BBE™

2002 SERIES INFORMATION MANUAL

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Thank you for buying the Barcus-Berry Electronics Model 2002 Audio Processor. You have selected a component designed with care to solve a set of problems present in all audio systems, large and small. By reading this manual you will be able to gain some understanding into the theory and operation of the Model 2002, as well as guidance in maintenance, calibration and trouble-shooting.

SPECIAL NOTICE

We suggest that first-time users of the Model 2002 read Section II of this manual carefully before using the unit. Experience has shown that reviewing the functions of the various front and rear panel features of the 2002 prior to its use can answer most, if not all, the questions our Service Department routinely fields. But if you still have questions on the BBE 2002, you may call us on our toll-free numbers 1-800-558-3963 (in California), 1-800-233-8346 (outside California). If calling outside of the United States, dial 714-897-6766.

SECTION I
PRODUCT DESCRIPTION

The BBE[tm] Model 2002 Audio Processor was designed to help solve a specific set of problems which are present in all sound systems. To put the problem in its most simple terms, amplifiers are not completely compatible with dynamic loudspeaker systems. When a constant-voltage output device (the amplifier) drives a transducer (the speaker) which requires a constant-current signal in order to accurately reproduce the audio signal, phase and amplitude shifts occur which cause the reproduced sound to become 'muddied' and less clear than the original. Additionally, physical limitations in most speaker systems cause further phase and amplitude changes which must be dealt with if the sound system is to perform at its best in reproducing audio. (These problems will be discussed in more detail in Section IV of this manual).

To help counter the effects of the speaker/amplitude interface, the Model 2002 'preconditions' the signal going to the amplifier. A predetermined phase shift, which has been found to be beneficial to virtually all sound systems, is applied across the audio frequency spectrum. In addition, a front panel control allows the user to variably adjust the amount of amplitude compensation desired. An indicator light system, consisting of amber, green and red LEDs for each channel, gives an indication of the relative amount of amplitude compensation being provided.

Additional front panel controls allow the user to: 1) select between BBE[tm] process mode and bypass mode, 2) to apply low frequency equalization if desired, and 3) to switch the signal input between the normal signal source and tape.

The Model 2002 is a dual channel, rack mountable device (rack ears included) which is designed for use in consumer and semi-professional applications. It can be interfaced with equipment which operates at the typical consumer-equipment signal level of -10 dBm. RCA connectors are provided at the rear panel for connection to the signal source and to a tape deck.

SECTION II
INSTALLATION AND SET-UP

The BBE[tm] Model 2002 has been designed to interface easily with most consumer audio equipment. It may be installed in a tape monitor loop (the preferred location), between a preamplifier and power amplifier, or inline between a signal source and preamplifier.

THE TAPE LOOP

The great majority of preamplifiers, integrated amplifiers and receivers available today include what is known as a 'tape monitor loop' to allow monitoring of the signal while recording. The tape loop is also generally considered to be the best place to connect a signal processing device, as it supplies a constant signal level, regardless of the volume control setting. To determine whether your equipment includes this feature, look at the front panel to see whether there is a switch labelled 'tape mon' or something similar, or whether a pair of selector switches labelled 'listen' and 'play' are provided. If either of these two arrangements are present, your equipment has a tape loop. If not, another means for installing BBE[tm] can be used. (See Preamp Loop/Single Source)

INSTALLING BBE[tm] IN THE TAPE LOOP (Figure 1A)

Locate the jacks on the rear panel of your equipment labelled 'Tape In' and 'Tape Out'. They may also be labelled 'Play' and 'Record' -- Play is the same as Tape In and Record is the same as Tape Out. There may be two sets of 'Tape In' and 'Tape Out' jacks on your equipment, probably labelled 'Tape One' and 'Tape Two' or something similar. Either set may be used for the BBE[tm] installation.

Connect one set of stereo interconnect cables between the 'Tape Out' jacks on your equipment and the 'Source In' jacks on the Model 2002. Connect the second cable set between 'Tape In' on your equipment and the 'Source Out' on the BBE[tm] unit. Be sure that Left and Right connections are correct for both cables.

