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Datasheet for the decision of 9 January 2023

Case Number: T 1289/20 - 3.5.02

Application Number: 11873200.7

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Title of invention:
Main electric motor for railway vehicle

Patent Proprietor:
Mitsubishi Electric Corporation

Opponent:
Siemens Mobility GmbH

Relevant legal provisions:
EPC Art. 56

Keyword:
Inventive step - Main request (yes)

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Case Number: T 1289/20 - 3.5.02

D E C I S I O N
of Technical Board of Appeal 3.5.02
of 9 January 2023

Appellant: (Opponent)	Siemens Mobility GmbH Otto-Hahn-Ring 6 81739 München (DE)
Representative:	Siemens Mobility GmbH Postfach 22 16 34 80506 München (DE)
Respondent: (Patent Proprietor)	Mitsubishi Electric Corporation 7-3 Marunouchi 2-chome Chiyoda-ku Tokyo 100-8310 (JP)
Representative:	Witte, Weller & Partner Patentanwälte mbB Postfach 10 54 62 70047 Stuttgart (DE)
Decision under appeal:	**Decision of the Opposition Division of the European Patent Office posted on 25 March 2020 rejecting the opposition filed against European patent No. 2763287 pursuant to Article 101(2) EPC.**

Composition of the Board:

Chairman	R. Lord
Members:	C.D. Vassoille
	R. Cramer

Summary of Facts and Submissions

I. The appeal of the opponent lies against the decision of the opposition division rejecting the opposition against European patent no. 2 763 287.

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

D9: US 2011/0101906 A1
E1: US 7,554,238 B2
D1: US 2010/0277029 A1
E2: WO 2011/093202 A1

III. In the decision under appeal, the opposition division *inter alia* came to the conclusion that the subject-matter of claim 1 of the patent as granted (main request) involved an inventive step. Furthermore, the objection based on document D9 in combination with the common general knowledge of the skilled person, which was considered to be in part exemplified by document E2, was considered to constitute the only substantiated objection under Article 100(a) in combination with Article 56 EPC.

IV. The appellant (opponent) requested in writing that the decision under appeal be set aside and that the patent be revoked.

The respondent (patent proprietor) requested that the appeal be dismissed (main request), auxiliarily that the patent be maintained in amended form on the basis of one of the auxiliary requests 1 to 29C, all filed with the reply to the statement of grounds of appeal.

The respondent requested oral proceedings only as an auxiliary measure. The appellant did not request oral proceedings.

V. Claim 1 of the patent as granted, according to the respondent's main request, reads as follows (feature numbering added in squared brackets):

"**[1.1]** A driving system that includes an inverter circuit and a main motor (1) that is rotationally driven upon receiving an AC power supplied from the inverter circuit and that is driven by the main motor (1),
[1.2] wherein the inverter circuit includes a switching element formed by using a semiconductor that has a larger bandgap than silicon,
[1.3] the main motor (1) is a three-phase AC motor driven by having a voltage having a PWM waveform applied from the inverter circuit in at least part of a speed range of the driving system,
[1.4] the main motor (1) includes a stator that is configured to include an annular stator core (2) provided with a plurality of slots (30) in a circumferential direction and coils (3) that are wound on the stator core (2) and are accommodated in the slots (30),
[1.5] and that includes a stator winding that is three-phase star-connected and is composed of parallel circuits and comprises a number of stator poles per phase,
[1.6] wherein in each phase, the number of parallel circuits is the same as the number of stator poles;
[1.7] and a rotor that is arranged on an inner side of the stator core (2),
[1.8] wherein the number of poles is a positive even number."

Claims 2 to 4 are dependent on claim 1.

VI. The arguments of the appellant which are relevant for the present decision can be summarised as follows:

The opposition division in the assessment of the disclosure of feature 1.6 in document D9 and the obviousness of the subject-matter of claim 1 in view of this document, did not take into account the whole disclosure of D9. In particular, they did not consider that document D9 disclosed a further embodiment having only two inverters instead of three three-phase inverters.

Furthermore, D9 in paragraph [0004] addressed the problem of higher switching losses due to a higher switching frequency, which was required to increase the motor torque.

