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D E C I S I O N
of 4 February 1998

Case Number: T 0002/94 - 3.4.1

Application Number: 88308823.9

Publication Number: 0309254

IPC: G01R 15/02

Language of the proceedings: EN

Title of invention:
Apparatus and process for detecting direct current magnetic flux deflections of an electrical transformer

Applicant:
Mitsubishi Denki Kabushiki Kaisha

Opponent:
-

Headword:
Direct current magnetic flux deflection/MITSUBISHI DENKI KABUSHIKI KAISHA

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step - yes (after amendments)"
"Skilled person - a team of experts specialising in the relevant fields"

Decisions cited:
T 0099/89, T 0424/90, T 0321/92

Catchword:
-

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Case Number: T 0002/94 - 3.4.1

D E C I S I O N
of the Technical Board of Appeal 3.4.1
of 4 February 1998

Appellant: Mitsubishi Denki Kabushiki Kaisha
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Decision under appeal: **Decision of the Examining Division of the European Patent Office dated 12 August 1993 refusing European patent application No. 88 308 823.9 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: G. Davies
Members: R. K. Shukla
G. Assi

Summary of Facts and Submissions

I. European patent application No. 88 308 823.9 relating to an apparatus and process for detecting direct current magnetic flux deflections of an electrical transformer was refused by a decision of the Examining Division, dated 12 August 1993, on the ground that claims 1 to 6 as originally filed did not involve an inventive step within the meaning of Article 56 EPC, having regard to the following prior art documents:

D1: US-A-4 255 705 and
D2: US-A-3 863 109

II. The applicant lodged an appeal on 13 October 1993 paying the appeal fee on 12 October 1993, and filed a new set of claims 1 to 4 and amended pages of the description with the statement of the grounds of appeal on 22 December, 1993.

In relation to independent claims 1 and 4 forming the basis of the contested decision, new independent claims 1 and 4 were amended so that they were in a two-part form according to Rule 29(1) EPC taking into account the prior art as disclosed in document D1. Also, the new independent claims were amended so as to specify that the magnetic detector does not form part of the transformer.

III. In a communication, dated 27 February 1997, the Board informed the appellant of its provisional view that the subject-matters of claims 1 and 4 did not appear to involve an inventive step having regard to the above-cited prior art documents and what was common general knowledge in the art.

IV. In response to the above communication, the appellant filed two sets of claims forming respectively the basis of a first auxiliary request and a second auxiliary request. By way of a third auxiliary request, the applicant requested that oral proceedings should be appointed.

V. In a further communication, dated 22 December 1997, the Board informed the appellant of its provisional view that the invention as claimed in the first and second auxiliary requests did not appear to involve an inventive step.

VI. At the oral proceedings held on 4 February 1998, the appellant filed a new set of claims 1 to 4 and revised pages 1 to 8 of the description, and requested the grant of a patent on the basis of these documents, and the drawing sheets 1/5 to 5/5 as originally filed.

VII. Independent claims 1 and 4 of the above request have the following wording. The wording of claim 1 has been divided into features (a) to (h) by the Board to facilitate its discussion:

Claim 1

"An apparatus for deriving an AC voltage from a DC voltage, the apparatus comprising:

(a) an inverter (11) for converting the DC voltage to an AC voltage;

(b) an electrical transformer (10) comprising a primary winding (3), a secondary winding (2) and a core (1) around which the primary winding and secondary winding are wound.for providing a magnetic circuit path;

(c) means for connecting the AC voltage from the inverter to the primary winding (3) of the transformer; and

(d) means for detecting direct current magnetic flux deflection of the transformer (10), the means for detecting direct current magnetic flux deflection comprising :

a magnetic detector (4) separate from the magnetic circuit path for detecting the magnetic flux deflection of the transformer and for generating an output voltage waveform in response to the magnetic flux deflection;

(e) an integrator (12) connected to said magnetic detector (4) for integrating said output voltage waveform form said magnetic field detector;

