equivalent Q parameter for units that need it (eg miniDSP, Hypex).

Please note that that despite the close advertised slope, fixed 6dB/oct and 12dB/oct shelving filters are not at all equivalent to the ones used here.

Frequency is assumed to be the middle of the shelving filter, but variations do exist among existing units (cutoff, center, corner). <u>You might have to check your particular implementation and adjust frequency so that half of the final gain is reached at the intended center frequency</u>.

<u>Even when using DSP crossover with adjustable Qs, it is recommended to measure the output and compare it to a known reference (see appendix 1).</u>

Upper channel

Frequency (Hz) (<u>center</u> frequency)	Gain (dB)	High Shelf variable slope (dB/oct)	High Shelf variable Q alternative equivalent
7100	5	11	1.35

Lower channel

Frequency (Hz) (<u>center</u> frequency)	Gain (dB)	High Shelf variable slope (dB/oct)	High Shelf variable Q alternative equivalent
135	-8	5.5	0.73

Alternative for upper channel (approximation)

As a last resort, if you are unsure about your shelving implementation here is an approximated equivalent using two EQs. The difference stays within +0.2dB/-0.5dB up to 18kHz.

Frequency (Hz)	Gain (dB)	Symmetrical Constant Q	Proportional Q alternative
5500	-8	1.2	0.76
9300	10	0.9	0.51

Alternative for lower channel (approximation)

This shelving is not as easy to replace with EQs, but with its Q=0.73 it is close to what some DSP units call 12dB/oct shelving (Q=0.707). Beware that in these implementations the Fc is generally not the center of the shelving.

Delays

Lower channel

Time (us)	Distance (cm)	Samples at 48kHz	Samples at 44.1kHz (approximation)
270.8	9.3	13	12

These delays are implemented within the rePhase FIR presets published in appendix 3 (centering setting).

Filters

Upper channel

Frequency (Hz)	Slope (dB/oct)	Type
782	6	1st order high-pass

Lower channel

Frequency (Hz)	Slope (dB/oct)	Type
790	36	Linkwitz-Riley low-pass

Linkwitz-Riley 36dB/oct filters are not always available in crossover units.
Here are three possible alternatives for the lower channel low-pass filter:

Alternative 1 for lower channel (exact equivalent)

Frequency (Hz)	Slope (dB/oct)	Type
790	18	Butterworth low-pass
790	18	Butterworth low-pass

Alternative 2 for lower channel (exact equivalent)

Frequency (Hz)	Slope (dB/oct)	Type
790	12	second order low-pass Q=0.5 (Linkwitz-Riley)
790	12	second order low-pass Q=1
790	12	second order low-pass Q=1

Alternative 3 for lower channel (approximation, 0.2dB maximum difference)

| Frequency (Hz)	Slope (dB/oct)	Type
790	24	Butterworth low-pass
790	12	Butterworth low-pass

