Marchand Electronics Inc.
Tel:(585) 423 0462
info@marchandelec.com www.marchandelec.com

WM8 Installation Instructions

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SPECIFICATIONS*

Frequency Response (Boost=0, Qs=Qb)	2 Hz-100kHz
Harmonic Distortion	<.01% (1 kHz)
Signal/Noise Ratio	>110 dB (Ref. 10 V)
Input Impedance	80 kΩ
Output Impedance	10 Ω
Maximum Output Voltage	25 V (P-P)
Output Load Capability	100 Ω (min.)
Bass Boost Range	0-24 dB
Net Q Range	.25 - 1.0
Dimensions	17"W x 8.5"D x 3.5"H

*Specifications subject to change without notice.

INTRODUCTION

The BASSIS is a specialized electronic equalizer which enables acoustic-suspension (closed-box) loudspeakers to take on a wide range of alternative bass responses improving some vented (bass-reflex) designs.

By adjusting the front panel controls, the line-level audio signal is equalized as the exact inverse of a given loudspeaker's bass response, and the new bass cutoff frequency and damping are defined. The filtered signal is then passed to the power amp and on to the speakers, where the existing bass response is cancelled and replaced by the desired bass response. Figure 1 illustrates the frequency response at various points in the signal path.

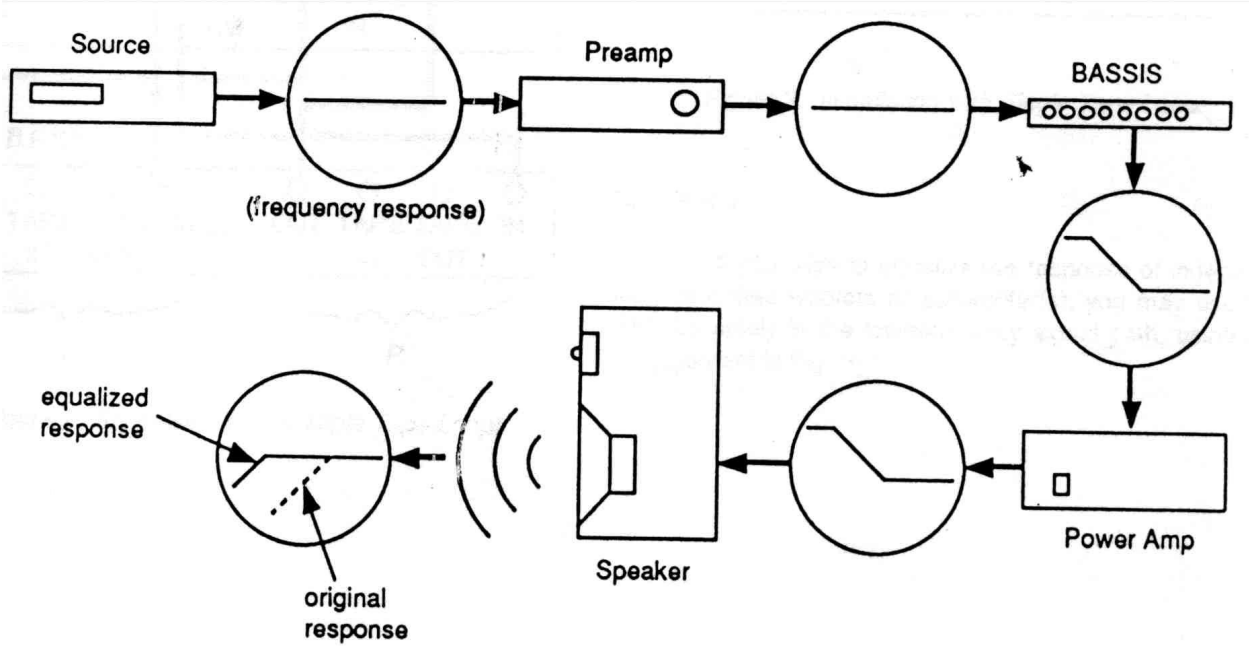

Figure 1. Installation with Separate Components

INSTALLATION

There are several ways of connecting the BASSIS to you system, depending upon your present setup. In any case, *make sure all components are turned off while making connections, and read the rear panel labelling carefully.* Do not apply power to the unit when installation is complete. You must make the adjustments described in "Operation" first.

