**Internal distribution code:**
(A) [ ] Publication in OJ
(B) [ ] To Chairmen and Members
(C) [ ] To Chairmen
(D) [X] No distribution

# Datasheet for the decision of 17 April 2013

**Case Number:** T 1711/09 - 3.5.02

**Application Number:** 05025262.6

**Publication Number:** 1659678

**IPC:** H02M 3/158

**Language of the proceedings:** EN

**Title of invention:**
Interleaved DC/DC converter

**Applicant:**
HONDA MOTOR CO., LTD.

**Headword:**
-

**Relevant legal provisions:**
EPC Art. 54

**Keyword:**
"Novelty - (no)"

**Decisions cited:**
-

**Catchword:**
-

Europäisches Patentamt | European Patent Office | Office européen des brevets

Beschwerdekammern | Boards of Appeal | Chambres de recours

**Case Number:** T 1711/09 - 3.5.02

# D E C I S I O N
**of the Technical Board of Appeal 3.5.02**
**of 17 April 2013**

**Appellant:** (Applicant)
HONDA MOTOR CO., LTD.
1-1, Minamiaoyama 2-chome
Minato-ku
Tokyo (JP)

**Representative:**
Herzog, Markus
Weickmann & Weickmann
Patentanwälte
Postfach 86 08 20
D-81635 München (DE)

**Decision under appeal:**
**Decision of the Examining Division of the European Patent Office posted 2 April 2009 refusing European patent application No. 05025262.6 pursuant to Article 97(2) EPC.**

**Composition of the Board:**

**Chairman:** M. Ruggiu
**Members:** M. Léouffre
P. Mühlens

## Summary of Facts and Submissions

I. The applicant lodged an appeal against the decision of the Examining Division, posted on 2 April 2009, on the refusal of the application No. 05 025 262.6. The Examining Division held that the claimed invention was not novel in the sense of Article 54 EPC having regard in particular to document D1 = EP 1 300 934 A1.

II. The statement setting out the grounds of appeal was received on 12 August 2009. With the statement of grounds the appellant filed a new set of claims accompanied with a new description, and referred to a Wikipedia article concerning the definition of an autotransformer (Annex 1).

III. The appellant did not reply to the board's summons to oral proceedings dated 24 January 2013, wherein the board expressed the preliminary opinion that the subject-matter of claim 1 would lack novelty having regard to D1.

IV. Oral proceedings before the board took place on 17 April 2013. The appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of claims 1 and 2 filed with letter dated 12 August 2009.

V. Claim 1 reads as follows:

"A voltage-boosting/lowering DC/DC converter including a low-voltage-side port and a high-voltage side port, said voltage-boosting/lowering DC/DC converter comprising:

a voltage-boosting/lowering function section (L0, T1) having an inductor (L0) and a transformer (T1), said inductor (L0) being connected at one end to a positive-pole terminal (TA1) of the low-voltage-side port, and said transformer (T1) including a primary winding (L1) and a secondary winding (L2) interconnected in an oppositely-wound configuration, a common terminal (c) of the primary winding and secondary winding being connected to another end of the inductor (L0), wherein the winding ratio between the primary winding (L1) and the secondary winding (L2) is 1:1;

first switching means (SW1) for controlling an energizing current of the primary winding (L1) which flows to a common reference terminal (E1);

second switching means (SW2) for controlling the energizing current of the primary winding (L1) which flows to a positive-pole terminal (TA2) of the high-voltage-side port;

third switching means (SW3) for controlling an energizing current of the secondary winding (L2) which flows to the common reference terminal (E1); and

fourth switching means (SW4) for controlling the energizing current of the secondary winding (L2) which flows to the positive-pole terminal (TA2) of the high-voltage-side port,

characterised in that

said transformer (T1) is configured as a magnetic-field cancellation type transformer in which the primary winding (L1) and the secondary winding (L2) are intercoupled magnetically via a single core (21) such that an exciting current flowing in one of the primary winding (L1) and the secondary winding (L2) and an excited current simultaneously flowing in the other one

of the primary winding (L1) and the secondary winding (L2) cancel the DC magnetization of the core (21), and

said inductor (L0) being configured to have a waveform relaxation/variation function."

Claim 2 is dependent on claim 1.

VI. The appellant essentially argued as follows:

The voltage-boosting/lowering DC/DC converter of the invention comprised a transformer including a primary and a secondary winding magnetically intercoupled via a single core and interconnected in an oppositely-wound configuration.
The invention thereby taught about the physical arrangement of the windings on the core of the transformer. The transformer comprised one core and two different coils wound in opposite directions.

