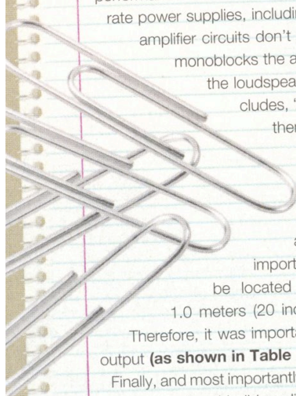
The Car Audio System Nobody Would Build *part 4*

BY JON R. WHITLEDGE

In part three, we defined the basic system configuration, discussed the selection criteria for the head unit and loudspeaker transducers, and included calculations to estimate the required amplifier power. **Table 1** summarizes the results of the calculations from part three. In this month's article the component selection process will continue, with particular emphasis on amplifiers, interconnects, loudspeaker cables, and power cables.

Amplifiers

Last month, I established that each loudspeaker transducer would be powered by its own amplifier, preferably a monoblock. Robert Harley, editor of *The Absolute Sound*, says, "Monoblocks generally perform better than a single stereo unit for several reasons. First, because the two amplifier channels are in a separate chassis, there is no chance of interaction between channels. Consequently, monoblocks typically have better soundstage performance than stereo units. Second, monoblocks have completely separate power supplies, including power transformers; left- and right-channel amplifier circuits don't have to share their current source. This gives monoblocks the ability to provide more instantaneous current to the loudspeaker, all other factors being equal." Harley concludes, "If you want all-out performance and can afford them, monoblocks are the way to go."[1]



In addition to my preference for monoblocks, I prefer amplifiers that don't use cooling fans. I find fan noise in most amplifiers to be both audible and annoying. Fan-less operation was particularly important in my system because the amplifiers would be located directly overhead, essentially within 0.5 to 1.0 meters (20 inches to 39 inches) from the listening position. Therefore, it was important to find amplifiers with the necessary power output **(as shown in Table 1)** that didn't use fans.

Finally, and most importantly, I required the amplifiers to possess audiophile-grade sound and build quality. Although there are a number of high-quality amplifiers available, those manufactured by Genesis I.C.E. met my design requirements.[2] **Table 2** shows the Genesis Dual Mono and Dual Mono Xtreme amplifiers exceeded my power requirements as specified in Table 1. It's important to note that the subwoofer would demand considerable current from the Dual Mono Extreme, since its impedance was estimated to be 2.67 ohms (each isobaric pair would be wired in series and the three pairs would be wired in parallel). **Table 2** also shows the maximum power consumption of the amplifiers.

In addition to superb sound quality and fan-less operation, the Genesis amplifiers possessed numerous attributes that were appealing to me as an engineer. First, I liked their ingenious, but elegantly simple design. The polished extruded aluminum chassis isn't only aesthetically gorgeous, but also an excellent heat sink and a secure mounting platform. Second, I liked the build quality. While many manufacturers mount the amplifier connections directly to the circuit board and "poke" them through the chassis, the Genesis Series III line of amplifiers, instead, solidly mount each of the connections to the chassis to isolate the stresses induced by the attached cables from the circuit board. These solid connection points accept wires terminated with crimp sleeves or ferrules, which I prefer instead of spade terminals. Third, the chassis fuses are located conveniently next to the power input connections. This is an important consideration for competitors, since IASCA requires access to fuses in 45 seconds or less and fuse replacement in 5 minutes or less.[3]

Channel	Loudspeaker transducer	Intended range of operation (Hz)	Power required (watts)
1	L front tweeter	2,000-30,000	130
2	R front tweeter	2,000-30,000	130
3	L front midrange	80-2,000	100
4	R front midrange	80-2,000	100
5	L front woofer	40-80	200
6	R front woofer	40-80	200
7 & 8	Subwoofers	<40	1,140

Table 1. Audio system power requirements.

