

Over the past few years the term “processor” has become something of a buzz word. Unfortunately, the internal workings of a processor, or the advantages of “processor-based” loudspeaker systems have rarely been explained, leaving an information gap. To complicate matters, when the first “black box” processors were introduced, little information was made available regarding their specific purpose or operation. This has led to a great deal of speculation and more than a few misconceptions about processors. In an attempt to shed some light on the subject, the following discussion will present an overview of the basic design concepts and potential advantages of processor-based systems in general, with occasional focus on Apogee systems. Part 2 of this discussion will concentrate on the form and function of Apogee systems in particular.

In the beginning...

During the late 1970s, audio professionals began using the terms “processor controlled” or “processor-based” when referring to an emerging class of loudspeaker systems. These new products sprang from the basic concept that a loudspeaker system should be designed with the total package in mind, as opposed to a conglomeration of stand-alone components; an approach which resulted in the development of “integrated” or “dedicated” processors. Acceptance of processors and processor-based systems has grown steadily since then, primarily because a “systems” design approach makes it possible to maximize the performance parameters of the driver/enclosure network, which when correctly implemented results in greater fidelity and reliability. Today, processor-based systems of various designs and manufacture have improved most system performance aspects and supplanted conventional systems in virtually every type of professional sound application.

Q: What is a “processor-based” system?

A: At the onset it is important to point out that processor-based systems produced by various manufacturers, while perhaps similar in concept, differ widely in form and function. Some systems have simply been repackaged while others have been designed from the ground up. Likewise, processors span the gap from high-tech multi-stage devices to simple crossover networks. Given this, it is not likely that any single definition can apply to all processor-based systems.

We at Apogee define a “processor-based” system as one in which the loudspeaker enclosures, drivers, and the associated signal processing electronics are conceived and designed as a total system. Apogee systems

combine loudspeaker technology and signal processing technology to achieve optimum system performance. For this reason, Apogee refers to its systems as “electronically coupled”.

Q: In general, what distinguishes an Apogee processor-based system from others?

A: Some manufacturers focus on creating systems which are “bullet proof” or impervious to damage, an approach which virtually by definition sacrifices dynamic range, bandwidth and fidelity at operating extremes to achieve a few extra dB of sustainable output. Others seem to have jumped on the processor bandwagon with no clear design goals in mind at all. Conversely, Apogee’s intention is to optimize as many performance aspects and physical characteristics as possible while providing enough protection to offer a solid margin of safety at operating extremes. Please note that if you consistently run any system “in the red”, you need a larger system! Apogee systems are thoughtfully designed to allow you to discover this without destroying the system in the process.

Certain manufacturers processors incorporate protective circuits which manipulate the signal almost constantly, causing justifiable concern about audible “artifacts” throughout the systems operating range. Apogee processors are intentionally conservative in this respect, designed to keep signal manipulation to an absolute minimum. Towards this end, Apogee starts by building the highest quality, highest performance loudspeakers possible, reducing the need for protective “processing” at all but extreme operating levels. The processors protective circuits simply prevent the clearly audible distortion which leads to driver damage and failure. Prior to the point where distortion and damage would start to occur, the protective circuits are essentially “off line”, leaving the source signal unchanged.

Apogee systems do *not* employ sliding crossovers or dynamic equalization (which alters the high and low rolloff points) for system protection. For those not familiar with the sliding crossover protective scheme, the basic idea is to protect the more easily damaged high frequency drivers by shifting the crossover point upwards when signal levels become excessive, thereby reallocating a portion of the high frequency band to the midrange driver. We feel that sliding crossovers are inappropriate because they cause audible shifts in transient response, polar response and power response. In defense of this assertion, if the upward shifting of a crossover point doesn’t change the systems response in any appreciable way, as its proponents might argue, why

not simply set the crossover to the upper limit to begin with? Similarly, we avoid dynamic equalization as a form of driver protection because it likewise causes audible changes in frequency response and sonic balance. Once again, protection schemes of this type trade off fidelity for acoustic output, an approach we find unacceptable.