(f) a positive peak value detector (13a) connected to said integrator (12) for detecting positive peak values of the output voltage waveform integrated by said integrator;

(g) a negative peak value detector (13b) connected in series to said integrator (12) and in parallel to said positive peak value detector (13a) for detecting negative peak values of the output voltage waveform integrated by said integrator; and

(h) a comparator (14) connected to said positive and said negative peak value detectors (13a, 13b) for comparing the positive and negative peak values from said peak value detectors (13a, 13b)to provide peak difference values indicative of the direct current magnetic flux deflection of said transformer."

Claim 4

"A process for deriving an AC voltage from a DC voltage, the process comprising: inverting the DC voltage to an AC voltage;

applying the inverted AC voltage to a primary winding (3) of a transformer (10), which transformer further comprises a secondary winding (2) and a core (1) around which the primary winding and secondary winding are wound for providing a magnetic circuit path; and

detecting direct current magnetic flux deflection of the transformer, the process for detecting direct current magnetic flux deflection comprising:

detecting a magnetic flux deflection of the transformer and generating an output voltage waveform in response to the magnetic flux deflection using a magnetic field detector which magnetic field detector is separate from the magnetic circuit path;

integrating said output voltage waveform from said magnetic field detector (4);

detecting positive peak values of the output voltage waveform integrated by said integrator;

detecting negative peak values of the output voltage waveform integrated by said integrator ;

comparing the positive and negative peak values from said peak detecting steps to provide peak difference values indicative of the direct current magnetic flux deflection of said transformer."

VIII. The appellant submitted essentially the following arguments in support of inventive step in the claimed subject-matter:

(i) The present invention addresses the problem of DC flux generated in the core of a transformer when driven by a DC to AC inverter by providing a detection circuit arrangement which is non-intrusive in that it is not directly connected to the secondary winding of the transformer as in the apparatus disclosed in document D1. The detection circuit arrangement of the present invention, therefore, does not affect the characteristics of the transformer circuit and is not susceptible to damage by the release of the secondary winding.

(ii) Document D1 discloses a compensation circuit arrangement in a watt hour meter installation which compensates for a deviation in the output voltage waveform of a transformer caused by the influence of the DC magnetic flux deflection, by supplying a current to a compensating winding of the transformer core in such a direction to cancel the DC saturation of the transformer core. Thus, the arrangement according to this document does not strictly detect the DC magnetic flux deflection. Moreover, the compensation circuit arrangement is incorporated into the circuitry of the secondary winding of the transformer. Document D1 thus does not provide the solution according to the present invention and also does not provide any incentive to modify the compensation circuit arrangement disclosed therein to arrive at the arrangement and the method claimed in the present application.

(iii) An engineer concerned with designing an inverter operated power supply requiring high primary current cannot reasonably be expected to look for solutions in the field of watt hour meters, to which document D1 pertains, requiring minute currents, and then also to modify the teaching of this document so as to arrive at the subject-matter of the present invention.

Reasons for the Decision

1. The appeal is admissible.

2. *Amendments*

As a result of amendments, (i) amended claim 1 relates to **an apparatus for deriving an AC voltage from a DC voltage, (ii) the apparatus comprising an inverter, an electrical transformer (10) comprising a primary winding, a secondary winding and a core around which the primary and secondary windings are wound for providing a magnetic circuit path.** Moreover, in relation to claim 1 as originally filed, it is stated in the amended claim that (iii) the magnetic detector is **separated from the magnetic circuit path,** (iv) the output voltage wave form from the magnetic detector is **in response to the magnetic flux deflection** and (v) the peak difference **values provided by the comparator are indicative of the direct current magnetic flux deflection of the transformer**.

Independent claim 4 has been amended to relate to a process **for deriving an AC voltage from a DC voltage** and includes further amendments corresponding to the amendments (ii) to (v) mentioned above.

