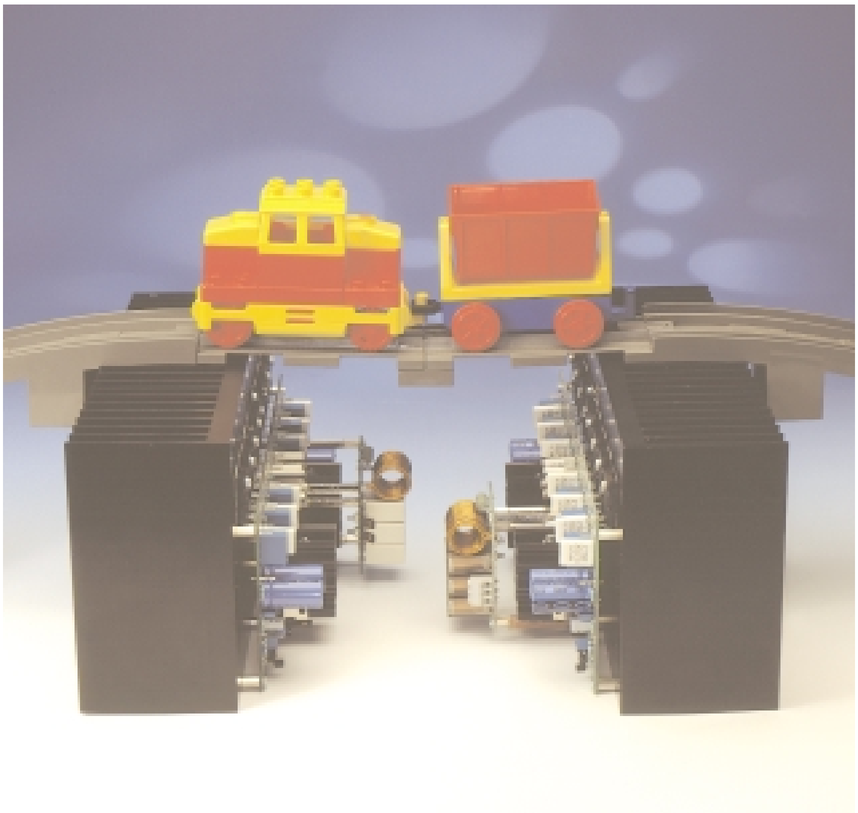
Titan 2000

Part 5: half-bridging two single amplifiers



In the introduction to Part 1 it was stated that the Titan 2000 could deliver up to 2000 watts of 'music power', a term for which there is no standard definition but which is still used in emerging markets. Moreover, without elaboration, this statement is rather misleading, since the reader will by now have realized that the single amplifier cannot possibly provide this power. That can be attained only when two single Titan amplifiers are linked in a half-bridge circuit. The true power, that is, the product of the r.m.s. voltage across the loudspeaker and the r.m.s current flowing into the loudspeaker, is then 1.6 kilowatts into a 4-ohm loudspeaker.

Design by T. Giesberts

BRIDGING: PROS AND CONS

Bridging, a technique that became fashionable in the 1950s, is a way of connecting two single output amplifiers (valve, transistor, BJT, MOSFET, push-pull, complementary) so that they together control the passage of an alternating current through the loudspeaker. This article describes what is strictly a half-bridge configuration, a term not often used in audio electronics. When audio engineers speak of bridge mode, they mean the full-bridge mode in which four amplifiers are used.

In early transistor audio power amplifiers, bridging was a means of achieving what in the 1960s were called public-address power levels as high as,

