UM10155

Discrete Class D High Power Audio Amplifier

Rev. 01 — 1 August 2006 User manual

Document information

Info	Content
Keywords	Class D Audio Amplifier, Universal Class D, UcD, PWM Audio Amplifier, High Power Audio.
Abstract	This user manual describes the operating instructions and the most important background information of the Philips Semiconductor Discrete Class D High Power Audio Amplifier Demonstrator Board. With proper heatsinking of the Power MOSFETs and a well dimensioned power supply, the PWM amplifier is capable of supplying 200 W of high quality audio power into a 4 Ω loudspeaker.

Revision history

Rev	Date	Description
01	20060801	initial version

Contact information

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1. Introduction

The Universal Class D (UcD) version 1.00 demonstrator board implements a 200 W true RMS (into a 4 Ω load) high quality audio power amplifier on a very compact printed-circuit board. The amplifier is built-up of discrete components only, and makes use of Philips patent WO 03/090343.

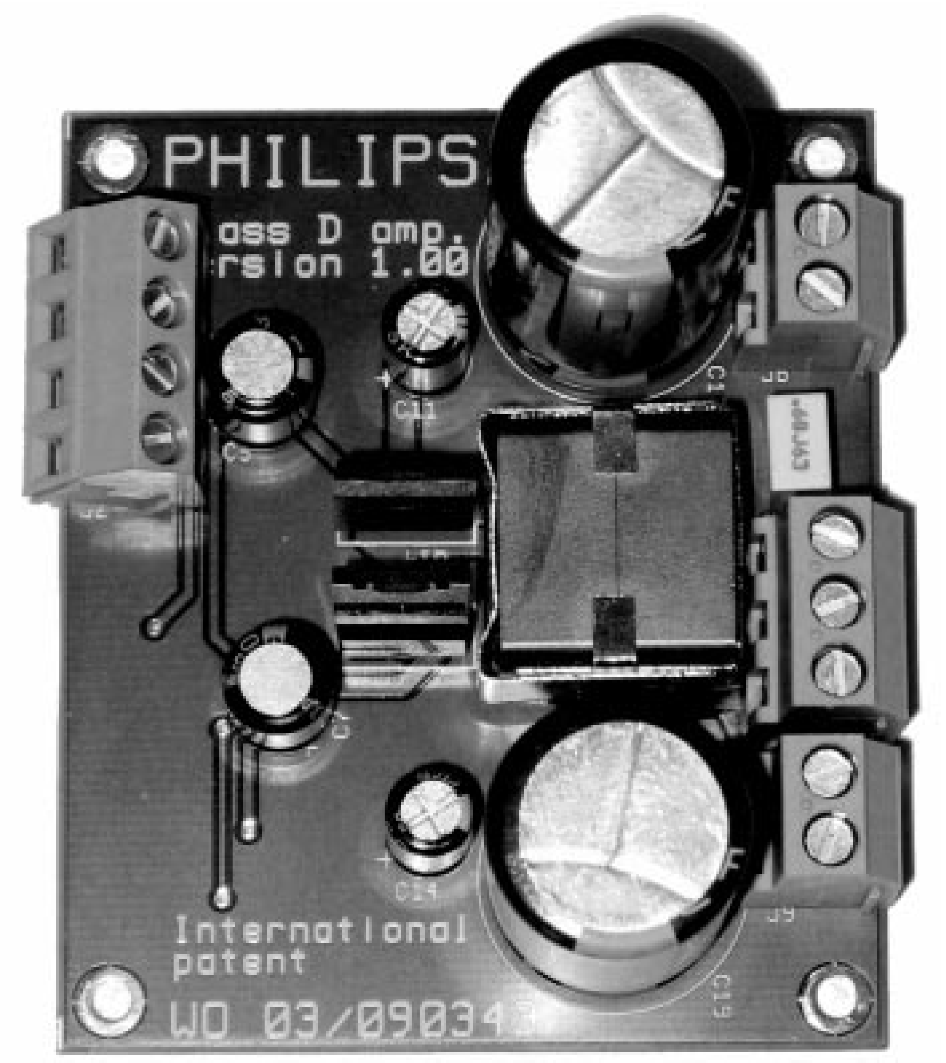

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Fig 1. General view

The demonstrator board is intended to illustrate the capability of Philips Power MOSFETs in discrete high-end PWM audio amplifier applications. The board is self-contained and only requires a simple (non-stabilized) dual power supply, an audio source (e.g. function generator, CD player) and a loudspeaker to demonstrate its capabilities. For evaluation at high output power a provision is made to attach an appropriate heatsink to the MOSFETs on the board.

