

A QSC Application Note: Upgrading to Dolby Digital - Surround EX

INTRODUCTION

The aural experience of moviegoing continues to develop with the debut of the Dolby Digital – Surround EX format, which adds a third surround channel to the film soundtrack. This additional channel is located in the back of the auditorium and provides another spatial dimension to the audio. With left, right, and rear surround channels, left, center, and right screen channels, and the mono subwoofer channel, the Surround EX format is literally a 6.1 system.

A cinema playback system using the Dolby Digital – Surround EX format is 100% compatible with films that use the Dolby Digital 5.1 surround system. Upgrading a current 5.1 system to the Surround EX format requires some additional equipment and auditorium rewiring. The scope of this handbook is to help guide cinema system designers and installers make the upgrade smoothly and effectively.

The surround basics

Figure 1 shows a typical screen channel system, with active crossovers, amplifiers, and 3-way speakers. The left, center and right full-range channels constitute three of the channels in a 5.1 or 6.1 surround system, and the subwoofer channel represents the “.1” in the designation.

That leaves two channels, left surround and right surround, in a 5.1 system or three channels, left surround, right surround, and back surround, in a 6.1 system.

Obviously, the step up from 5.1 to 6.1 requires you to install surround speakers on the back wall of the auditorium if there are currently none. It also requires at least two additional channels of amplification, as well as a Dolby Model SA-10 Digital Surround EX Adapter.