SEPARATE COMPONENTS

If you own a separate preamp/power amp combination, you can use the arrangement shown in Figure 1, where the **OUTPUT** from the preamp is connected to the BASSIS' **INPUT** jacks, and the BASSIS' **OUTPUT** jacks are connected to your power amp's **INPUTs**. The **BYPASS** switch removes the BASSIS circuitry from the signal path by connecting the INPUT directly to the **OUTPUT.** This allows easy evaluation of the equalizer's effectiveness.

If you own an integrated amplifier or receiver with **PREAMP OUT** and **POWER AMP IN** jacks, the same connection as for separates can be used.

MULTIPLE TAPE LOOPS

If your integrated amp or receiver has an unused tape loop (or a dedicated signal-processing loop), you may connect the BASSIS as shown in Figure 2, below.

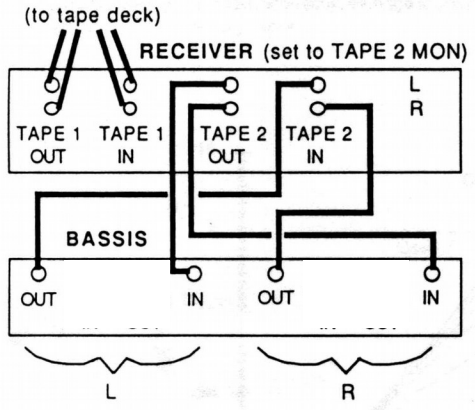

Figure 2. Installation with Multiple Tape Loops

Be sure to press the **TAPE 2 MON** button on your receiver. You can remove the BASSIS from the signal path in two ways now: (1) turn off the **TAPE 2 MON** button on your receiver, or (2) use the **BYPASS** switch on the BASSIS.

BIAMPING

If you wish to equalize the response of independently amplified woofers or subwoofer(s), you may use the BASSIS solely in the low-frequency signal path, using the arrangement in Figure 4.

OPERATION

The various controls on the BASSIS must be adjusted to match your system's requirements *before* power is applied to the unit. If the 24 dB (factor of 16) maximum **BOOST** setting is applied incorrectly, damage to your speakers and/or amplifier may result.

SETTING Qs

Figure 5 shows the bass response of various acoustic-suspension loudspeakers. If the speaker's Q is greater than 0.7, the response may reach a peak at the "resonant frequency", then fall off at a rate of 12 dB/octave at lower frequencies. If your speaker has a "boomy" or "heavy" sound, then it is likely that it Q is in the "underdamped" range from 1.0 to 1.6. On the other hand, speakers whose Q is .5 or .6 will be "well-damped", with a "tight" or even "lightweight" sound (due to the prematurely-falling bass response).

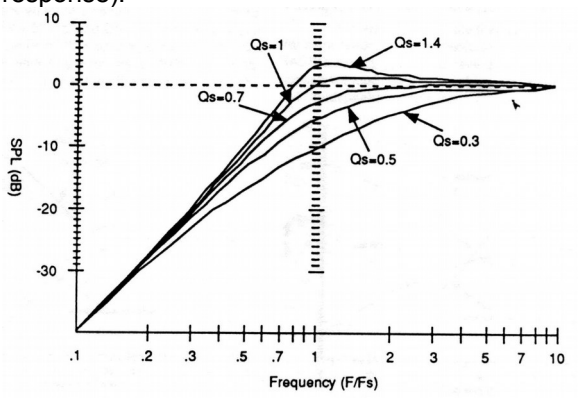

Figure 5. Damping of Various Acoustic-Suspension Loudspeakers

You must adjust the Left and Right channel controls labelled **Qs** (Speaker Q) according to your own speakers' characteristics. (You will ordinarily use the same settings for Left and Right channels.) Choose a value which approximates the damping for your speakers, as suggested above. If in doubt, use a setting around .7, corresponding to the value most speaker designers aim for. You can later fine-tune the setting if necessary.