2. Circuit diagram

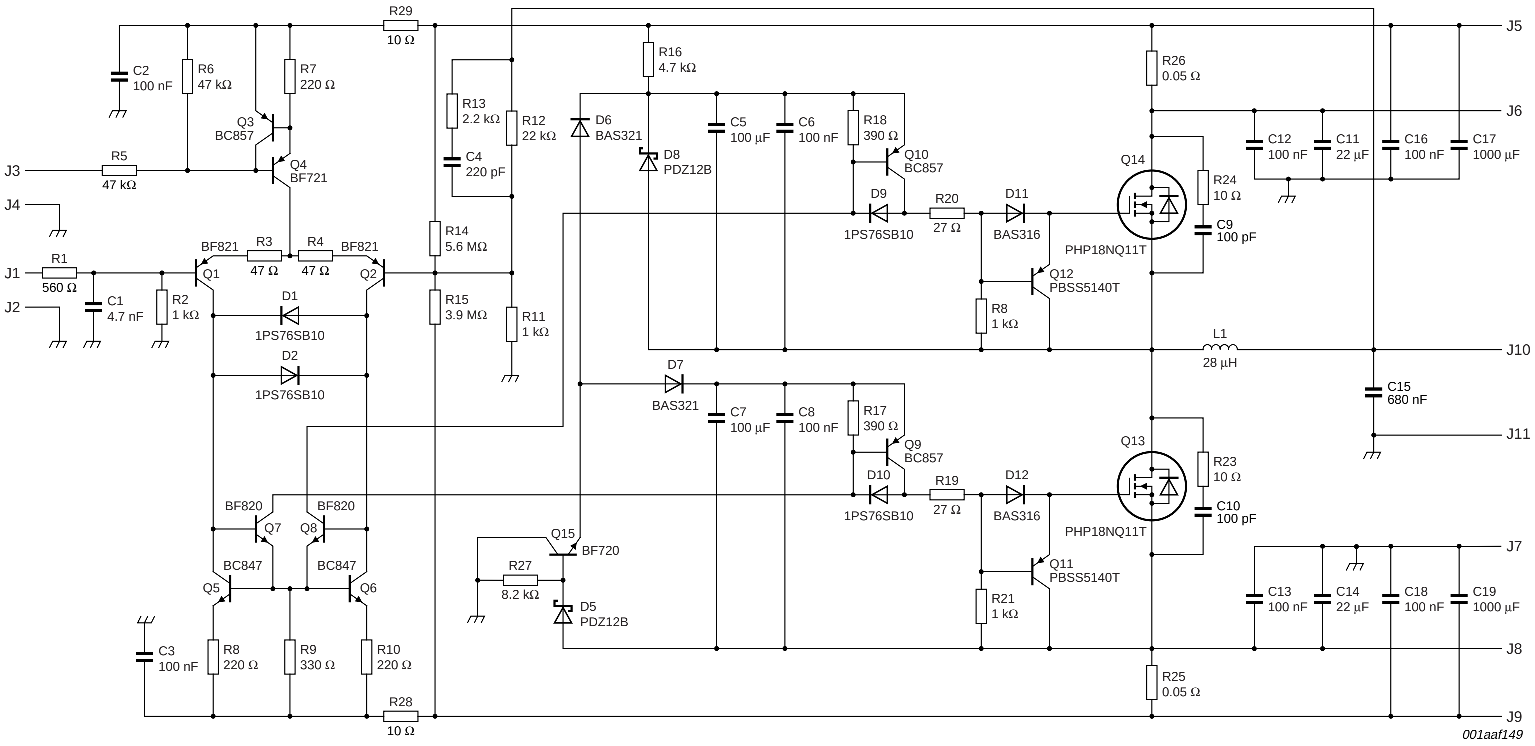

Fig 2. Circuit diagram

Table 1. Connections

Connector	Function	Remarks
J1	audio in - signal	use together with J2
J2	audio in - ground	use together with J1
J3	amplifier enable	when connected to ground (J4) the amplifier is enabled
J4	ground	use together with J3
J5	positive supply voltage	30 V to 45 V (no need for a stabilized power supply)
J6	positive current sense	can optionally be used in an overcurrent protection scheme
J7	power supply ground	0 V
J8	negative current sense	can optionally be used in an overcurrent protection scheme
J9	negative supply voltage	–30 V to –45 V (no need for a stabilized power supply)
J10	loudspeaker output	use together with J11
J11	loudspeaker ground	use together with J10