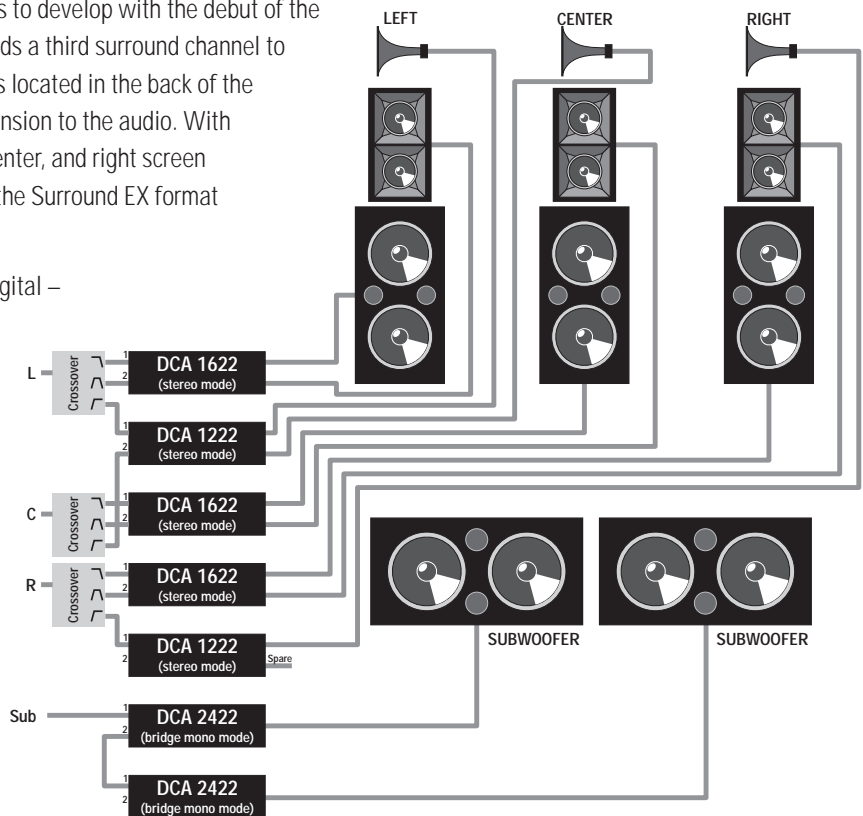


Figure 1. An active 3-way screen system

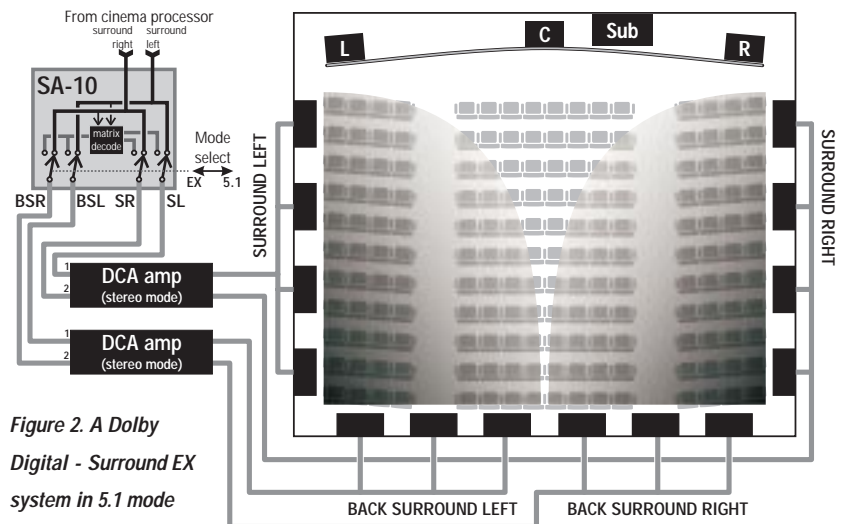


Figure 2. A Dolby Digital - Surround EX system in 5.1 mode

During presentation of a film print encoded with Surround EX, the back surround speakers will all put out the same program (Figure 2). When a print with 5.1 surround is shown, though, the back surround speakers split into two channels, with the ones on the left side joining with those on the left wall to produce the left surround program. Likewise, those on the right side become part of the right surround system along with the speakers on the right wall. Thus, the back speakers are in use even during a 5.1 surround presentation, and they in fact help the surround sensation for patrons seated near a side wall by bringing the far surround information somewhat closer.

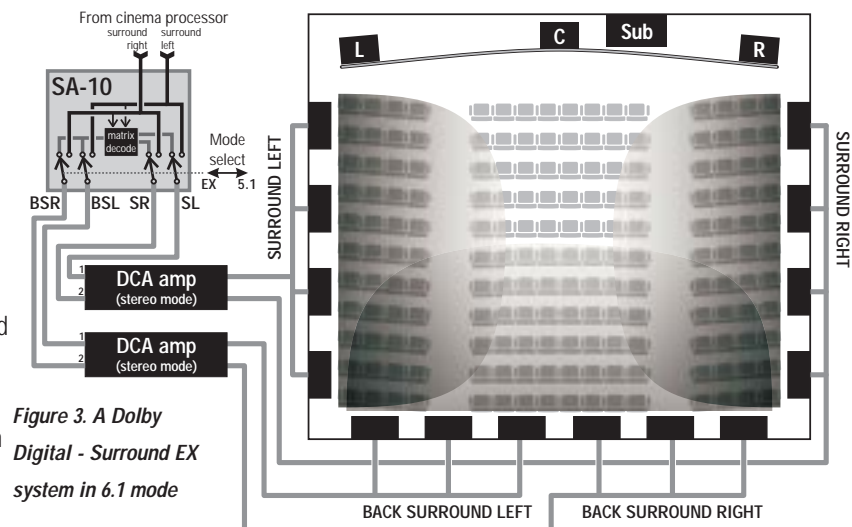


Figure 3. A Dolby Digital - Surround EX system in 6.1 mode

The Dolby Model SA-10 Digital Surround EX Adapter has two analog inputs—for the left and right surround signals from the digital cinema processor—and four outputs: left surround, right surround, back surround left, and back surround right. In 5.1 mode, the SA-10 passes the two input channels unaltered to the outputs: the left surround in to the left surround and back surround left outputs, and the right surround in to the right surround and back surround right outputs.