Setting Fs

You must now set the Left and Right channel **Fs** (Speaker Corner Frequency or -- less accurately -- Resonant Frequency) controls. If you have frequency response specifications for your loudspeakers of the form:"55 Hz to 18 kHz ± 3dB" or ".3 dB point at 75 Hz", you can approximate **Fs** by making use of Figure 5 and your estimate for **Qs.** For example, if your speaker's value for **Qs** is .5, then Figure 5 shows that its -3 dB point is near 1.6 x **Fs.** Thus, if your specs indicate a -3dB poi9nt of 75 Hz, then a setting of **Fs** = 75/1.6=45Hz should be used. On the other hand if your speaker has **Qs**= 1.4 (boomy-sounding), then Figure 5 indicates its -3 dB point is near .65 x **Fs.** Hence if its specifications indicate a frequency response like: "52 Hz to 22 kHz ± 3dB", then you should use a setting of **Fs** + 52/.65 = 80Hz. Finally, if you assume **Qs** = .7 for your speakers, then **Fs** equals the specified -3 dB point.

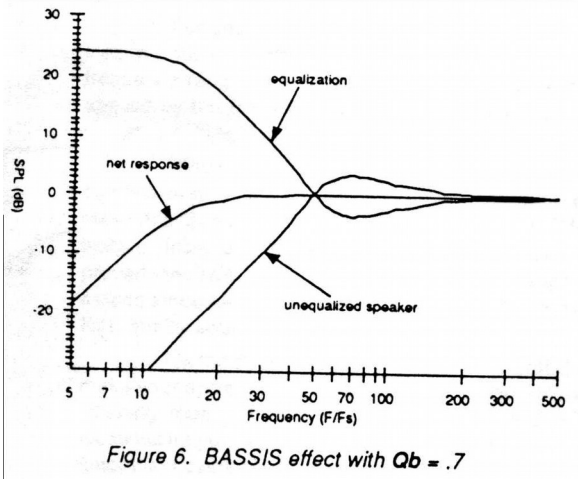

*Figure 6. BASSIS effect with **Qb** = .7*

If you have no frequency response specs for your loudspeakers, or if the specs are of the form "50 Hz to 20 kHz" (without ± x dB limits) then you will have to estimate **Fs.** Most medium-size "bookshelf" speakers have **Fs** around 65 Hz; compact speakers (enclosure less than 14" high) may have **Fs** closer to 80 Hz; large speakers (greater than 30" high) may have **Fs** around 40-50 Hz. For those tiny die-cast speakers like Radio Shack's Minimus 7, try a value of 100 Hz or higher for **Fs**, with **Qs** around .8 or .9.

While these settings are not too critical, it is important to get in the ballpark of the correct setting before using the BASSIS. The settings may be fine-tuned later if necessary. As an example of the effect of a severe mismatch, suppose your speaker has Fs = 50 Hz, and Qs = 1, and suppose that you incorrectly set the BASSIS according to Fs =100 Hz, Qs = .5. If you make the remaining adjustments (Boost and Qb, as described below) to try to extend the bass response, the BASSIS will give a 6 dB boost