There may already be a piece of equipment installed in the tape loop you have chosen for your BBE^{tm} installation. If that equipment is a tape deck, it should be connected to the Tape jacks on the rear of the Model 2002. Connect the 'Tape In' (or 'Record') jacks on the tape deck to 'Tape Out' on the BBE^{tm} unit. Connect the 'Tape Out' (or 'Play') jacks on the tape deck to 'Tape In' on the BBE^{tm} unit. (See Figure 1B)

Many stereo installations already have one or more signal processors installed in the tape loop. Equalizers, reverb units, and surround sound units are but a few of the devices available to the consumer which are typically installed in the same fashion as BBE^{tm}. If you already have processor(s) in your tape loop, the Model 2002 may be easily added. We suggest that the BBE^{tm} unit be the FIRST in the processing chain, as its dynamic circuitry assumes that it is receiving a relatively 'flat' (unprocessed) signal at its input. The 'Tape Out' connector on the amp/preamp/receiver should be connected to the 'Source In' connector on the Model 2002; the 'Source Out' connector on the BBE^{tm} unit should go to the Input of the next processor in line. This is known as 'daisy chaining' the processors. (See Figure 1C). Please note: the "Tape In" and "Tape Out" connectors on the Model 2002 are NOT configured as a process loop, but are supplied for convenient connection of a tape recorder only. Other processors connected to the tape connectors will not function correctly. They should be connected in the 'daisy chain' configuration as described above.

THE PREAMP-AMP LOOP (Figure 2)

If a tape loop is not available, the BBE^{tm} processor may be installed between a preamplifier and power amplifier. This is a simple task if the preamp and amp are physically separate units. Additionally, some integrated amplifiers and receivers allow a user to remove a link between the device's preamplifier and amplifier so that a processor may be inserted between the two.

The preamp-amp loop connection will allow BBE^{tm} to correct the signal from any of the signal sources connected to the preamp as that signal passes to the amplifier.

There are two drawbacks to this method of interface, however. First, because the BBE^{tm} unit is installed after the preamp's volume control, the level of processing will vary with the volume setting. This is primarily an inconvenience, making it necessary that the process level control be readjusted whenever the volume control level is changed. The second drawback is that any processor installed between the preamp and the power amp cannot be used to correct the signal going to a tape deck. As we will explain in Section III of this manual, making tape dubs using BBE^{tm} is one of the more exciting applications of the device.

USING BBE^{tm} WITH A SINGLE SOURCE (Figure 3)

If no other means is available, the Model 2002 can be connected between a signal source and preamp, integrated amp, or receiver. For example, you may wish to disconnect your CD player from the amp, plug it into the BBE^{tm} 'Source In' jacks, then connect the BBE^{tm} 'Source Out' jacks to the amp's input. With this hookup, the big drawback is that only one signal source may be processed, but on the positive side, the normal taping and process loop functions will be operated with BBE^{tm} intact for that source.

SECTION III
OPERATION OF THE BBE^{tm} MODEL 2002

GENERAL INSTRUCTIONS

Processing:

The pushbutton marked 'BBE^{tm} Process' selects between 'Process' and 'Bypass' modes. Below the pushbutton is a green LED. When this LED is lit, signal passes through the correction circuitry of the Model 2002. When the LED is dark, the signal passes through high-quality relay contacts directly to the outputs, bypassing the BBE^{tm} process. The drive circuitry is designed so that the unit powers up in Process Mode.

In 'Process Mode', the amount of phase correction provided is fixed by the BBE^{tm} Processor. The amount of amplitude correction is adjusted via the front panel knob. The dual banks of LEDs to the left of the Process Control' knob provide a visual indication of the process level. The knob should first be adjusted

