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D E C I S I O N
of 23 October 2000

Case Number: T 0879/98 - 3.5.2

Application Number: 94925065.8

Publication Number: 0714567

IPC: H02P 5/402

Language of the proceedings: EN

Title of invention:

Circuit for speed control for a one-phase or three-phase motor

Applicant:

WÖEL ELEKTRONIK HB

Opponent:

-

Headword:

-

Relevant legal provisions:

EPC Art. 56

Keyword:

"Inventive step (yes) after amendment"

Decisions cited:

-

Catchword:

-



Case Number: T 0879/98 - 3.5.2

D E C I S I O N
of the Technical Board of Appeal 3.5.2
of 23 October 2000

Appellant: WÖEL ELEKTRONIK HB
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Decision under appeal: Decision of the Examining Division of the
European Patent Office posted 18 March 1998
refusing European patent application
No. 94 925 065.8 pursuant to Article 97(1) EPC.

Composition of the Board:

Chairman: W. J. L. Wheeler
Members: F. Edlinger
B. J. Schachenmann

Summary of Facts and Submissions

I. The appeal is against the decision of the examining division refusing European application No. 94 925 065.8 (published as International application WO 95/06353). The reason given for the refusal was that the subject-matter of the independent claims then on file lacked an inventive step in view of the following documents:

D1: DE-3 409 299 and

D2: ELFA-katalog nr 39, ELFA AB 1990,
ISSN 91-88032-01-0 sid 1077, PVI 5100,
"Optokopplare med isolerad utspänning".

The use of optical coupling circuits (eg as disclosed in D2) was considered as an obvious choice for the galvanic isolation means in the circuit known from D1.

II. With the statement setting out the grounds of appeal and in response to communications of the Board, the appellant filed several sets of claims. The Board introduced documents:

D3: GB-A-2 154 820 and

D4: US-A-4 390 790, to which D3 refers as prior art.

With fax dated 27 September 2000, the appellant filed new claims 1 to 13 and pages 1 to 20 of the description. Later that day (received "9:32"), the appellant faxed a replacement page 2 of the description.

III. Claim 1 now reads as follows:

"1. Circuit for controlling the speed of a three-phase motor, comprising

driving stages (8-16) connected directly to three-phase mains (R,S,T) and connected for passing mains voltage directly to the motor windings under control of a pulse width modulated signal,

a control circuit (18) adapted to generate the pulse width modulated signal under control of the actual speed of the motor,

a power module in each driving stage, comprising a bridge connection of two anti-parallel connected power transistors (70,72) which are each series-connected with a blocking diode (74,76) for directly receiving and passing the respective half-period of a mains phase to a motor winding, characterized by

an optical coupling circuit (78,80) interconnected between the control circuit (18) and each power transistor, at least one of the power transistors being of type IGBT (Insulated Gate Bipolar Transistor), the optical coupling circuit comprising an electrically activable light emitting component (90) connected to the control circuit to have the emitted light modulated by the pulse width modulated signal, and a light sensitive component (102) adapted to, without any external driving voltage of its own, generate an output signal under influence of received light of the kind that is emitted by the light emitting component, and connected for receiving the pulse width modulated

emitted light to generate a voltage modulated by the pulse width modulated signal, said voltage being applied as a control voltage between the control electrode (71,73) and the emitter of the respective power transistor, and

an amplifier stage (T1,T2) interconnected between the optical coupling circuit and the respective power transistor, which amplifier stage obtains its supply voltage via a further circuitry (S1), the amplifier stage comprising two series connected transistors (T1 and T2), the first transistor (T1) having its collector terminal connected to a first output terminal of the further circuitry (S1), the base terminal connected to a first output terminal (94, 96) of the optical coupling circuit (78, 80), and the emitter connected to the control electrode of the corresponding power transistor and the emitter of the second transistor (T2), the second transistor (T2) having its collector terminal connected to the emitter of the power transistor, to a second output terminal of the further circuitry (S1), and to a second output terminal (98, 100) of the optical coupling circuit (78, 80), and the base terminal connected to the first output terminal (94, 96) of the optical coupling circuit (78, 80)."