Specification	Dual Mono	Dual Mono Xtreme
Rated power per channel @ 14.4 V into 4 ohms	100 watts	200 watts
Typical power per channel @ 14.4 V into 4 ohms	150 watts	325 watts
Typical power bridged @ 14.4 V into 4 ohms	500 watts	1,000 watts
Maximum current draw	58 amp	110 amps

Table 2. Genesis amplifier specifications.

Table 3 shows the total power output of the audio system was 2,250 watts, and the total amperage required by the audio system was 336 amps. This is an incredible amount of power for an audio system by anyone's measure and validates my original assertion in part one that incredible levels of power may be required for an audio system dedicated to sound quality. This power output justifies the 200-amp alternator and large auxiliary battery I also specified in part one. The front soundstage alone delivered 1,250 watts of total power output and required 226 amps of current. Of course, these current demands represent the maximum required, which was useful for selecting power cables with sufficient margin of safety. The actual current required for musical playback at the 80-phon level, for instance, would be substantially less.

Perhaps it's appropriate to correlate these design goals and requirements with "real world" performance. It's been said that the sound quality in my Sprinter van is among the finest most have heard. Of course, the overall performance of a mobile audio system represents the combined performance of the room, loudspeakers, amplifiers, digital front-end, cables, and any other components in the signal path, as well as the interaction(s) between the components.

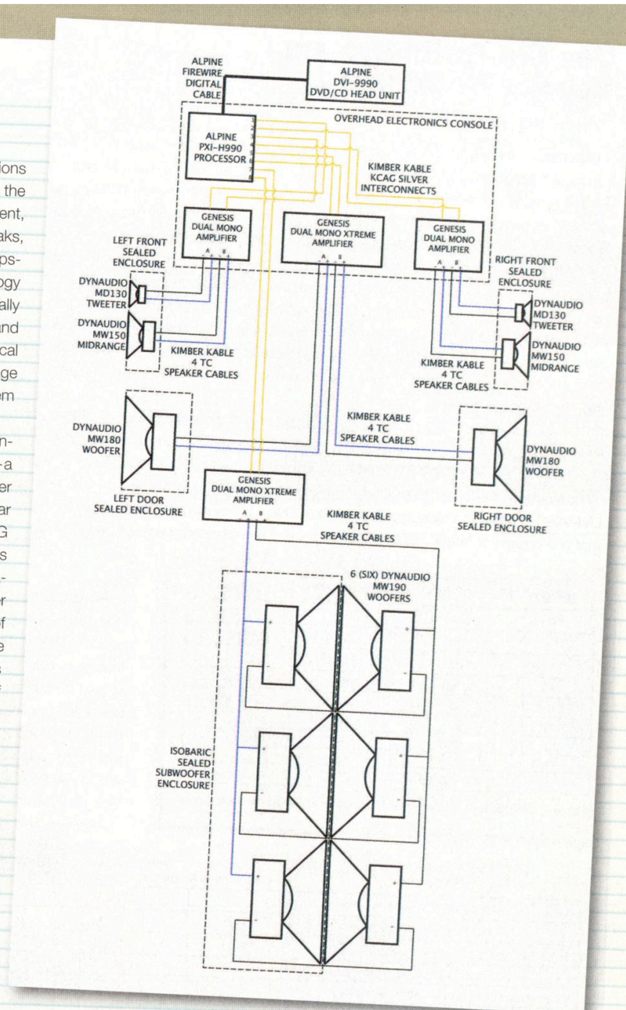
While it can be argued that loudspeakers have the most difficult task of any of the components in the playback chain, it isn't debatable that appropriately matching the amplifier to the loudspeakers is of paramount

Application	Loudspeaker transducer	Amplifier	Power (watts)	Current (amperes)
Front soundstage	L front tweeter	Dual Mono	150	58
	R front tweeter		150	
	L front midrange	Dual Mono	150	58
	R front midrange		150	
	L front woofer	Dual Mono Xtreme	325	110
	R front woofer		325	
Subwoofer	Subwoofer	Dual Mono Xtreme	≥1,000	110

Table 3. Total audio system power.

