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**Datasheet for the decision
of 21 July 2021**

Case Number: T 2995/18 - 3.5.02

Application Number: 13891690.3

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Title of invention:
Class-D amplifier

Applicant:
Kyosan Electric Mfg. Co. Ltd

Relevant legal provisions:
EPC Art. 56

Keyword:
Main request - Inventive step - (yes)



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Case Number: T 2995/18 - 3.5.02

D E C I S I O N
of Technical Board of Appeal 3.5.02
of 21 July 2021

Appellant: Kyosan Electric Mfg. Co. Ltd
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Decision under appeal: **Decision of the Examining Division of the
European Patent Office posted on 19 July 2018
refusing European patent application No.
13891690.3 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman R. Lord
Members: C.D. Vassoille
W. Ungler

Summary of Facts and Submissions

I. This is an appeal of the applicant against the decision of the examining division to refuse European patent application no. 13 891 690.3.

II. The following documents are relevant for the present decision:

D1: EP 1 086 526 B1 (family member of JP 2002 515665 A, cited as document D4 in the procedure)

D2: JP 2006 262121 A (also cited as document D5 in the procedure)

D3: US 2012/037616 A1 (family member of WO 2010/050486 A1, cited as document D7 in the procedure)

D6: JP 2003 516014 A

D8: JP 2008 228304 A (cited in the application)

III. In the reasons for the decision the examining division found *inter alia* that the subject-matter of claim 1 of the main request did not involve an inventive step in view of document D1.

IV. The applicant (appellant) has requested in writing that the decision under appeal be set aside and a patent be granted on the basis of the main request or, if this was not possible, according to the first or the second auxiliary request, these requests having been filed with the statement setting out the grounds of appeal on 31 October 2018 and the first two of which correspond

to the requests filed on 18 June 2018, underlying the decision under appeal.

V. Given that the board has decided in favour of the appellant's main request, the present decision could be issued without holding of oral proceedings in writing.

VI. Claim 1 of the main request reads as follows:

"A class-D amplifier comprising
a class-D amplifier circuit (1A, 1B) incorporating a
bridge circuit (2A, 2B) comprising at least one series
circuit of switching elements (2a to 2d), and
an oscillation absorption circuit (3) connected to a
power input terminal of the class-D amplifier circuit,
the oscillation absorption circuit (3) being configured
by a parallel circuit of a resistor and an inductor to
attenuate oscillations in the high frequency range;
the resistance of the oscillation absorption circuit
(3) constituting damping resistance in an oscillation
circuit that is made up of the oscillation absorption
circuit (3) and the class-D amplifier circuit (1A, 1B),
characterized by
incorporating in a package, said bridge circuit
comprising said at least one series circuit of
switching elements (2a to 2d) and a bypass capacitor
connected in parallel to the series circuit of
switching elements (2a to 2d);

wherein the oscillation absorption circuit (3) is
connected outside of the package;

wherein a value R of the resistor configuring the
oscillation absorption circuit (3) being set using a
value C of the bypass capacitor as a parameter, the
value R being equal to a value obtained by dividing an

attenuation coefficient by a product of a resonance frequency and the value C of the bypass capacitor, a value of the resonance frequency of the oscillation circuit corresponding to a reciprocal value of the square root of the product of the wiring inductance Ld and the capacitance Cd of the switching elements (2a to 2d); and the attenuation coefficient being equal to $C \cdot R / (2 \cdot \sqrt{Ld \cdot Cd})$."

Claim 2 is dependent on claim 1.

- VII. In the statement setting out the grounds of appeal, the appellant provided arguments *inter alia* in support of the presence of an inventive step of the subject-matter of claim 1 of the main request, in particular having regard to documents D1 and D8.