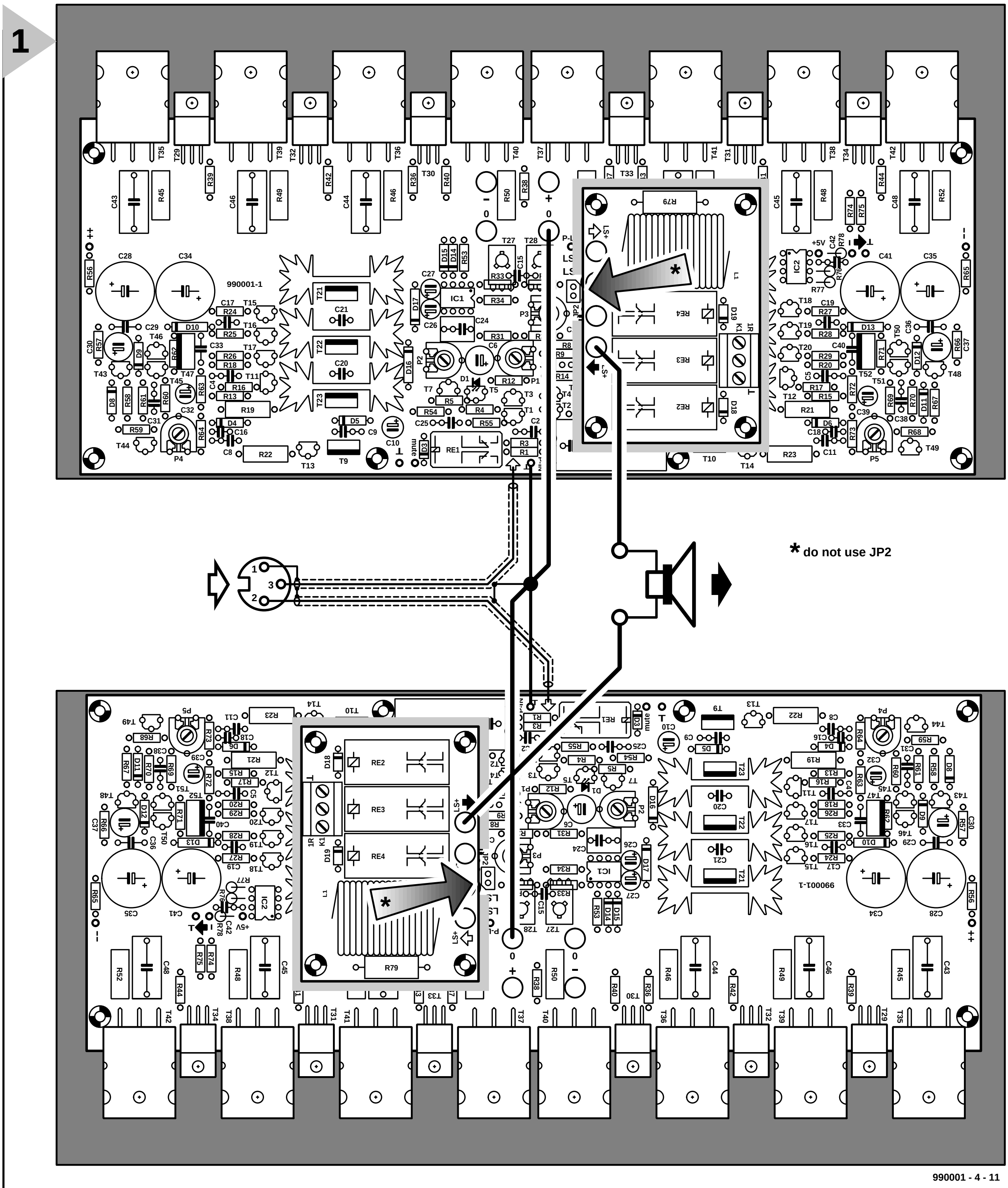


Figure 17. The interlinking required to form a half-bridge amplifier from two single Titan 2000 units. Note that the resulting balanced input may be reconverted to an unbalanced one with the Brangé design (Balanced/unbalanced converters for audio signals) published in the March 1998 issue of this magazine. The PCB for that design (Order no. 980026) is still stocked.

say 50–80 W into 8 Ω. Such power levels were then way beyond of what the voltage ratings of output transistors would permit.

Bridging is considered by many to be a good thing, since it automatically provides a balanced input (drive). However, opponents will quickly point out that it halves output damping, doubles the circuitry and virtually cancels even-order harmonics created in the amplifier.

Opponents also claim that bridging amplifiers is tedious and requires too much space. It is, however, not simple either to design a single amplifier with the same power output and the requisite power supply. A single 2 kW amplifier requires a symmetrical supply voltage of ±130 V, that is, a total of 260 V. The power supply for this would be quite a design. And where would a designer find the drivers and output transistors for this? Advocates point out that bridging amplifiers have the advantage of requiring a relatively low supply voltage for fairly high output powers.