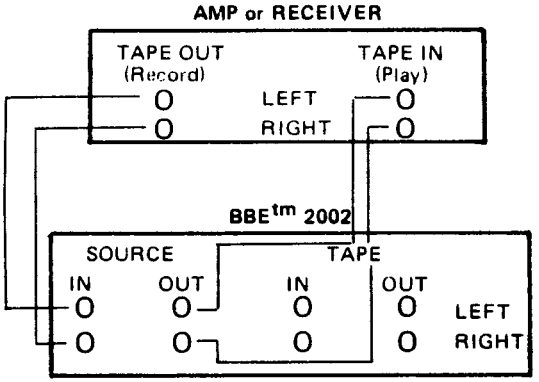

FIGURE 1A
INSTALLING BBE™ IN THE TAPE LOOP

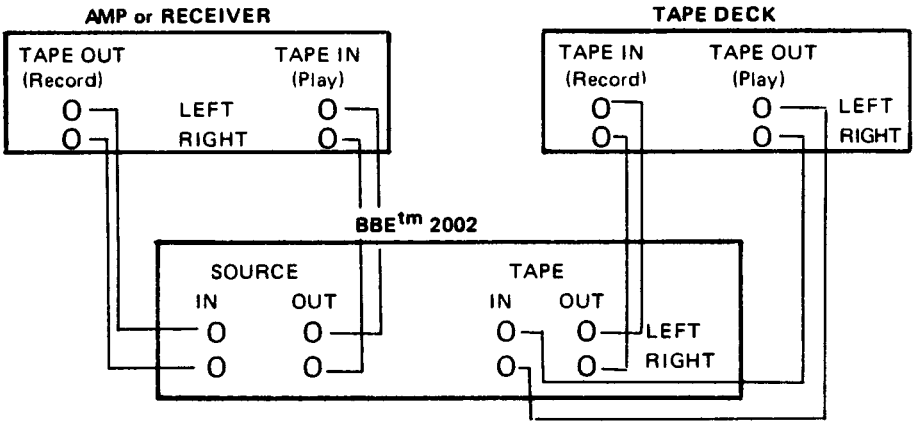

FIGURE 1B
ADDING A TAPE RECORDER TO THE BBE™ 2002

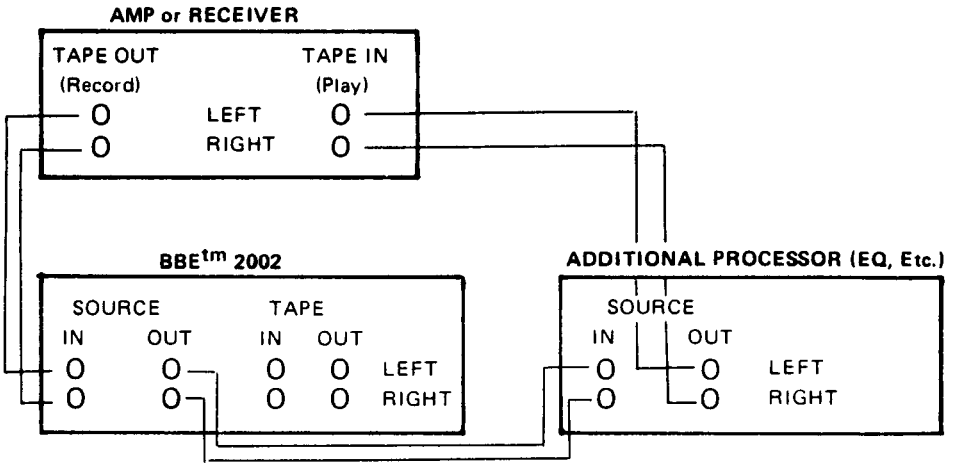

FIGURE 1C
USING AN ADDITIONAL PROCESSOR WITH THE BBE™ 2002

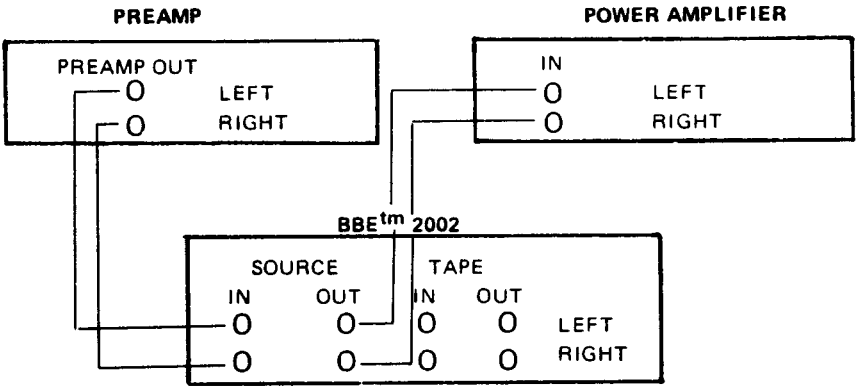

FIGURE 2
INSTALLING BBE tm IN THE PREAMP LOOP

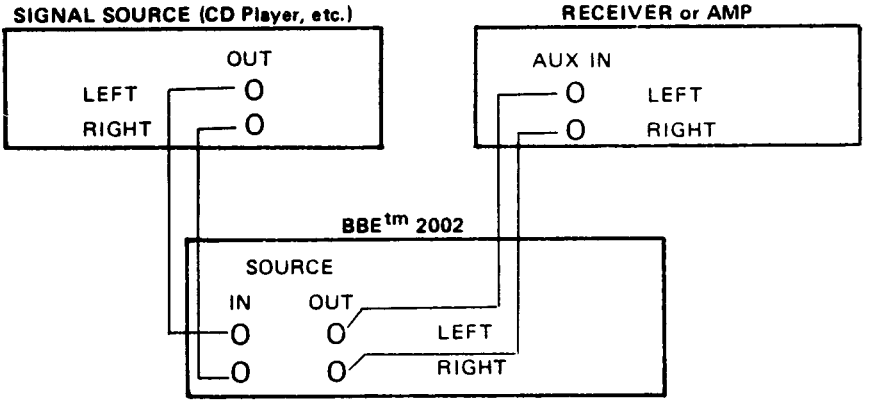

FIGURE 3
USING BBE tm WITH A SINGLE SIGNAL SOURCE

so that average program flashes the green LED on peaks. This setting will calibrate the Model 2002's circuitry for an 'average' amplitude correction appropriate for the program being sent through the unit.

NOTE: The process level should always be ultimately set by ear. The LED system is useful primarily as a set-up guide. Adjusting the process control to show constant amber LEDs does not necessarily mean too little processing, only that a minimal amount of processing is taking place. By the same token, red does not mean danger -- only that a good deal of processing is taking place.

Bass Equalization:

The Bass EQ switch provides the user with a switchable bass equalization of +3dB at 50 Hz. With the green LED under the Bass EQ lit, the bass lift is in effect. When the LED is extinguished, the low frequency response of the unit is flat. When the Model 2002 powers up, the Bass EQ function is on. The primary use for this function is in 'filling out' the sound of smaller speaker systems as desired.

Tape Monitor:

The Tape Monitor switch selects whether the signal input to the unit comes from the 'Source In' or the 'Tape In' jacks at the rear of the Model 2002. When the green LED under the switch is lit, tape is used as the input signal. This function is used when the user wishes to play back a tape. The Tape Monitor function should not be used when recording to tape. Pushing the Tape Mon button during recording will cause the record signal to be lost. The Model 2002 powers up in the 'Source In' mode.

Tape Dubbing:

One of the more interesting uses for the Model 2002 is in dubbing tape copies. Because the BBE^{tm} process is completely recordable and does not require a decoder for playback, a tape cassette, for example, which has been recorded with BBE^{tm} processing will sound wonderfully clear and open whether played back on a home system or on a car cassette player.