Independent claim 8 reads as follows:

"Circuit for controlling the speed of a one-phase motor, comprising

a driving stage (110) connected directly to mains (112) and connected for passing mains voltage directly to the motor winding (114) under control of a pulse width modulated signal,

a control circuit adapted to generate the pulse width modulated signal under control of the actual speed of the motor,

a power module in the driving stage, comprising a bridge connection of two anti-parallel connected power transistors, which are each series-connected with a blocking diode for directly receiving and passing the respective half-period of the mains voltage to the motor winding, characterized by

an optical coupling circuit interconnected between the control circuit and each power transistor, at least one of the power transistors being of type IGBT (Insulated Gate Bipolar Transistor), the optical coupling circuit comprising an electrically activable light emitting component connected to the control circuit to have the emitted light modulated by the pulse width modulated signal, and a light sensitive component adapted to, without any external driving voltage of its own, generate an output signal under influence of received light of the kind that is emitted by the light emitting component, and connected for receiving the pulse width modulated emitted light to generate a voltage modulated by the pulse width modulated signal, said voltage being applied as a control voltage between the control electrode and the emitter of the respective power transistor, and

an amplifier stage (T1,T2) interconnected between the optical coupling circuit and the respective power transistor, which amplifier stage obtains its supply voltage via a further circuitry (S1), the amplifier stage comprising two series connected transistors (T1 and T2), the first transistor (T1) having its collector

terminal connected to a first output terminal of the further circuitry (S1), the base terminal connected to a first output terminal (94, 96) of the optical coupling circuit (78, 80), and the emitter connected to the control electrode of the corresponding power transistor and the emitter of the second transistor (T2), the second transistor (T2) having its collector terminal connected to the emitter of the power transistor, to a second output terminal of the further circuitry (S1), and to a second output terminal (98, 100) of the optical coupling circuit (78, 80), and the base terminal connected to the first output terminal (94, 96) of the optical coupling circuit (78, 80)."

Claims 2 to 7 and 9 to 13 are dependent on claims 1 and 8 respectively.

IV. The appellant argued essentially as follows:

D1 disclosed a circuit for controlling the speed of a three-phase motor comprising the features recited in the preambles of claims 1 and 8. D1, in general terms, referred to galvanic isolation means between the pulse width modulation circuit and the respective gates of the power transistors. Although D2 to D4 disclosed optical coupling circuits comprising photovoltaic generators, a combination of any of these documents with D1 would not lead to the subject-matter of claim 1 or to that of claim 8.

D2 and D3 did not deal with the problem addressed in the present application as to how a circuit for controlling the speed of motors may be improved to take full advantage of advanced switching control techniques in a wide frequency range. D4 disclosed two separate

circuits for reducing the fall time (Figure 1C) and the rise time (Figure 7) of MOSFET transistors to increase the switching speed. Even if these circuits were combined, they would not work in a circuit with power transistors of type IGBT as now specified in claims 1 and 8 because, in typical motor applications, the gate-emitter voltages of the IGBTs would be above a tolerable maximum of 20 V.

The subject-matter of claims 1 and 8 constituted a selection of a particular circuit for coupling the control signals to the driving stages in a circuit for controlling the speed of a motor. The combination was so arranged as to provide fast rise and fall times for the power transistors with a simple amplifier stage controlled by a single control signal. Moreover, the circuit had the advantage of providing a floating potential at the gate of the respective power transistors.

Starting from D1, the person skilled in the art would have had to carry out a non-obvious series of steps to arrive at the subject-matter of claim 1 or of claim 8, ie select the specified power transistors and coupling circuits, find the cause for malfunctions with high frequencies, combine the two separate circuits disclosed in D4 (Figures 1C and 7) and finally modify this combination as specified in claims 1 and 8 to provide floating gate potentials.

V. The appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of the following documents:

Claims: 1 to 13 filed with the fax dated

27 September 2000;

Description: pages 1 to 20 filed with the fax dated 27 September 2000 (page 2 as replaced with fax received "9:32"); and

Figures: sheets 1/8 to 8/8 as published with the International application.

Reasons for the Decision

1. The appeal is admissible.
2. Claim 1 combines claim 1 and part of claim 2 of the International application as published (WO 95/06353) and additional features which are based on pages 18 and 19 and Figures 3e and 10a of WO 95/06353. Similarly, claim 8 is derived from claims 8 and 9 and the above pages of WO 95/06353. Claims 2 to 7 and claims 9 to 13, apart from obvious corrections, correspond to the claims with the same numbers of WO 95/06353. The description has been adapted to the amended claims. The Board is satisfied that these amendments do not infringe Article 123(2) EPC.
3. *Inventive step*
 - 3.1 The preamble of claim 1 specifies a circuit for controlling the speed of a three-phase motor comprising driving stages between mains and motor as disclosed in D1 (Abstract and Figure), including in particular a bridge connection of two anti-parallel connected power transistors and a control circuit to generate pulse width modulated signals. The characterising portion of

claim 1 specifies an optical coupling circuit and an amplifier stage connected between the optical coupling circuit and the respective power transistor of the driving stages, in short the gate driving part of the circuit, and further defines at least one of the power transistors as being of type IGBT. An optically isolated gate driving circuit comprising transistor switches for increasing the switching speeds of power transistors is disclosed in D4 (column 2, lines 20 to 29; column 3, line 58 to column 4, line 28; column 5, lines 7 to 29).