Appendix 1: Crossover response curves

These amplitude and phase response curves represent the action of the gain, EQ, shelving and filter parameters described in this document as they should measured at the output of the crossover unit.
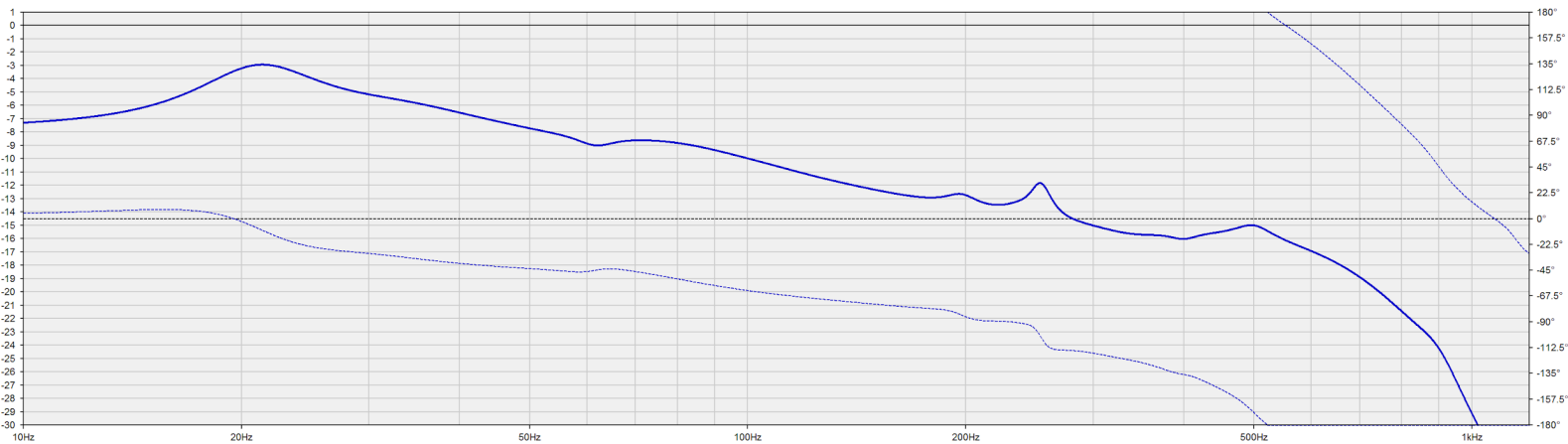
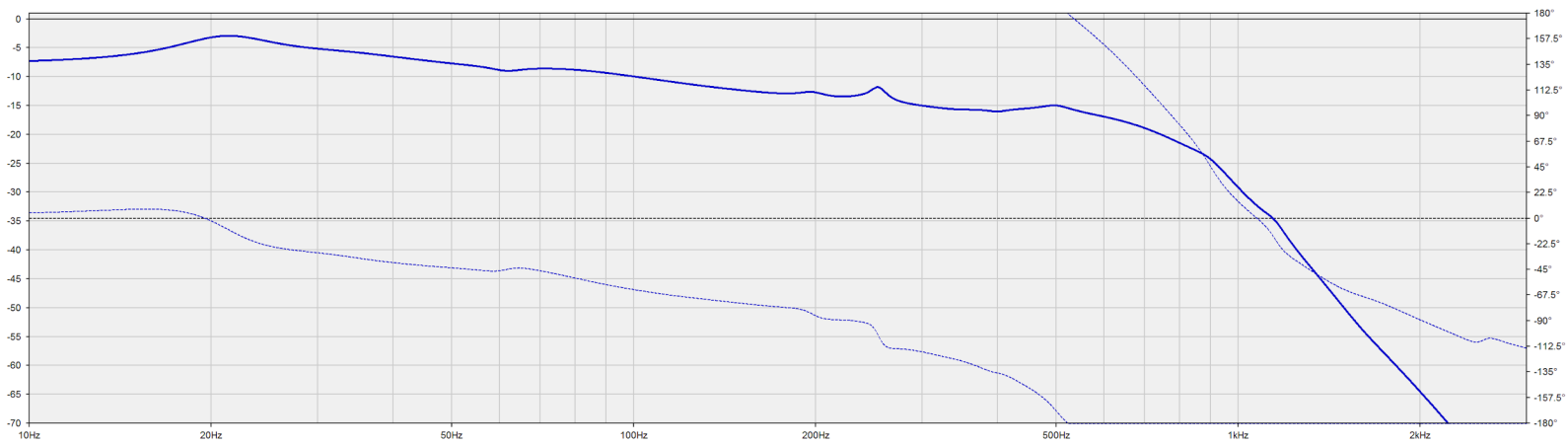These were obtained using rePhase and the modified settings described in appendix 2.

You can zoom into the document to see the details and visually check your settings.