In addition, D9 in paragraphs [0008] and [0009] stated that ripples or distortions of the motor current, occurring during operation of the inverter with a low switching frequency, were also to be reduced in order to reduce vibrations and noise of the motor. According to D9 in paragraph [0011], this problem was solved by using a lower switching frequency for at least one of the inverters, which caused interference between the motor currents of the inverters, suppressed the ripples of the motor current with the lower switching frequency, and at the same time reduced switching losses. It was also clear from the further disclosure of D9 (see in particular figures 8A to 13 and 9 to 12 and the description in paragraphs [0088] to [0101], in particular paragraphs [0094] to [0097], as well as paragraph [0145]) that a higher switching frequency

(20kHz) always led to significantly reduced ripples of the motor current. This advantageous effect was achieved in the same way for both relevant embodiments of D9.

Hence, the person skilled in the art would understood from D9 that, irrespective of the number of three-phase windings and three-phase inverters, the operation of an inverter with a higher switching frequency reduced the ripple of the motor current. This applied also to an embodiment with only one inverter, if it was operated with a higher switching frequency.

The use of three three-phase inverters was thus not the central aspect of document D9. Rather, it disclosed the advantageous aspect of operating an inverter with an increased switching frequency such as to increase the motor torque and at the same time reducing ripples of the motor currents, which led to a reduction of vibrations and noise. These advantages were independent of the number of three-phase inverters and three-phase windings used in the driving system.

Document D9 did not disclose specific reasons for using two or three inverters. Document E1, however, disclosed in column 1, lines 10 to 21 that connecting individual inverters separately to independent three-phase windings was advantageous from the point of view of space saving. It followed that, provided that no space limitations existed, it was also possible to use only one appropriately dimensioned three-phase inverter and a three-phase winding connected to it.

Based on the disclosure of document D9 in combination with the knowledge of the possibility to select a number of three-phase inverters and associated three-

phase windings as a means of dimensioning the driving system of document E1, it was thus obvious for the skilled person to arrive at the subject-matter of claim 1, including feature 1.6, without inventive step.

With regard to feature 1.6 of claim 1, reference was further made to document D1, which was cited in paragraph [0005] of the contested patent. In particular, paragraphs [0120] and [0159] of D1 disclosed a three-phase winding of a stator whose number of parallel circuits and number of poles of each phase were identical.

VII. The arguments of the respondent which are relevant for the present decision can be summarised as follows:

During the first instance proceedings, the combination of document D9 with the common general knowledge of the skilled person and/or E2 was considered by the opposition division to be the only sufficiently substantiated objection. The appellant's objections based on D9 in combination with documents E1 or D1, as argued in the statement of grounds of appeal, constituted new facts and thus, were not to be admitted into the appeal procedure.

The subject-matter of claim 1 was not rendered obvious by a combination of document D9 with the common general knowledge of the skilled person. While it was agreed that document D9 disclosed several embodiments, every embodiment had at least one inverter which was operated with a higher frequency (20 kHz) and at least one further inverter which was operated with a lower frequency (10 kHz).

Paragraphs [0011] and [0012] of D9 disclosed that by using inverters having a higher carrier frequency (20 kHz) the motor ripple (causing the motor to vibrate) was reduced while by using inverters having a lower carrier frequency (10 kHz) the switching loss was reduced (see also paragraphs [0011], [0094]-[0097), [0101], [0145]). D9 clearly taught in paragraph [0012] to use a combination of these measures, i.e. using inverters with higher and lower carrier frequency in combination, such as to achieve both effects.

Consequently, the teaching of D9 was not only directed at a reduction of the motor ripples but to a reduction of the motor ripples, while reducing at the same the switching losses. In the configuration of D9, a reduction of the switching loss could only be achieved by using at least one inverter having a lower carrier frequency. The skilled person thus would not reduce the number of inverters to one (in particular the one having a higher switching frequency), as this would cause the advantageous effects such as the reduction of the switching loss not to be achieved. To achieve these effects at least two inverters were necessary, i.e. one with a higher switching frequency and the other with a lower carrier frequency.

