

(12) PATENT
(19) AUSTRALIAN PATENT OFFICE

(11) Application No. AU 199720444 B2
(10) Patent No. 708498

(54) Title
Pwm converter control apparatus

(51)⁶ International Patent Classification(s)
B60L 009/24 H02M 007/162
H02M 007/155 H02M 007/17

(21) Application No: **199720444**

(22) Application Date: **1997.03.31**

(87) WIPO No: **WO98/43848**

(43) Publication Date : **1998.10.22**

(43) Publication Journal Date : **1998.12.10**

(44) Accepted Journal Date : **1999.08.05**

(71) Applicant(s)
Mitsubishi Denki Kabushiki Kaisha

(72) Inventor(s)
Noriaki Nakamoto

(74) Agent/Attorney
GRIFFITH HACK,GPO Box 4164,SYDNEY NSW 2001

(56) Related Art
JP 07-274517
JP 06-351106

PC

OPI DATE 22/10/98 APPLN. ID 20444/97
 AOJP DATE 10/12/98 PCT NUMBER PCT/JP97/01112



AU9720444

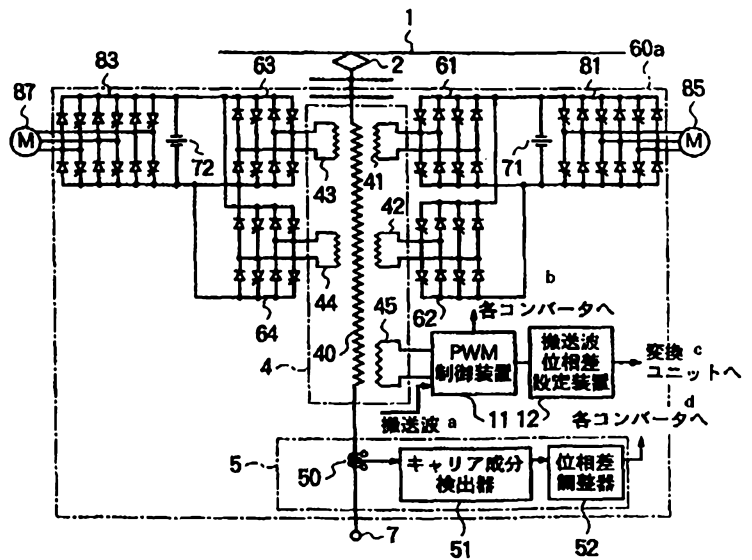
<p>(51) 国際特許分類6 B60L 9/24, H02M 7/155, 7/162, 7/17.</p>	<p>A1</p>	<p>(11) 国際公開番号 WO98/43848</p> <p>(43) 国際公開日 1998年10月8日(08.10.98)</p>
<p>(21) 国際出願番号 PCT/JP97/01112</p> <p>(22) 国際出願日 1997年3月31日(31.03.97)</p> <p>(71) 出願人 三菱電機株式会社 (MITSUBISHI DENKI KABUSHIKI KAISHA)[JP/JP] 〒100 東京都千代田区丸の内二丁目2番3号 Tokyo, (JP)</p> <p>(72) 発明者 中本紀明(NAKAMOTO, Noriaki) 〒100 東京都千代田区丸の内二丁目2番3号 三菱電機株式会社内 Tokyo, (JP)</p> <p>(74) 代理人 弁理士 曾我道照, 外(SOGA, Michiteru et al.) 〒100 東京都千代田区丸の内三丁目1番1号 国際ビルディング8階 曾我特許事務所 Tokyo, (JP)</p>	<p>(81) 指定国 AU, CN, JP, KR, 欧州特許 (FR, GB).</p> <p>添付公開書類 国際調査報告書</p>	

(54)Title: **PWM CONVERTER CONTROL APPARATUS**

(54)発明の名称 **PWMコンバータの制御装置**

(57) Abstract

A PWM converter control apparatus is capable of simply reducing the higher harmonics of an electric rolling stock formation unit without strictly setting the zero-phase detection tolerance of a reference signal. The control apparatus is adapted to detect components which are n-times as many as the carrier frequency components of a primary current, and a phase is finely regulated with respect to a pre-designated phase difference so that the phase difference of each converter unit is at a level not lower than a desired level, whereby a phase shift due to a difference in the accuracy of detecting the reference frequency of each converter and a difference in the delay of on-off switching actions is corrected. This enables an ideal phase difference operation to be attained.