Upper channel
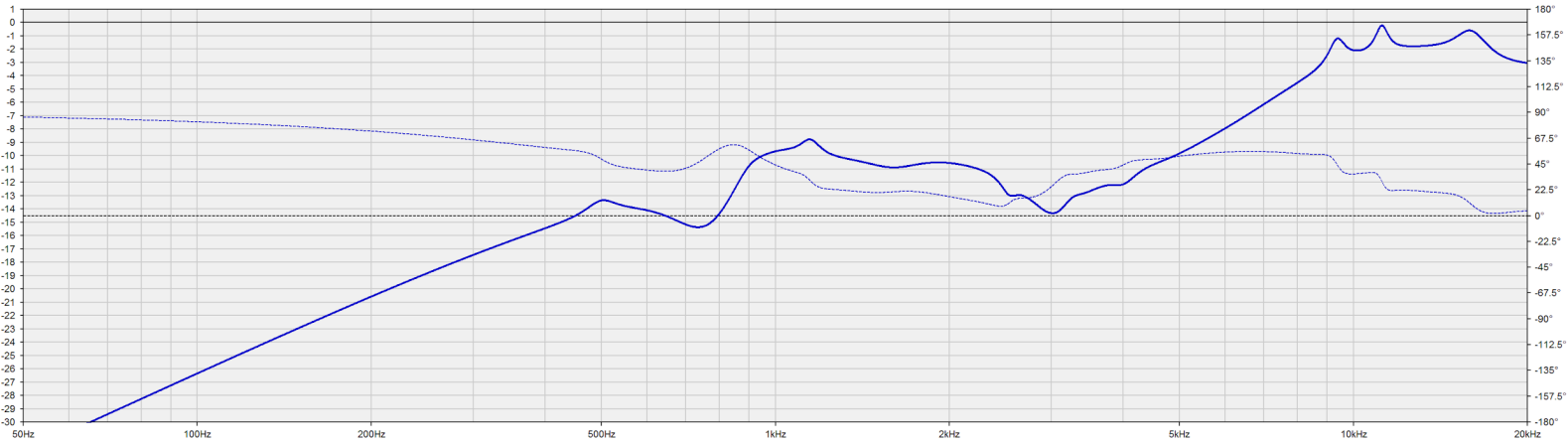
Lower channel

Appendix 2: rePhase settings

These rePhase settings can be used to generate a FIR correction implementing the gain, EQ, shelving, delay and filter parameters described in this document.
They have been adjusted based on an actual measurement of a BSS crossover unit running the M2 preset
This this and the following posts.

The default impulse settings are set to fit an openDRC device (6144 taps, 48kHz sampling rate, IEEE-754 format), but can be changed to whatever format you need.
For example txt or wav output formats can be used to load the resulting FIR in a measurement analysis software such as HOLM Impulse or REW and compare it to the output of your crossover.
The centering setting includes the relative LF/HF delay.

The correction is entirely minimum-phase and the implied delay with the present centering settings is 1ms.

rePhase version 1.0.0 or greater is required : rePhase.org
To load these settings, copy the whole content of the box and use the "Load Settings From Clipboard" file menu functionality.

Upper channel

```
rePhase settings
eNrtW19v2zYQ/yqCnjrUJkjqfx635WHDgnXPbSDQFm0LkUhNopOmQb77jqToyLIbpEhQYC2RwBLv
jne83x15gg56CFfyc7mpG8X7Ibz4+DEMF2GUhNeLM3fXi3DNBUjWYhtehKQdgLHe8fXNsG81YZVQ
zNYJzVekSquYp4RuomyT5XnGsnWqpXs5DHN7BGPs7LztPawYbHHBWg7ru6Llrt7uyqu/fw81oz9a
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j7RH2iPtkfZIe6Q90t8f6etFuO1ZtysHrlQttoNpKVSr0oCeLMytbjssMwwDvrUMkruR4Znhrq54
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97gIhVQ6vf789a/gigamRy5hbuDS5pP4TbZdzwfdEQ2qvrbMtS4En+DvA6wVaEHXgyJDDQRXd7K/
CeohGPZdJwdeBUoGKx7UIugatubBu6Zj1fs163TXVXawrvrLobZISD+m+IxTbhope9OF1Q53X+vB
FvhcM8BVpqVp5Z4WrKGRHZ8VrfFt9Vi35m+xXfma010Vm9NtMZtTXU07eUc+lrYTqwk+Z9IWulOT
tt698LX8WP1OTdoiOKfHZ7W4knjGZnbGH9eNPLFp6uQzPYICv1GU/aPJSx4CPdwebg+3h9vD7eH2
cHu4Pdwebg+3h9vD7eH2cHu4Pdwebg/3j9ys7GTD+lrdA3pC9i3wB9Z2zaSfsGkkU45uv9OLc/t6
d5Abdcd6DX3PP4xNY0csh/1q/EzuDPPoYyyEK83br+bf8dHD13fHd7BwxTrd/khJHLsWSFX3tlfx
5MwhMfqRdeiAAPOuFpW8sy7tmBDh439HrH6H
```