In Surround EX mode (Figure 3), the SA-10 engages a decoding matrix. From the two input signals, the matrix derives the left and right surround channels, which appear at their respective outputs, as well as the back surround channel, which appears simultaneously at the back surround left and back surround right outputs.

Therefore, the back surround speakers need discrete amplification, separate from the side speakers. And because the back surround speakers will sometimes split into left and right, the amplification must be at least two channels. This can be handled in many cases with a single two-channel amplifier. Some particularly large cinema auditoriums might require more than one additional amplifier, or perhaps higher-powered models.

Overall system upgrades

Planning an upgrade from 5.1 surround to Surround EX capability is an opportune time to evaluate the overall cinema sound system. Taking care of these situations now will be much easier than tackling them at a later date and will maximize the quality and effectiveness of the audience's surround experience. Check your system for these:

SERIES-PARALLEL SPEAKER CONNECTION

Some past accepted practices such as series-parallel connection of surround speakers, as shown in Figure 4, can be improved upon to gain better performance. In this example, the two surround channels are powered by a single two-channel amplifier, with each channel driving six 8-ohm speakers. The series-parallel connection yields a per-channel load of 5.3 ohms. This was acceptable when cinema amplifiers lacked strong 2-ohm capability, but improvements in amplifier technology have significantly remedied that limitation.

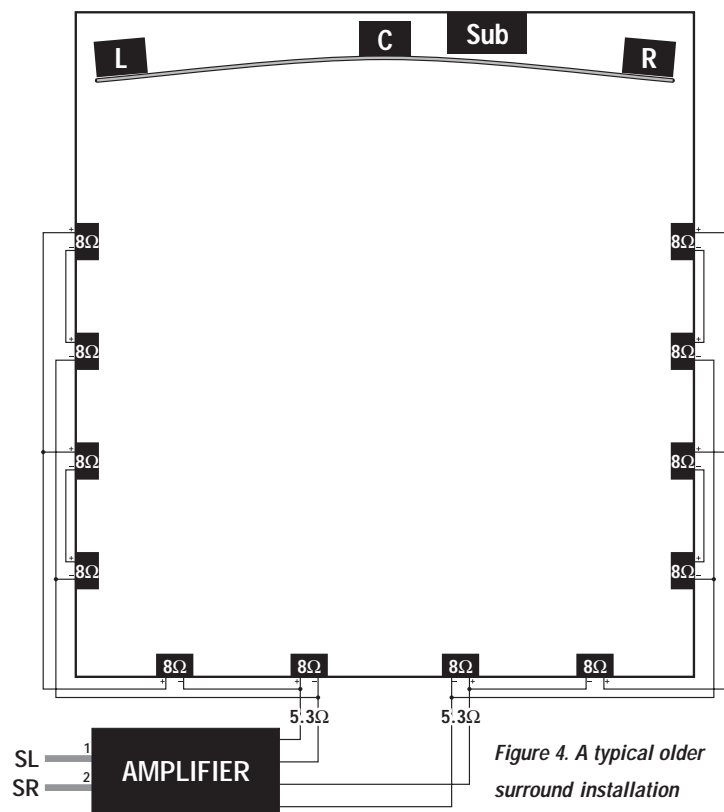


Figure 4. A typical older surround installation

Figure 5 shows one of the series-parallel surround channels from the system depicted in Figure 4, with four 8-ohm speakers wired to create an overall load of 5.3 ohms. This series-parallel connection permits driving multiple speakers while keeping the amplifier's load impedance high and therefore easy to drive. But each speaker affects the other in series with it; the failure of just one will be magnified by putting the other out of action as well.

Figure 6 is an improved series-parallel configuration. The intermediate connections between the speakers give it a good measure of immunity to the failure of any single speaker, although such an occurrence will alter the distribution of the power among the remaining speakers, with some getting more than others. It also presents a load of 5.3 ohms to the amplifier.