In D1, the primary and secondary windings were magnetically coupled. But the transformer of figure 3 of D1 comprised two distinct cores and D1 did not disclose the physical arrangement of the transformer. Section [0014] of D1 mentioned an autotransformer. This term did not help to understand the figures showing two cores. The Wikipedia article (annex 1) showed the differences between an autotransformer and a transformer. In an autotransformer one winding was used in common for the primary winding and the secondary winding. Figure 3 of D1 did not show one winding used in common for the primary and secondary windings nor any physical implementation of the transformer of D1. Furthermore, the primary and secondary windings of the invention were wound in opposite directions. This was

not unambiguously derivable from D1. Since at least a part of the winding of an autotransformer acts as both primary and secondary windings, inherently, an autotransformer according to D1 could not have two windings interconnected in an oppositely-wound configuration.
In the invention the two windings were overlapping each other and wound on a single core in opposite directions.

## Reasons for the Decision

1. The appeal is admissible.

2. The subject-matter of claim 1 lacks novelty (Article 54 EPC) in view of D1 for the following reasons:

2.1 D1 discloses a voltage-boosting/lowering DC/DC converter (cf. sections [0043] and [0050] and figure 3) including a low-voltage-side port (terminals 6 and 12) and a high-voltage-side port (terminals 16 and 18). Said voltage-boosting/lowering DC/DC converter comprises:

a voltage-boosting/lowering function section having an inductor L1 and a transformer 1, said inductor L1 being connected at one end to a positive-pole terminal 6 of the low-voltage-side port, and said transformer 1 including a first winding 5A and a second winding 5B, a common terminal 4 of the first winding and second winding being connected to another end of the inductor $L_1$, wherein the winding ratio between the first winding and the second winding is 1:1 (cf. last sentence of section [0014]); and

first switching means AL (cf. figure 3) for controlling an energizing current of the first winding 5A which flows to a common reference terminal 12;

second switching means AH for controlling the energizing current of the first winding 5A which flows to a positive-pole terminal 8 of the high-voltage-side port;

third switching means BL for controlling an energizing current of the second winding 5B which flows to the common reference terminal 12; and

fourth switching means BH for controlling the energizing current of the second winding 5B which flows to the positive-pole terminal 16 of the high-voltage-side port.

According to section [0039], the current IA in the first winding 5A induces a current IB in the second winding 5B. The first winding 5A can therefore be seen as a primary winding and the second winding 5B as a secondary winding.

2.2 Claim 1 specifies further that:
- "the primary winding and the secondary winding are interconnected in an oppositely-wound configuration".

2.2.1 According to the appellant, an autotransformer as shown in D1 having, inherently, only one winding, does not have a primary winding and a secondary winding in oppositely-wound configuration.

2.2.2 However, in the view of the Board the term "autotransformer" does not differentiate the transformer 1 of D1 from the transformer T1 of the invention.

Actually an autotransformer comprises a winding with two end terminals and an intermediate terminal. Classically an autotransformer is connected such that a portion of the winding acts as a part of both the primary and the secondary (cf. annex 1), whereby the primary and secondary share the intermediate terminal called the middle tap. The primary receives power while the secondary provides power. Windings L1 and L2 of transformer T1 of the invention are called primary winding L1 and secondary winding L2, but the output voltage V2 of the transformer T1 is the voltage across the serial connection of both windings L1 and L2. Thus, the serial circuit comprised of windings L1 and L2 in fact constitutes the secondary of the transformer T1, while one of the two windings L1 and L2 constitutes the primary to which the input voltage V1 is applied. The same applies to the windings 5A and 5B of the transformer 1 of D1 (cf. D1, figures 1 and 3), wherein the serial connection of windings 5A, 5B in fact constitutes the secondary.

A usual autotransformer having one continuously wound coil provided with three electrical connection terminals (cf. annex 1) may also be seen as comprising two serially interconnected winding sections across which one of the input voltage or output voltage is applied while the other of the input or output voltage is applied across only one of the two winding sections. As the appellant noticed, D1 does not disclose a physical implementation and is not limited to an autotransformer (cf. section [0019]), having a continuous winding. D1 must comprise either two windings or at least two winding sections which are considered as two windings.

Therefore the Board disagrees with the appellant that, "inherently, an autotransformer cannot have two windings".

2.2.3 The expression "two windings interconnected in an oppositely-wound configuration" has no clear meaning. The expression "oppositely-wound configuration" may refer to the physical clockwise or counter-clockwise direction of the windings. The expression "interconnected in oppositely-wound configuration" may refer to the usual definition of the winding directions which takes account of the currents flowing clockwise (south face) or counter-clockwise (north pole). Hence the winding directions of two aligned solenoids carrying the same current, e.g. two serially connected identical solenoids, would present alternative north and south pole faces N-S, N-S when configured as wound in the same direction, or opposing north, respectively south pole faces, when configured as wound in opposite directions", e.g. N-S,S-N. However a configuration of two solenoids carrying a same current and presenting alternating north and south poles, may result either from the solenoids being physically wound in the opposite directions, or from a particular interconnection of the solenoids wherein the currents in the two aligned identical solenoids flow in opposite directions. This is the case, for example, when the interconnection point of two serially connected identical solenoids is used as current input or current output.