Compatibility with other processors:

A sheet is packed in the Model 2002 shipping carton which advises the first time user to "set all equalization, tone control, and other signal processing devices flat or off entirely". This is not to imply that the BBE^{tm} process is incompatible with the range of signal processing gear available to the consumer, nor that he must discard any of his other expensive pieces of equipment. The Model 2002 addresses specific problems with the speaker-amplifier interface in a way which is completely compatible with other equipment. Our experience has shown, however, that many people have been using other equipment in their sound systems in somewhat of a 'shotgun' approach to attempt to solve the problems addressed directly by the Model 2002. Virtually all signal processors used in this way have severe side effects due to the fact that they were not designed to address this specific problem, but were intended as 'general purpose' processors. A common response from first-time users of the Model 2002 is that they no longer feel the need for equalization or tone controls. Because the BBE^{tm} processor is performing corrections accurately, additional modification to the sound is generally not needed. Of course, personal taste is the ultimate deciding factor, and other processing may be added if desired!

SECTION IV
THEORY OF OPERATION

Dynamic loudspeakers, as a family, have difficulty dealing with the electrical signals which the amplifier supplies. These difficulties cause major phase and amplitude non-linearities, which make the sound reproduced by a speaker differ significantly from the sound produced by the original source.

At bass frequencies, major problems in phase-accurate reproduction arise from attempts to drive a physical mass a relatively large distance very quickly, have it stop its motion essentially instantly, and return accurately to its point of origin. The speaker cone's mass causes inertia which resists acceleration. As it is asked to respond rapidly to the attack of the bass note, some time delay to the rise time of that note results. As the applied waveform

reaches its maximum amplitude in a positive direction, the speaker cone is still accelerating. As the waveform begins its descent to its maximum negative amplitude, the speaker retains momentum in a positive direction, thus causing an 'overshoot' condition.