In the application as originally filed, two embodiments of a detection apparatus for DC magnetic flux deflection are described with reference to Figures 4 and 10, both of these embodiments providing a measure of the DC magnetic flux deflection of an inverter (11) driven electrical transformer (10), the latter comprising a primary winding (3), a secondary winding (2) and a transformer core (1) as claimed. Also, the magnetic detector (4) for detecting DC magnetic flux deflection is not wound around the transformer core, so that the detector is not a part of, and is separate from, the magnetic circuit path provided by the core. It , therefore, follows that the amendments (i) to (iii) have a basis in the original description. The amendments (iv) and (v) merely specify the functions of the detector and the comparator, respectively, these functions being clearly derivable from the description of Figures 5 to 8 as originally filed.

Thus, the amendments to claims 1 and 4 do not go beyond the content of the application as originally filed. Dependent claims 2 and 3 and the description have been adapted to the amended claims 1 and 4. The application as amended thus complies with the requirements of Article 123(2) EPC.

3. The only issue which needs to be considered is that of inventive step in the subject-matters of claims 1 and 4.

3.1 In the decision under appeal, document D1 disclosing peak value detectors and a comparator, was considered as the prior art coming closest to the claimed invention which then related to an apparatus and process for detecting direct current magnetic flux deflection. The claims as amended now relate to an apparatus and process for deriving an AC voltage from a DC voltage and the detection of DC magnetic flux

deflection. In the discussion of the background of the present invention in the application, reference is made to a conventional inverter driven transformer and the degradation of the transformer characteristics due to the presence of DC magnetic flux deflection in the transformer. Japanese Patent Application No. 62-28353 (corresponding to JP-A-63/198581) which is acknowledged in the description as disclosing an example of such a conventional transformer, was however published on 17 August 1988, i.e. after the priority date of 5 February 1988 of the present application, and therefore does not belong to the state of the art according to Article 54(2) EPC. Nevertheless, as acknowledged in the application, a DC to AC inverter connected to the primary winding of a transformer is generally known in the art. Also, in such a conventional apparatus, a secondary winding and the primary winding are wound around the core of the transformer so as to provide a magnetic circuit path. As the present invention relates to an apparatus and process for inverting a DC voltage to AC voltage, the correct starting point for the evaluation of inventive step, in the Board's view, is such a conventional apparatus, and not a watt hour meter installation described in document D1.

3.2 The apparatus according to claim 1 is distinguished from such a conventional apparatus by the features (d) to (h) mentioned above, and is concerned with detecting and measuring the DC magnetic flux deflection of the transformer which is caused by the presence of a DC voltage component in the AC output voltage of the inverter (see column 1, lines 1 to 30 of the application as published). Moreover, the applicant's submission in the grounds of the appeal that, as the magnetic detector is separate from the magnetic circuit path, it is not susceptible to damage when the secondary winding is released, is plausible, since it

is commonly known that, in highly inductive circuits involving transformers, transient voltages are produced by a sudden change in the magnetic linkage when, e.g., a secondary winding is released. The objective problem addressed by the present invention can, therefore, be regarded as providing in the conventional DC to AC inverter apparatus means to detect and measure DC magnetic flux deflection, which is not susceptible to damage due to transient voltages.

3.3 Document D1 is concerned with a method and apparatus for detecting a direct current (DC) component superimposed on an alternating current (AC) which is being measured by a watt hour meter installation and for deriving a feedback current for cancelling the effect of the DC component on the AC being measured (see, in particular, column 1, lines 10 to 17; column 2, lines 5 to 24). In the compensation circuit described with reference to Figure 1 of this document, the voltage induced in the secondary winding (N2) of a current transformer (CT) and appearing across a sensing resistor (R) is supplied to peak voltage detectors and hold circuits (13,12) which detect and store the positive and negative peak voltage values V+ and V- of the sensed signal at least over one full cycle of the supply alternating current. A difference voltage proportional to the difference between the positive and negative peak voltage values V+ and V- is provided by a summing circuit (14) and is converted into current I_c by a voltage to current converting circuit (15). The current I_c is proportional to the direct current component superimposed on the supply AC and is supplied to a compensating winding N_c provided on the core (11) of the transformer in a direction so as to desaturate the core and thereby to nullify the effect of the DC component (see, in particular, column 3, lines 25 to 46; column 4, lines 29 to 53; column 6, lines 22 to 28).