- a...CARRIER WAVE
- b,d...TO EACH CONVERTER
- c...TO CONVERSION UNIT
- 11...PWM CONTROL UNIT
- 12...CARRIER WAVE PHASE DIFFERENCE SETTING UNIT
- 51...CARRIER COMPONENT DETECTOR
- 52...PHASE DIFFERENCE REGULATOR

DESCRIPTION**TITLE OF THE INVENTION****CONTROL APPARATUS FOR PWM CONVERTER****Technical Field**

The present invention relates to a control apparatus for a PWM converter for controlling the operation of a plurality of converter units each comprising a plurality of PWM (pulse width modulation control) converter to control a plurality of electric car loads mounted on electric cars of the same formation.

Background Art

FIG. 9 shows an application of a control apparatus for a conventional PWM converter described for example in Japanese Patent Laid-Open No. 7-274517. In FIG. 9, a plurality of pantographs 2 for feeding a current to an electric car are connected to a single-phase current power supply line 1, and converter units 60a to 60d serving as PWM converters in the electric cars of the same formation are connected in parallel to the pantographs 2 through a high-voltage straight pull 3 in the electric cars. Each of the respective converter units 60a to 60d comprises one primary winding 40 connected to the single-phase current power supply line 1 through the high-voltage straight pull 3 and the pantograph 2, a plurality of secondary windings 41 to 44, a transformer 4 having one ternary winding 45, a plurality of converters 61 to 64 independently connected to the secondary windings 41 to 44 of the transformer 4, a PWM controller 11 connected to the ternary winding 45 of the transformer 4, and a carrier phase difference setting unit 12 connected to the output side of the PWM controller 11.

In the respective converter units 60a to 60d, the carrier phase difference setting units 12 set phase differences of 0, $\pi/8$, $2\pi/8$, and $3\pi/8$ with respect to a reference phase detected from the ternary winding 45 of the transformer 4.

5 The operation of the prior art will be described below. Currents from the secondary windings 41 to 44 of the transformer 4 are switched at offset timings to reduce a harmonic wave. In the formation of electric cars, phase differences of $\pi/2n$ are given to respective carrier waves
10 among the converter units 60a to 60d, so that harmonic currents generated by the converter units 60a to 60d are cancelled.

 However, in the conventional device described above, in order to perform a phase-difference operation as
15 described above, phase differences predetermined depending on the number of converter units 60a to 60d must be set, and the precision of zero-phase (zero-cross) detection of the voltage, serving as a reference signal, of the ternary winding 45 must be high in each of the converter units 60a
20 to 60d. For this reason, if the tolerance of zero-cross detection of the reference signal is not very severely set for each of the converter units 60a to 60d, it is difficult to ideally reduce a harmonic wave.

25 Summary of the Invention

 It is preferably an advantage of the present invention to provide a control apparatus for a PWM converter which can easily reduce a harmonic wave for each formation of electric cars without making the tolerance of zero-phase
30 (zero-cross) detection of a reference signal severe.

 According to one aspect of the present invention, there is provided a control apparatus for a PWM converter including a plurality of converter units for converting an AC power into a DC power to supply the DC power to a

plurality of electric car loads, wherein each of the converter units comprises: a plurality of converters for converting an AC power into a DC power; PWM control means for performing pulse width modulation control to the converters by using a reference signal and carrier waves; carrier phase difference setting means for offsetting phases of carrier waves supplied to the converters with respect to each other and setting desired phase differences between carrier waves supplied to the converter units; and phase difference adjusting means for adjusting the phase differences of the converters such that a carrier frequency of a primary current component of an AC power supply is set at a desired value when the carrier phase difference setting means does not perform a phase difference setting operation.

Preferably, the phase difference adjusting means of the converter units set phase differences of the converters such that the carrier frequency of the primary current component of the AC power supply becomes maximum.