3. Printed-circuit board layout

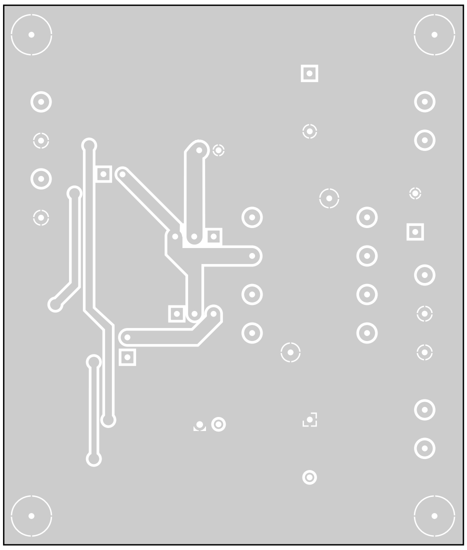

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Fig 3. Top copper layout

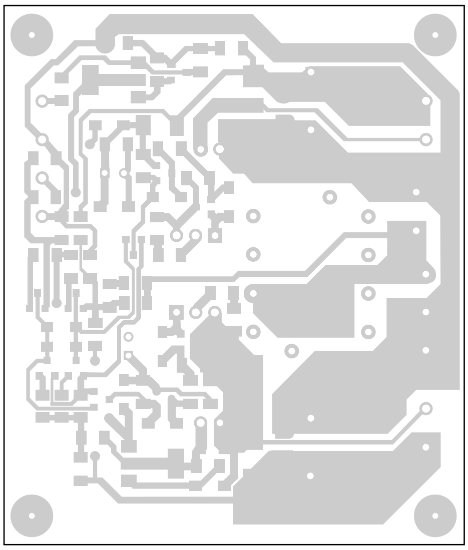

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Fig 4. Bottom copper layout

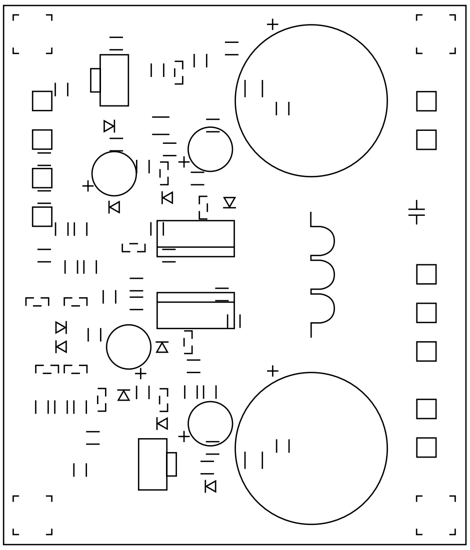


Fig 5. Component layout

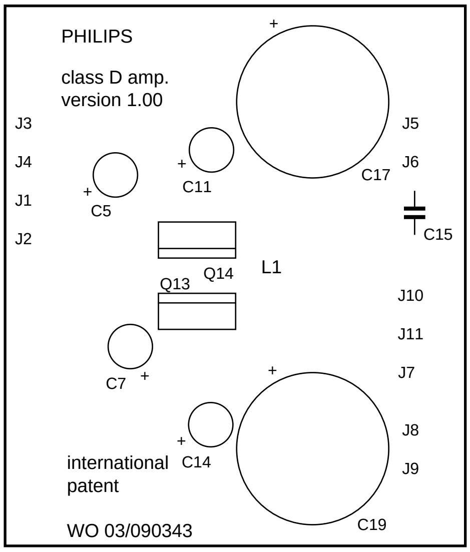


Fig 6. Top silk-screen

4. Specifications

Table 2. Specifications

Symbol	Parameter	Conditions	Value
V_P	supply voltage	equal positive and negative supply voltages	±30 V to ±45 V
P_L	output power	V_P = ±45 V; R_L = 4 Ω; appropriate heatsink needed	200 W (RMS)
η	efficiency	P_L = 100 W; R_L = 4 Ω	> 92 %
THD+N	total harmonic distortion-plus-noise	P_L = 10 W; frequency range from 20 Hz to 20 kHz	< 0.03 %
S/N	signal-to-noise ratio		> 120 dB
f_{PWM}	PWM frequency	idle	~ 400 kHz
V_{offset}	offset voltage	DC value	< 50 mV

4.1 Pop-less/click-less startup and shutdown