importance. Frequently, loudspeaker systems in mobile applications are of low impedance and as a result demand more current from the amplifier. Harley says if the amplifier cannot deliver the required current, "The result is musical strain—or even distortion—on musical peaks, weak bass, loss of dynamics, hardening of timbre, and a collapsing soundstage."[4] The Genesis amplifier's true monoblock topology resulted in superb control over the loudspeakers, and substantially avoided the potential problems Harley cited. Numerous home and mobile audiophiles have commented favorably on my system's musical sense of ease and transparency, in addition to its precise soundstage and ferocious dynamics. Others have said that my car audio system outperforms many home audio systems.

Another benefit of the Genesis amplifiers is their surprisingly cool-running nature. My amplifiers, by necessity, are mounted upside-down—a less favorable configuration for cooling. Yet the amplifiers have never gotten excessively hot, even at high levels of output at extreme in-car temperatures of 100° F (38° C). I suspect this is due to the "Class G Technology," which is said to confer the sonic advantages of a "Class AB design," but with the benefit of high efficiency and low heat generation like a "Class D design." I really don't know much about amplifier design, but I have met Gordon Taylor, the designer and founder of Genesis, and I have attended one of his presentations regarding the design attributes of his amplifiers. As a scientist and engineer, it was easy to recognize his extensive theoretical and practical knowledge of amplifier design and his passion for achieving sound quality.



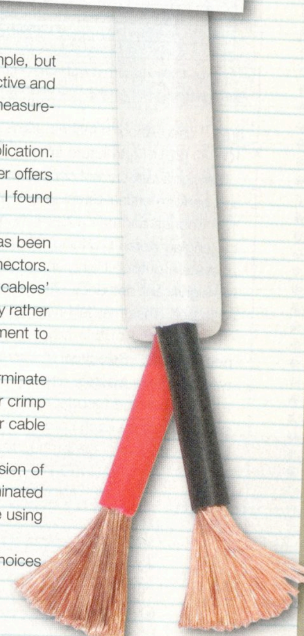
Cables and Connections

Continuing with the selection of components in the musical signal path, I'd like to turn our attention to loudspeaker cables, interconnects, and connections (RCAs, binding posts, spades, banana plugs, and the like). These components function to connect other components in the musical playback chain and are only capable of maintaining or degrading the quality of a musical signal. Therefore, the shortest possible interconnects and loudspeaker cables, combined with the fewest number of connections, will sound best. This is why in part one I asserted my goal for using the shortest possible interconnects and loudspeaker cables. Logically, high-quality interconnects, loudspeaker cables, and connections will allow a system to perform at its highest potential.

Kimber Kable has been making interconnects and loudspeaker cables for over 25 years. Its designs are elegantly simple, but clever, and its choice of materials makes them state-of-the-art. Kimber products are created using its own OSCaR ("Objective and Subjective Correlation and Results") engineering process. Kimber strives to correlate listening impressions to scientific measurements in order to produce cables that offer the highest performance-to-price quotient.[5]

One of my design goals was to capitalize on the sonic benefits of cables designed for home audio in my car audio application. As most of you know, car audio cabling often requires custom lengths and flexible options for cable terminations. Kimber offers bulk cabling for interconnects and loudspeaker cables, thereby allowing customers to create application-specific cables. I found this to be particularly appealing, since I desired to make my own perfectly fitted cables.

Custom cabling requires custom connections and terminations. WBT, a German manufacturer of audio connectors, has been manufacturing high-quality audio connections for over 20 years and holds more than 20 patents pertaining to audio connectors. In my opinion, they're the finest in existence, and I used their products exclusively for my interconnects' and loudspeaker cables' connections (e.g., RCAs, binding posts, spades, banana plugs, and crimp sleeves).[6] I feel WBT's products look like jewelry rather than audio connectors, and when combined with Kimber's cabling, they form the perfect aesthetic and sonic complement to the Genesis amplifiers.



