

APPARATUS FOR CONTROLLING A THREE-PHASE
INVERTER SUPPLYING THE A.C. MOTOR OF A LIFT

The present invention concerns an apparatus for
5 controlling a three-phase inverter supplying the a.c.
motor of a lift.

The frequency-controlled a.c. motor is the most
advanced design, for instance for lift motor drives.
With frequency control the efficiency is high at all
10 motor speeds, and the mains power factor is nearly 1.
Frequency control is applicable in lifts with, as well
as without, gear transmission and at any speed. In
addition, a simple and moderately priced short-circuit
motor can be used. In lift use, an inverter implemented
15 with transistors is best suited for frequency control
since with transistors it is possible to achieve the
highest switching frequency, among present power
electronics components. Also the use of GTO thyristors
is possible since their switching times are approximately (
20 of equal length. However, mains current switching is
more complicated with GTO thyristors than with
transistors because of the required switching guards.

Experience has revealed that a good strategy
for controlling a short-circuit motor is to keep the
25 magnetic flux constant. The magnetic flux is in general
associated with slow response. If the magnetic flux

changes, a time constant is introduced in the system. Stabilizing the magnetic flux can be achieved by keeping constant the magnetic flux of the stator, rotor or air gap. It is most advantageous to keep the magnetic flux
5 of the stator constant since in this case the risk of saturation of the components of the magnetic circuit is least.

In present-day inverter technology, current feedback is employed for improving the curve shape,
10 in which the phase currents obtained from the inverter output are measured. A disadvantageous feature of current feedback is slow response. This is due to the fact that in current feedback the inductances of the motor give rise to time constants. The control
15 loop is usually the slower the greater the number of time constants. Moreover, current measuring elements are expensive because they are required to be able to measure direct current as well.

If in the inverter, pulse width modulation is
20 applied with a comparator, by comparing a sinusoidal and triangular voltage, without feedback, the current supplied to the motor by the inverter is not sufficiently sinusoidal, for instance for lift use, because in the rectified intermediate voltage circuit,
25 from which the three-phase a.c. voltage supplying the motor is obtained by rectification of the three-phase

mains, with the inverter, the voltage is not constant. Also, the semiconductor switch does not follow the control without experiencing a delay. A third factor causing error is the differential voltage which is
5 caused by the residual voltage across the power electronics component, compared with the voltage appearing with the other direction of current, when the diode in parallel with the semiconductor switch is conductive. In practice, these errors cause
10 vibration of the motor, which (for instance) in lift operation impairs the performance of the lift and causes discomfort to the passengers.

With the aid of the present invention it is possible to eliminate the above-mentioned drawbacks.
15 An apparatus in accordance with the present invention for controlling a three-phase inverter supplying an a.c. lift motor comprises a speed regulator for forming the frequency of the rotor current and the reference voltage frequency from the actual value and the
20 reference value of velocity, a curve family calculator for forming the amplitude of the reference voltages from the rotor current frequency and the frequency of the reference voltages, a three-phase oscillator for forming the reference voltages from the reference
25 voltage frequency and amplitude, and voltage regulators for forming the control voltages for the pulse width

modulators from the reference voltages and the actual value voltages obtained from the inverter output.

In an advantageous embodiment of the apparatus of the invention, the speed regulator comprises a
5 differential unit for forming the difference between the actual value and the velocity reference, a P controller and an I controller for controlling the difference between the actual velocity value and the reference value, a summing unit for combining the
10 output signals from the P controller and the I controller with the velocity reference value to form the rotor current frequency, and a summing unit for forming the reference voltage frequency from the rotor current frequency and the velocity reference value.

15 In another advantageous embodiment of the invention the curve family calculator comprises, for forming the amplitude of the reference voltages with the aid of a constant flux curve family representing the motor, with the exception of low frequencies of
20 the inverter reference voltages, a summing unit for combining a correction component proportional to the rotor current frequency with the frequency of the reference voltages, an absolute value amplifier for forming the absolute value of the amplitude in the
25 case of negative reference voltage frequencies, and a control unit for controlling the correction component

dependent on the rotor current frequency, for the purpose of approximating the non-linear portion at said low frequencies with a horizontal portion, a summing unit for forming the horizontal part

5 approximating the minimum of the curve at positive reference voltage frequencies, a summing unit for adding the minimum value of the basic curve to the amplitude value obtained from the summing unit at negative reference voltage frequencies, a control

10 unit for controlling the correction component dependent on the rotor current frequency, and a control unit for controlling the minimum value of the basic curve and, for forming the amplitude in different parts of the curve, diodes and a diode threshold error correcting

15 circuit.