A provision has been added to the circuit to provide pop-less/click-less startup and shutdown. To make use of the startup facility, make sure that the supply power (pins J5 and J9) is applied prior to enabling the amplifier (connecting J3 to J4). To benefit from the pop-less shutdown feature, disable the amplifier (disconnect J3 and J4) prior to removing the supply power.

4.2 Overcurrent protection

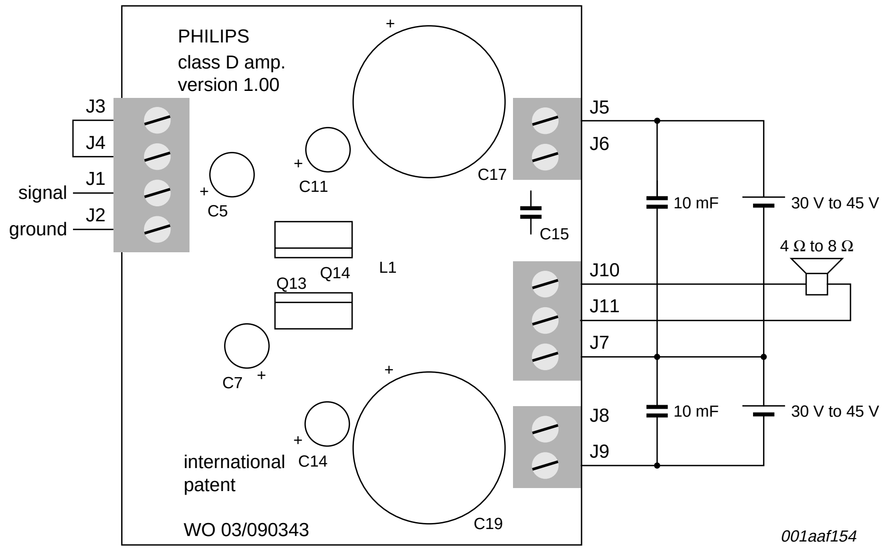
A provision has been added to the circuit to monitor the current flowing through the Power MOSFETs (Q13 and Q14). The voltage appearing between pins J5 and J6 is proportional to the current in MOSFET Q14 (ratio: 50 mV/A) and the voltage between J8 and J9 is proportional to the current in MOSFET Q13 (ratio: 50 mV/A). With the use of an external circuit these two signals may be used to disable the amplifier (disconnect J3 and J4) in case of an overcurrent situation. Similarly the J3-J4 pin combination can be used to disable the amplifier in case of other fault conditions.