Bridging just about doubles the rated output power of the single amplifier. Again, opponents point out that loudness does not only depend on

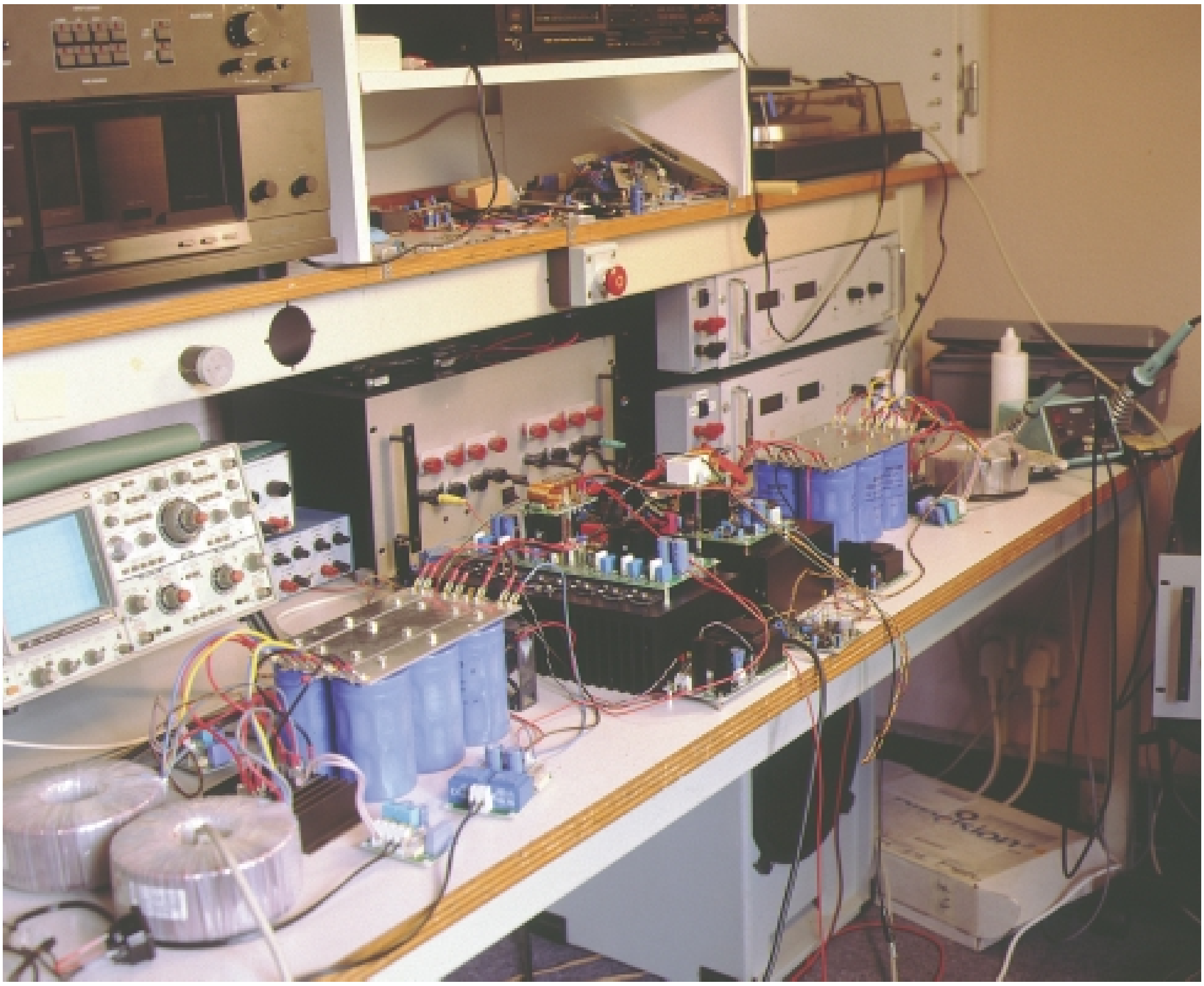


Figure 18. Test setup for the prototype half-bridge amplifier (centre). Note the large power supplies at the left and right of the amplifier.

the amplifier, but also on the loudspeaker. Bear in mind, they say, that just changing a loudspeaker with a sensitivity of, say, 90 dB_{SPL} per watt per metre to one with a sensitivity of 93 dB_{SPL} per watt per metre is equal to doubling the amplifier power rating.

Clearly, bridging two amplifiers is a mixture of good and bad audio engineering and sonics.

INTERCONNECTING

It is, of course, necessary that two completed single Titan 2000 amplifiers are available, each with its own power supply. It should then be possible to simply interlink the earths of the two units, use the inputs as a common balanced input, and connect the loudspeaker between terminals LS+ on the two amplifier. However, a few matters must be seen to first.

Owing to the requisite stability, it is imperative that the two amplifiers are juxtaposed with the space between them not exceeding 5 cm (2 in). They should, of course, be housed in a common enclosure.

The interwiring is shown in **Fig-ure 17**. Make sure that the power supplies are switched off and that the smoothing capacitors have been discharged before any work is carried out.

