Compact 200 W Output Stage

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There is no doubt that this small power amp packs a punch. It is capable of delivering a healthy 200 W into 4 Ω. Into 8 Ω it can still output 125 W (see **Figure 2**). These large power outputs are made possible through the use of Darlington transistors made by Sanken, the SAP16N and its opposite number, the SAP16P (in our prototype we used their predecessors, the SAP15N and P, because the SAP16 versions were not available at that time). These power transistors have an emitter resistor built in, as well as a diode for temperature compensation. Because of this, the whole emitter follower stage has just two components (and a preset for setting the quiescent current, shown in the circuit in **Figure 1**).

One small disadvantage is that the transistors have to operate at a relatively low

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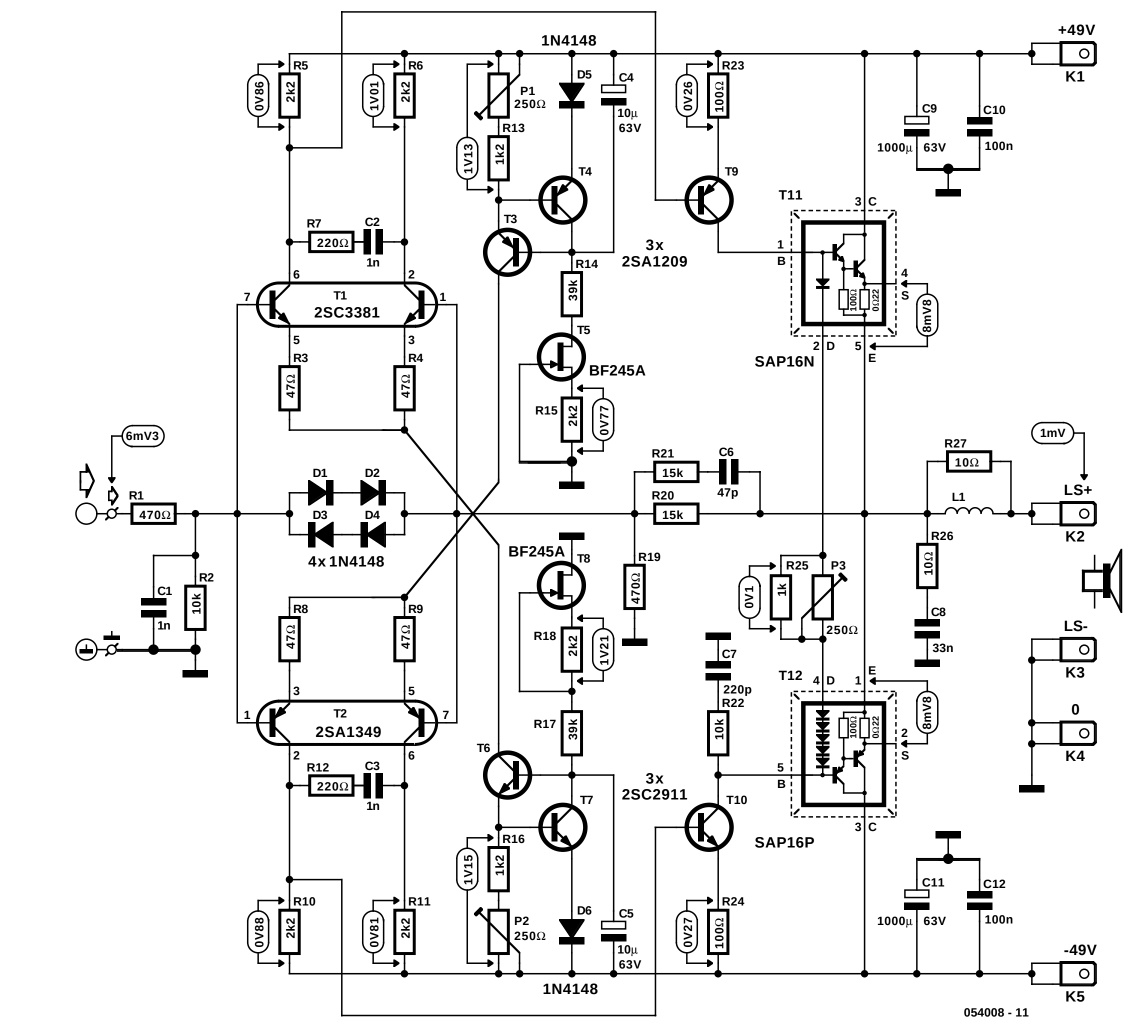

quiescent current, according to the datasheet. This causes an increase in distortion and a reduction in bandwidth. The current through the diodes has to be set to 2.5 mA, when the quiescent current will be 40 mA. This has the advantage that the driver transistors (T9, T10) do not need heat sinks, which helps to keep the circuit small.