3.2 D1 constitutes the more realistic starting point for an objective assessment of inventive step because it relates to the technical field of applications in which problems with high switching speeds may naturally occur in practice. The person skilled in the art would then consult the field of driving circuits to solve such problems. Starting from D4, which discloses power transistors and driving circuits for integration on a chip but no circuits for speed control (D4, column 1, lines 16 to 25; column 5, lines 33 to 36 and Figures 1 to 11), the person skilled in the art would have to select the particular application disclosed in D1 among countless other possible applications.

3.3 The subject-matter of claim 1 differs from the circuit disclosed in D1 by the features of its characterising portion. The claimed circuit can provide safe operation of the power transistors even with high power supply voltages and high frequencies of the pulse width modulated control signal (cf page 8, lines 30 to 37 of the present description).

3.4 D4 aims at providing optically isolated power FET

switches which are capable of operating at very high frequencies. In one of the embodiments, rapid charge and discharge of the gate-source capacitance of the power FET is obtained by connecting a transistor (Q-2, Figure 1C) between gate and source of the power FET. The transistor has a very low impedance when the power FET is turned off, and a very high impedance when the power FET is turned on (D4, column 4, lines 21 to 28). Another embodiment for enhancing turn-on speed is shown in Figure 7 of D4 where a transistor (Q-2) with reduced gate capacitance connects the gate of the power FET to the power supply terminal to which the drain is connected, to rapidly turn on the power FET. In each of these embodiments, said transistor (Q-2) is photovoltaically activated by a further diode array (D-V₂) and simultaneously controlled with the power FET (D4, column 4, lines 21 to 24; column 5, lines 12 to 24). A further possibility of enhancing the switching speeds is shown in Figure 8 of D4, where a pulse transformer (T-1) is used to supply charge and discharge pulses to the gate of the power FET in order to achieve very fast turn-on and turn-off times (D4, column 5, lines 37 to 65).

- 3.5 However, D4 does not suggest providing an amplifier stage interconnected between the optical coupling circuit and at least one IGBT power transistor, as now specified in claim 1, wherein the amplifier stage obtains its supply voltage via further circuitry (S1) and consists of two series connected transistors (T1, T2), the first of which having its collector terminal connected to a first output terminal of the further circuitry (S1), the base terminal connected to a first output terminal (94, 96) of the optical coupling circuit (78, 80), and the emitter connected to the

control electrode of the corresponding power transistor and the emitter of the second transistor (T2). This has the effect that the charging and discharging of the gate capacitance of the power transistor may be controlled by the pulse width modulated signal at the first output of the optical coupling circuit which is supplied to both bases of the series connected transistors and, via these transistors, to the gate of the respective power transistor. Complementary switching of these transistors makes it possible to rapidly charge and discharge the gate capacitance while maintaining a floating potential at the gate because it is connected to the further (S1) circuitry from which it obtains supply voltage. This is different in structure and function from the circuits of D4 where the gate of the power transistor is directly connected to the optical coupling circuit (D-V) and short-circuited by one of the transistors to either of the drain or source terminals, and thus to the power supply. Therefore, even a combination of the circuits of Figure 1C and 7 (which might be inferred from lines 25 to 29 of column 5 in D4) would not suggest a driving circuit for an IGBT-transistor as specified in the circuit for controlling the speed of claim 1.

3.6 D2 and D3 are less relevant than D4 because they do not disclose a transistor for connecting the gate of a power transistor to a power supply when the power transistor is turned on. Since none of the other documents cited in the search report hints at the subject-matter of claim 1, it has to be considered as involving an inventive step (Article 56 EPC).

3.7 This finding also applies to the subject-matter of claim 8 which specifies the same components in a

circuit for controlling the speed of a one-phase motor comprising a driving stage connected directly to mains. Claims 2 to 7 and 9 to 13 are dependent on claim 1 and claim 8, respectively and their subject-matter therefore involves an inventive step for the same reasons.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.
2. The case is remitted to the first instance with the order to grant a patent in the following version:

Claims: 1 to 13 as filed with the fax dated 27 September 2000;

Description: pages 1 to 20 as filed with the fax dated 27 September 2000 (page 2 as replaced with fax received "9:32"); and

Figures: sheets 1/8 to 8/8 as published with the International application.

The Registrar:

The Chairman:

M. Hörnell

W. J. L. Wheeler