Advantageously, the three-phase oscillator comprises an absolute value unit for forming the absolute value of the reference voltage frequency, a voltage-controlled oscillator for producing a square

20 wave having a frequency proportional to the frequency of the reference voltages, memory circuits for storing the curve shape of each reference voltage, digital/analog converters for transforming the reference voltages presented in digital form into analog voltages,

25 an up-and-down counter for forming the address of the memory circuits, and a comparator for detecting the

sign of the frequency of the reference voltages and thereby the direction of rotation of the motor.

In an advantageous embodiment of the invention, each voltage regulator comprises an actual value
5 voltage forming circuit for forming the actual value voltage from the voltage measured at the inverter output, and an actual value forming circuit for forming the control voltage of the pulse width modulator from the actual value voltage and the
10 reference voltage.

In another advantageous embodiment of the invention, the actual value voltage forming circuit comprises a summing unit combining the positive and negative voltages of a pulsating d.c. voltage
15 obtained by full-wave rectification from the three-phase mains voltage, and with a summing unit combining the voltage measured at the inverter output with the a.c. voltage obtained as described.

Advantageously, the control voltage forming
20 circuit comprises a differential unit comparing the actual value voltage and the reference voltage, with an amplifier integrating said difference, and with a summing unit enabling the differential thus obtained to be superimposed on the reference value to become
25 a control voltage taking into account the momentary state of the a.c. motor.

An advantageous embodiment of the apparatus of the invention is also characterised in that each driver comprises a delay circuit to account for the switching delay of the semiconductor switch, and a semiconductor switch driver circuit provided with an optoisolator.

An advantageous embodiment of the apparatus of the invention is also characterised in that the inverter is a transistor inverter in which the controlled semiconductor switches in the power stage are transistors.

10 An advantageous embodiment of the apparatus of the invention is also characterised in that the inverter is a GTO thyristor inverter in which the controlled semiconductor switches in the power stage are GTO thyristors.

15 The speed regulator is fast, owing to the integrating controller. This is indispensable in lift applications because no velocity error can be tolerated. The curve family calculator approximately implements the constant stator flux characteristic curves for the
20 given stator flux, yet the accuracy is adequate for lift driving. Moreover, the job of tuning the curve family calculator of the invention is easier than the corresponding task in the case of a calculator which would implement the given curves exactly. Instead of
25 the three-phase oscillator, servo-technology, for example, may be used in the reference voltage forming

process. However, motor drive component tests and research are easier to perform with the aid of said oscillator.

Since in the control of the inverter, voltage
5 regulators instead of current regulators are employed, control is faster because voltage regulators are free from delay caused by inductive phenomena. Moreover, the use of expensive current-measuring components in the inverter output is avoided. The isolation of the
10 inverter's power stage with the aid of an optoisolator efficiently prevents the access of interference from the main current path to the control circuits.

The invention is described further hereinafter, by way of example only, with reference to the
15 accompanying drawings, in which:-

Fig. 1 shows a lift drive in which an a.c. motor is supplied by a frequency converter;

Fig. 2 is a circuit diagram of one embodiment of a speed regulator in accordance with the present
20 invention;

Figs. 3a-3c illustrate the operation and design of a curve family calculator of the invention;

Fig. 4 shows a three-phase oscillator for an apparatus in accordance with the invention;

25 Figs. 5a-5b illustrate the operation and structure of a voltage regulator in accordance with

the invention; and

Fig. 6 shows a semiconductor switch driver for an apparatus in accordance with the invention.

In the following, the operation of an apparatus
5 of the invention is described by examining the lift
drive depicted in Fig. 1, in which an a.c. motor 10
is supplied by a frequency converter. The three-phase
voltage supplying a power stage 8 of the frequency
converter, the phase voltages of which are UR, US,
10 and UT, is rectified with a rectifier 16 comprising
a number of diodes, to become the d.c. voltage of an
intermediate voltage circuit. The d.c. voltage of the
intermediate voltage circuit is filtered using a
capacitor C1. The power stage 17 comprises transistors
15 T1 to T6 and diodes D1 to D6 which rectify the d.c.
voltage of the intermediate circuit to become an a.c.
voltage supplying the a.c. motor 10, the phase voltages
of which are UA, UB and UC. The diodes D1 to D6 are
zero diodes constituting current paths for inductive
20 currents.