Start by interlinking the negative supply lines (terminals 0) with insulated 40/02 mm wire. Remove the insulation at the centre of the length of wire since this will become the central earthing point for the new (balanced) input. Link the ⊥ terminals on both boards to the new central earth with 24/02 mm insulated wire.

Connect the loudspeaker terminals to the LS+ terminals on the two boards with 40/02 mm insulated wire.

Link pins 2 and 3 of the XLR connector to the input terminals on the boards with two-core screened cable. Solder the screening braid to pin 1 of the XLR connector and to the new central earthing point.

Finally, on both boards remove jumper JP_2 from the relevant pin strip.

FINALLY

When all interconnections between the boards as outlined have been made, the single amplifiers form a half-bridge amplifier. If all work has been carried out as described, there should be no problems.

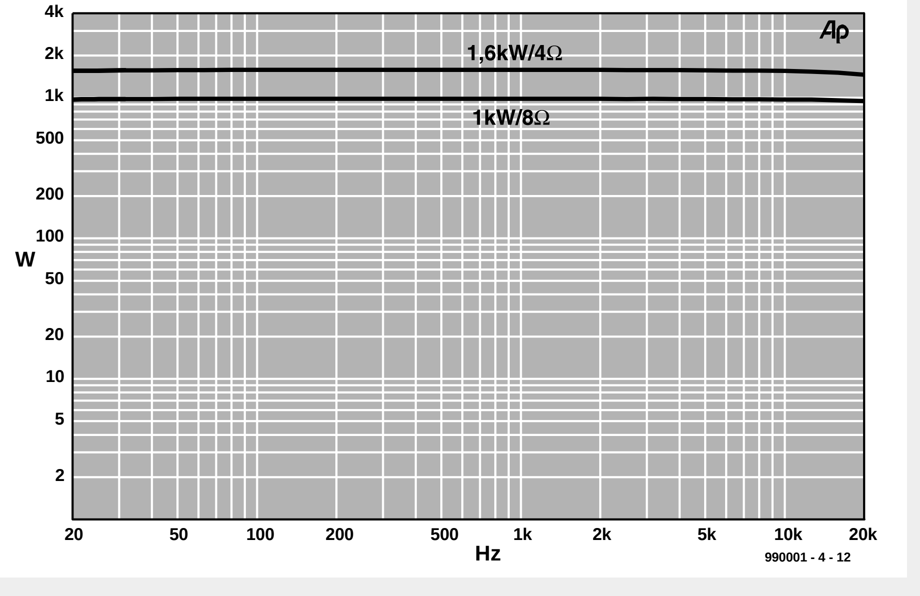
In the design stages, network R_9-P_1, inserted into the circuit with pin jumper JP_1 (see Part 1), was considered necessary for common-mode suppression. However, during the testing of the prototype, the network was found to be superfluous. It may be retained if the half-bridge amplifier is to be used with a second half-bridge amplifier for stereo purposes, when it may be used to equalize the amplifications of the two half-bridge amplifiers.

[990001]

Parameters

With a supply voltage of ±70 V (quiescent ±72 V) and a quiescent current of 200–400 mA

Input sensitivity	2.1 V r.m.s.
Input impedance	87 kΩ
True power output for 0.1% THD	950 W into 8 Ω; 1.5 kW into 4 Ω
True power output for 1% THD	1 kW into 8 Ω; 1.6 kW into 4Ω
Power bandwidth	1.5 Hz – 220 kHz
Slew limiting	170 V µs^{-1}
Signal+noise-to-noise ratio (at 1 W into 8 Ω)	97 dB (A-weighted
	93 dB (B=22 kHz)
Total harmonic distortion (B=80 kHz)	
at 1 kHz	0.0033% (1 W into 8 Ω)
	0.002% (700 W into 8 Ω)
	0.0047% (1 W into 4 Ω)
	0.006% (700 W into 4 Ω)
at 20 kHz	0.015% (700 W into 8 Ω)
	0.038% (1200 W into 4 Ω)
Intermodulation distortion	
(50 Hz:7 kHz = 4:1)	0.0025% (1 W into 8 Ω)
	0.0095% (500 W into 8 Ω)
	0.004% (1 W into 4 Ω)
	0.017% (500 W into 4 Ω)
Dynamic intermodulation distortion	
(square wave of 3.15 kHz and	0.0038% (1 W into 8 Ω)
sine wave of 15 kHz)	0.0043% (700 W into 8 Ω)
	0.005% (1 W into 4 Ω)
	0.0076% (1200 W into 4 Ω)
Damping (with 8 Ω load)	≥ 350 (at 1 kHz)
	≥ 150 (at 20 kHz)
Open-loop amplification	×8600
Open-loop bandwidth	53 kHz
Open-loop output impedance	3.2 Ω