Early on, processor-based systems often received bad press, sometimes deservedly so, charging that they were only a means to enhance the performance of inferior or marginal drivers. Though less founded these days, the concern has merit. Common sense dictates that to achieve optimum performance, you start with a high quality loudspeaker, *then* add a performance enhancing processor. The latter approach perfectly describes Apogee's philosophy in this regard; a philosophy which unfortunately is not embraced by all manufacturers.

Apogee loudspeaker and processors have been refined to the point where they must be used together as a system; hence the term "dedicated processor". Apogee processors are integrated, multi-stage electronic devices based in part on a real-world model which we call a "conventional processor".

INTEGRATED vs CONVENTIONAL



Q: What is a "conventional processor"?

A: Conventional loudspeaker systems more often than not include a small arsenal of electronic devices similar to those depicted in Figure 1. Some of these devices, such as the crossovers and time delay components perform functions which may be absolutely essential to the operation of the loudspeakers. Other devices, such as equalizers and limiters, though optional, are commonly added to either enhance some performance aspect of the speaker system, or to protect the loudspeakers from damage due to various causes. Let's examine the role of each of these components in a *conventional* system.

A **crossover** is essential in any multi-way system to divide the full-band signal into frequency bands for the individual drivers. Crossovers take the form of passive devices built into the loudspeaker itself, or in the case of bi-amplified or tri-amplified systems, the crossover is usually an active electronic device which goes between the signal source and the amplifiers. Since the highest performance systems are at least bi-amplified, an active crossover is one of the most common signal processors found in a conventional system. For this reason, crossovers are also usually one of the first devices incorporated into an integrated processor.

High frequency compensation is normally necessary to counter the effects of power rolloff, a common characteristic in compression drivers. Power rolloff typically occurs when the mass of the diaphragm becomes large in relation to the fre-

quency being reproduced, resulting in a gradual high frequency loss starting somewhere between 2 kHz and 10 kHz, depending on the size of the diaphragm. Many systems incorporate either a parametric or graphic equalizer to correct this common problem.

System equalization is usually required to compensate for frequency response anomalies inherent in the drivers themselves (like the high frequency compensation just mentioned), or those caused by interaction between drivers and/or interaction between the drivers and the enclosure. Since few conventional loudspeakers perform so well that their frequency response could not be improved by the careful application of equalization, many designers again rely upon EQs and filter circuits to flatten loudspeaker response. These can take the form of passive networks in the enclosure (which rob power), or active (and

usually adjustable) multi-band devices such as graphic and parametric equalizers. *Note:* It is common for a single equalizer to be used to correct both system *and* room response anomalies simultaneously. While this appears to be a valid approach, experience will reveal that it is often impossible for a single equalizer to adequately correct both problems at the same time. A more plausible

approach is to correct the system's response with one EQ (in a controlled environment, using precise test and measurement equipment), and the room's resonances and anomalies with another.

Along this same line, concerns have arisen that a processor will restrict the engineer's control over the system. Closer inspection will reveal quite the opposite. For example, by relying on the processor to insure that the system's frequency response is flat, the engineer can now use his/her equalizer (which previously pulled double-duty EQing the system *and* the room) to exercise much greater control over room resonances and other acoustical conditions. In turn, the channel EQs can now be used for more artistic (rather than corrective) purposes, as they were intended.

Electronic time delay can greatly improve the intelligibility and clarity of multi-way loudspeakers in which the driver's voice coils are physically offset from one another. This alignment of the points from which the sound originates is usually achieved by electronically delaying the signal feeding the forward driver by an amount which corresponds to the time it takes for sound to travel the distance between the two drivers, thus making it appear that the sound from both drivers is originating from the same vertical plane. While it is debatable whether or not *all* physically offset drivers need to be aligned in this way, it has been fairly well established that proper alignment

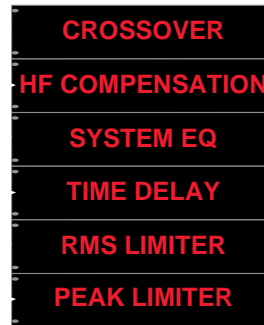


Figure 1

is crucial to intelligibility when the crossover point for the drivers in question is in the vocal range.