Furthermore, document D9 did not provide a hint to pick and apply only the inverter having switching elements with wide bandgaps. Document D9 also did not teach to maintain all other aspects, in particular the wiring and arrangement of the stator, and to only change the number of inverters to one and change its connection to the stator to arrive at the subject-matter of claim 1.

The subject-matter of claim 1 was also not rendered obvious by a combination of document D9 with E1. E1 in

the relevant passage in column 1, lines 10 to 21 did not disclose the use of a single inverter. Rather, E1 disclosed an attempt to reduce the size of the individual driving devices by connecting the driving devices (inverters or the like) separately to independent three-phase exciting windings of a multi-winding motor for synchronous driving.

As far as the disclosure of D1 is concerned, the skilled person had no reason to specifically extract the feature of the same number of stator poles per phase and parallel circuits from the overall disclosure of D1 and to combine this teaching with D9.

Reasons for the Decision

1. The appeal is admissible.

2. *Right to be heard*

The appellant did not request oral proceedings in accordance with Article 116(1) EPC. The respondent requested oral proceedings only as an auxiliary measure if their main request was not allowed. The board also did not consider oral proceedings to be expedient.

Since the present decision is in accordance with the respondent's main request, the conduct of oral proceedings was not necessary.

Furthermore, since the present decision is based on reasons which were known to the appellant and on which they were able to present their arguments, their right to be heard under Article 113 EPC is respected.

The board is therefore in a position to decide in writing (Article 12(8) RPBA).

3. Extent of the appeal

The statement of grounds of appeal did not contest the opposition division's findings in the decision under appeal as regards the grounds for opposition under Article 100(b) and (c) EPC. In accordance with Article 108 and Rule 99(2) EPC, the appeal is thus limited to a review of the decision under appeal as far as the ground for opposition under Article 100(a) in combination with Article 56 EPC is concerned (section II.B.3 and points 13 to 15 of the reasons for the decision under appeal).

4. Main request - Inventive step (Article 100(a) in combination with Article 56 EPC)

4.1 The subject-matter of claim 1 involves an inventive step in view of document D9, which was the only document used by the appellant as a starting point in the assessment of inventive step.

Distinguishing feature

4.2 The subject-matter of claim 1 differs from document D9 at least in feature 1.6, which has the following wording:

> "wherein in each phase, the number of parallel circuits is the same as the number of stator poles;"

4.3 The board agrees with the relevant findings in the decision under appeal that the stator teeth groups 8a, 8b, 8c, 8a', 8b' and 8c' (see e.g. D9 in figure 2) each form a pole and that D9 thus discloses a stator having six poles, each phase having two poles. The board further agrees that D9 discloses six parallel circuits per phase, which is the number of parallel connections of the inverters per phase times the number of parallel connections between the stator coils (81a and 81a', 81b and 81b', 81c and 81c'), see in particular figure 4 of D9. Therefore, in each phase, the number of parallel circuits is different from the number of stator poles in each phase (see the opposition division's explanations under point 13.5 of the reasons for the decision under appeal).

4.4 In the statement setting out the grounds of appeal the appellant referred to the grounds for opposition where it was argued that for each phase (of a single inverter) two parallel windings and two stator poles per phase were provided. It was further held that the opposition division did not take into account the whole disclosure of document D9, which referred to a further variant of the first embodiment having only two three-phase inverters (see paragraphs [0113] to [0134] and [0145], and figures 16 to 19).

4.5 The board agrees with the appellant to the extent that D9 discloses a further variant of the first embodiment which has only two three-phase inverters. However, the opposition division was right to conclude that the skilled person, when reading document D9 as a whole, would not consider only one of the inverters in isolation. In particular, the technical teaching of D9 clearly concentrates on the combination of one inverter operated with a higher switching frequency (20 kHz) and

one or two further inverter(s) operated with a lower switching frequency (10 kHz). Reference is particularly made to D9 in paragraphs [0011] and [0012], as well as the further disclosure in paragraphs [0094] to [0097], [0101] and [0145].

4.6 The board therefore concludes that document D9 does not disclose feature 1.6 of claim 1.

Objective technical problem

4.7 Neither of the parties has explicitly formulated an objective technical problem in the appeal proceedings. From point 13.7 of the reasons for the decision under appeal it appears, however, that the appellant considered the objective technical problem of the distinguishing feature 1.6, when starting from D9, to be a simplification of the driving system.

