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AUDIO
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***“EXCELLENT...
CLEAN AND POWERFUL”***



The Servo-15, Paradigm's top subwoofer, is part of the company's Paradigm® Reference line, which includes the Eclipse/BP, Studio/100, and Active/20 speakers (reviewed in the August 1995, July 1996, and September 1997 issues, respectively), along with other models. The Servo-15 is one of five powered systems comprising the Active subgroup of the line.

The Servo-15's beefy 15-inch woofer is housed in a solidly constructed, sealed enclosure and driven by a built-in 400-watt amplifier. The amp incorporates a servo circuit that monitors the woofer's activity via an instrumentation-grade piezoelectric accelerometer on the driver. The subwoofer comes with an electronic controller that provides crossover functions and phase adjustment for the subwoofer and line-level high-pass filtering for the rest of your audio system. Two versions of this unit are available:

the X-20, which has speaker-level inputs, and the X-30, with line-level inputs, that I reviewed. (Each is also sold separately, for \$159.)

The Servo-15's nearly cubical enclosure has a grille on its front that covers the driver; the power amp's controls, input jack, and power cord are on the rear. The controls are minimal, consisting of a level knob and a tiny three-position power switch (“Always Off”, “Auto On/Off” and “On”). There is a line-level RCA jack, but no speaker-level input, because the Servo-15 is intended to be driven from its controller or directly from a low-pass-filtered subwoofer output on a surround processor, preamp, or receiver.

“an excellent all-around performer, clean and powerful with particularly good output in the very low bass”

Although the Servo-15's driver is nominally a 15-inch unit, it is actually 16 to 17-3/4 inches, depending on where you measure the diameter of the heavy-duty, diecast aluminum frame. The cone is a Kevlar-fiber reinforced composite (whose high internal damping and stiffness are said to significantly reduce unwanted resonances and distortion) and has a multilayer surround. Rated excursion is a healthy 1 inch, peak to peak.

BY

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The driver's large motor assembly has three ceramic magnets, each 6 inches in diameter and 3/4 inch thick: Two power the woofer, and the remaining one is a bucking magnet that reduces external magnetic fields. The magnet assembly, computer-optimized for low distortion and high field strength, has a low-turbulence center vent that exits to the rear. Two aluminum shorting rings around the pole piece are intended to improve heat transfer and lower distortion. The voice coil has bifilar windings on an aluminum/Nomex former that's 2.1 inches in diameter and 1.4 inches long. The accelerometer is bonded to the front of the voice coil, under the woofer's dust cap. Three leads connect it to the built-in amplifier.

The Servo-15's power amplifier is a purely linear design, using no switching output or power-supply circuitry. It is mounted to a removable rear subpanel that includes a large heat sink. The amp's circuitry is on a large glass-epoxy board that is at right angles to the rear panel; its eight output transistors are attached to that panel, just behind the heat sink. The amp's large toroidal power transformer is on the bottom of the cabinet.

The accelerometer and the amp's servo circuits form a closed-loop system that compares the accelerometer's output to the audio input signal and then corrects any discrepancies in the driver's motion. The amp also has limiting circuitry to prevent clipping and guard against excessive cone excursion.

Paradigm's patented automatic circuitry turns the subwoofer on quickly whenever there is an input signal and turns it off about 15 to 20 minutes after the signal stops. Paradigm says the amp consumes less than 1.5 watts while it's waiting for a signal, which is said to be significantly less than competing designs draw.

“effortless and clean... The Servo-15's low-frequency output is very nearly the highest of all subwoofers I have tested.”

The Servo-15's cabinet is made of 1-inch medium-density fiberboard (MDF) and is heavily braced. Front and rear baffles use self-locking joints for additional rigidity. The enclosure is strengthened by two full-perimeter vertical braces of 3/4-inch MDF. One brace connects the top and bottom to the two sides, while the other connects them to the front and rear; Paradigm calls this a Cascade™ design. A removable grille with a 3/4-inch MDF frame plugs into the front of the cabinet. Large feet are provided, and gold-plated feet with adjustable spikes are available.

The X-30 and X-20 electronic-crossover/controllers are recommended for use in audio systems that lack appropriately filtered subwoofer outputs. The X-30 is small and intended to be placed near your system's other electronics. An audiophile-grade RCA-to-RCA cable is provided for connection to the subwoofer. This cable is 23 feet long, which should be enough

to extend from a controller stacked with your other components to a Servo-15 at the opposite end of your listening room. Paradigm sent me the X-30 for review; it has controls for subwoofer level, low-pass cutoff (which is variable from 35 to 150Hz), and subwoofer phase (which affects only one of the two mono subwoofer output jacks on the rear panel). The latter two controls enable the Paradigm Servo-15 to be used with virtually any main speaker system, located at any distance from the subwoofer. The X-30 also has 18dB/octave high-pass filters, with separate line-level stereo output jacks for 50-, 80- and 120Hz cutoff frequencies.

Measurements

The Servo-15's on-axis anechoic frequency response (Fig.1) is quite flat and well behaved, with a bandwidth of about 20 to 150Hz at the 3dB-down points and a maximum output at about 60Hz. These are ground-plane measurements, made with the subwoofer's level control at its middle position and an input of 0.1 volt rms.