The amplifier is of a standard design and doesn't require much explanation. The input is formed by two differential amplifiers (T1, T2), which are each followed by a buffer transistor (T9, T10). T9 and T10 together make a push-pull stage that drives the output transistors.

For T1 and T2 we've used special complementary dual transistors made by Toshiba. These, along with the driver transistors, have been used previously in the *High-End Power Amp* in the March 2005 issue. The driver transistors are a complementary pair made by Sanyo, which have been designed specifically for these applications.

Compensation in the amplifier is provided by R7/C2, R12/C3, R21/C6, R22/C7 and R26/C8. The dual transistors are protected by D1 to D4. The output inductor consists of 8 turns of 1.5 mm diameter enamelled copper wire (ECW).

Since the current through the diodes is just 2.5 mA, the operating point of T9 and T10 has to be set precisely. This operating point is determined purely by the operating point of the differential input amplifiers. Since the ambient temperature affects the operating point, any potential drift in the operating point of T9 and T10 is compensated for by the current sources of the differential amplifiers.

The voltage drop across D5 (D6) and the base-emitter voltage of T4 (T7) determine the current through P1 (P2) and R13 (R16). T4 (T7) controls the voltage at the base of T3 (T6) and creates a constant current that is independent from the supply voltage. Since the voltage across D5 (D6) and T4 (T7) depends on the temperature, the voltage at the base of T10 (T9) has been temperature-compensated as well as possible. T3 and T4 (T6 and T7) are fed by a simple constant current source built around JFET T5 (T8), which makes the differential amplifier around T2 (T1) even less dependent on the supply voltage. R14 (R17) restricts the maximum voltage across T5 (T8), which may not exceed 30 V. According to the datasheet the JFET current should be about 0.5 mA, but in practice a deviation of up to 50% is possible. The actual value is not critical, but the voltage across the JFET must

Specifications

Input sensitivity		1 V_{eff}
Input impedance		10 kΩ
Sine-wave power	8Ω	125 W, THD+N = 1 %
	4Ω	200 W, THD+N = 1 %
Bandwidth		135 kHz (1 W/8Ω)
Slew rate		20 V/µs
Signal/noise ratio		101 dB (1 W/8 Ω, 22 Hz to 22 kHz)
		104 dBA
THD+noise		0.014 % at 1 kHz (60 W/8Ω)
Damping factor		>700 (1 kHz)
		>400 (20 kHz)

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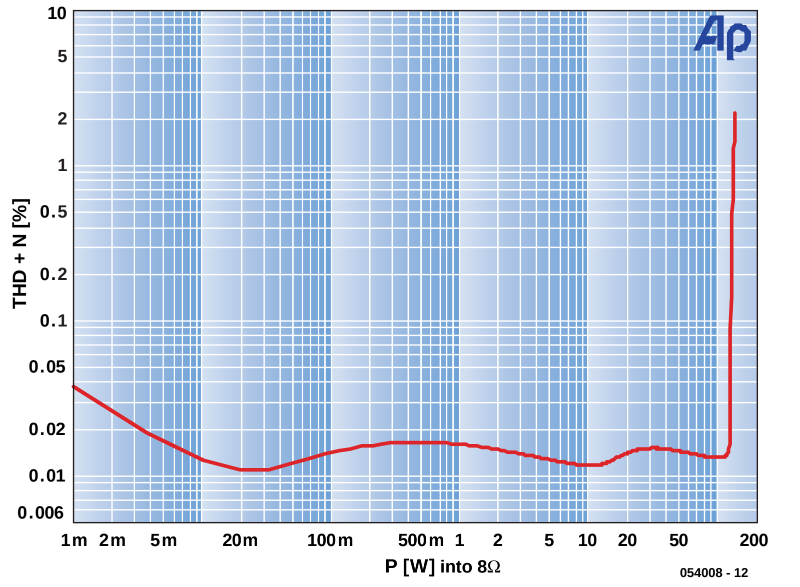

COMPONENTS LIST

Resistors:
R1, R19 = 470Ω
R2, R22 = 10kΩ
R3, R4, R8, R9 = 47Ω
R5, R6, R10, R11, R15, R18 = 2kΩ2
R7, R12 = 220Ω
R13, R16 = 1kΩ2
R14, R17 = 39kΩ
R20, R21 = 15kΩ
R23, R24 = 100Ω
R25 = 1kΩ
R26, R27 = 10Ω 1W
P1,P2,P3 = 250Ω preset

Capacitors:
C1,C2,C3 = 1nF
C4, C5 = 10µF 63V radial
C6 = 47pF
C7 = 220pF
C8 = 33nF
C9, C11 = 1000µF 63V radial
C10, C12 = 100nF

Inductors:
L1 = 8 turns 1.5mm dia. ECW, inside diameter 10mm.