For the front soundstage, I chose Kimber's KCAG interconnect cable made from Varistrand "Hyper-pure silver." To terminate the interconnects, I chose WBT's WBT-0108 RCA-type connectors, which use set screws to compress and secure silver crimp sleeves, rather than solder. The loudspeaker cables in the front soundstage were made using Kimber's 4TC loudspeaker cable and WBT's spades (part number WBT-0680Cu), bananas (part number WBT-0645), and copper crimp sleeves.

Since the interconnects for the subwoofer were about 6 meters (20 feet) long, I chose Kimber's limited-production version of its popular PBJ-series of interconnects (with copper conductors), protected by a non-metallic shield. These were also terminated with WBT-0108 RCA-type connectors and copper crimp sleeves. The loudspeaker cables for the subwoofer were made using Kimber's 4TC loudspeaker cable and WBT's spades (part number WBT-0680Cu), and copper crimp sleeves.

Thus far, all of the essential components in the musical playback chain have been chosen. Figure 1 illustrates these choices in the form of a system diagram.

Calculating Needs Based on Power

It is essential to estimate the power consumed by a car audio system to properly determine the size of the power cables, alternator, and auxiliary battery. For my system, I knew the current demand for the audio system would be high, so I chose the most powerful alternator available as a factory option, a Bosch with 200 amps of rated output. Because my system could draw as much as 336 amps of current, a larger alternator, if available, would've been preferable. Nonetheless, the 200-amp alternator has provided adequate service, since the system is never played at maximum output.

It's vitally important to use appropriately sized power cables. Not only is it a matter of achieving the desired sound quality, it's a matter of safety. IASCA's rules provide guidelines for selecting the proper power cable size, or gauge, based on current demand and length of power cable.[7] In former rulebooks, IASCA specifically stated the maximum permissible voltage drop in any current-carrying conductor was 0.5 volt over its entire length.[8] For systems operating nominally at 12 volts, this represents a voltage loss of 4.17 percent over the length of the conductor, a reasonably conservative specification. The current rulebook uses the same "Power Cable Calculator" chart as in previous rule books; therefore, the maximum voltage drop per conductor still applies.

For those who wish to calculate the maximum permissible length of their conductors, L_{max}, according to IASCA's rules, the following equation may be used:

$$L_{\max} = \frac{V_d}{\Psi \bullet I}$$

where V_d is the maximum permissible voltage drop, **Ψ**(Greek symbol psi) is the resistance of the conductor in Ohms per foot, and I is the current flowing through the conductor in amperes.

Table 4 provides tabulated values for **Ψ** for conductors commonly used in mobile audio applications.[9]

For example, the current demand for the front soundstage in my system was estimated to be 226 amps for the amplifiers plus 7.5 amps each for Alpine's DVI-9990 DVD-Audio/Video tuner and PXI-H990 Multimedia Manager, bringing the total current consumption to 241 amps. From **Table 4**, it can be seen that a 0-gauge, or larger, cable could be used. The maximum permissible length was estimated to be:

$$L_{\max} = \frac{0.5}{9.83E-5 \bullet 241} = 21.11 ft$$

Wire gauge	Resistance Ω/1,000 feet	Maximum amperage for chassis wiring	Ψ Ω/feet
0000	0.0490	380	4.90 x 10-5
0	0.0983	245	9.83 x 10-5
1	0.1239	211	1.239 x 10-4
4	0.2485	135	2.485 x 10-4
8	0.6282	73	6.282 x 10-4
10	0.9989	55	9.989 x 10-4
12	1.5880	41	1.588 x 10-3
14	2.5250	32	2.525 x 10-3
16	4.0160	22	4.016 x 10-3

Table 4. American Wire Gauge specifications for common conductor sizes.