An even better, more reliable solution—and one that fits with adding the back surround channel—is to wire the speakers in parallel (to the extent that the amplifier can drive the resulting load impedance), as shown in Figure 7, which breaks the six speakers into two separate parallel-connected lines, one with four speakers for a total of 2 ohms, and the other with two speakers and amounting to a 4-ohm load. The DCA Series amplifiers, as can most modern amplifiers, can easily drive loads of 2 ohms per channel, and the DCA 1222 can even be loaded with 1.6 ohms per channel—equivalent to five 8-ohm speakers in parallel. Larger auditoriums may require more than four or five surround speakers on each wall, and therefore will require additional amplifiers also.

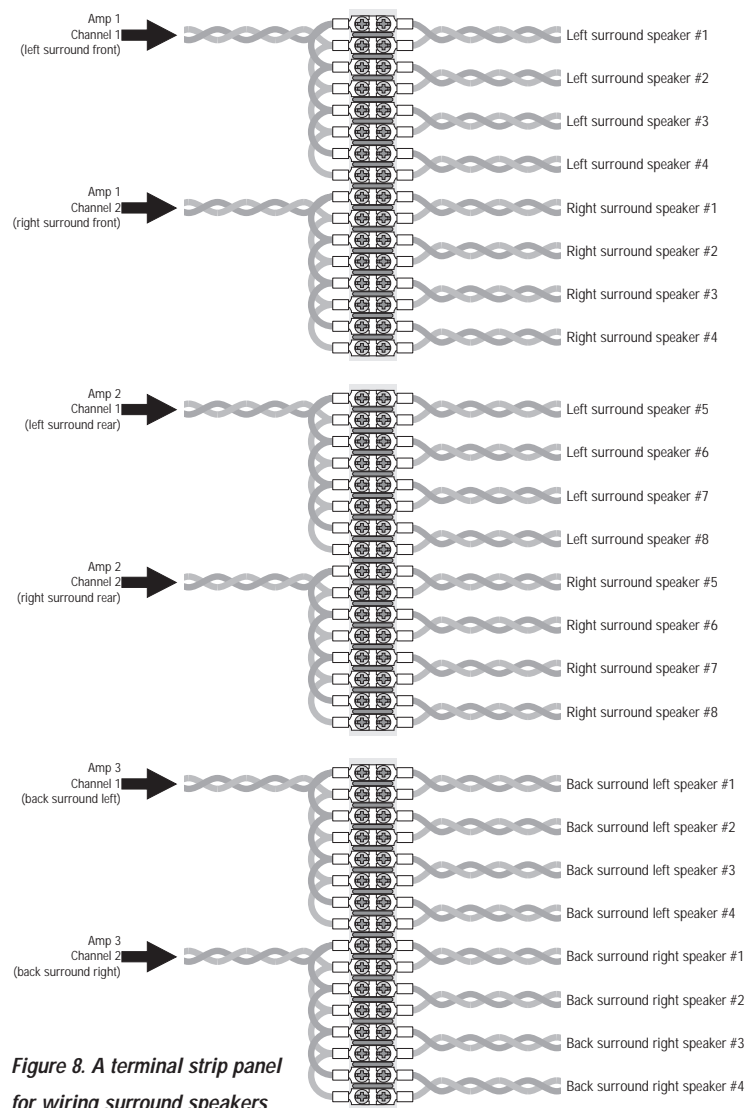


Figure 8. A terminal strip panel for wiring surround speakers

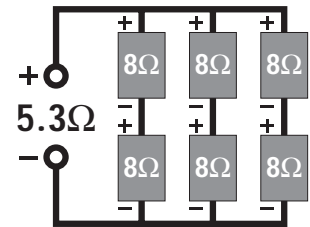


Figure 5.

Not good: series-parallel

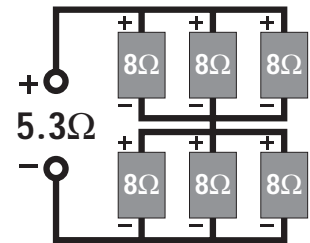


Figure 6.

