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Datasheet for the decision of 9 March 2023

Case Number: T 2980/18 - 3.4.01

Application Number: 11769940.5

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Language of the proceedings: EN

Title of invention:
CLOSED-LOOP CURRENT TRANSDUCER WITH SWITCHED MODE AMPLIFIER

Applicant:
LEM International SA

Headword:
Closed-loop current transducer / LEM International

Relevant legal provisions:
EPC Art. 84, 52(1), 54, 56
RPBA 2020 Art. 13(1)

Keyword:
Claims - clarity - main request (yes)
Novelty - main request (yes)
Inventive step - main request (no)
Amendment to appeal case - suitability of amendment to resolve issues raised (no)

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Case Number: T 2980/18 - 3.4.01

D E C I S I O N
of Technical Board of Appeal 3.4.01
of 9 March 2023

Appellant: (Applicant)	LEM International SA Chemin des Aulx 8 1228 Plan-les-Ouates (CH)
Representative:	reuteler & cie SA Chemin de la Vuarpillière 29 1260 Nyon (CH)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted on 26 July 2018 refusing European patent application No. 11769940.5 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chair	P. Fontenay
Members:	T. Petelski
	C. Almberg

Summary of Facts and Submissions

I. The appellant (applicant) lodged an appeal against the Examining Division's decision to refuse the European patent application for lack of clarity (Article 84 EPC) and lack of novelty (Articles 52(1) and 54(1) and (2) EPC) over

D1: WO 98/36281 A1.

II. In its statement of grounds of appeal, the appellant requested that the appealed decision be set aside and that a patent be granted based on a set of claims according to the main request underlying said decision and re-filed with the statement.

III. Together with summons to oral proceedings, the Board issued its preliminary opinion, according to which

- the claims were clear, and

- the subject-matter of claim 1 was novel, but did not involve an inventive step over D1, because the distinguishing feature did not have a technical effect that could make an inventive contribution. In particular, the broad definition of claim 1 did not reflect the effect referred to in the embodiments of the description, namely that the supply currents were balanced in such a way that they always remained positive and never changed direction.

IV. Together with a letter of 7 March 2023 the appellant submitted a new set of claims according to a first auxiliary request.

V. At oral proceedings, the appellant maintained the aforementioned requests.

VI. Claim 1 of the main request reads (reference signs omitted):

A closed-loop current transducer system for measuring a current flowing in a primary conductor,

the system powered by series connected voltage supplies and comprising a magnetic field detector, a signal processing circuit including an amplifier circuit connected to the magnetic field detector, and a compensation coil connected to the amplifier circuit and configured to generate an opposing magnetic field seeking to cancel a magnetic field generated by the current flowing in the primary conductor,

characterised in that the amplifier circuit comprises

a first switched mode power stage fed by the voltage supplies and configured to drive the compensation coil and supply an output current for a measurement resistor connected to a first reference voltage, where the

voltage across the measurement resistor provides an image of the current flowing in the primary conductor thus providing an absolute measurement signal output of the transducer referred to said first reference voltage, and

at least a second independently regulated switched mode power stage fed by the voltage supplies with an output connected to a second reference voltage through an inductor and configured to output a balancing current,

whereby the first and second reference voltages may be the same or different, and wherein the second switched mode power stage is independently regulated in the sense that the output of the second switched mode power stage is provided with its own regulation loop.

VII. Claim 1 of the first auxiliary request adds, with respect to claim 1 of the main request (reference signs omitted):

...,
wherein the second switched mode power stage is connected to the first switched mode power stage via a summing circuit comprising resistors, differential amplifiers and a regulator circuit to regulate the current in the second switched mode power stage.