The a.c. motor 10 drives with the aid of a shaft
12 the traction sheave 13 moving the counterweight 14
and the lift car 15 with the aid of lifting ropes. For
the return energy, in this instance a braking resistor
25 R1 and a braking transistor T7 have been provided.
The control of the braking transistor T7 is not dealt

with in this connection since it is an independent unit which operates when the d.c. voltage of the intermediate circuit rises over a preset limit.

The power stage 17 of the inverter is controlled
5 by the apparatus of the invention, comprising a control electronics unit 1, a tachometer generator 11, pulse width modulators 6a to 6c, voltage-measuring elements 9a to 9c, a speed regulator 2, a curve family calculator 3, a three-phase oscillator 4, voltage regulators 5a to
10 5c, and drivers 7a to 7f for the semiconductor switches of the inverter power stage 17. The inputs of the speed regulator 2 are the actual value v of the speed of rotation of the motor and a velocity reference value v^* obtained from the control electronics unit 1. The
15 operation of the control electronics unit 1 for forming the velocity reference value v^* represents technology with which a person skilled in the art is familiar. The outputs of the speed regulator 2 are the frequency f_s of the reference voltages and the frequency f_r of
20 the rotor current. The frequency f_s of the reference voltages and the frequency f_r of the rotor current are inputs for the curve family calculator 3, in which the amplitude A_s of the reference voltages is formed.

The frequency f_s of the reference voltages is,
25 in addition to the amplitude A_s , also carried to the three-phase oscillator 4, where the reference voltages

Va*, Vb* and Vc* of the three phases are formed. From the reference voltages Va*, Vb* and Vc* and from the voltages Va, Vb, and Vc measured as feedback quantities at the voltage-measuring elements 9a, 9b, and 9c, the control voltages Va', Vb' and Vc' for the pulse width modulators 6a, 6b and 6c are obtained in the voltage regulators 5a, 5b and 5c.

From the pulse width modulators 6a, 6b and 6c are obtained the input signals A1, B1 and C1 of the transistor drivers 7a, 7c and 7e provided with optoisolators and floating power sources, as well as the control signals A2, B2, and C2 for the driver 7b, 7d and 7f of the second transistor in each transistor phase, said control signals being the complementary signals to the control signals A1, B1 and C1. For instance, with the aid of a comparator the control signal A2 is obtained as the complementary signal to the control signal A1, e.g. with the aid of a comparator. The design of the pulse width modulators 6a to 6c represents technology well familiar to a person skilled in the art, and their operation will not be described in detail. The transistor drivers 7a to 7f drive the transistors T1 to T6 in the power stage of the inverter.

In the following, the apparatus of the invention is described in more detail. The main characteristic

features of the speed regulator 2 are shown in Fig. 2. The difference between the velocity reference value v^* and the actual velocity value v is calculated in the differential unit 18. The differential signal is supplied to the inputs of the P (proportional) controller 19, and the inputs of the I (integrating) controller 20. Before supplying it to the I controller 20 the level of the differential signal is adjusted to be appropriate, using a potentiometer TM1. An electronic switch S1 is needed in order that the I controller 20 can be set to its initial value when the lift starts. The output signal of the P controller 19 is adjusted with the potentiometer TM2. The I and P control components are combined with the velocity reference v^* , in the summing unit 21, which from the sum of said terms forms the frequency f_r of the rotor current. Since it is generally valid that the frequency of the stator voltage is obtained by combining the product of the motor's rpm and the number of pole pairs with the frequency of the rotor current, the frequency f_s of the reference voltages is obtained in the summing unit 22 by combining the actual velocity value v with the frequency f_r of the rotor current.

The method of the invention for forming the amplitude A_s of the inverter's reference voltages is next explained by examining, to begin with, the constant

flux curve family describing the short-circuit motor, shown in Fig. 3a. The curve family of Fig. 3a represents the amplitude A_s of the stator voltage of the motor, i.e. the amplitude A_s of the inverter's reference voltages, as a function of the frequency f_s of the stator voltage of the motor, i.e. the inverter's reference voltages, at different rotor current frequencies f_{r0} to f_{r4} when the magnetic flux of the stator is constant. At the value zero of the rotor current frequency f_r the basic curve f_{r0} is obtained, its minimum being the minimum value of the amplitude of the control voltages. The substantially U-shaped curves of the curve family are composed of linear parts constituted by the high positive and negative reference voltage frequencies, and of non-linear parts relating to low positive and negative frequencies f_s .