When supplied over the middle tap, the two winding sections of a continuous winding present the same poles facing each other at the middle tap. They are thus "interconnected in oppositely-wound configuration". The

same applies to the two windings sections 5A, 5B of the autotransformer of D1, which might be parts of a continuous single winding having a middle tap and are supplied over the middle tap 4 (cf. figure 3), defining a primary winding and a secondary winding, which thereby can be considered as being "interconnected in oppositely-wound configuration". The above expression is therefore not sufficient to differentiate the invention from the prior art represented by D1.

The appellant interprets the above mentioned feature as defining two windings coiled concentrically on a single core and in opposite directions.
This interpretation refers to a possible physical configuration, wherein starting at the same end of a core, one winding would be wound clockwise and the other winding counter-clockwise while the current would be supplied to the two winding sections over the same side which would correspond to the middle tap. There is however no information in the application to support this restrictive interpretation. The expression "windings interconnected in oppositely-wound direction" is therefore not specific enough to differentiate the transformer of the invention from the transformer of D1.

2.2.4 Furthermore and alternatively, assuming that the feature "interconnected in an oppositely-wound configuration" would refer to the position of the dot symbols on the transformer T1 of the application (cf. figures 2, 3, 5, 7, 9, 11 and 13), the autotransformer of D1, which is supplied over its middle tap, may be seen as a transformer having two winding sections interconnected in an oppositely-wound

configuration exactly like the windings of transformer T1 of the application.

2.3 According to claim 1 the DC/DC converter is further characterised in that
- the transformer is configured as a magnetic-field cancellation type transformer in which the primary and secondary windings are intercoupled magnetically via a single core 21, such that an exciting current flowing in one of the primary winding 5A and the secondary winding 5B and an excited current simultaneously flowing in the other one of the primary winding 5A and the secondary winding 5B cancel the DC magnetization of the core.

2.3.1 The description of D1 mentions unambiguously an autotransformer (cf. sections [0014] and [0025]) having two magnetically linked windings 5A, 5B (cf. section [0038]), an intermediate terminal contact ("borne intermédiaire 4") and terminal contacts 2, 3 at the ends of windings 5A, 5B (cf. section [0018]). The core symbols shown in figure 3 of D1 might be interpreted as showing two distinct core parts. However these two core parts taken together must magnetically link the primary and secondary windings of D1. The two core parts thus act as a single magnetic core. Therefore, the board considers that the feature "a transformer in which the primary winding ($L_1$) and the secondary winding ($L_2$) are intercoupled magnetically via a single core" is disclosed in D1.

2.3.2 The method of operation of the converter of D1 is the same as the method of operation of the converter of the invention, and the transformer of D1 corresponds to the

transformer T1 of the invention. Therefore the effect of the primary winding 5A and the secondary winding 5B of D1 on the magnetic field of the transformer must also correspond to the effect of the two windings $L_1$ and $L_2$ of T1.

If according to the invention, "an exciting current flowing in one of the primary winding (L1) and the secondary winding (L2) and an excited current simultaneously flowing in the other one of the primary winding (L1) and the secondary winding (L2) cancel the DC magnetization of the core (21)" (cf. claim 1 and sections [0042], [0066], [0073] and [0101] of the published application), the same effect must be achieved with the currents flowing in the primary winding 5A and the secondary winding 5B of D1.

Therefore, the board considers that the feature "a transformer configured as a magnetic-field cancellation type transformer in which the primary and secondary winding are intercoupled magnetically via a single core, such that an exciting current flowing in one of the primary winding and the secondary winding and an excited current simultaneously flowing in the other one of the primary winding and the secondary winding cancel the DC magnetization of the core" is disclosed in D1.

2.4 The last feature of claim 1 "said inductor (L0) being configured to have a waveform relaxation/variation function" does not imply any technical feature which would not be known from D1 either.

Actually any waveform of a current flowing through an inductor is modified by the inductor. Thus any inductor can be seen as configured to have a waveform variation function. The inductor $L_1$ of D1 is a smoothing coil (cf. D1, figure 3 and section [0035]) which might

exhibit a low inductance value. Nevertheless a smoothing coil inherently varies the current waveform and repeatedly loads and unloads energy, i.e. provides a "relaxation" effect. The energy stored in the inductor $L_1$ of D1 may only be released through one or the other coil of the autotransformer at times determined by the switching times of the transistors AL, BL, AH and BH. The effect of inductor $L_1$ cumulates with the effect of one or the other winding of the autotransformer, and the level of the contribution of the inductor $L_1$ depends directly on the value of the inductor . The inductor $L_1$ is connected exactly at the same place as the inductor L0 of the invention i.e. between the positive terminal of the low-voltage-side port and the common terminal of the primary and secondary windings. If a waveform relaxation/variation function is achieved by the inductor L0 of the invention, the same effect is achieved by the inductor $L_1$ of D1.

3. The Board considers therefore that the subject-matter of claim 1 is known from D1 and that the application does not meet the requirements following from Article 54 EPC.

**Order**

**For these reasons it is decided that:**

The appeal is dismissed.

The Registrar: The Chairman:

U. Bultmann M. Ruggiu