Reasons for the Decision

Content of the application

1. The invention is about a closed-loop current transducer. Such kind of transducers measure the magnetic field around a conductor through which flows the current to be measured. Based on the measured magnetic field strength, a first power stage is controlled to generate a current through a compensating inductor such that the magnetic field generated by this inductor cancels the magnetic field generated by the current to be measured. If controlled in this way, the current flowing through the inductor mirrors the current to be measured. The first power stage is a switched mode power stage, supplied by series connected voltage supplies. The invention proposes a second power stage that generates a current opposite in sign to the current generated by the first power stage. The current generated by the second power stage is regulated independently from the first power stage in such a way that the supply currents of the two series connected sources are balanced, in the sense that they never change direction and the supply sources never have to absorb power. This allows the use of simpler and less potent power supplies.

Main request - clarity and claim interpretation

2. The Examining Division found several features of claim 1 to be unclear (Article 84 EPC) and provided an interpretation of these features for the assessment of novelty and inventive step.

3. The appellant disagrees with the Examining Division's view of those features. In the understanding of the skilled person the features in question had a clear meaning, and, when understood in that way, also contributed to novelty and inventive step.

4. In the following, the Board explains its appreciation of the contested features. This understanding is mostly broader than alleged by the appellant but does not result in any clarity objections.

Independently regulated

5. The Examining Division held unclear the definition that the second switched mode power stage was "independently regulated". Claim 1 did not define, with respect to which other entity there should be independence.

6. In this question, the Board finds the appellant's view more persuasive. Claim 1 itself defines that "independently regulated" is to be understood "in the sense that the output of the second switched mode power stage is provided with its own regulation loop". The skilled person understands this to mean that the second power stage has a regulation circuit that is different from any other regulation circuit, including the one of the first power stage. This definition, however, does not imply a complete electronic separation. For example, it neither excludes that some electronic components are common with another regulation circuit (as defined in claim 6), nor that the same signals are used. For example, two identical, redundant control loop circuits using the same input signal and generating (nearly) identical output signals would

still have their own regulation loops. Also, the second power stage would be "independently regulated", in the sense of having "its own regulation loop", if it used the output of the first power stage as input signal. This understanding is in line with all embodiments of the description and with the dependent claims, in particular with dependent claims 2, 3 and 10.

7. Hence, although the Board does not agree with the Examining Division's finding of this feature being unclear, it comes to the same conclusion regarding the interpretation of this feature, namely in that it includes the option of the second power stage using the output signal of the first power stage as input signal.

Regulation loop

8. According to the Examining Division it was not clear, which elements in Figures 1, 2 and 7 formed the regulation loop other than the circuit 23. Further, these figures showed the regulation circuit 23 not being at the output of the second power stage, as it was defined in claim 1.

9. The question of which elements are part of the regulation loop has no relevance on the clarity of claim 1. Regardless of this, the regulation loop is recognisable for the person skilled in electronics from Figures 1 (see elements 23, 2, L2 and Σ), 2 and 7, the respective output signal being a part of the loop. Although the formulation "the output ... is provided with its own loop" could have been phrased better from a technical point of view, it does not obstruct this understanding.

Absolute measurement signal output

10. The appellant disagrees with the Examining Division's interpretation of "an absolute measurement signal output" as defined in claim 1 and is of the opinion that this measurement signal could not be a differential signal and had to be output by a single pin.

11. The appellant's arguments are not persuasive. A transducer provides an absolute measurement signal if the signal is indicative of the measured quantity in absolute terms, without the need to compare it to some external reference. This stands in contrast to a relative measurement signal, which requires a comparison with a reference signal that is not provided together with the measurement signal. An absolute measurement signal can be output by one pin as a non-differential signal (if the zero reference is provided from another location) or by two pins as a differential signal (in which one pin is a reference, e.g., a zero reference). This is in line with claim 1 itself, which defines the absolute measurement signal output as "the voltage across the measurement resistor", the resistor being connected to a reference voltage. Hence, the term "absolute signal" only distinguishes from a "relative signal", but does not imply a certain output mode, especially not a non-differential mode. In the case of claim 1, the absolute measurement signal output of the transducer must be a signal that directly allows determination of the current flowing through the primary conductor (e.g., in Amperes), without the need to further compare it to some external reference. The absolute measurement signal defined in claim 1 may well result from a comparison with a known (absolute)

reference signal within the transducer. The skilled person would understand this meaning of "absolute measurement signal" from the claim alone, without having to resort to the description.