According to another aspect of the present invention, there is provided a control apparatus for a PWM converter including a plurality of converter units for converting an AC power of an AC power supply into a DC current to supply the DC power to a plurality of electric car loads, wherein each of the converter units comprises: a transformer, mounted on an electric car of the same formation and having a primary winding, a plurality of secondary windings, and a ternary winding connected to the AC power supply, for transforming the AC voltage of the AC power supply; a plurality of converters, respectively connected to the secondary windings of the transformer, for converting an AC power into a DC power; PWM control means, connected to the ternary winding of the transformer, for performing pulse width modulation control to the converters by using a reference signal and carrier waves; carrier phase

difference setting means for offsetting phases of carrier waves supplied to the converters in the same conversion unit with respect to each other and setting desired phase differences between carrier waves supplied to the converter units; and phase difference adjusting means for adjusting the phase differences of the converters such that a carrier frequency of a primary current component of an AC power supply is set at a desired value when the carrier phase difference setting means does not perform a phase difference setting operation.

Preferably, the phase difference adjusting means of the converter units set the phase differences of the converters such that the carrier frequency of a total sum of primary currents flowing in the primary windings of the transformers becomes a desired value.

Preferably, the phase difference adjusting means of the converter units set phase differences of the converters such that the carrier frequencies of primary currents flowing in the primary windings of the transformers become maximum.

Preferably, the phase difference adjusting means of the conversion units set the phase differences of the converters such that a carrier frequency of a total sum of ternary winding voltages of the transformers becomes a desired voltage.

Preferably, the phase difference adjusting means of the converter units set the phase differences of the converters such that carrier frequencies of ternary winding voltages of the transformers become maximum.

Preferably, the phase difference adjusting means of each of the converter units comprises: a carrier component detector for detecting a carrier frequency of a primary current flowing in the primary winding of the corresponding transformer; and a phase difference adjuster for setting

phase differences of the converters such that the carrier frequency of the primary current becomes a desired value.

Features and advantages of the present invention will become apparent from the following description of an embodiment thereof, by way of example only, with reference to the accompanying drawings.

Brief Description of Drawings

FIG. 1 is a view showing the arrangement of the outline of a control apparatus for a PWM converter according to an embodiment of the present invention.

FIG. 2 is a detailed circuit diagram of the control apparatus.

FIG. 3 is a block diagram showing the arrangement of a carrier phase difference setting device in FIG. 2.

FIG. 4 is a graph showing an example of a primary current waveform of the PWM converter.

FIG. 5 is a waveform chart of a secondary winding current of the PWM converter when superposed current waveforms have the same phase.

FIG. 6 is a waveform chart of a secondary winding current of the PWM converter when superposed current waveforms have phases which are offset from each other.

FIG. 7 is a waveform chart of a secondary winding current of the PWM converter when superposed current waveforms have phases which are offset from each other.

FIG. 8 is a waveform chart obtained when the phases of

carrier waves according to the embodiment of the present invention are offset from each other.

FIG. 9 is a view showing the arrangement of the outline of a control apparatus for a conventional PWM converter.

Best Mode for Carrying Out the Invention

The present invention will be described in detail with reference to the accompanying drawings. The same reference numerals as in the prior art in FIG. 9 denote the same parts in embodiments of the present invention to be described below.

Embodiment 1

FIG. 1 shows the arrangement of the outline of a control apparatus for a PWM converter according to Embodiment 1 of the present invention. Referring to FIG. 1, a plurality of converter units 60a to 60d are connected to an AC line 1 through a pantograph 2 and a high-voltage straight pull 3. Each of the converter units 60a to 60d comprises one transformer 4, a phase difference adjusting means 5, a PWM control device 11, a carrier phase difference setting device 12, a plurality of converters 61 to 64, and inverters 81 and 83.

The transformer 4 has a primary winding 40 connected to the AC line 1 through the pantograph 2 and the high-voltage straight pull 3, a plurality of secondary windings 41 to 44, and a ternary winding 45. The secondary windings 41 to 44 of the transformer 4 are connected to the converters 61 to 64, respectively. The output sides of the converters 61 and 62 are connected to an inverter 85, and the output sides of the converters 61 to 64 are connected to an inverter 87.