Semiconductors:
D1-D6 = 1N4148
T1 = 2SC3381 (Toshiba) (Huijzer; Segor Electronics)
T2 = 2SA1349 (Toshiba) (Huijzer; Segor Electronics)
T3,T4,T9 = 2SA1209 (Sanyo) (Farnell # 410-3841)
T5, T8 = BF245A
T6, T7, T10 = 2SC2911 (Sanyo) (Farnell # 410-3853)
T11 = SAP16N (Sanken) or SAP15N (Farnell # 410-3749)
T12 = SAP16P (Sanken) or SAP15P (Farnell # 410-3750)

Miscellaneous:
K1-K5 = 2-way spade terminal, PCB mount, vertical
Heatsink <0.5 K/W
Mica washers for T11 en T12, e.g., Conrad Electronics # 189049.
4 wire links on PCB
PCB, ref. 054008-1 from The PCBShop

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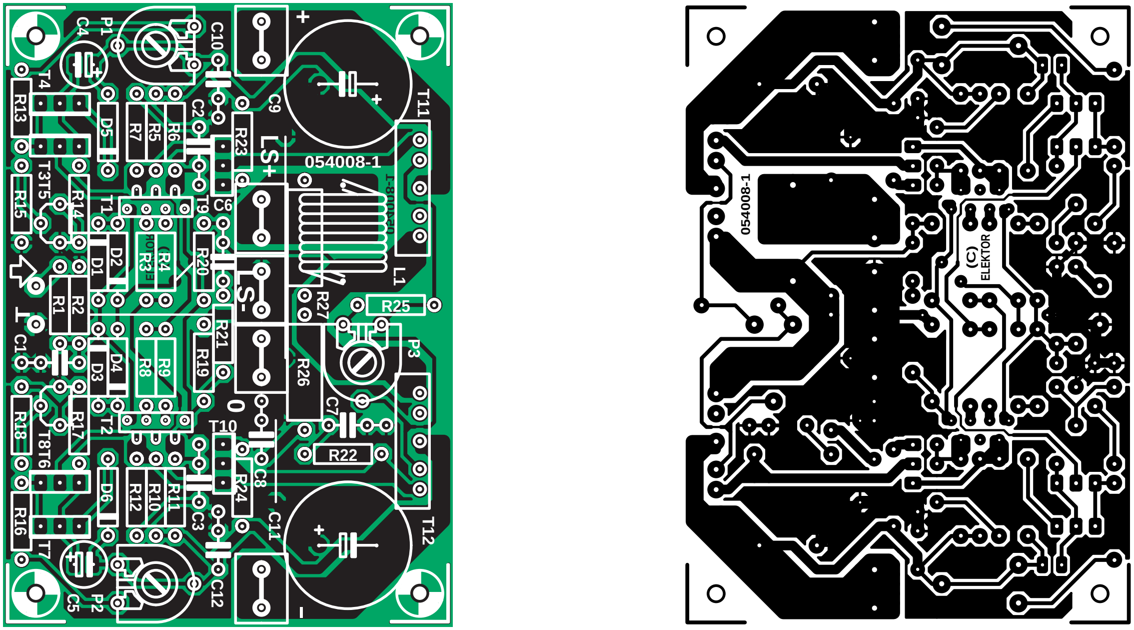

always stay below the maximum value (also take into account any possible mains voltage variations). If you do need to reduce the voltage, that should be done by **lowering** the value of R15 (R18). This causes the voltage across R14 (R17) to increase and hence the voltage across the JFET will drop.

P1 and P2 are required to compensate for various tolerances. With the input open circuit you should set the output to zero, while keeping the current through T9 and T10 as close as possible to 2.5 mA. This can be measured across R23 and R24. It is not a problem if the current is a few tenths of a mA more than this.

The quiescent current is set by P3. In the reference design a 200 Ω preset is used. We have put this together using a (standard) preset of 250 Ω in parallel with a 1 kΩ resistor. An incidental advantage of this parallel resistor is that it limits any possible current spikes when the wiper of the potentiometer makes a bad contact during the adjustment of the quiescent current.

This amplifier provides a good opportunity to experiment with the Sanken transistors. If you want to use the output stage in a complete power amplifier (refer to the print layout in **Figure 3**), you will need to add an input decoupling capacitor, a power-on delay with a relay for the loudspeaker and a beefy power supply. The input decoupling capacitor is certainly a necessity, since the offset is determined by the various tolerances and differences between the complementary transistors. In our prototype the input offset was 6.3 mV for a 0 V output voltage. This is amplified by a factor of 33, which would result in an output offset of over 200 mV if the input was shorted by, for example, a volume control.

Elsewhere in this issue is a design for a small board, which contains an input decoupling capacitor (MKT or MKP) and a relay with a power-on delay.

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