Somewhat better: series-parallel

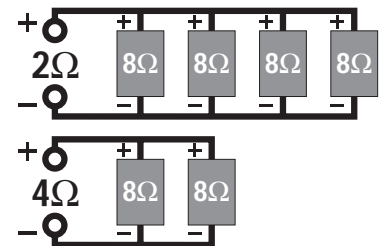


Figure 7.

Best: parallel

Parallel connections make more use of an amplifier's power capabilities, too; an amp that can drive 2-ohm loads on each channel will typically have 2 to 2.5 times the power at 2 ohms than at 5.3 ohms.

If your existing surround speakers were installed with the foresight to have each speaker's cabling run directly back to the projection booth or wherever the amplifier rack is located (a "home run," in other words), rewiring from series-parallel to parallel is very easy. Figure 8 is an example of terminal strips wired so each speaker has a "home run."

Other advantages of "home run" wiring are that it keeps damping factor high and minimizes power loss in the wire. It also makes it easy to test individual speakers for maintenance purposes.

PASSIVELY CROSSED-OVER SCREEN CHANNELS

If your screen channel speakers have passive crossovers to split the audio frequency bands, seriously consider adding active crossovers and additional amplifiers and cabling to make the systems active 2- or 3-way; correctly done, it will dramatically improve the sonic performance and clarity of the screen channels and will make the mid- and high-frequency drivers much less susceptible to damage from clipping. QSC's **DCA Series** amplifiers are ideal for this type of performance upgrade:

- They are only 2 RU tall, so you can put more power and more channels of amplification into a rack previously filled with 3- and 4-RU amplifiers. They weigh only 21 pounds (9.5 kg) apiece, so it's now also feasible to pre-install the amplifiers in racks before shipping them to the cinema location.
- DCA amps accommodate rear panel plug-in accessories (XC-3 Two-Way Crossover, LF-3 Low Frequency Filter, and SF-3 Subwoofer Filter) that provide all necessary crossover functions for subwoofer and 2- or 3-way active systems without needing additional rack space or AC outlets. The accessories feature optional functions such as built-in screen loss compensation, time alignment delay, and level compensation. Figure 9 shows two channels plus the subwoofer of an active 3-way screen system, constructed from DCA amplifiers and their accessories. Figure 10 shows an XC-3 accessory; the others are similar.
- Extra-low noise (-106 to -108 dB, depending on model) and lack of AC hum gives them a dynamic range worthy of today's demanding digital soundtracks.
- High electrical efficiency reduces the amount of waste heat produced, which in turn reduces the cooling requirements for the projection booth.
- DCA amplifiers have separate monitor outputs to simplify their connection to a speaker monitor panel.