AC outputs from the secondary windings 41 and 42 of the transformer 4 are converted into DC currents by the

converters 61 and 62 and superposed each other. The superposed current is converted into a three-phase AC current by the inverter 81. Loads such as AC motors 85 and the like are driven by the three-phase AC current serving as a power supply. Similarly, AC outputs from the secondary windings 43 and 44 of the transformer 4 are converted into DC currents by the converters 63 and 64 and superposed each other. The superposed current is converted into a three-phase AC current by the inverter 83. Loads such as AC motor 87 and the like are driven by the three-phase AC current serving as a power supply to move electric cars.

The phase difference adjusting means 5 comprises a current detector 50 connected to the primary winding 40 of the transformer 4, a carrier frequency component detector 51, connected to the output side of the primary current detector 50, for detecting the carrier frequency component of a primary current, and a phase difference adjuster 52, connected to the carrier frequency component detector 51, for adjusting the phase of the carrier frequency component to supply the carrier frequency component to the converters 61 to 64. The phase difference adjuster 52 adjusts phase differences between carrier frequencies supplied to the converters 61 to 64 in the same converter unit.

The PWM control device 11 is connected to the ternary winding 45 of the transformer 4, and a carrier wave 32 shown in FIG. 4 is input to the PWM control device 11. By comparing the carrier wave 32 with a reference signal 31 from the ternary winding 45, the ON/OFF timings of the thyristers of the converters 61 to 64 are controlled. Reference numeral 7 denotes a wheel of the electric car.

FIG. 2 shows a detailed electric circuit arrangement of each conversion unit. In FIG. 2, each of the converters 61 to 64 is constituted by a single-phase converter comprising

a plurality of power semiconductor devices, e.g., a plurality of thyristers and diodes, for converting an AC current into a DC current. Inverters 81 and 83 are constituted by variable-voltage/variable-frequency inverters, comprising a plurality of power semiconductor devices, e.g., a plurality of thyristers and diodes, for converting a DC current into an AC current to supply the AC current to the motors 85 and 87, respectively. The converters 61 and 62 are connected to the inverter 81 through a smoothing capacitor 71, and the converters 63 and 64 are connected to the inverter 83 through a smoothing capacitor 72.

FIG. 3 is a block diagram showing the arrangement of the carrier phase difference setting unit 12. This carrier phase difference setting device 12 is constituted by a measuring transformer 14, a synchronous power supply 15, a zero-cross comparator 16, a one-shot circuit 17, a register 18, a counter 19, an oscillator (OSC) 20, and a pattern ROM 23.

The synchronous power supply 15 lowers a ternary voltage of the ternary winding 45 of the transformer 4 and extracts a fundamental wave component (sine wave). The zero-cross comparator 16 detects the zero point (point where the sine wave changes from negative to positive) of the fundamental component extracted by the synchronous power supply 15, and outputs a pulse when the zero point is detected. The one-shot circuit 17 inputs a one-shot pulse to the counter 19 each time the pulse from the zero-cross comparator 16 is input to the one-shot circuit 17.

The register 18 stores initial phase data in advance, and outputs initial phase data depending on an initial phase input command input by an input means (not shown). When the four converters 61 to 64 exist in one converter unit as

shown in FIG. 2, for example, the phase angles θ of carrier waves of the converters 61 to 64 are set at 0° , 90° , 22.5° , and 112.5° , respectively. In this case, the phase difference between the converters 61 and 62 is 90° , and the phase difference between the converters 63 and 64 is 90° . When the phase difference is set at 90° as described above, a harmonic component having a frequency twice the carrier wave frequency can be removed. This is because an amount of a harmonic component of a high order is lower than that of a low order. When the phase difference is set at 90° , a harmonic wave of a low order can be removed.

When the counter 19 receives a pulse from the one-shot circuit 17, the counter 19 receives initial phase data from the register 18. By using the phase data as an initial phase, the counter 19 increments phase angle data each time a signal from the oscillator 20 is input to the counter 19.

An addressed carrier digital data is stored in the pattern ROM 23. The oscillator 20 sets the address of the pattern ROM 23. The pattern ROM 23 sets a pre-stored carrier wave according to the address set by the oscillator 20.

In this manner, by designating the address of the phase angle data of the counter 19, predetermined carrier digital data stored in the pattern ROM 23 is output. Since the carrier phase difference setting device 12 shown in FIG. 3 and described above is arranged in each converter unit, the phases of carrier waves for the converter units can be set by inputting an initial phase command to the register 18.