4.8 The board does not consider the technical effect of feature 1.6 to correspond to a simplification of the driving system. Rather, it is clear from the patent that the technical effect of providing the same number of parallel circuits and poles per phase lies in preventing a circulating current from flowing between the parallel circuits (see in particular paragraph [0054] of the patent).

4.9 Therefore, the objective technical problem when starting from D9 and in view of the distinguishing feature 1.6 can be considered to be to provide a driving system having an increased efficiency.

Obviousness

4.10 The solution to the above objective technical problem according to feature 1.6, when starting from document D9, is not rendered obvious to the person skilled in the art.

4.11 The person skilled in the art would clearly understand the essential technical teaching of document D9 to be that the combination of an inverter operating at a lower frequency (10 kHz) with an inverter operating at a higher frequency (20 kHz) constitutes the central aspect of its technical teaching.

4.12 The board particularly refers to paragraph [0011] and [0012] of D9, where it is explicitly stated that the driving system determines the carrier (switching) frequency of at least one of the three-phase inverters to be lower than the others to cause the ripples of the motor currents output from the three-phase inverters to interfere with each other, so that the ripples of the motor current output from the three-phase inverter that operates with the lower carrier frequency can be suppressed. The inverter operated at the lower frequency at the same time contributes to a reduction of the switching loss.

4.13 The respondent further cited paragraphs [0094] to [0097], which explain in detail the effects of the different switching frequencies of the parallel inverters and the reasons why a combination of two inverters with a lower switching frequency (10 kHz) with an inverter operated at a higher switching frequency (20 kHz) is advantageous. In particular, according to paragraph [0097], the advantageous technical effect resulting from setting the operating frequencies of the three-phase inverters at 10 kHz, 20 kHz and 10 kHz, is based on a change of magnetic flux

caused by the current applied to the three-phase coil with the operating frequency of 20 kHz, which suppresses the changes of magnetic flux caused by the currents applied to the three-phase coils with the operating frequency of 10 kHz, which significantly reduces the waveform distortions of the motor current.

4.14 Paragraph [0101] further expresses the advantage of combining "some of the three phase-inverters based on a gate control signal generated with a carrier signal of 10 kHz", and that "the switching loss is reduced to be lower than the case where all the three-phase inverters are operated based on gate control signals generated with a carrier signal of 20 kHz". It is further stated that the waveform distortion of the motor current due to the ripples is reduced to be at a lower level than in a case where all the three-phase inverters are operated based on gate control signals generated with the frequency of 10 kHz. A similar conclusion is drawn in paragraph [0145] of D9 for the embodiment using two parallel inverters, one of them being operated at 10 kHz and the other operated at 20 kHz.

Consequently, there cannot be any doubt that the skilled person would understand the main teaching of D9 to lie in the combination of the inverters operated at different frequencies (10 kHz and 20 kHz), to achieve the technical effect of suppressing motor ripples, thus reducing vibration and noise while reducing switching losses.

4.15 Document D9 may indeed disclose certain advantages of an inverter operated with a higher switching frequency and comprising switching elements with a larger bandgap than silicon (see D9 in particular in paragraph [0089]). However, contrary to the appellant's view, it

is not the use of an inverter operated at a higher switching frequency of 20 kHz that the skilled person would derive from D9 as an isolated teaching. Rather, it is clearly the interaction between an inverter operating at a higher switching frequency with at least one inverter operating at a lower frequency which reduces switching losses while reducing vibration and noise by reducing motor current ripple. In particular, the reduction of the overall current ripple only results from this combination with an inverter which has a lower switching frequency (see D9 in particular in paragraph [0097] and [0101]). Furthermore, the use of inverters having exclusively a higher switching frequency of 20 kHz is explicitly found to be less advantageous in terms of switching loss, as explained in paragraph [0101] of D9.

4.16 It follows that the skilled person would not consider modifying the driving system disclosed in document D9 to use only one of the inverters, in particular the one operated at 20 kHz, as this would be contrary to the essential teaching of D9 and would eliminate the beneficial technical effects resulting from the synergistic use of the at least two parallel inverters, one operated at 20 kHz and the at least one other at 10 kHz.