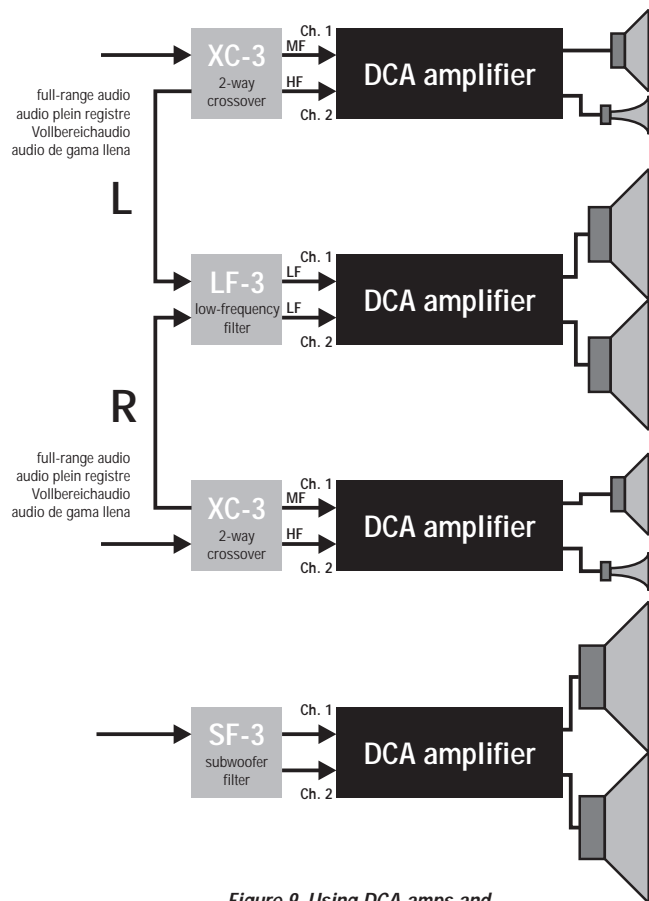


Figure 9. Using DCA amps and crossover accessories to make an active 3-way plus subwoofer system

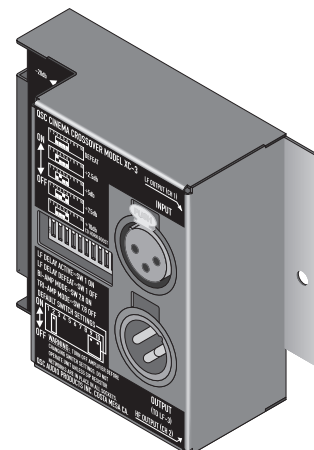


Figure 10. An XC-3 accessory for the DCA Series amplifiers.

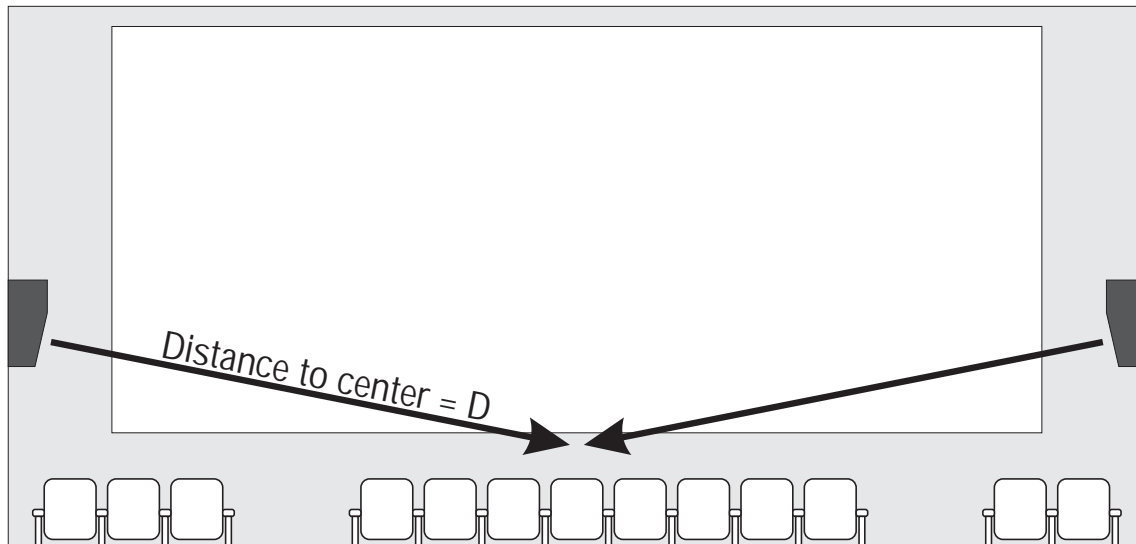


Figure 11. Calculating surround power needed to achieve the correct SPL at the center of the theater

CALCULATING SURROUND POWER REQUIREMENTS

To determine the amount of amplifier power required for the surround systems, measure the distance from the surround speakers to the center of the audience seating area (Figure 11). For the side surround channels, this will be about one-half the width of the auditorium. This distance, measured in meters, is D (if you measure in feet, divide by 3.3 to arrive at the distance in meters). We're using meters because speaker sensitivity specs are typically measured with 1 watt of power input at a distance of 1 meter from the speaker. You also need to know the specified sensitivity of the model of surround speaker you use.