Figure 2 shows response at the X-30 controller's subwoofer outputs for various low-pass frequency settings. (The input was again 0.1 volt rms, the X-30's subwoofer level control was in its mid position, and the test load was 1 megohm. With these settings and the cutoff control at 150Hz, the X-30's gain was +2dB at 50Hz.) Infra-sonic frequencies are rolled off at 6dB/octave below about 8Hz, while the high-frequency cutoff, specified as 18dB/octave, actually has a 12dB/octave slope. As can be seen, a relatively large gap exists between the 150- and 120Hz positions. (In this and the following graph, note that the frequency scale extends down 2Hz.)

Figure 3 shows the frequency response of the X-30's high-pass outputs. (Response above the graph's 2kHz limit was perfectly flat to 20kHz.) Each curve exhibits a classic third-order, 18dB/octave, high-pass response, as specified. The measured cutoff (-3dB) frequencies are quite close to those indicated on the jacks: 48Hz at the 50Hz, 75Hz at the 80Hz output, and 119Hz at the 120Hz output.

Figure 4 shows the combined frequency response of the Servo-15 and X-controller. The frequencies indicated on the X-30 are significantly different from the measured -3dB points, instead corresponding roughly to the -6dB points.

I was quite impressed with the Servo-15's low-frequency output and general sonic cleanliness at high levels. I found it impossible to make this subwoofer sound bad by overloading it, no matter what the input frequency or level. Furthermore, the cabinet was essentially vibration-free. The woofer's maximum excursion was about 0.8 inch, peak to peak, and occurred at 20Hz. By removing the woofer from the cabinet and driving it directly from my amplifier, I found that it could easily reach excursions of 1 inch, peak to peak, with fairly low distortion. No dynamic offset distortion was evident.

I would suspect that even without the accelerometer servo feedback, distortion would be quite acceptably low.

Figure 5 shows the Servo-15's harmonic distortion versus frequency and SPL (and includes the effects of room gain). The distortion presented is the sum of the first 10 harmonics, expressed as a percentage of the power in the fundamental. (This method yields essentially the same results as measuring total harmonic distortion, which includes all harmonics – even those above the tenth – and excludes noise.) The second and third harmonics predominate at most frequencies and levels.

“bass that rivaled a live concert's. On recordings having high levels of low bass... the Servo-15 was the clear and decisive winner... playing much louder and cleaner.”

At each test frequency, the Servo-15's limiter put a cap on the maximum sound pressure level; beyond a certain point, increasing the input level produced no further increase in output level or distortion. The limiter allowed the subwoofer to generate 113dB SPL at 40Hz but only about 98dB at 20Hz. At all the test frequencies, the Paradigm Reference sub sounded quite effortless and clean, and its distortion was less than 10%. In fact, as you can see in Fig. 5, it rose to only 9% at 20Hz, was just 6.8% at 25Hz, stayed below 5% at 32 and 40Hz, and was less than 2% from 50Hz on up.

Figure 6 shows the Servo-15's short-term peak sound output versus frequency. The subwoofer was driven directly, without the X-30 controller. The maximum peak SPL at each frequency was constrained by the subwoofer's limiter. The tone burst signal sounded quite clean and powerful at all levels up to the limit. However, if I turned up the input level well past the limiting point, the signal changed its tonal characteristics (though it still seemed undistorted). Observing the output on an oscilloscope, I saw that the shape of the tone burst changed significantly: Levels were highest near the start of each burst instead of in the middle. Although the tone burst's envelope changed significantly at high overload levels, the sine waves making up each burst were still essentially sinusoidal. The sound was thus fairly clean.

With room gain, the maximum peak output in Fig. 6 starts quite strongly, at 110dB SPL at 20Hz, and then rises quickly to a peak of 115dB SPL at 50Hz. At higher frequencies, the maximum SPL drops smoothly to a still strong 108dB at 200Hz, passing through 113dB at 100Hz. The Servo-15's low-frequency output is very nearly the highest of all subwoofers I have tested.

Use and Listening Tests

The Paradigm Reference Servo-15 weighs nearly 80 pounds and is 23 inches deep with its grille on, making it somewhat of a chore to move around and reposition. The large plastic feet,

which look like hockey pucks, make it easier to move the speaker and provide convenient handholds for lifting it. My review sample, supplied in the black ash finish, was quite attractive. (I found it a lot more attractive than my wife did. Any speaker that can generate lots of clean, powerful bass must be attractive, right?)

With its grille removed, the woofer looks more like a heavy-duty 18-incher than a 15-incher. Hookup was simple and easy, thanks to the Servo-15's single RCA input jack and the facilities of the X-30 controller. I used this subwoofer primarily in my home theater and judged it with stereo music CDs and laserdiscs. The Servo-15 was driven by the X-30, which provided a convenient bass volume control.

The Servo-15's manual is short but informative and detailed. It covers, among other things, placement, controls, and operation with an X-series controller (which is covered in greater detail in the X-30's own manual).