It follows from the above that, although the compensation circuit described in document D1 automatically nullifies the effect of the DC component in the supply AC, and does not measure the DC magnetic flux deflection due to the DC component, the difference voltage provided by the summing circuit (14) would provide a measure of the rate of change of the DC magnetic flux deflection. Moreover, the operation of the compensation circuit is based essentially on the same principle as the one employed in the claimed invention, i.e. it employs positive and negative peak values of the induced voltage to obtain a difference value which is a measure of the DC flux deflection. The teaching of document D1 is thus relevant in so far as it discloses a circuit arrangement which is capable of providing a measure of DC flux deflection in a transformer.

In connection with document D1, it was submitted by the appellant that a skilled person concerned with the problem of DC flux deflection in an inverter operated power supply cannot reasonably be expected to look for solutions in the field of watt hour meters, since the current requirements in both these fields are very different (see paragraph VIII(iii) above). The Board, however, cannot agree with this submission, since the subject-matter of claim 1 does not provide any indication of the values for the voltage and current, so that this distinction from the prior art cannot be taken into consideration. Moreover, it is the established case law of the boards of appeal that in certain areas of technology, such as the present one, i.e. a power supply including an inverter and a transformer, it is appropriate to consider a skilled person as a team of experts specialising in the relevant fields (see, e.g. T 99/89; T 424/90; T 321/92). In the present case, a team of experts would include not only a specialist in DC to AC inverters but

also electrical engineers designing transformers. Also, such a specialist in transformers would consult in the course of his routine activities related technical fields, i.e. the watt hour metre, where the problem of saturation of the transformer core due to the direct current is likely to occur.

3.4 Since in the watt hour meter installation of document D1, the compensation circuit automatically nullifies the effect of the DC component, the circuit is directly connected to the secondary winding N2. In other words, the secondary winding itself forms the magnetic detector for detecting the DC flux deflection. Moreover, document D1 is not concerned with the problem of transient voltages induced in the magnetic detection coil when the secondary winding is released. In the context of the overall teaching of this document, therefore, there is no hint to a skilled person which would lead him to provide a magnetic detector which is separate from the secondary winding.

In the decision under appeal, it was contended that the use of an exterior coil (in combination with an integrator) as a magnetic detector in the circuit of document D1 was an interchangeable alternative to a secondary coil, and therefore obvious to the skilled person, especially since search coils and Hall effect generators for measuring magnetic fields are known from document D2 (see column 2, lines 59 to 67). In the Board's view, however, in the compensation circuit of document D1, an exterior coil intercepting only a weak leakage magnetic field cannot be regarded as an alternative to the secondary coil surrounding the transformer core where almost the entire magnetic flux generated by the supply AC is confined. Such a modification was, therefore, not obvious in the context

of the teaching of document D1 taken as a whole, so that the skilled person would not regard document D1 to be relevant to the problem confronting him.

3.5 For the foregoing reasons, in the Board's judgement, the subject-matter of claim 1 was not obvious within the meaning of Article 56 EPC having regard to the cited prior art documents D1, D2 and the prior art acknowledged to be generally known in the application.

3.6 The process according to independent claim 4 is carried out using the apparatus according to claim 1, so that claim 4 also involves an inventive step. Claims 2 and 3 are dependent on claim 1, so that these claims are also allowable.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the department of first instance with the order to grant a patent on the basis of the appellant's request as set out in paragraph VI above.

The Registrar: The Chairman:

M. Beer G. Davies