The target maximum SPL at the center of the audience seating area, from one surround channel, is 103 dB. Use the formula

$$\text{Power (in dBW)} = 20\log D + 103 - \text{speaker sensitivity}$$

to determine the amount of power required for each surround channel. Note that dBW is an expression of power referenced to 1 watt; i.e., 0 dBW = 1 watt, +3 dBW = 2 watts, etc. Then use

$$\text{Power (watts)} = 10^{(\text{dBW}/10)}$$

to convert dBW to watts.

For example, if D is 6.3 meters and the surround speakers have a specified sensitivity of 91 dB (1W @ 1m), the calculations will be

$$\begin{aligned} \text{Power (in dBW)} &= 20\log(6.3) + 103 - 91 \\ &= 16 + 103 - 91 = 28 \text{ dBW} \end{aligned}$$

$$\begin{aligned} \text{Power (watts)} &= 10^{(28/10)} = 10^{2.8} \\ &= 631 \text{ watts per surround channel} \end{aligned}$$

A good rule of thumb for determining quantity and location of surround speakers is to place one every 8 to 12 feet (2.4 to 3.6 meters) in the back 2/3 of the auditorium. Smaller rooms need closer spacing to reduce localization, while stadium theaters generally need closer spacing in the back due to reduced ceiling height. The approximate number of surround speakers the room requires, n , can be determined by

$$n = (4/3L + W)/S$$

where S is the desired spacing between speakers and L and W are the length and width, respectively, of the auditorium. Round n to the nearest even integer.

Divide the required power by the number of speakers on each surround channel to determine the power per speaker; make sure it doesn't exceed the speakers' program power rating. If necessary, add more speakers or select a more efficient speaker model, i.e., one with a higher sensitivity rating, and re-calculate the power needs.

Selecting the amplifiers

Once you've determined the number of surround speakers and their power requirements, you can select the amplifiers to drive them.

Table 1 lists QSC amplifiers suitable for cinema use, along with their power ratings and minimum load capabilities. All listed are two rack spaces tall. Choose amplifiers that offer the power levels and the load handling ability you need. For example, if you need two channels of 900 watts each driving three parallel 8-ohm surround speakers (a 2.7 ohm load), the DCA 2422 would be a suitable choice. If you needed two channels of 550 watts each driving five parallel 8-ohm speakers (a 1.6 ohm load), the DCA 1222 would be the ideal choice.

It's likely that no amplifier will exactly match your calculated power requirements, so always err on the side of higher power. It is far better to have more than enough audio power than not enough; underpowering increases the likelihood of clipping, which can cause audible distortion and speaker damage, especially in passively crossed-over systems such as most surround speaker products.

Recycling power

If you wish to re-use the old surround amplifier, a suitable use for it would be to power the two groups of back surround speakers, since they generally have fewer speakers (and therefore higher load impedances) on each channel as well as lower power-per-channel requirements.

Model	Minimum load per channel		Power rating per channel			Accessory compatibility
	Total	Parallel equivalent	8Ω	4Ω	2Ω	
MX 700	2Ω	4 × 8Ω	170W	270W	350W	none
DCA 1222	1.6Ω	5 × 8Ω	200W	325W	600W	DCA Accessories
DCA 1622	2Ω	4 × 8Ω	300W	500W	800W	DCA Accessories
DCA 2422	2Ω	4 × 8Ω	425W	700W	1200W	DCA Accessories
DCA 3022	2Ω	4 × 8Ω	550W	900W	1500W	DCA Accessories
DCA 3422	2Ω	4 × 8Ω	700W	1100W	1700W	DCA Accessories

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