Reasons for the Decision

1. The appeal is admissible.
2. *Main request - Inventive step (Article 56 EPC)*
 - 2.1 The subject-matter of claim 1 of the main request involves an inventive step in the sense of Article 56 EPC.
 - 2.2 The board considers the examining division's finding that document D1 represents the closest prior art document, to be appropriate, which was not contested by the appellant.
 - 2.3 Furthermore, it was not contested by the appellant that document D1 discloses the following features of claim 1:

A class-D amplifier circuit (reference numeral 2, see also paragraphs [0003], [0034] and [0036]) incorporating a bridge circuit (see figure 3, as well as paragraphs [0038] to [0040]) comprising at least one series circuit of switching elements (see figure 3, in particular switches 34 and 35, as well as paragraphs [0038] to [0040]), and an oscillation absorption circuit (1) connected to a power input terminal (5, 6) of the class-D amplifier circuit (see figure 1, reference numeral 1 and figure 5 as well as paragraphs [0042] and [0043]), the oscillation absorption circuit (1) being configured by a parallel circuit of a resistor (16) and an inductor (13) to attenuate oscillations in the high frequency range (see figures 1 and 5 as well as paragraph [0042]); the resistance (16) of the oscillation absorption circuit (1) constituting damping resistance in an oscillation circuit that is made up of the oscillation absorption circuit and the class-D amplifier circuit (see in particular paragraphs [0042] to [0044] of D1).

2.4 It was however disputed by the appellant that the following distinguishing features of claim 1 are obvious in view of document D1:

a) incorporating in a package, said bridge circuit comprising said at least one series circuit of switching elements and a bypass capacitor connected in parallel to the series circuit of switching elements, and

b) a value R of the resistor configuring the oscillation absorption circuit being set using a value C of the bypass capacitor as a parameter, the value R

being equal to a value obtained by dividing an attenuation coefficient by a product of a resonance frequency and the value C of the bypass capacitor, a value of the resonance frequency of the oscillation circuit corresponding to a reciprocal value of the square root of the product of the wiring inductance L_d and the capacitance C_d of the switching elements, and the attenuation coefficient being equal to $C \cdot R / (2 \cdot \sqrt{L_d \cdot C_d})$.

- 2.5 The technical effect of the distinguishing features cited above, results from the advantageous combination of a bypass capacitor incorporated in the package with an oscillation absorption circuit composed of a parallel circuit of a resistor and an inductor and connected to the input terminal of the class-D amplifier, and lies in an overall increased efficiency of the class-D amplifier, because of an effective absorption of spurious oscillations caused by the parasitic capacitances and inductances of the switching elements, while at the same time increased turn-on and turn-off times of the switching elements are effectively avoided by the use of (only) a bypass capacitor.
- 2.6 In the light of the technical effect, the board can accept the appellant's proposed objective technical problem in view of D1, which is that of efficiently damping spurious oscillations caused by the switching operation, without increasing turn-on and turn-off times of the switching elements.
- 2.7 The question to be answered in the present case is thus that of whether it would have been obvious to the skilled person, when starting from a class-D amplifier as disclosed in D1 and being confronted with the

objective technical problem, to implement the above cited distinguishing features, in particular to provide a bypass capacitor incorporated in the package, as well as setting the value R of the resistor of the oscillation absorption circuit using a value C of the bypass capacitor as a parameter, as further defined in claim 1.

The board has come to the conclusion that the question must be answered in the negative.

- 2.8 Document D1 in paragraphs [0010] and [0011] discloses that ringing and the resulting distortion of the audio signal may be partly limited by establishing a parallel snubber circuit of a known type over the switches which attenuates the oscillations that occur because of the parasitic inductances and capacities of the switching circuit. It is further disclosed that despite the drawback of such a circuit, namely that of a reduced efficiency of the amplifier, parallel snubber circuits are nonetheless used to comply with the current standards.

The invention of D1 proposes a noise attenuating circuit ("correction circuit block"), corresponding to an oscillation absorption circuit in the sense of claim 1, which according to the embodiment of figure 5 and in connection with the description in paragraphs [0042] and [0043] may be combined with a snubber circuit in order to additionally reduce a distortion of the square-wave pulses (see also D1 in paragraph [0029]). The snubber circuit may however be omitted completely (see paragraph [0043]).

It is further to be noted that document D1 in paragraph [0024] states that the predominantly resistive

impedance at high frequencies provides the advantage that the circuit serves as a current limiter during the transient switching sequences in the switched circuit and that the predominantly resistive behaviour of the noise attenuating circuit at high frequencies additionally has the advantage that the high-frequency ringing, which normally occurs because of parasitic inductances and capacities in the switched circuit, is attenuated considerably. D1 in the same paragraph further explains that, compared to parallel snubber circuits, where the same could be achieved, the noise attenuation circuit had less losses, because there was "no parallel capacitor that must be voltage shifted by the switches".