RMS and PEAK limiters have been used for many years, together and separately, to provide a measure of protection to the drivers. An RMS limiter with a relatively long time constant can effectively protect the drivers against long term overdrive, but must be used conservatively to prevent loss of dynamics. Using an RMS limiter in this way still leaves the drivers susceptible to high level transients (spikes) such as may be caused by a dropped microphone. To protect against these damaging transients, a PEAK limiter with a relatively short time constant can be used along with the RMS limiter and adjusted to “kick in” 6 dB or more above the RMS limiter. In this way, dynamic range can be maintained while still providing a fair amount of protection against common causes of driver damage.

When used as suggested as part of a conventional loudspeaker system, these signal processing components can be referred to collectively as a “conventional processor”.

In application, some or all of these components are usually strung together in series and inserted between the signal source and the amplifiers. This approach has some inherent shortcomings which are easily overcome by integrating these devices into a single dedicated processor.

Q: How does a processor-based system improve upon conventionally designed systems?

A: Many of the advantages of Apogee systems over conventional systems can be attributed to two design facets. First are those benefits which come from refining and integrating multiple general purpose components into a single dedicated device. Second are those which spring from the systems design approach which treats the loudspeakers and signal processing electronics as a unit rather than non-related components.

Let’s look first at the benefits attributable to the processor.

By definition, a dedicated device can be expected to outperform a general purpose device which must sacrifice performance for versatility. At Apogee, we strive to manufacture dedicated processors with circuits designed to do no more and no less than is required, resulting in optimal performance. Reducing the circuitry to essential elements minimizes many undesirable side effects such as noise, phase shift and distortion, while a dedicated design allows desirable system attributes such as bandwidth, power handling and acoustic output to be optimized.

We improve many performance aspects simply by consoli-

dating multiple functions into a single device. Redundant input and output buffer stages are eliminated, again minimizing circuitry with its inevitable noise and distortion. The performance of each stage is matched, removing the weak links which normally limit overall system performance and waste money. Interconnections are minimized, increasing reliability and reducing maintenance. Finally, setup and operation is greatly simplified, thus promoting consistency, saving time and reducing the possibility of user error.

Now, let’s consider those benefits which stem from the “systems” approach.

Extending the electro-mechanical/acoustical system design concept to include the signal processing circuitry allows the enclosures and drivers to be refined in ways that may otherwise

be impractical or impossible. While it is beyond the scope of this paper to delve into enclosure and driver design, suffice it to say that an obvious distinction of Apogee systems is the drastically reduced size of the cabinets and a seemingly contradictory increase in acoustic output and power handling.

Manufacturers of conventional loudspeakers must take a relatively conservative design approach because they have no way to control the selection of the signal processing devices which will be added to their speakers. This equates to untapped performance! In turn, anyone trying to optimize the performance of a conventional system with a general purpose signal processor will be restricted by the fixed characteristics of the speakers, and the inherent limitations of general purpose devices. By manufacturing complete loudspeaker systems, we avoid both of these restrictions by having the option to manipulate the electronic design, the design of the enclosure and its components, or both, whichever will yield the best results.

Finally, the “systems” approach used at Apogee has allowed, and sometimes mandated, the re-thinking and refinement of virtually every system parameter from cabling and connectors to cabinet shape and rigging. Because of these refinements, processor-based systems in general, and Apogee systems in particular, have advanced the state-of-the-art.

Q: What prompted the evolution from conventional systems to those with dedicated processors?