The curve family calculator of the invention calculates the amplitude A_s of the inverter reference voltages using the linear approximation of the constant curve family shown in Fig. 3b. In Fig. 3b, the curve 0 is the approximation of the basic curve f_{r0} of Fig. 3a. The minimum of the curve 0 is K_0 . This amplitude A_s applies when the rotor current frequency f_r is zero. When the horizontal axis is interpreted so that negative frequencies f_s of the reference voltages correspond

to the other direction of rotation, then in order for the voltage to also be correct with negative frequencies f_s the absolute value of the straight line must be taken.

If to the curve 0 is added a correction component K_1

5 proportional to the frequency f_r of the rotor current and the absolute value is taken therefrom, the approximate value is obtained for the curve family in Fig. 3a, with the exception of low reference voltage frequencies f_s .

10 At low reference voltage frequencies f_s , the bottom height of the curves is proportional to the frequency f_r of the rotor current augmented by the minimum value K_0 of the basic curve. The entire approximate curve i is obtained by combining the curve
15 of frequencies f_s of reference voltages with a high absolute value, with the curve of low frequencies f_s of the reference voltages.

Fig. 3c shows the curve family calculator accomplishing the linear approximation of the constant
20 flux curve family as shown in Fig. 3b. The inputs are the frequency f_s of the stator voltages of the motor, i.e. of the inverter reference voltages, and the rotor current frequency f_r . At frequencies f_s of reference voltages with a high absolute value, the amplitude
25 As of the reference voltages is obtained by combining the frequency f_s of the reference voltages with the

correction component K_1 obtained from the rotor current frequency f_r , and which can be regulated by a trimmer TM_3 in the summing unit 23. The amplitude of the reference voltages thus obtained is carried, in the
5 case of positive reference voltage frequencies f_s , to diode D_7 and to the diode threshold error correcting circuit 27, from the output of which the amplitude A_s is obtained. Thereafter, the amplitude A_s is carried to the three-phase oscillator 4, where the inverter
10 reference voltages can be formed. The diode threshold error correcting circuit 27 comprises an amplifier 28, a diode D_{11} and a resistor R_2 . At negative reference voltage frequencies f_s , the amplitude is first carried to the absolute value amplifier 24, in which the
15 negative amplitude becomes positive, and thereafter through the diode D_8 to the diode threshold error correcting circuit 27.

At low reference voltage frequencies f_s , the amplitude A_s of the reference voltages is formed by
20 carrying the correction component K_2 , formed from the rotor current frequency f_r , first to a summing unit 25 in order to combine the correction component K_2 with the minimum value K_0 of the basic curve. At positive values of the rotor current frequencies f_r , an amplitude
25 is obtained from the amplifier which is composed of the sum of the correction component K_2 and the minimum

value K_0 , as shown in Fig. 3b. The amplitude A_s is carried through the diode D9 to the diode threshold error correcting circuit 27. At negative values of the rotor current frequency f_r , the quantity obtained from the summing unit 25 is once again combined with the minimum value K_0 of the basic curve, in the summing unit 26, the amplitude obtained from this being carried to the correcting circuit 27 through the diode D10 for forming the amplitude A_s . The correction component K_2 produced from the rotor current frequency f_r can be adjusted by means of a trimmer TM4. The minimum K_0 of the basic curve can be adjusted by a trimmer TM5.

Fig. 4 shows a modern design for implementing the three-phase oscillator. Input quantities are the frequency f_s of the reference voltages and the amplitude A_s . In an absolute value unit 29, the absolute value of the frequency f_s of the reference voltages is formed, which thereafter is supplied to a voltage-controlled oscillator 30. The output of this oscillator is a square wave of which the frequency corresponds to the frequency f_s of the reference voltages. The parallel-mode output of the up-and-down counter 33, of which the counting direction is determined by the comparator 34, and which uses for input the square wave from the oscillator 30, is used as an address for three memories 31a to 31c. The

comparator 34 detects the sign of the frequency f_s of the reference voltages and thereby the direction of rotation of the motor which is being controlled. In the memory circuits 31a to 31c is stored the curve shape
5 of each reference voltage with 120-degree phase differences, and hereby is obtained a symmetric, digitally encoded three-phase system at the outputs of the memories 31a to 31c. The digital words are carried to three identical digital/analog converters
10 32a to 32c with the purpose of producing respective analog reference voltages V_a^* , V_b^* and V_c^* . Control of the amplitude of the voltages V_a^* , V_b^* and V_c^* is expediently accomplished at this stage through the reference inputs of the digital/analog converters
15 32a to 32c with the aid of the amplitude instruction As coming from the curve family calculator 3. The end results are thus three amplitude and phase-controlled analog reference voltages V_a^* , V_b^* and V_c^* , which constitute a symmetrical three-phase system.