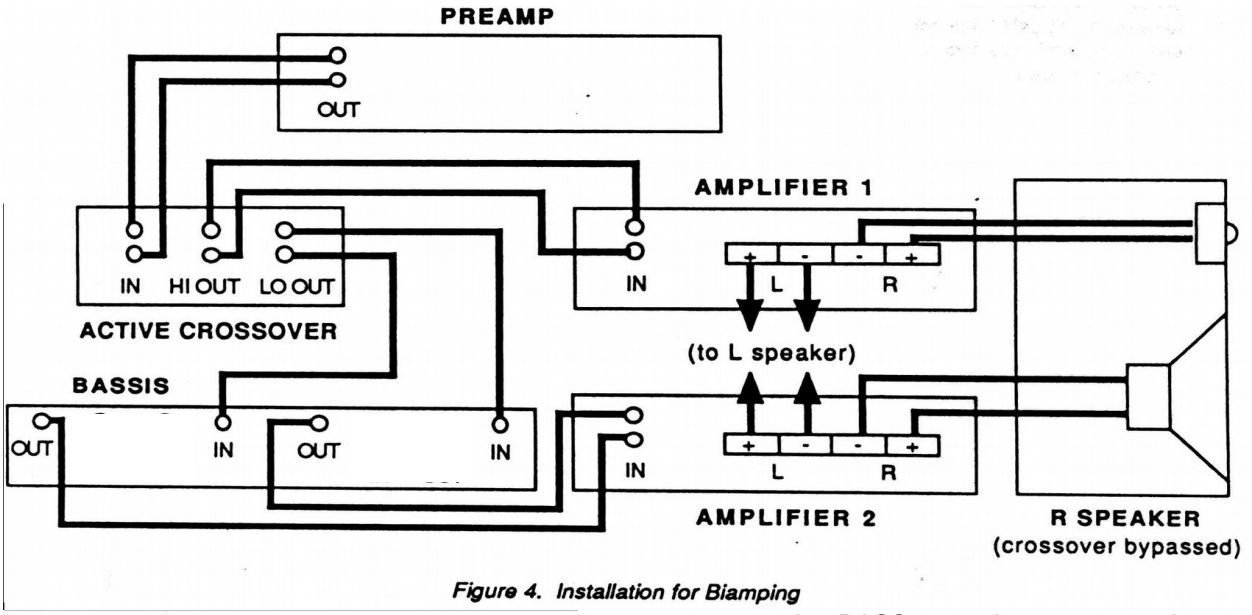

Figure 4. Installation for Biamping

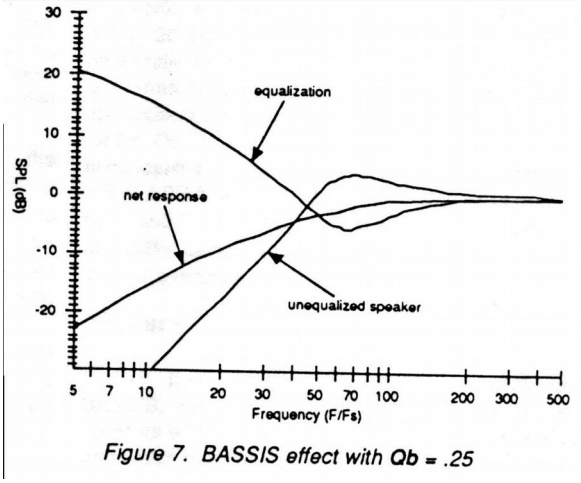

Figure 7. BASSIS effect with Qb = .25

In the net response at 100 Hz and more than 12 dB too much bass at 50 Hz. (This speaker would be nearly flat to 50 Hz. without equalization.) The unnecessary bass boost will give a very "heavy" sound to most recordings, and may damage the speakers or cause distortion when listening at high levels.

SETTING BOOST

Once the correct settings of **Fs** and **Qs** have been made to match your loudspeakers, you may never need to readjust these controls. However, the remaining controls -- **BOOST** and **Qb** -- may be adjusted to give the best results with your choice of listening levels and source material. **BOOST** indicates the amount by which low frequency signals are amplified. If the **Fs** and **Qs** setting are correct, only those frequencies where your speaker is deficient will be amplified, so that the effect is to extend bass response. (In contrast, the BASS control on your receiver or preamp indiscriminately boosts the entire low-frequency portion on the signal, often leading to a "boomy" or "heavy" quality.) A setting of **BOOST** = 0 dB will not extend the bass, but will allow you to effectively adjust your woofer's damping by changing **Qb** as described below. A setting of **BOOST** = 12 dB will extend bass response one octave lower, and a setting of **BOOST** = 24 dB will extend bass by two octaves.