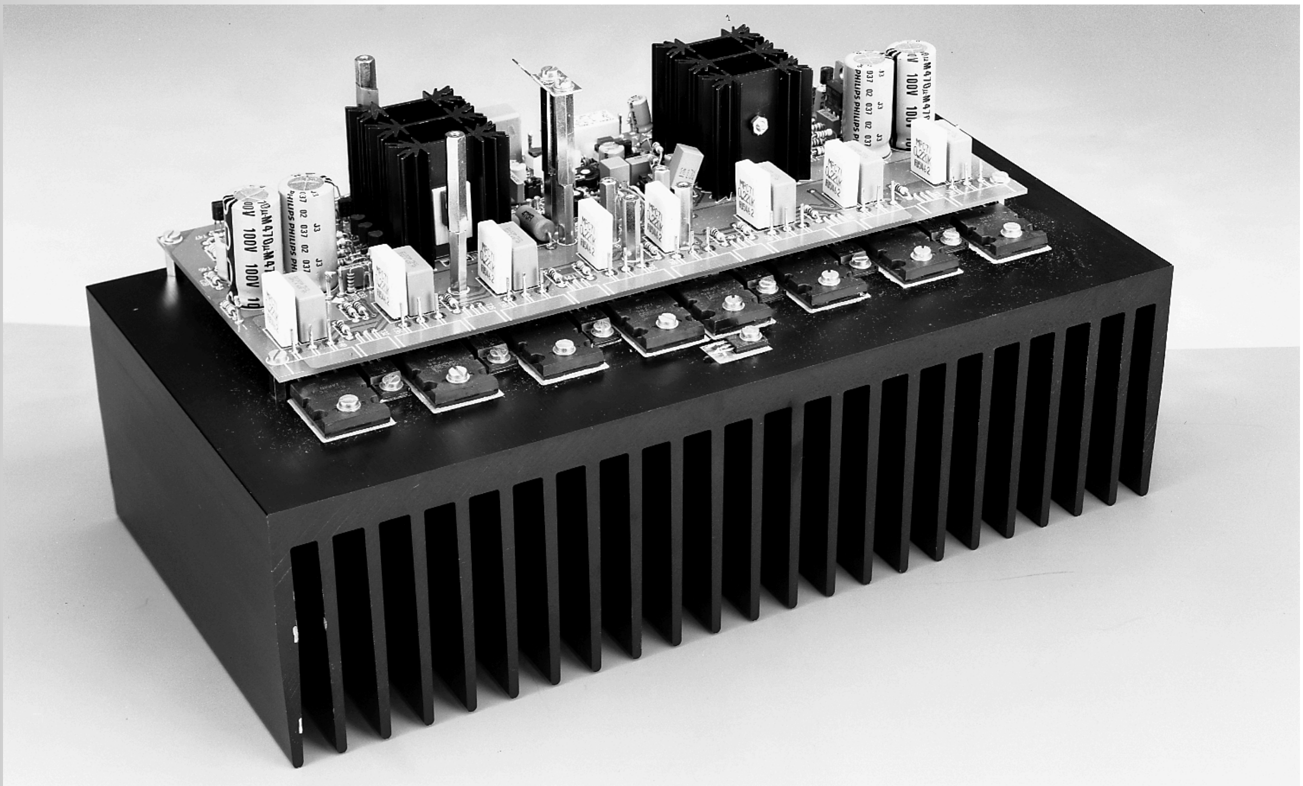


A comparison of these parameters with the specifications given in Part 4 ((May 1999 issue) show that they are generally in line. In fact, the intermodulation distortion figures are slightly better. Because of this, no new curves are given here other than power output (1 kW into 8 Ω and 1.6 kW into 4 Ω) vs frequency characteristics for 1 per cent total harmonic distortion.

During listening tests, it was not possible to judge the half-bridge amplifier at full volume, simply because there were no loudspeakers available that can handle this power output. However, up to 200 W true power output, the half-bridge amplifier sounds exactly the same as the single amplifier. Instrument test figures show no reason to think that the performance at higher output powers will be degraded.

Titan 2000

Part 4: wiring and performance



This fourth of five parts deals primarily with the wiring up of the amplifier and ends with a brief resume of its performance and specifications. The fifth and final part of the article in a forthcoming issue will deal with the temperature control, bridge configuration and some other practical hints.