In the control apparatus for a PWM converter arranged as described above, for example, when the motors 85 and 87 are powered, an AC voltage from the AC line 1 is collected through a pantograph 21, and the corrected AC voltage is lowered and insulated by the transformer 4, and rectified

and boosted by the converters 61 to 64, and then smoothed by the smoothing capacitors 71 and 72. The powers smoothed by the smoothing capacitors 71 and 72 are converted into three-phase AC currents by the inverters 81 and 83, respectively. By the converted three-phase AC currents, the AC motors 85 and 87 are driven in parallel with each other.

At this time, the phase difference adjusting means 5 adjusts the phase differences between the converters 61 to 64 such that the carrier frequency of the primary current component of the AC power supply is set at a desired value when the carrier phase difference setting means 12 does not perform a phase difference setting operation.

More specifically, the carrier frequency component detector 51 detects an n-fold frequency component from an output from the current detector 50. If the detected value is a predetermined value or less, the phase difference is increased or decreased by the phase difference adjuster 52 to be adjusted until the detected value becomes the predetermined value or more.

For example, in FIG. 4, reference numeral 31 denotes a reference frequency component, and 32 denotes a primary current of the transformer 4, i.e., a carrier wave. At this time, the ripple component of the carrier wave 32 is a sum of secondary currents converted by the converters 61 and 62 respectively connected to the secondary windings 41 and 42 or the converters 61 to 64 respectively connected to the secondary windings 43 and 44. As this frequency component, if a phase-difference operation is ideally performed, components having a number which is equal to the number of converters 61 and 62 or the number of converters 63 and 64 are generated. A current waveform in this case, for example, as shown in FIG. 5, a doubled or combined component ($IS1 + IS2$) of secondary winding currents $IS1$ (winding 41)

and IS2 (winding 42) is generated as a primary current. When the operation phases of the secondary windings 41 and 42 are offset from each other, for example, as shown in FIGS. 6 and 7, the doubled or combined component of the carrier is eliminated or reduced. By using this characteristic, as shown in FIG. 8, a phase difference between the phase of a reference carrier wave 32a and the phase of a carrier wave 32b which are basically offset by $\pi/2n$ is increased or reduced, so that a phase difference at which the detected value of the n-time component of a carrier wave is set at a predetermined value or more or a peak point is determined by the phase difference adjuster 52.

Therefore, an n-fold component of the carrier frequency component of a primary current is detected, and the phases of the converters 61 to 64 is finely adjusted with respect to a pre-designated phase difference (e.g., 0, $\pi/8$, $2\pi/8$, or $3\pi/8$) such that the n-fold component is set at a desired value or more. When an error of detection precision of the reference frequencies of the respective converters 61 to 64 and a phase error caused by a difference between delays of ON/OFF-switching operations are corrected, a more ideal phase difference operation can be realized.

FIG. 8 is a view showing an example obtained in setting the initial values of the phase angles of the carrier waves 32a and 32b when n converter units are arranged in the same formation of electric cars. In this case, the initial values are set at equal intervals of $\pi/(2n)$.

In this manner, when phase differences between carrier waves to be supplied are set for the converters 61 to 64 in the same formation of electric cars, generation of a harmonic current superposed on a power supply current can be suppressed. This principle will be described below with

reference to FIG. 6. In consideration of the two converters 61 and 62, when the phases of the carrier waves 32a and 32b of the converters 61 and 62 are offset, as shown in FIG. 6, switching timings are offset. At a timing at which the current instantaneous value IS1 of one converter 61 has a wave crest, the current instantaneous value IS2 of the other converter 62 has a wave trough. When the currents of the two converters 61 and 62 are summed up ($IS1 + IS2$), the peak of the wave crest of the current instantaneous value IS1 and the peak of the wave trough of the current instantaneous value IS2 are canceled out, the heights of the peaks of the crest and trough of the synthesized current instantaneous value ($IS1 + IS2$) are lowered, the number of crests and troughs is twice that of the current instantaneous value IS1 or IS2. In other words, the original frequency components (peaks of original crest and trough) disappear, and harmonic components having a number that is twice the number of frequency components are left. Similarly, when the phases of the carrier waves of n converters are offset by equal intervals, harmonic waves having a number up to n times the number of carrier waves can be reduced.