4.3 Important notice

The ‘High Power Class D Audio Amplifier Demonstrator Board’ is meant to demonstrate the capabilities of the specific Class D Amplifier design and its semiconductor components. No provisions for short-circuit and overcurrent protection were made on the demonstrator board itself. Neither was an operating temperature compensation feature implemented on the board. The circuit on the board is reduced to its essentials.

In this implementation the ‘High Power Class D Audio Amplifier Demonstrator Board’ is not intended to be used for long term operation or under extreme temperature conditions when delivering substantial output power.

5. Wiring diagram and powering-up



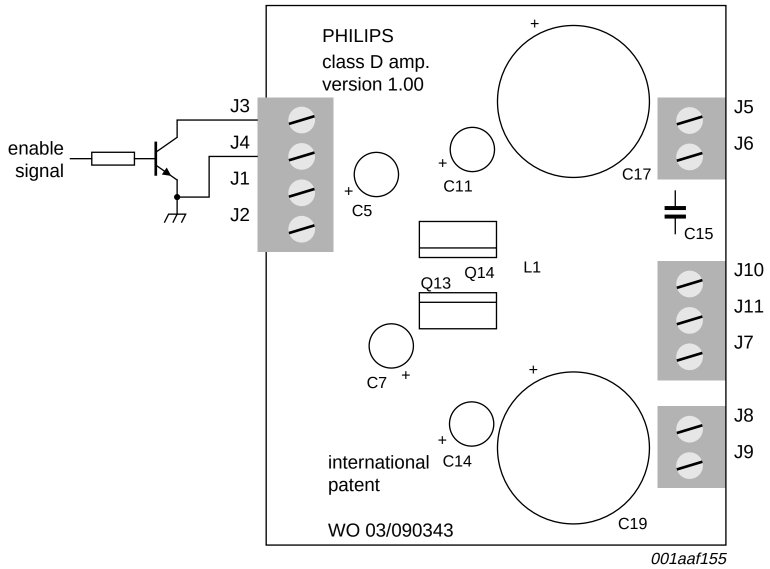
Audio input: J1 is signal; J2 is ground

Initially, leave J6 and J8 unconnected; J7 and J11 are at the same (ground) potential

Fig 7. Wiring diagram

6. Adding external features

6.1 Electronic enabling/disabling of the amplifier



Enable signal:

(HIGH = enable)

(LOW = disable)

Fig 8. Enabling/disabling of the amplifier

Electronic enabling/disabling can be used for:

- Implementing pop-less and click-less start-up and shut-down
- Shutting down the amplifier in case of a failure condition (short-circuit/overcurrent/over-temperature)

The transistor in the enabling/disabling circuit must be low current, 60 V type (such as BC846) and the resistor must limit the base current of the transistor to approximately 1 mA (in case of logic level driving, that would mean R = 4.7 kΩ).