4.17 It is also not apparent to the board that the skilled person would expect an increase in efficiency by using only one inverter with 20 kHz. In particular, there is nothing in D9 that would lead the skilled person to assume that an equal number of poles per phase and parallel windings in the sense of feature 1.6, resulting from the use of only one inverter, could lead to an increase in efficiency. To the contrary, as explained above, given the overall teaching of D9, the

skilled person would expect a deterioration in efficiency if only one of the inverters, in particular the one operating at a higher frequency, was used.

4.18 The board therefore agrees with the respondent that the person skilled in the art, when starting from D9 and being confronted with the objective technical problem of how to further increase the efficiency of the driving system, would not be prompted to modify the driving system of D9 such as to arrive at the subject-matter of claim 1.

4.19 For the sake of completeness, the board points out that the above conclusion also applies if the objective technical problem is considered to be simplifying the driving system of D9. In any case, the use of only one inverter would not be considered by the skilled person, since in this case the advantageous effect of the invention described in D9 would no longer be achieved and thus a deterioration in efficiency would be expected. The skilled person would not accept the latter, even if the modification would result in a simplified driving system.

4.20 Nor do the teachings of documents D1 and E1 in combination with D9 lead the skilled person to the subject-matter of claim 1.

4.21 Document E1 in column 1, lines 10 to 21 discloses the reduction of "the size of the individual driving devices by connecting the driving devices (inverters or the like) separately to independent three-phase exciting windings of a multi-winding motor for synchronous driving". Contrary to the appellant's argument, the board cannot see anything in this passage that could have motivated the skilled person to use the

inverter with a higher switching frequency in isolation, despite the expected reduction in efficiency. E1 rather suggests to the skilled person to provide several inverters for space-saving reasons, as is already the case in D9.

The board has no doubt that the skilled person was aware of the possibility to provide only one inverter. However, he would not have modified the driving system disclosed in D9 accordingly, as this would clearly contradict the overall teaching of D9 (see in particular the board's remarks under point 4.16 above).

As the disclosure of document E1 in any case does not change the board's conclusion under point 4.18 above, the question of whether the objection based on this document should be taken into account in the appeal proceedings can remain unanswered.

4.22 The same applies to document D1. With regard to this document, the appellant merely stated in the grounds of appeal that it disclosed feature 1.6. Reference was particularly made to paragraphs [0120] and [0159]. While the appellant's arguments with regard to D1 do not seem to meet the requirements of a sufficiently substantiated factual submission, it in any case does not convince the board in substance.

Document D1, among other configurations, indeed discloses a configuration of a driving system where the number of parallel circuits in each phase is equal to the number of magnetic poles (see e.g. paragraph [0159]). However, the board agrees with the respondent that it is not apparent that the skilled person would have extracted this specific feature from the overall disclosure of D1 to implement it in the driving system

of D9. The appellant did not provide any arguments in this respect. Again, the board notes that this would have required the skilled person to modify the teaching of D9 to use only one of the inverters, which would go against the essential teaching of D9 (see the board's findings under points 4.11 to 4.18 above).

Given that the appellant did not provide any further arguments with regard to document D1, the board concludes that the subject-matter of claim 1 is not rendered obvious in view of a combination of documents D9 and D1. Thus also in this case the question whether this objection should be taken into account in the appeal can be left unanswered.

4.23 Since the subject-matter of claim 1 is not rendered obvious by a combination of document D9 with the common general knowledge of the skilled person or with E1 or with D1, the board concludes that the ground for opposition under Article 100(a) EPC in combination with Article 56 EPC does not prejudice the maintenance of the patent as granted.

For the sake of completeness, the board notes that document E2 was cited by the appellant only in the context of features other than feature 1.6, so is of no relevance for the above conclusion.

5. Conclusion

Given that the ground for opposition under Article 100(a) EPC in combination with Article 56 EPC does not prejudice the maintenance of the patent as granted, and that no further objections have been raised by the appellant in the appeal, the board had to accede to the respondent's main request.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

K. Boelicke R. Lord

Decision electronically authenticated