Design by T. Giesberts

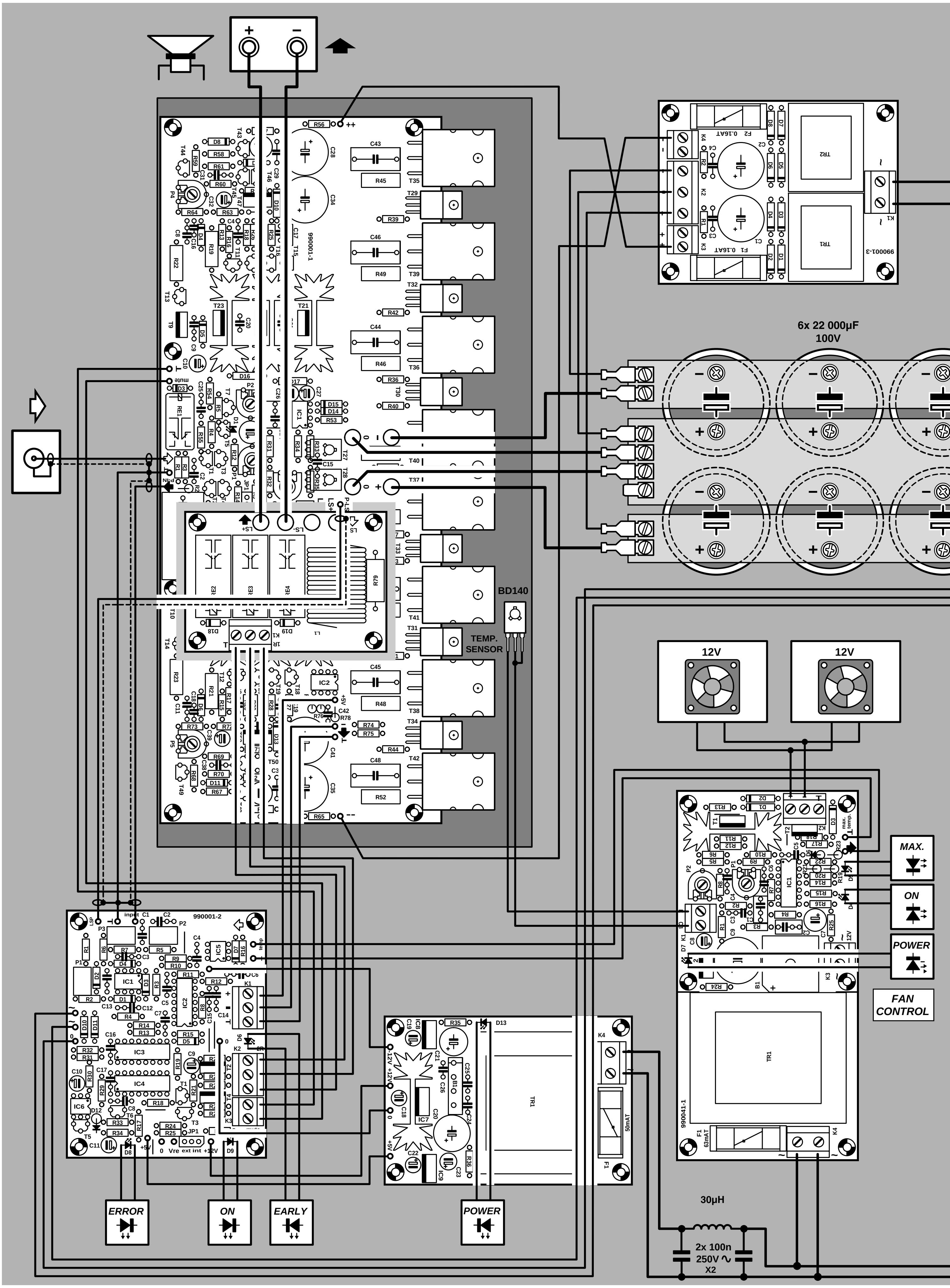
WIRING UP

How the various board, power supplies, controls and terminals are combined into an effective and interference-free unit is shown in **Figure 16**.