6.2 Short-circuit and overcurrent protection

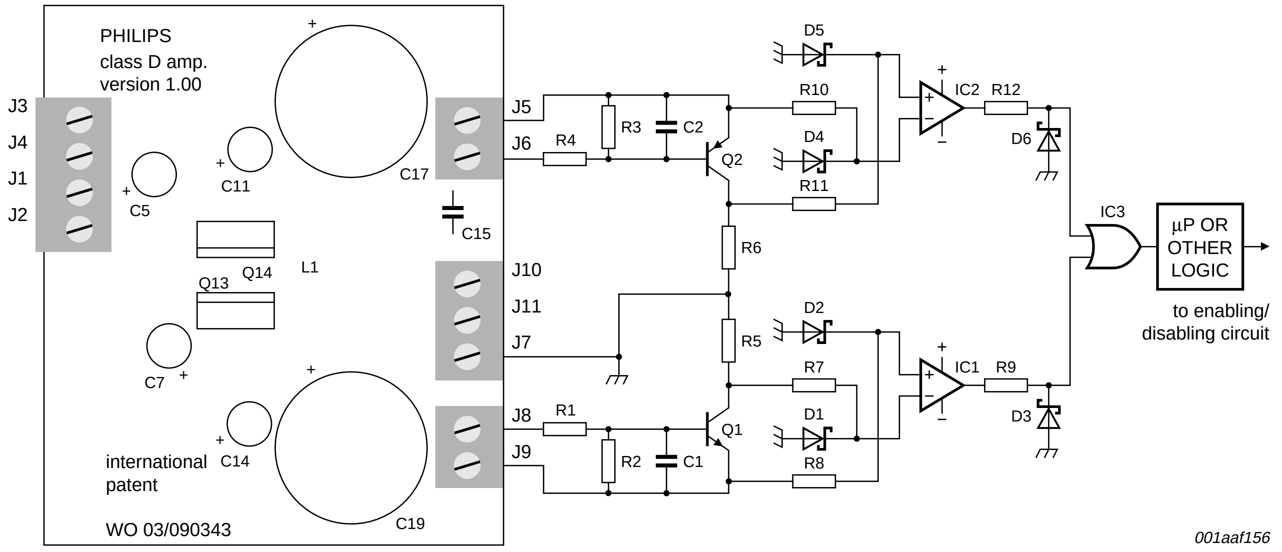


Fig 9. Short-circuit and overcurrent protection

The ‘Short-circuit and overcurrent protection’ circuit must be used together with the ‘Electronic enabling/disabling’ circuit.

The output pins of IC1 and IC2 produce a HIGH logic level pulse when overcurrent is detected in either the low side MOSFET (Q13 on the Demonstrator Board) and high side MOSFET (Q14 on the Demonstrator Board) respectively. The two signals are combined through the IC3 or-gate. The resulting signal must be processed in the ‘µP or other logic’ block. One of the simplest solutions would be a latch circuit, which on a high pulse forces the output go low. This causes the ‘Electronic enabling/disabling circuit’ to disable the amplifier. Through manual intervention and/or after a certain while, the latch should be reset to a HIGH logic level, which in turn re-enables the amplifier.

Table 3. Components

Component	Value
R1, R4	270 Ω
R2, R3	4.7 kΩ
R5, R6, R7, R8, R9, R10, R11, R12	10 kΩ
C1, C2	4.7 nF
D1, D5	Philips PDZ10B
D2, D3, D4, D6	Philips PDZ5.1B
Q1	Philips BC846
Q2	Philips BC856
IC1, IC2	Fast operational amplifier; feed with +12 V and –12 V supplies
IC3	Philips HEF4071; feed with 5 V

6.3 Sonic performance versus Efficiency trade-off

The dead-time that is allowed between Q13 and Q14 conduction determines the efficiency of the Demonstrator Board for a great deal; a long dead-time leads to better efficiency. On the other side, long dead-time also leads to worse sonic performance; it has important adverse consequences for e.g. THD.

Short dead-time causes quiescent current to go up, thus reducing efficiency and improving sonic performance. The higher quiescent current is the result of more cross-conduction of Q13 and Q14. So, most of the power that is lost in this way is dissipated in Q13 and Q14, which may heat-up excessively. This may cause thermally instable behavior of the MOSFETs. For that reason, the Demonstrator Board is shipped in low quiescent current mode – during initial evaluation the risk of damaging the MOSFETs through thermal runaway is thus reduced.

Nevertheless, by modifying one resistor value, the dead-time can be shortened and evaluation in enhanced sonic performance mode can take place. Changing R9 to a lower value decreases dead-time. It is left the responsibility of the experimenter to prevent thermal runaway, but assistance from Philips will be available through the local sales representatives.

To reduce the risk of thermal runaway in the enhanced sonic performance mode, a thermal feedback loop can be implemented: the operating temperature of the MOSFETs can be fed-back to the dead-time control by changing the fixed R9 value, mounting a PTC resistor on the heatsink of the MOSFETs and connecting the PTC in parallel with R9. Again, any changes are left the responsibility of the experimenter, but assistance from Philips will be available through the local sales representatives.

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8. Contents

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