SETTING Qb

The best setting for **Qb** is largely dependent upon your taste and on the listening-room acoustics. This control adjusts the Q (see Figure 5) of the new bass response dictated by the BASSIS. If you want a very "tight" sound, choose a **Qb** = .5 or smaller. If you want a "looser", more "full" bass, use **Qb** = 1. **Qb** = .7 gives the "maximally-flat" response. Figures 6 and 7 show the results when the BASSIS is used to correct a somewhat boomy-sounding speaker whose response drops below 60 Hz (**Qs** = 1.4, **Fs** = 60). In both cases **BOOST** = 24 dB is used, but in Figure 6 a setting of **Qb** = .7 is used, while in Figure 7 **Qb** = .25 is used.

It is interesting to note that settings of **Qb**≤ .5 give a transient response with absolutely no "ringing", so that the BASSIS allows you to achieve a "non-resonant" bass response without need for a refridgerator-sized "transmission-line" loudspeaker enclosure.

VENTED SPEAKERS

The BASSIS can be used to reduce the boominess of poorly tuned vented ("ported", "bass-reflex", or "passive radiator") speakers. In this case, use a setting of **BOOST** = 0 dB (*never* boost the bass below the resonant frequency of a vented speaker!), **Qs** = 1.4, and adjust **Qb** to your taste. Or, you can plug the vent and forego the efficiency advantage of the vented design, allowing you to use the entire range of equalization options as you would for an acoustic-suspension loudspeaker.

FINAL ADJUSTMENTS

You are now ready to apply power to your system including the BASSIS. Advance your **VOLUME** control slowly to make sure the unit is working properly. If you have difficulties, see the "Troubleshooting" section of this manual (Appendix F). There are a few additional points to keep in mind to obtain optimum performance.

If your source materialis LP records, you should test your system's sensitivity to record warps. Remove the grilles from your speakers. With the **VOLUME** control set low and the BASSIS set with **BOOST** = 24 dB, play the silent lead-in observing your woofer cones. If a significant "pumping" motion is visible at your normal **VOLUME** setting, engage the **20 HZ CUT** filter on the BASSIS.

Even when properly adjusted, the bass extension offered by the BASSIS must be used with discretion. While the BASSIS can give a 6-1/2" woofer the same bass response as that of a 12" woofer, it cannot increase the *power handling* of small speakers. Do not engage your preamp or receiver's **LOUDNESS** button or make excellive use of the **BASS** tone control while using the BASSIS. When listening at high **VOLUME** levels to material with significant low-bass content, it is wise to reduce the **BOOST** setting, reduce **Qb**, or **BYPASS** the unit entirely.

Fortunately, the low-bass content of most recordings is much smaller than the content of the remaining frequency range. In these cases the low-frequecy boost applied by the BASSIS will not impair the speaker or amplifier power capabilities.

When using the BASSIS, don't expect to hear the sort of elevated bass produced by turning up your preamp or receiver's **BASS** tone control or pressing the **LOUDNESS** button. Instead, the mid-bass will be reproduced with impoved neutrality and "openness", and the response will extend smoothly into the lower bass, particularly when using high-quality source material.

On the other hand, extending the bass response will make your system more sensitive to "standing waves" in the listening room. You may have to experiment with new locations for your loudspeakers or listening seat to obtain the smoothese overall bass response.

TECHNICAL DESCRIPTION

The equalization offered by the BASSIS can be described in terms of the biquadratic *transfer function:*

$$G(s) = \frac{w_s^2 + 2\,d_s w_s s + s^2}{w_b^2 + 2\,d_b w_b s + s^2}$$

where w_s and d_s are the corner frequency and damping ratio of the woofer and w_b and d_b are the new corner frequency and damping ration chosen by the user (w =2piF and d =0.5/Q). The numerator cancels the 2nd-order high-pass effect of the acoustic-suspension woofer and the denominator defines the new 2nd-order cutoff.