Current transducer

12. The Examining Division found claim 15 to be unclear because it referred to a "current transducer according to any preceding claim", whereas each preceding claim referred to a "current transducer system".

13. The Board does not follow this finding. It is apparent that claim 15 merely adds a further definition to the current transducer system of any of the previous claims. The "current transducer" is, therefore, the same as the "current transducer system", although a consistent denotation would have been preferable.

Measurement signal output of the transducer

14. According to the Examining Division, it was unclear in view of the combination of claim 15 and claim 1 whether the measurement resistor was part of the transducer (voltage output) or not (current output).

15. Claim 1 defines, as parts of the current transducer system, only the magnetic field detector, the signal processing circuit including an amplifier circuit, and the compensation coil. Neither the primary conductor, nor the voltage supplies, nor the measurement resistor or the inductor are defined as part of the claimed transducer.

16. The first switched mode power supply is defined as configured to "supply an output current for a measurement resistor". Claim 1 goes on to define that it is the voltage across the (external) measurement resistor that provides "an absolute measurement signal output of the transducer". From these definitions, the skilled person understands that the transducer provides an output current, which can be converted by an external measurement resistor to a voltage signal that is indicative of the absolute measured current in the primary conductor. This understanding of claim 1 is in line with claim 15. Hence, the Board does not follow the Examining Division's clarity objection in this regard.

Balancing current

17. According to the appellant, the balancing current defined in claim 1 referred to balancing the reverse current generated by the first power stage in the power supplies.

18. However, this meaning cannot be derived from claim 1. The claim neither defines the balancing current explicitly, nor does it define the electronic circuits in sufficient detail to allow an implicit deduction of what is to be balanced. Hence, the claim must be interpreted in a way that includes any balancing effect of the current output by the second power stage.

19. It follows that the claims of the main request are clear (Article 84 EPC) but allow an interpretation that is broader than that applied by the appellant.

Main request - novelty

20. The proprietor contests that D1 discloses the features

(a) that the transducer provided an absolute measurement signal output; and

(b) that there was a second switched mode power stage that was independently regulated and

(c) configured to output a balancing current.

21. Re feature (a): Reference is made to the above understanding of claim 1. Thereafter, the measurement resistor is not part of the claimed current transducer. The output of the transducer is a current signal that can be translated into a voltage signal on an external resistor. The same holds for the voltage over the resistor 7' in the embodiment of Figure 5 of D1, which is indicative of the current to be measured, as explicitly mentioned on page 5, lines 9 to 14 of D1 (the respective paragraph refers to the split-coil embodiment of Figure 5). The current through the resistor 7' is, therefore, an output signal that represents an absolute measurement of the current i_1 through the primary conductor 1. According to D1, a voltage measurement signal U_a is taken at two points, one of which is between coil 6' and resistor 7'. Hence, this point is not within the transducer, as is argued by the appellant, but is an accessible output of the transducer, which offers the option to measure the current through 7' - or the voltage across 7'. Whether this is actually done in D1 is irrelevant because the resistor and the measurement are not part of the transducer defined by claim 1. Hence, D1 discloses a

transducer providing an absolute signal output (at the exit of coil 6').

22. Re feature (b): The circuit in Figure 5 of D1 is a fully balanced H-bridge circuit. Due to the splitting of the secondary coil into two coils 6', 6'', and the connection to ground through resistors 7' and 7'', the H-bridge circuit is separated into two parts that are functional "push-pull stages" (page 8, lines 26 - 29) on their own. Hence, the two parts can be understood as separate first and second switched mode power stages, the first delivering a current to coil 6', the second delivering a current to coil 6''.