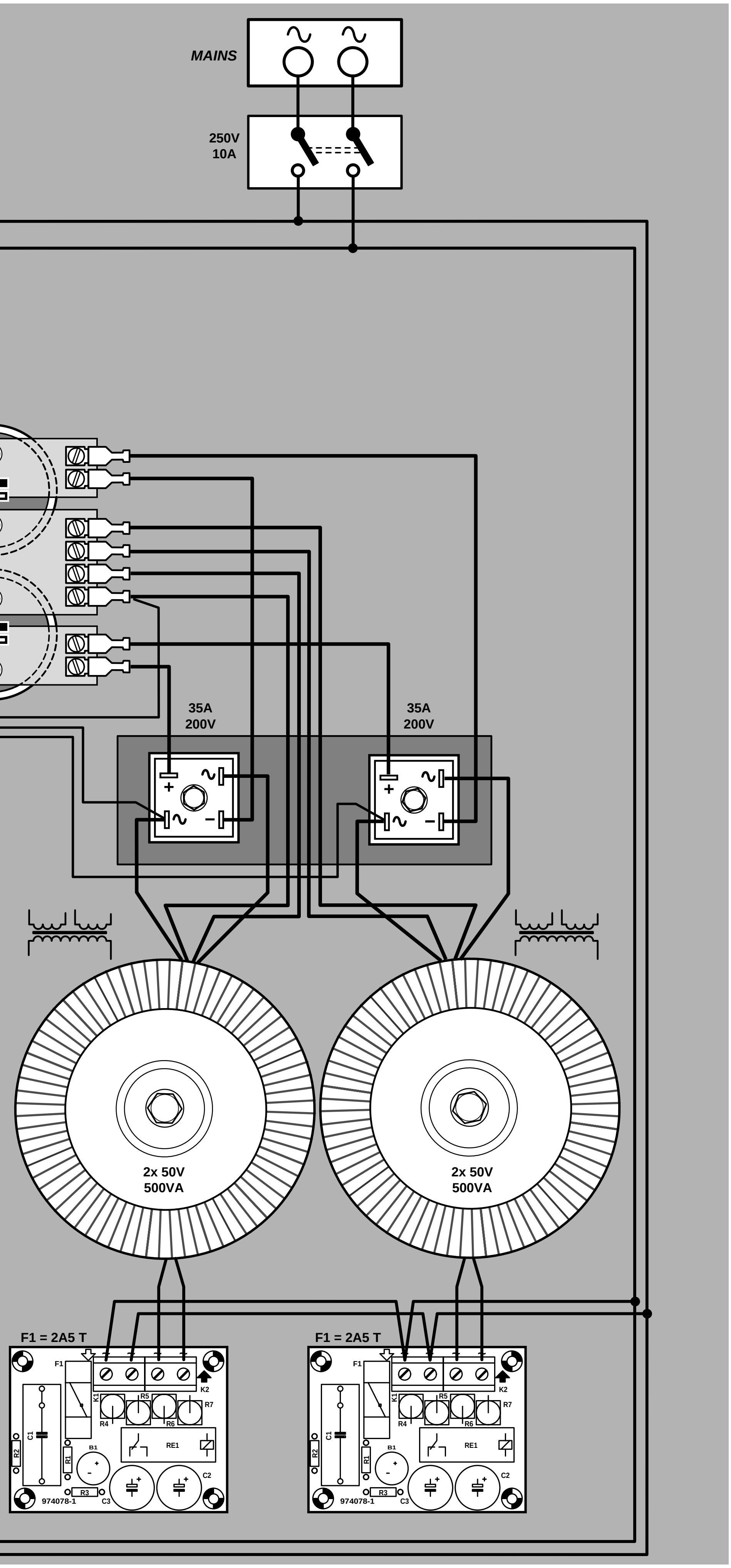
As already mentioned in Part 2, all wiring carrying the main supply voltage (±70 V) must be insulated, high-current wire to BS6321 with a conductor size of 50/0.25 (2.5 mm^2). This wire should also be used to link the output terminals of the power transistors and the loudspeaker terminals. Any wiring between smoothing capacitors and the board should not exceed 15 cm and be preferably much shorter. This kind of wire is best terminated into car-type connectors.

Other wiring may be made in light-duty, stranded, insulated hook-up wire. It is advisable (and may prove to be very helpful in case of problems) to use wire with different colour insulation for dissimilar functions.

The connections between the input socket and board must, of course, be in screened audio cable. To avoid earth loops, the socket should be isolated from a metal enclosure. Bear in mind that the supply earth and the enclosure are linked by metal spacers between the two '0' terminals and the heat sink. It is, therefore, essential that the heat sink is firmly strapped to the metal enclosure.



6x 22 000µF
100V
BD140
TEMP.
SENSOR
12V
12V
MAX.
ON
POWER
FAN
CONTROL
ERROR
ON
EARLY
POWER
30µH
2x 100n
250V ~
X2



The on/off indicator, the functional indicators, and the mains on/off switch should, of course, be fitted on the front panel of the enclosure. The mains on/off switch must be a 10 A or 15 A type.