CIRCUIT

The circuitry for each channel of the BASSIS is contained on an individual printed circuit board (PC board), using high-speed op-amps and close-tolerance passive components. A power supply is contained on a third board. The schematic diagram of a single channel is shown in Appendix A.

The heart of the circuit is a 4-amplifier biquadratic filter, supplemented with additional op-amps to allow the independent adjustment of the damping and cutoff frequency pararmeters. Op-amps IC1, IC2 and IC3 provide the equalization, while IIC4A is part of the **20 Hz CUT** filer. Op-amp IC4B provide low output impedance and high current capability, to allow long cable runs with minimal loading effects.

Dual potentiometer VR3 adjusts the frequency matching the speaker's corner frequency over the range: Fs = 30 Hz to 130 Hz. Potentioometer VR2 adjusts the damping which exactly cancels the speaker's response, for speakers with Qs from .4 to 1.6. Potentiometers VR1 and VR4 set the corner frequency and damping of the new bass response over the range: Fb = Fs to Fs/4 and Qb = .25 to 1. Since each octave of bass extension requires 12 dB of amplification at low

frequencies, pot VR1 is actually labelled BOOST, with a range of 0 to 24 dB.

Switch S1 activates the **20 HZ CUT** (high-pass, infrasonic, or "subsonic") filter with an 18 dB/octave slope below 20 Hz, to avoid the amplification of inaudible but potentially destructive low-frequency signals. Switch S2 combines the Left and Right channels at frequencies below the speaker's original corner frequency (provided the settings for **Fs, Qs**, **BOOST**, and **Qb** are identical for both channels) to cancel out-of-phase **RUMBLE** signals. Switch S4 provides a **BYPASS** function to eliminate the equalizer from the signal pather, and Swith S3 allows the user to regain tape monitoring capability, in the event that the BASSIS is used in the sole tape loop of a receiver or preamp.

OPTION 1

If you are constructing your own enclosure for the BASSIS, you may choose to calculate the values of fixed resistors which reflect your particular speaker's Fs and Qs, and which provide a fixed amount of boost. This allows you to eliminate all but a
Single potentiometer -- which controls the damping (Qb). Since the setting of the **Qb** control influences the level of bass about the new corner frequency (compare Figures 6 and 7), you retain control of the net bass extension. To implement this option, follow the assembly procedure detailed in the next section of this manual, *except:* (a) leave out the Molex connectors which attach the **BOOST** and **Fs** pots to the PC board; (b) wire only that part of Molex connector P2 which attaches the **Qb** pot to the PC board; (c) recalculate the values of resistors R7, R8, R16, R4, and R26 according to your speakers' characteristics and the desired amount of boost:

$R_7 = R8 = 1/(6.28 \times F_s \times C_1)$

$R_{16} = R_{19} \times Q_s$

$R_4 = R_{26} = R_{28} \times 10^{boost/40}$.

Where BOOST is given in dB. Now you can use a dual 10k linear pot to adjust the damping (Qb) of the Left and Right channels simultaneously. Or, if you want to eliminate the remaining control as well, remove VR4 and recalculate R11 for the desired (fixed) value of Qb:

$R_{11} = R_2 \times Q_b$.

OPTION 2

There is space in the standard BASSIS enclosure for an additional power supply for constructors interested in true dual-mono operation. Simply follow the steps in the "Assembly" section of this manual, but wire the inputs of a second $\pm$ 15 V power supply to the power cord as well, and power the Right-channel PC board from this power supply.

OPTION 3

On the other hand, if the BASSIS is to be used with a single-channel, independently-amplified subwoofer, then only a single PC board need be assembled, and a smaller enclosure may be employed. Assembly is the same as described in this manual, except that the switches may be SPDT rather than DPDT.