20 Figs. 5a and 5b illustrate the operation and structure of the sophisticated voltage regulator operating according to the principle of superposition. The regulator of Fig. 5a is applicable in controlling the control voltage of one phase going to the pulse
25 width modulator in the inverter control apparatus of the invention. In the following, the operation of the

voltage regulator of the invention is examined with the aid of Figs. 5a and 5b, in the phase A. The inputs of the voltage regulator are the voltage V_a , measured at the inverter output with the measuring element 9a, obtained as feedback, and the reference voltage V_a^* . The voltage regulator comprises an actual value voltage forming circuit 35 and a circuit 36 forming the control voltage V_a' for the pulse width modulator. In the actual value voltage forming circuit 35, the summing unit 37 forms the synthetic zero level voltage V_0 of Fig. 5b. The synthetic zero level voltage V_0 , which has a frequency three times the basic frequency, is obtained by combining the positive voltage pU_1 and the negative voltage nU_1 of the pulsating d.c. voltage across the capacitor C_1 , which has been obtained by full-wave rectification with the rectifier 16, to become the a.c. voltage V_0 . In the summing unit 38, the synthetic zero level a.c. voltage V_0 is combined with the actual value voltage V_a measured at the inverter output.

In the pulse width modulator control forming circuit 36, the differential unit 39 forms the difference between the actual value voltage and the reference voltage V_a^* , this difference being controlled with the integrating amplifier 40. The gain of the amplifier 40 can be changed with the aid of a trimmer TM_6 .

In the summing unit 41, the reference voltage V_a^* and the correction component formed from the difference between the reference voltage V_a^* and the actual value voltage are combined to constitute the control voltage
5 V_a' of the pulse width modulator 6a. The differential unit 39 comprises a summing circuit with one of its two inputs negative. The operation of the voltage regulators 5b and 5c in the other phases is similar to the operation of the voltage regulator 5a in phase A.

10 It is necessary in this context to take into consideration the effect of storage time. That is, when from a transistor carrying current the base current is removed, the transistor will conduct for about another twenty microseconds. During that time the transistor
15 operating as its pair must not be opened as a short-circuit would otherwise ensue. The transistor stops conducting only after the base charge has dissipated. The transistor driver in the power stage, depicted in Fig. 6, consists of a delay circuit 42 and the driver
20 circuit proper 43. The asymmetric delay in the transistor control is achieved with the aid of a hysteresis gate 44, to make sure that the other transistor T2 of the transistor terminal will not start to conduct before the transistor T1 has ceased
25 conducting. The switching delay is determined by the product of resistor R3 and capacitor C2. The diode D12

is required in order that switch-off might occur without delay. The input signal A is one of the driver input signals A1, A2, B1, B2, C1, or C2.

The driver circuit 43 has two floating power
5 supplies. The negative supply is needed to provide a powerful negative base current to speed up the switching-off of the transistors in the power stage 17 of the inverter. These two floating voltages are produced using rectifying diodes D13 to D20 and filtering
10 capacitors C3 and C4. The power supply of the driver circuit 43 is a high-frequency chopper current source 45, the secondary of its transformer TR1 having a sufficient number of windings to cater for all floating current sources required. Energy is supplied from the
15 transformer TR1. An optoisolator 46 supplies the end transistors T8 and T9 of the driver by means of resistor R4. These transistors constitute a dual-emitter follower circuit.

The diode D21 is a so-called Baker diode. It
20 prevents the power transistor proper from becoming saturated. This reduces and stabilizes the storage time. Furthermore, the switch-off power of the transistor will be less owing to said diode. The resistor R4 is needed for the Baker diode D21 to operate
25 properly. The point O/E is the ground of the oscillator electronics. The diode D22 is the

protective diode for the optoisolator 46. The output signals of the driver are thus obtained, for instance, the signals C, B and E driving the transistor T1.

It is obvious to a person skilled in the art that
5 different embodiments of the invention are not
exclusively confined to the above example but may vary
within the scope of the claims stated below. In
addition to a transistor inverter implemented with
transistors, the apparatus of the invention may also
10 be used in a GTO thyristor inverter implemented using
GTO thyristors.