In the above embodiment, the AC motors 85 and 87 are exemplified as electric car loads, and a case wherein the outputs of the converters 61 to 64 are converted into AC currents by the inverters 81 and 83 to operate the AC motors 85 and 87 is described. However, DC loads such as DC motors may be used as electric car loads. In this case, outputs from the converters 61 to 64 may be directly used.

Embodiment 2

In Embodiment 1 described above, the primary current of the transformer 4, and phase differences are adjusted according to the magnitude of the n-fold component of the

carrier component of the primary current. However, primary current components of all converter units 60a to 60d in a formation of cars are summed up, and the n-fold component of the carrier component of the sum is used for control, so that harmonic currents in the formation of all cars can be reduced.

Embodiment 3

When detection of a primary current component is performed such that the n-fold components of the carrier current components of the converter units 60a to 60d are detected and controlled, the same effect as that in each of the above embodiments can be obtained.

Embodiment 4

Even if no transformer is used, a converter current voltage component can be detected to make it possible to control phase differences in a similar manner.

As has been described above, according to this invention, since errors in the phase differences of the converter units can be adjusted, even if the detection tolerance of a reference signal is not severely controlled, a harmonic wave can be reduced. More specifically, the n-fold components of the carrier frequency components of AC primary currents of converter units serving as PWM converters are detected to adjust the phase differences of the converter units, thereby contributing to a reduction in harmonic current component.

Industrial Applicability

This invention can be used to control a plurality of electric car loads mounted on electric cars of the same formation, and harmonic waves can be easily reduced for each formation of electric cars without making a zero-phase

(zero-cross) detection tolerance of a reference signal
severe.

CLAIMS

1. A control apparatus for a PWM converter including a plurality of converter units for converting an AC power into a DC power to supply the DC power to a plurality of electric car loads,

wherein each of said converter units comprises:

a plurality of converters for converting an AC power into a DC power;

PWM control means for performing pulse width modulation control to said converters by using a reference signal and carrier waves;

carrier phase difference setting means for offsetting phases of carrier waves supplied to said converters with respect of each other and setting desired phase differences between carrier waves supplied to said converter units; and

phase difference adjusting means for adjusting the phase differences of said converters such that a carrier frequency of a primary current component of an AC power supply is set at a desired value when said carrier phase difference setting means does not perform a phase difference setting operation.

2. A control apparatus for a PWM converter according to claim 1, wherein said phase difference adjusting means of said converter units set phase differences of said converters such that the carrier frequency of the primary current component of said AC power supply becomes maximum.

3. A control apparatus for a PWM converter including a plurality of converter units for converting an AC power of an AC power supply into a DC current to supply the DC power

to a plurality of electric car loads,

wherein each of said converter units comprises:

a transformer, mounted on an electric car of the same formation and having a primary winding, a plurality of secondary windings, and a ternary winding connected to said AC power supply, for transforming the AC voltage of said AC power supply;

a plurality of converters, respectively connected to said secondary windings of said transformer, for converting an AC power into a DC power;

PWM control means, connected to said ternary winding of said transformer, for performing pulse width modulation control to said converters by using a reference signal and carrier waves;

carrier phase difference setting means for offsetting phases of carrier waves supplied to said converters in the same conversion unit with respect to each other and setting desired phase differences between carrier waves supplied to said converter units; and

phase difference adjusting means for adjusting the phase differences of said converters such that a carrier frequency of a primary current component of an AC power supply is set at a desired value when said carrier phase difference setting means does not perform a phase difference setting operation.

4. A control apparatus for a PWM converter according to claim 3, wherein said phase difference adjusting means of said conversion units set the phase differences of said converters such that the carrier frequency of a total sum of primary currents flowing in said primary windings of said transformers becomes a desired value.

5. A control apparatus for a PWM converter according to claim 4, wherein said phase difference adjusting means of said converter units set phase differences of said converters such that the carrier frequencies of primary currents flowing in said primary windings of said transformers become maximum.

6. A control apparatus for a PWM converter according to claim 3, wherein said phase difference adjusting means of said conversion units set the phase differences of said converters such that a carrier frequency of a total sum of ternary winding voltages of said transformers becomes a desired voltage.