More convincing is the appellant's argument that the second power stage in D1 was not independently regulated in the sense that it had its own regulation loop. Figure 5 of D1 shows one single regulation loop that is partly split into two interdependent branches. The single quantity to be regulated is the magnetic field in the core 2. A signal representing this field enters the regulation loop at detector 3. The signal is conditioned in circuitry 4, and comparator 21 generates a triggered signal and causes the transistors 17 and 18 to be alternately switched on and off. The second comparator 21' simply inverts the triggering to alternately switch transistors 17' and 18' in the second branch counter to those in the first branch. This leads to equivalent amounts of current delivered to coils 6' and 6'', which, *in sum*, amounts to the feedback signal that regulates the magnetic field in core 2 to the desired level (which is zero). Since this feedback loop relies on the common control and summed feedback of the two branches, it would not be appropriate to speak of an independent regulation.

23. Re feature (c): The claim neither defines nor implies the nature and purpose of the balancing current. Hence, the current through coil 6'' can be understood as balancing current in the sense that it contributes to compensate (or "balance") the magnetic field generated by current i_1 through primary coil 1 in the core 2.

24. It follows that the subject-matter of claim 1 differs from the embodiment according to Figure 5 of D1 only in that the second power stage is independently regulated.

25. The other embodiments of D1 are not more relevant than the embodiment according to Figure 5 of D1. They also do not disclose an independent regulation.

26. Hence, the subject-matter of claim 1 is novel (Article 54(1) and (2) EPC).

Main request - inventive step

27. The feature that distinguishes claim 1 from the embodiment of Figure 5 of D1 is the independent regulation of the second switched mode power stage. Claim 1 defines that second power stage as configured to output a "balancing current" to an external inductor. The claim fails to define the quantity that is to be balanced by the balancing current. It is impossible for the skilled person to deduct, from the claim, a purpose or technical effect of the balancing current, and, thereby, of the whole second switched mode power stage and its regulation that would apply over the whole scope of the claim. Therefore, the only feature that distinguishes the subject-matter of claim 1 from D1 does not have a technical effect relevant for

the assessment of inventive step in the context of the invention.

28. Consequently, the subject-matter of claim 1 does not involve an inventive step.

29. According to the appellant, however, the invention was made in view of the problems of a single switched-mode power stage, like the one illustrated by Figure 1 of D1. The imbalance of the supply currents was a problem for such power stages, and no one had foreseen the use of a second power stage for balancing the supply currents before the priority date of the application. The skilled person would understand that the second power stage in claim 1 had to have a technical effect. This could be nothing else than the balancing of the supply currents, such that they always remained positive, in the sense that the supply sources delivered power to the circuit, and never changed direction. The certainty that there were no reverse currents made superfluous any recurring to specially designed power supplies capable of absorbing power. The second power stage thus allowed for a less complex and less expensive design of the power supplies. The presence of such a second power stage alone, together with the single-pin output of an absolute measurement signal, was sufficient to establish an inventive step over the prior art that used a single power stage.

30. The embodiment illustrated by Figure 5 of D1 was the wrong starting point for an inventive step attack. Only with the benefit of hindsight could it lead to the invention. The problem, which the invention set out to solve, was not present in the transducer of Figure 5, because the currents were already inherently balanced, such that the power supplies never absorbed power.

This, however, came at the cost of a split compensation coil and a differential current measurement via the voltage *Ua*. The skilled person would not take a measurement over the resistor 7' only, because leakage currents through ground could distort the measurement. It would always have to be the two-pin differential measurement of *Ua*, which, however, stood in contrast to the absolute measurement defined in claim 1. Hence, when starting from the transducer of Figure 5 of D1, the skilled person would have foreseen neither a single-pin absolute output of the measurement signal, nor an independently regulated second power stage.