The actual length of the conductor was about 19 feet (5.8 meters) and, therefore, complied with IASCA's rules. Similar calculations were performed with each of the principle power conductors in my system and tabulated in **Table 5**. **Table 5** shows that each of my principle power conductors complied with IASCA's requirements. It should be noted that these calculations are rather simplistic and do not take into consideration applications at elevated temperatures, or when wires are bundled together. Consider your application carefully and increase the wire gauge, or use wire with high-temperature resistant insulation, or both, if necessary, to improve the safety of your wiring. Remember, IASCA awards 0 or 5 points for appropriately sized power wires. One miscalculation or oversight could result in the loss of 5 points.

Wire gauge	Current consumption A	Wire gauge	L_{max} feet	Approximate length (feet)
Auxiliary battery to front soundstage	241	0	22.51	19
Alternator to main battery	200	1	20.18	6
Main battery to auxiliary battery	200	0	25.43	25
Auxiliary battery to subwoofer amplifier	110	1	36.69	13
Subwoofer amplifier ground to front soundstage ground	110	1	36.69	23
Fused distribution block to head unit power supply	7.5	16	16.60	12
Head unit power supply to DVI-9990	7.5	16	16.60	9
Fused distribution block to PXA-H990	7.5	16	16.60	6

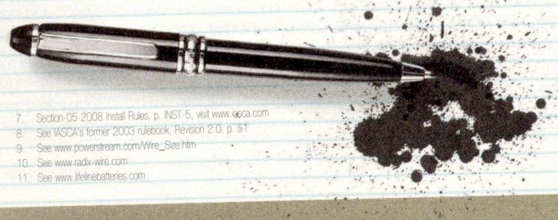
Table 4. Maximum permissible conductor lengths.

Although a number of manufacturers produce high-quality power cables, I chose from Radix Wire's Sil-A-Blend 200 family of power cables for my large gauge needs.[10] These extraordinary power cables use tin-coated copper conductors and silicone insulation reinforced with fiberglass braid. Unlike most car audio power cables, Sil-A-Blend 200 cables are rated for continuous usage at 200° C (392° F), and ideally suited for routing within engine compartments. For small gauge wires in the engine compartment and dashboard areas, I used GXL automotive wiring, which is insulated with cross-linked polyethylene and rated for continuous usage at 125° C (257° F). For other small gauge wires in the cockpit area, I used Ancor's marine-grade primary wire, which uses tin-coated copper conductors and a premium vinyl insulation rated for continuous usage at 105° C (221° F). In future articles, I'll discuss wire terminations, routing, and protection.

The significant current consumption of the audio system required the auxiliary battery to have considerable storage capacity. I intended to both compete and perform critical listening with the engine off, relying completely upon the auxiliary battery for power. A large 4D marine battery typically weighs about 135 pounds and has a capacity of about 200 ampere-hours ("A-hr"). My system, at maximum output, would drain this battery in about 35 minutes, if the engine weren't running. At half the output, the system would be expected to play for about 50 minutes, and substantially longer at even lower levels of system output. Using an inductive current measuring device, I determined the current draw to be about 6 amps with the system idling. Because of the significant demands placed on the battery, I chose a large, 4D marine-grade, deep-cycle battery manufactured by Lifeline Batteries, which employs absorbed glass mat technology.[11]

The purpose of this article was to stress the importance of matching the amplifiers to their loudspeaker systems to achieve maximum sonic performance. Selection of the appropriate amplifiers determined the power consumption of the system, which in turn, influenced the size and type of power cables, alternator, and auxiliary battery selected. The importance of often overlooked components in the musical signal path such as interconnects, loudspeaker cables and audio connectors was also discussed. Finally, this article emphasized the importance of component selection, since each component in the playback chain can only maintain or degrade, not enhance, the performance of a musical playback system.

Next month, we'll begin the fabrication process.



Resources

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2. See www.genesiscaraudio.net and www.theautophile.com
3. Section-05-2008 Install Rules, p. INST-6, visit www.iasca.com
4. R. Harley, The Complete Guide to High-end Audio, 1st Ed., Acapella Publishing, p. 141, 1994.
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8. See IASCA's former 2003 rulebook, Revision 2.0, p. 51.
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