- 2.9 Document D8, which is mentioned in the application as pertinent prior art document, might disclose a bypass capacitor connected in parallel to the series circuit of switching elements of the bridge circuit in accordance with the above distinguishing feature a).

Document D8 is particularly based on prior art which includes a bypass capacitor within the package (see D8 in paragraph [0008]) and is concerned with problems resulting from the use of a bypass capacitor, which is solved by providing a shorter current path, and thus lower inductance, within the package (see D8 in paragraphs [0016] and [0017]).

In view of the foregoing, it is not apparent to the board what would have motivated the skilled person to modify the class-D amplifier of D1 such as to implement the distinguishing features recited above.

More specifically, as has been argued by the appellant, document D1 clearly emphasises a solution to the

objective technical problem which provides for a predominantly resistive component and corresponding strong damping effect of the attenuation circuit, which can even completely dispense with the snubber circuit (see in particular paragraph [0043]: "... so that the capacitor 14 and the resistor 15 can be completely omitted"). In paragraph [0024], the disadvantages of having a parallel capacitance provided are further emphasised ("... must be voltage shifted by the switches").

Furthermore, the board observes that document D8 substantially addresses oscillation problems arising from the use of a bypass capacitor within the package and suggests as a solution to this problem to limit the current path that flows in the bypass capacitor to thereby minimise inductance (see D8 in paragraph [0022]). The board therefore does not see that document D8 provides a motivation to the skilled person to use a bypass capacitor within the package when seeking for a solution to the objective technical problem. To the contrary, document D8 gives the impression that new problems arise with the use of a bypass capacitor and does not provide a hint towards solving these problems by combining the bypass capacitor with an oscillation absorption circuit as defined in claim 1 and disclosed in D1.

Thus, the board concludes that, while the use of a bypass capacitor within a package of a class-D amplifier might well have been known to the skilled person as such, the skilled person would not have considered this specific solution in the class-D amplifier of D1, in particular not in view of D8, having regard to the overall teaching of these documents. More specifically, it is not apparent why

the skilled person would have been motivated to replace the snubber circuit by a bypass capacitor within the package or to additionally provide the same within the package, given that the teaching of D1 is clearly focused on the provision of a predominantly resistive character of the "correction circuit block", which is described in D1 as already sufficiently solving the problem of ringing and in particular to provide a reduced dead time and turn-on and turn-off rates of the switching elements (see for example D1 in paragraph [0028]). This is all the more true in view of figure 5 and the corresponding description in paragraph [0043], which discloses either to select the resistor infinitely great (so that the capacitor 14 and the resistor 15 can be omitted) or to provide an increased resistance when the resistors 15 and 16 are coupled in parallel at high frequencies.

- 2.10 The further documents D2 to D7 cited in the procedure do not go beyond the disclosure of document D8 and thus, the board's findings in sections 2.1 to 2.9 also apply to a combination of document D1 with these documents.
- 2.10.1 The board has therefore come to the conclusion that the subject-matter of claim 1 is not rendered obvious to the skilled person by document D1, in particular not in combination with any one of the prior art documents D2 to D8 cited in the procedure.
- 2.11 Since the board considers already the implementation of the distinguishing feature a) in a class-D amplifier as described in D1 not to be rendered obvious, the question of whether this would also apply to a combination of distinguishing features a) and b), could be left unanswered.

2.12 The board concludes that the subject-matter of claim 1 involves an inventive step in the sense of Article 56 EPC.

3. *Result*

Given that the subject-matter of claim 1 involves an inventive step in the sense of Article 56 EPC and since claim 1 also fulfils the further requirements of the EPC, the board had to accede to the appellant's main request.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.
2. The case is remitted to the examining division with the order to grant a patent on the basis of the claims according to the main request filed with the statement setting out the grounds of appeal on 31 October 2018 and a description to be adapted thereto.

The Registrar:

The Chairman:



A. Chavinier Tomsic

R. Lord

Decision electronically authenticated