Lower channel

```
rePhase settings
eNrtW0tv4zYQ/isGTy1iEyT1zrFoDi026OPSw9YQaJu2iUikK9HxJkH+e4ek5JVlb7DbBD1kCRgW
OSTnI78zcgQO9IQW+lO5lpURTYuuP35EaIqiBM2nF0rzKVoKBT2l2qBrROv2imUE5/sWOiy3YnnX
7mtoSFZ0yZOVINkiLgQh64IvVjQmiaA8W3Bqeze6bce4lBDS471tGWYOWELxWsD8bllZ6UN5+9vP
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Usl6X89cA3QwDzvrEEutWsOVmfwBsnte7YX3hSuKqQVJiP1PceZWC9IkhnrhpAnOe21kMS1166ae
mRnM2lVT94hw2ouZrbMkdq3sqNj1Yu6RY+rEpFNB/AOT9y2dP08vmDN9C3PGn18G7DsPjb0x4Aiz
9ZTizJm5MyjBRWInVWTYPrPe/ATH9ghjUeLkebeUK4bTzqZ2VNRZD7QnVnsUewcojlJbj926i24m
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oK/E/ErIeLhQRl6zUuu4J7hj2DPvKhuu7tA1jJGjrGOlD30C7YNUdwdpHmd/yko82C0Ezq32VfU5
mZYVxIsuJN9YPO7tN1jo/mJ3sFUteLtvRC2UQddPaPHghlprrbjhYCY3+Pg397nIUq/XYF9wD+cb
A3+xZlb3ojGuCGey2YM6OxMjazEc9zxFShvrYr/+9GFyyyYuPa5h7KR3nb/VX1qvnWDpzv8p0jvQ
Ix+P4UCvRMONGLWU60rrxnqvy5fuvpQvLcily/s+mMxc2vU8xrSV3olRnOkumLtQM76A7yPOWN4H
nrHcx5+xtA9DZ9f7XTQ6Q/WJvzGkj03nkD5EfSF3cAbpA9Y5pI9bY3l8UUsfxS5gZhfW08W0c0wX
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```

Linear-phase versions

EQ and filter settings used in the original BSS/Crown crossover are all IIR minimum-phase. Using FIR would let us build a linear-phase acoustical crossover, resulting in a truly minimum-phase system. The woofer rolloff could also be phase-linearized to obtain a truly linear-phase system.

Alternative rePhase settings might be added in the future to build such systems.

Appendix 3: Passive network

Excerpt from the <u>JBL M2 technical manual</u>

The active parameters described in this document assume the following passive network to be inserted between the amplifier and compression driver, as is the case within the stock M2 loudspeaker enclosure.

Note: C2 value is stated as 33.3uF in the schematic from the technical manual, but it is a misprint and should read 3.3uF

Here is the corrected schematic:
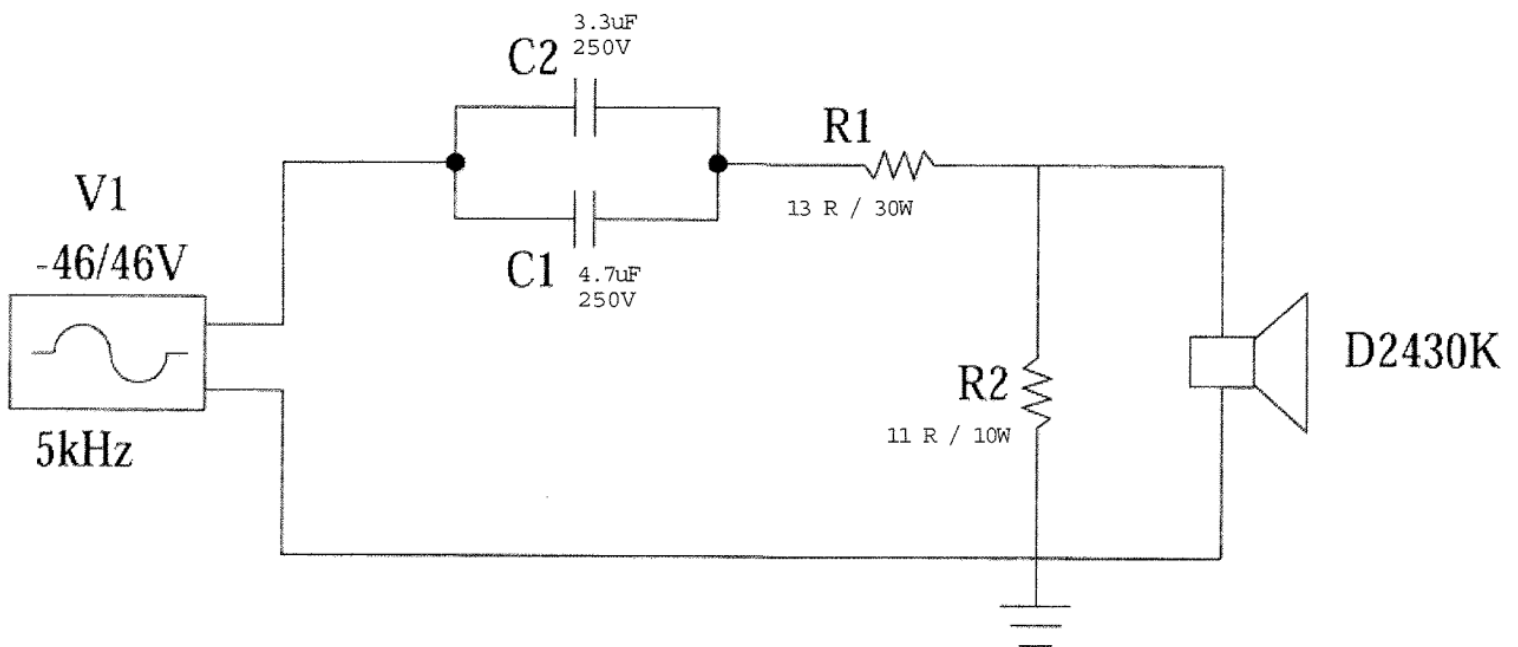
- The D2430K has its two diaphragms wired in series, for a 32 ohms nominal impedance.
- The R1/R2 L-pad corresponds to a 9dB attenuation for a 20 ohms load.
- The C1/C2 capacitors are equivalent to a 8uF capacitor, which corresponds to a 6dB/oct high-pass filter with a -3dB point at 1kHz for a 20 ohms load.

Appendix 4: Cloning

Here are some recommendations and general considerations regarding M2 cloning.

Using a different crossover unit

It is recommended that you either use the official BSS/Crown unit, or a fully FIR one with enough taps, like the openDRC.
This is due to potential differences in biquad implementations between IIR units, resultings in different correction curves.
For example the BSS unit has been found to substantially differ from the reference theoretical implementation (+/-1dB variations for the HF sections, +/-0.5dB variations for the LF section).
Considering these "errors" have been factored in during the conception of the M2 and its correction settings, they have to be reproduced when using a different crossover unit.