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CLAIMS

1. An apparatus for controlling a three-phase inverter supplying the a.c. motor of a lift, the power stage of the inverter incorporating semiconductor switches, said apparatus comprising an electronic control unit for producing a velocity reference value, a tachometer generator for producing an actual velocity value, voltage measuring elements for measuring phase voltages at the inverter output, pulse width modulators and controllers for controlling the semiconductor switches in the inverter's power stage using control signals obtained from the pulse width modulators, a speed regulator for forming the frequency of the rotor current and the frequency of the reference input voltages from said actual velocity value and from said velocity reference value, a curve family calculator for forming the amplitude of the reference voltages from the rotor current frequency and from the frequency of the reference voltages, a three-phase oscillator for forming the reference voltages from the frequency and amplitude of the reference voltages, and voltage regulators for producing control voltages for the pulse width modulators from the reference voltages and from the actual value voltages obtained from the inverter output.

2. Apparatus as claimed in claim 1, wherein the



speed regulator is a differential unit for forming the difference between the actual velocity value and the velocity reference value, a P controller and an I controller for controlling the difference between the
5 actual velocity value and the velocity reference value, a summing unit for combining the output signals of the P controller and the I controller with the velocity reference value in order to produce the rotor current frequency, and a summing unit for producing the
10 frequency of the reference voltages from the rotor current frequency and the actual velocity value.

3. Apparatus as claimed in claim 1 or 2, wherein the curve family calculator comprises, for producing the amplitude of the reference voltages with the aid
15 of a constant flux curve family representing the motor, except at low frequencies of the inverter's reference voltages, a summing unit for combining a correction component proportional to the rotor current frequency with the frequency of the reference voltages, an
20 absolute value amplifier for producing the absolute value of the amplitude at negative frequencies of the reference voltages, and a control member for adjusting the correction component dependent on the rotor current frequency for approximately the non-linear portion at
25 said low frequencies by a horizontal linear section, a summing unit for producing the horizontal part



approximating the minimum of the curve at positive frequencies of the reference voltages, a summing unit for adding the minimum value of the basic curve to the amplitude value obtained from the summing unit at
5 negative frequencies of the reference voltages, a control member for adjusting the correction component dependent on the rotor current frequency, and a control member for adjusting the minimum value of the basic curve, and for producing the amplitude in different parts of the
10 curve, and a diode threshold error correcting circuit.

4. Apparatus as claimed in any of the preceding claims, wherein the three-phase oscillator comprises an absolute value unit for producing the absolute value of the frequency of the reference voltages, a voltage-
15 controlled oscillator for producing a square wave proportional to the frequency of the reference voltages, memory circuits for storing the curve shape of each reference voltage, digital/analog converters for converting the reference voltages in digital form to
20 analog voltages, an up/down counter for producing the address of the memory circuits, and a comparator for detecting the sign of the frequency of the reference voltages, and thereby the direction of rotation of the motor.

25 5. Apparatus as claimed in any of the preceding claims, wherein each voltage regulator comprises an



actual value voltage forming circuit for forming the actual value voltage from the voltage measured at the inverter output, and a control voltage forming circuit for forming the control voltage for the pulse width
5 modulator from the actual value voltage and the reference voltage.

6. Apparatus as claimed in claim 5, wherein the actual value voltage forming circuit comprises a summing unit combining the positive voltage and the
10 negative voltage of a pulsating d.c. voltage obtained by full-wave rectification of a three-phase voltage, and a summing unit adding the voltage measured at the inverter output to the a.c. voltage thus obtained.

7. Apparatus as claimed in claim 5, wherein
15 the control voltage forming circuit comprises a differential unit comparing the actual value voltage with the reference voltage, an amplifier integrating said difference, and a summing unit from which the differential quantity thus obtained can be superimposed
20 on the reference value to become a control voltage taking into account the momentary state of the a.c. motor.

8. Apparatus as claimed in any of the preceding claims, wherein each driver comprises a delay circuit
25 implemented, and a semiconductor switch driver circuit provided with an optoisolator.



9. Apparatus as claimed in any of the preceding claims, wherein the inverter is a transistor inverter in which the controlled semiconductor switches in the power stage are transistors.

5 10. Apparatus as claimed in claim 1, 2, 3, 4, 5, 6, 7 or 8, wherein the inverter is a GTO thyristor inverter in which the controlled semiconductor switches in the power stage are GTO thyristors.

11. An apparatus for controlling a three-phase
10 inverter substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

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