Finally, the combined mechanical impedances of the speaker's surround and spider assemblies, and its enclosure, slow the motion of the speaker cone to a halt, somewhere beyond the time when the electrical signal had already reached its maximum. The whole exercise continues, of course, following the negative excursion of the waveform with a similar time delay and overshoot. The net result is a loss of percussive qualities with a general muddying of the sound.

At the higher frequencies, the effects of trying to drive a finite impedance with a fast-rising waveform result in further distortions in the coherence of the musical signal being reproduced. A typical full-range speaker can exhibit as much as 45 degrees of phase lag at 5 kHz with respect to the sound source; as much as 60 degrees at 20 kHz. Obviously, a speaker which is optimized by design to reproduce a specific, limited frequency range will exhibit less phase distortion when used in its intended range than a speaker which has been deisgned to reproduce the entire audio spectrum. Nevertheless, the amount of phase lag in a dedicated tweeter, for example, is still at a significant level.

As with the lower frequency drivers discussed previously, the mass of the high frequency driver also affects its response. As expected, attempting to drive a finite mass with an extremely fast rise-time signal results in amplitude attenuation which increases with the frequency of the input signal. As will be shown shortly, this energy inefficiency occurs precisely in the spectral areas where musical 'reality' is most directly affected.

Phase problems have , in the past, often been relegated to a position of secondary importance in audio system design. However, it is becoming increasingly apparent that phase integrity is essential to accurate sound reproduction. Research shows that the

information which the listener translates into the recognizable characteristics of a live performance are intimately tied into the complex time and amplitude relationships between fundamental and harmonic components of a given musical note or sound. These relationships define a sound's 'envelope'.

As already stated, the distortions that a speaker system imposes upon a musical program are frequency- and amplitude-related. In plain fact, the speaker has its worst problems precisely in the range we have described as being crucial to accurate program reproduction. With a perfectly reproduced musical note, the harmonics reach the listener's ear in a time relationship directly related to their frequencies -- as the frontal 'attack transient' propagates. The higher the frequency, the faster its slew rate, and therefore, the earlier it arrives at the listener's ear. When this complex time relationship among harmonics is modified by a speaker, the harmonics no longer reach the listener's ear in the proper order. Due to speaker nonlinearities, the higher orders are delayed more. Therefore, lower order harmonics may reach the listener's ear first, or perhaps even simultaneously, with that of a higher frequency. In some cases, the fundamental may be so time-shifted relative to the harmonic structure that it can reach the listener's ear ahead of some or all harmonics. If two harmonics arrive at the same time, masking occurs -- essentially, the harmonic with the lower amplitude is not heard at a normal level, or possibly cannot be heard at all. Slight overlaps result in changes in the amplitude of the already time-displaced harmonics. The listener perceives changes in the reproduced sound. Such relative terms as 'muddy' and 'smeared' are often used to describe the loss of musical integrity. With extreme sound coloration it becomes difficult to tell the difference among instruments. For example, an oboe and a clarinet may easily sound alike. Obviously, important sound information is lost to the listener.

Barcus-Berry Electronics' Engineering department has conducted extensive studies of many speaker systems over the last ten years. These studies have shown that, while there are differences among various speaker designs in the magnitude of their

needs for correction, the types of corrections needed are remarkably consistent. With this knowledge, it has been possible to arrive at a 'model speaker'. With the 'model' it has been possible to arrive at an 'idealized' solution to the amplifier/speaker interface problem.

The hardware implementation of this correction has been designated for the consumer sound market as the BBE Model 2002. In essence, it applies the knowledge gained in our studies to precompensate the audio signal. Using our understanding of the behavior of the interface model, we have designed the electronic 'complement' of the interface error. The BBE^{tm} process imparts fixed phase correction for the full program and dynamic corrections to the high frequencies where most harmonic information exists. This is done by breaking the signal into three bands, with crossovers at 150 Hz and 2000 Hz. The low frequency band has an adjustable level relative to the midband. The mid-band is then used as a point of reference to make dynamic amplitude corrections in both positive and negative directions to the high frequency band. Detectors monitor the levels of incoming midband and high band information and do an intelligent 'comparison of notes' to determine the harmonic content of the program. The overall balance ratio between the two detectors is adjusted with the front panel 'Process Control' knob using a combination of the LED process level indicators and listening tests to determine the optimal amount of correction for a given set of listening conditions.

The result is a major increase in the accuracy of the life-like reproduction of the musical signal, using the information which has always been available in a recording, but which has been masked by the amplifier/speaker interface.