A: Several performance limiting flaws exist with conventionally designed loudspeaker systems which can be addressed by the introduction of an integrated dedicated processor. First is the fact that the loudspeakers are only part of the system, and a significant number of buyers and users do not possess either the

INTEGRATED SYSTEM BENEFITS

- **Very High Power Handling**
- **Greater Reliability**
- **Higher Output**
- **Lower Distortion**
- **Very Wide Bandwidth**
- **Compact Size & Lightweight**

skills or tools necessary to “finish out” the system by assembling and calibrating a conventional processor package as described earlier. As a result, many conventional loudspeakers fail to deliver the performance the user paid for.

A second issue involves the design of the loudspeakers themselves. The advent of processor-based systems has opened up additional opportunities for the loudspeaker designer who, working with an electronic “front-end”, can make further improvements and refinements to both the drivers and enclosures which are beyond the limits of a conventional loudspeaker designer.

A third issue relates to the use of general purpose equalizers, limiters and crossovers to optimize the performance of the loudspeaker system as a whole. Even when optimally adjusted, the reliability and stability of multiple adjustable devices cannot compare to dedicated circuits. Dial settings on the conventional devices may be accidentally or intentionally altered, with potentially disastrous results. In addition, as mentioned before, such devices typically must sacrifice performance in order to be versatile enough to work with various conventionally designed loudspeaker models. By properly designing and integrating these components into a single device designed to serve the specific needs of a particular loudspeaker model (meaning “dedicated”), virtually every aspect of system performance can be improved.

In short, the move toward processor-based designs was prompted by the need for more complete and stable systems coupled with the desire to improve as many performance aspects as possible.

Q: What’s in it for the manufacturers?

A: Manufacturers of processor-based systems benefit from having greater control over how their speakers will actually perform. Extending the system design to encompass the signal processing reduces the possibility that the quality or reliability of their product will be compromised by the addition of inferior, inappropriate, or misused electronics. In short, most major loudspeaker manufacturers now produce processor-based systems because they generally perform better, with greater reliability, and therefore spare the manufacturer’s reputation from harm due to factors normally beyond their control.

Q: What about cost?

A: An Apogee system generally represents a better value than a conventional do-it-yourself sound system of comparable expense. While the apparent additional cost of the processor may at first seem unnecessary to the average buyer, when it is clearly understood that the processor replaces several components which must be purchased anyway (if remotely equal performance is desired), a proper evaluation can then be made. Compare the cost of an

Processor-based systems have improved most system performance aspects and supplanted conventional systems in virtually every type of professional application

Apogee processor to the total cost of the individual components it replaces and you will likely find that the processor not only costs less, but offers superior performance.

Q: Are processors of any kind really necessary?

A: In a perfect world, processors wouldn’t be necessary. A common loudspeaker would have perfectly flat frequency response from 20 Hz to 20 kHz, have little or no distortion, a perfectly controlled radiation pattern and a virtually indestructible design. The real world has yet to see such a device. Because of physical limitations in driver technology, the speaker itself is (and will likely remain for quite some time) the primary performance limiting factor in most sound systems. Conventional high performance systems and the newer processor-based systems *both* rely on signal processing to extend the speaker’s safe operating range and improve various performance aspects. Until driver technology advances substantially, signal processing will be a necessary part of any system offering above average performance; and dedicated processors will be required to achieve true high performance.

SUMMARY — Bowing to the demands of audio professionals who recognize the benefits of processor-based systems, virtually every major loudspeaker manufacturer now has some type of processor-based system in their lineup, including those who were staunch and vocal critics of the processor-based approach in the recent past. This “systems” approach was the next logical step in the development of professional quality loudspeaker systems, allowing the refinement of the electronics as well as the loudspeakers themselves. This has resulted in the development of smaller and smaller speakers capable of producing more sound with higher fidelity than was previously possible. In short, processor-based systems have reset the standards by which all loudspeaker systems are measured.

COMING UP — “PROCESSOR-BASED SYSTEMS, Part 2: Inside Apogee” will take a closer look at the internal workings and features of Apogee processor-based systems.

APOGEE ENGINEERING BRIEF is a regular publication designed to communicate technical and educational information about the art and science of sound reinforcement.

Suggested topics of interest, questions or comments are encouraged and should be directed to Patrick Price, Director of Education.



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