For comparisons, I used two other powered subwoofers. One was the Velodyne F-1500B, a servo-controlled sealed system with a 15-inch woofer, which is similar to the Servo-15. (The F-1500B is an upgraded version of the F-1500 I tested in the November 1992 issue.) The other sub was a Boston Acoustics VR2000, whose 12-inch woofer is in a vented enclosure and whose built-in amplifier has no servo-feedback or limiter/compressor circuitry (Audio, January 1997).

“The Paradigm was also an excellent performer with movies. The sound effects and bass stood out... The Servo-15's solid bass underpinning added a high degree of realism”

I positioned the Servo-15 to the left of my right front speaker (a KEF Reference Four) and faced it into the room. For A/B comparisons with the other subwoofers, I placed the Velodyne on top of the Paradigm Reference and the Boston on the floor in front of the right front speaker, facing across the room. This kept the woofers as close together as was reasonably possible.

All three subwoofers were driven by the X-30 controller through a line-level A/B switcher. I set the Velodyne and Boston subwoofers' low-pass cutoff controls to their highest frequencies. I set the X-30's cutoff control to its middle position (halfway between the 80- and 120Hz markings), which actually channeled all the bass below about 65Hz to the subwoofers. When playing pink noise in the octave around 31Hz, I used the subwoofers' level controls to match output levels.

The Servo-15 proved to be an excellent all-around performer, clean and powerful with particularly good output in the very low bass. It played significantly louder than the Velodyne at all

frequencies and easily dusted off the Boston at 40Hz and below. (The Boston was a very able performer above 40Hz, however.) On loud rock music, such as heavy metal with strong kick drum (whose energy is mostly above 40Hz), I slightly preferred the Boston to the Paradigm, while both the Paradigm and the Boston were significantly more dynamic than the Velodyne, with bass that rivaled a live concert's.

On recordings having high levels of low bass, such as the organ pedal notes on the Jean Guillou CD of Mussorgsky's *Pictures at an Exhibition* (Dorian Recordings DOR-90117, one of my favorite bass demos), the Servo-15 was the clear and decisive winner. On other pipe-organ recordings that had bass below 20Hz, this sub was an outstanding performer.

On the bass drum on track 1 (at 1:08 and 1:10) of *Winds of War and Peace* (Wilson Audio WCD-8823, another favorite bass demo), the Paradigm blew off the Velodyne and Boston Acoustics subs, playing much louder and cleaner. Compared to the Paradigm, the Velodyne wimped out: Its limiter acted so aggressively that its output was anemic compared to the Servo-15's, and low notes accompanying bass-drum whacks were considerably modulated.

A particularly useful test signal for subwoofer output is the 6.5-cycle, third-octave tone bursts that I use for my peak power tests (available on Syn-Aud-Con's Sound Reinforcement test CD). Like music, but unlike such test signals as sine waves, the signal is quite transitory in nature yet also very restricted in frequency content. By design, its energy is concentrated in a fairly narrow bandwidth. Just by listening, it's relatively easy to detect the onset of nonlinearities and distortion when the signal level is raised and to compare the outputs of different speakers.

As I pointed out in my review of the Boston VR2000, the Syn-Aud-Con test CD provides bursts at the rate of one per second in one channel and one every 2 seconds in the other channel. Summing the two channels into a monophonic signal yields a train of bursts that alternate in level by 6dB. This is also a very useful test signal for comparing speakers by ear. Just turn the level up until the higher burst is distorted, or, in the case of systems that have limiters or compressors, until the alternating bursts sound about equally loud. When this point is reached, compare the loudness of the two speakers. On this signal, the

Paradigm could play much louder than the Velodyne and still preserve the tone burst's alternating high-and-low volumes, though it did not sound as clean as the Velodyne. The Velodyne's output sounded very pure and distortion-free, but all the tone bursts were equally loud instead of alternating in level. (During this test, I noticed that the Servo-15's woofer motions were significantly greater in amplitude than the Velodyne's on the high-level burst. Apparently, the Velodyne's limiter was holding back its excursion and therefore restricting its acoustic output. The Velodyne's limiter is set so that distortion does not rise above a very low 1%, greatly reducing the speaker's potential maximum output.) Below 40Hz, the Paradigm could also play much louder than the Boston, which distorted quite badly on the higher-level bursts.

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The Paradigm was also an excellent performer with movies. The sound effects and bass stood out, especially on *The Mask* and *Terminator 2: Judgement Day*. The Servo-15's solid bass underpinning added a high degree of realism to both movies. Particularly memorable were the "Future War" sequence in *Terminator 2* (just preceding the intro credits), where the explosions and other special effects were outstanding, and the '40s nightclub sequence in *The Mask*, where the acoustic bass and live drum sounds were quite notable.

The Paradigm Reference Servo-15 powered subwoofer proved to be a very strong and extremely capable performer. Paradigm has struck a very good balance between the Servo-15's maximum output and its maximum distortion. Its distortion, although not super-low (it seldom is in subwoofers), nevertheless sounded quite acceptable. The Servo-15 should be seriously considered for any situation where the highest caliber of bass performance is required.