This is what was done to obtain the rePhase settings presented in appendix 2, and the resulting reference curves shown in appendix 1.

FIR does not have the same issues as IIR. Providing enough taps are available, any FIR-capable unit should be able to reliably reproduce the reference curves using the rePhase presets.
FIR precision is linear and depends on the number of taps relative to the sampling frequency. It is also predictable and rePhase will show you exactly what you will get with the red curve, which is basically an FFT of the FIR.
If the convolution engine of the FIR crossover unit is properly implemented, the output should be identical to that red curve.

Using one openDRC device per M2 speaker is a proven solution.

Using a different enclosure

Some EQs in the woofer section are especially tailored to correct very specific woofer/enclosure interactions, such as the effect of the back wave.
This seem to be the case for the 3 high Q EQ points around 200/250Hz.

Any slight modification in the geometry, driver or bracing placement, enclosure material, or even damping material can affect these interactions. As a result, the high Q corrections used to counter them might not be valid anymore, and even cause serious problems.

Hence, when building your own box it is recommended that you either measure the woofer in anechoic conditions (close mic measurement can be a solution when properly interpreted) and adjust these corrections accordingly, or simply remove these box-specific EQ points.

The rePhase settings presented in appendix 2 do include those 3 EQ points EQs in the 2nd bank of the paragraphic EQ tab, so you have to manually set them to 0dB before generating the FIR.

When using an official BSS/Crown crossover with a DIY loudspeaker enclosure it might be necessary to get an unlocked version of the preset file in order to be able to remove or alter these EQ points. Such versions have been uploaded on the audioheritage forum.
Alternatively, it might be possible to "cancel" these EQ points using additional opposite EQ points.
Another solution is of course to rebuild the whole EQ preset manually using the information found in this document, which exactly reflect the one found in the BSS/Crown preset.

Building the passive crossover network
The passive network described in appendix 3 is part of the M2 crossover, and cannot be ignored.
If you did not get an original one you can easily design your own based on the schematic.
Please make sure that you use a 3.3uF cap for C2, and not a 33.3uF one as erroneously noted in the spec sheet.
The original caps are Wima MKP10 250V DC / 180V AC 5%

The resistors forming the 9dB lpad cannot be omitted, even if you intend to use a low power / low noise amplifier. They are part of the network and linearize the impedance curve.

An alternative protection network could be used with a simple protection cap (eg 30uF), but the whole correction would have to be reworked.

This document might include alternative correction settings to tackle this case in the future.