If the output power of the amplifier is limited to no more than 500 W, in which case the enclosure does not need fan cooling, the heat sink may be mounted at the outside of the enclosure or even form the sidewall or back of a home-made enclosure.

For greater output powers, cooling fans with relevant apertures at the front and back of the enclosure are a must. The heat sink must then be located in the enclosure in such a position that it is directly between the two fans, ensuring a continuous supply of cooling air.

PERFORMANCE

The specification and associated comments in the box cannot, of course, give a full impression of the performance of the amplifier. It is a well-known fact that amplifiers with an almost identical specification, and using identical loudspeakers, can sound quite different.

Particularly at low frequencies, the amplifier maintains good control over the loudspeaker, which results in a clean fast (i.e., taut over the whole audio range) sound, totally lacking in reverberation. High and medium frequencies were also reproduced with excellent definition and without any trace of tizziness.

The overall impression is that the amplifier has plenty of reserve and is not strained in any circumstances.

In next month's final instalment, the temperature control and possible bridge configuration will be discussed.

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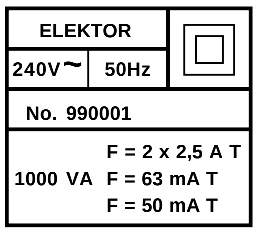

Figure 16. The wiring diagram clearly illustrates how the various parts of the amplifier are combined into a single unit.

Contents

Technical specifications

(Supply voltage = ±70 V; quiescent current = 200–400 mA)

Input sensitivity	1.1 V r.m.s.		
Input impedance	47.5 kΩ		
Sine-wave power output (0.1% THD)	280 W into 8 Ω; 500 W into 4 Ω; 800 W into 2 Ω		
Music power* (1% THD)	300 W into 8 Ω; 550 W into 4 Ω; 1000 W into 2 Ω		
Slew limiting	85 V µs^{-1}		
Open-loop bandwidth	53 kHz		
Open-loop amplification	×8600		
Power bandwidth	1.5 Hz – 220 kHz		
Signal-to-noise ratio (1 W into 8 Ω)	101 dB (A-weighted); 97 dB (B = 22 kHz)		
Damping factor (at 8 Ω)	>700 (1 kHz); >300 (20 kHz)		
Output impedance	1.6 Ω		
Harmonic distortion (THD) (B = 80 kHz)	8 Ω	4 Ω	2 Ω
at 1 kHz	0.003% (1 W)	0.0046% (1 W)	0.01% (1 W)
	0.005% (200 W)	0.0084% (400 W)	0.02% (700 W)
at 20 kHz	0.009% (200 W)	0.018% (400 W)	0.07% (700 W)
Intermodulation distortion (IM)			
(50 Hz:7 kHz = 4:1)	0.004% (1 W)	0.01% (1 W)	0.034% (1 W
	0.016% (150 W)	0.025% (300W)	0.07% (500 W)
Dynamic IM			
(square wave 3.15 kHz with sine wave 15 kHz)	0.003% (1 W)	0.0036% (1W)	0.0055% (1 W)
	0.003% (200 W)	0.005% (400 W)	0.0085% (700 W)

*See Part 1 about the validity of this meaningless quantity.

The specified figures were measured after the amplifier had been switched on for two hours. The figure show that the Titan 2000 compares favourably with most amplifiers. The slew limiting is a measure of the speed of the amplifier, which is exceptionally good in the Titan 2000.
Figure A shows the total harmonic distortion plus noise (THD+N) for an output of 1 W into 8 Ω (lower curve) and for 200 W into 8 Ω. The latter figure corresponds with 70% of the peak sine wave power and the curve shows that the distortion increases clearly only above 10 kHz.
Figure B shows the THD+N at 1 kHz as a function of the drive with an output impedance of 8 Ω. The curve is purposely drawn for a bandwidth of 22 kHz so that the noise above 20 kHz does not degrade the performance of the amplifier. From about 2 W, the distortion increases slightly with increasing drive, which is normal in most amplifiers.
Figure C shows the peak output of the amplifier at a constant distortion of 0.1% and a load of 4 Ω (upper curve) and 8 Ω. The bandwidth was 80 kHz.
Figure D shows a Fourier analysis of a reproduced 1 kHz signal at a level of 1 W into 8 Ω. It will be seen that the 2nd harmonics are down just about 100 dB, while the 3rd harmonics are down to –114 dB. Higher harmonics lie below the noise floor of –130 dB.