31. If the skilled person nevertheless started from the transducer of Figure 5 of D1, then the problem would have been to change the transducer for a single-pin measurement output. Sometimes, the use of split compensation coils, and the resulting differential output over two resistors by two pins was not desirable. In order to solve this problem, the skilled person would have turned to one of the embodiments of Figures 1 to 4 of the same document D1, which offered a single-pin solution. However, without a second power stage. Hence, the skilled person would not have arrived at a transducer according to claim 1.

32. The Board is not persuaded by these arguments. The fact that the problem, which the invention allegedly set out to solve, was already solved by the transducer of Figure 5 of D1, is no reason why the skilled person would not have started from this transducer. The objective technical problem must be re-defined based on the difference between the transducer of Figure 5 of D1 and the one defined in claim 1. By correctly applying the problem-solution approach, the risk of hindsight will be reduced as best as possible.

33. As explained above under point 21., the absolute measurement defined in claim 1 is not a distinguishing feature. Also, the claim does not exclude a split compensation coil. In D1, the inductor 6' in Figure 5 of D1 generates a magnetic field "seeking to cancel" the field generated by the current flowing through the conductor to be measured. The complete cancellation, through which both fields will be balanced, is achieved with the additional help of the field generated by the balancing current through inductor 6''. Therefore, the independent regulation of the second power stage remains the only difference between claim 1 and D1. It is only the technical effect of this difference, which could possibly contribute to an inventive step.

34. Since, however, the claim is devoid of features that would have allowed the skilled person to deduce a technical purpose of the second power stage, its regulation remains barred from any technical effect that could contribute to an inventive step. With respect to the transducer of Figure 5 of D1, an independent regulation for the second power stage, which would have to be regulated in synchronization with, and counter to, the first power stage, would have had no beneficial technical effect, but would only have made the circuit more complicated.

35. Therefore, the main request is not allowable for lack of an inventive step of the subject-matter of claim 1 (Articles 52(1) and 56 EPC).

First auxiliary request - admission

36. The first auxiliary request was filed two days before the oral proceedings. Its admission is subject to the Board's discretion under Article 13 RPBA 2020.

37. The appellant justifies the late filing in that it happened in response to the Board's preliminary opinion on the lack of technical effect of the independently regulated second power stage. Claim 1 was a combination of claims 1 and 10 of the main request and related to the embodiment of Figure 2. The skilled person understood that the second power stage was regulated based on the sum of the outputs of the first and second power stages. It was, therefore, even clearer than in claim 1 of the main request that the balancing current at the output of the second power stage served the purpose of balancing the supply currents of the series connected voltage supplies. The subject-matter of claim 1 was *prima facie* inventive, because it provided a solution for balanced supply currents without using a split compensation coil and a differential measurement signal as in D1. The inventive step argument set out with regard to claim 1 of the main request applied even more to claim 1 of the first auxiliary request.

38. However, the alleged presence of an inventive step does not, *prima facie*, convince the Board. The amendment to claim 1 defines that the second power stage "is connected to the first switched mode power stage via a summing circuit", the summing circuit comprising various electronic components, including a "regulator circuit to regulate the current in the second switched mode power stage". The claim fails to define the way in which the two power stages are connected and which signals are summed by the summing circuit. Also, the

function of the electronic components of the summing circuit and, hence, its function beyond the regulation is not defined. Without these definitions, however, the added feature merely defines a conglomeration of electronic components without a discernible technical effect.

39. Contrary to the appellant's assertion, claim 1 provides no indication that it would be the output signals of the two power stages that were summed. There is also no indication that the summed signal would be used as an input signal to the second power stage.

40. Hence, the amendment to claim 1 is, *prima facie*, not suitable to resolve the lack of an inventive step of claim 1 of the main request.

41. Consequently, the first auxiliary request is not admitted into the proceedings under Article 13(1) RPBA 2020.

Conclusion

42. The main request is not allowable for lack of an inventive step and the first auxiliary request is not admitted into the proceedings.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chair:

D. Meyfarth P. Fontenay

Decision electronically authenticated