7. A control apparatus for a PWM converter according to claim 6, wherein said phase difference adjusting means of said converter units set the phase differences of said converters such that carrier frequencies of ternary winding voltages of said transformers become maximum.

8. A control apparatus for a PWM converter according to claim 3, wherein said phase difference adjusting means of each of said converter units comprises:

a carrier component detector for detecting a carrier frequency of a primary current flowing in said primary winding of the corresponding transformer; and

a phase difference adjuster for setting phase differences of said converters such that the carrier frequency of the primary current becomes a desired value.

9. A control apparatus for a PWM converter, substantially herein described with reference to Figs 1 to 8 of the drawings.

Dated this 2nd day of June 1999
MITSUBISHI DENKI KABUSHIKI KAISHA
By their Patent Attorneys
GRIFFITH HACK

ABSTRACT OF THE DISCLOSURE

A control apparatus for a PWM converter can easily reduce harmonic waves for each formation of electric cars without making a zero-phase detection tolerance of a reference signal severe. In the control apparatus, phase differences of converter units, an n-fold component of the carrier frequency component of a primary current is detected, phases are finely adjusted with respect to pre-designated phase differences such that the n-fold component is set at a desired value or more, and an error of detection precision of reference frequencies of the converters and a phase error caused by a difference between delays of ON/OFF-switching operations are corrected, so that a more ideal phase difference operation can be realized.

FIG. 1

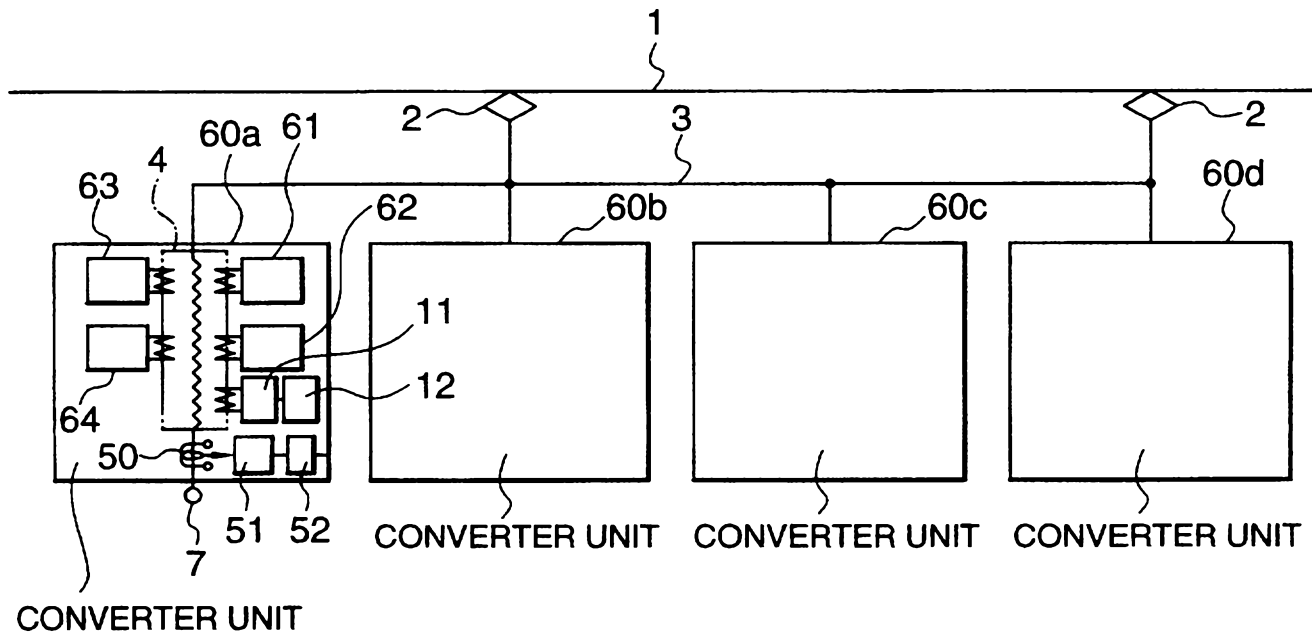


FIG. 2

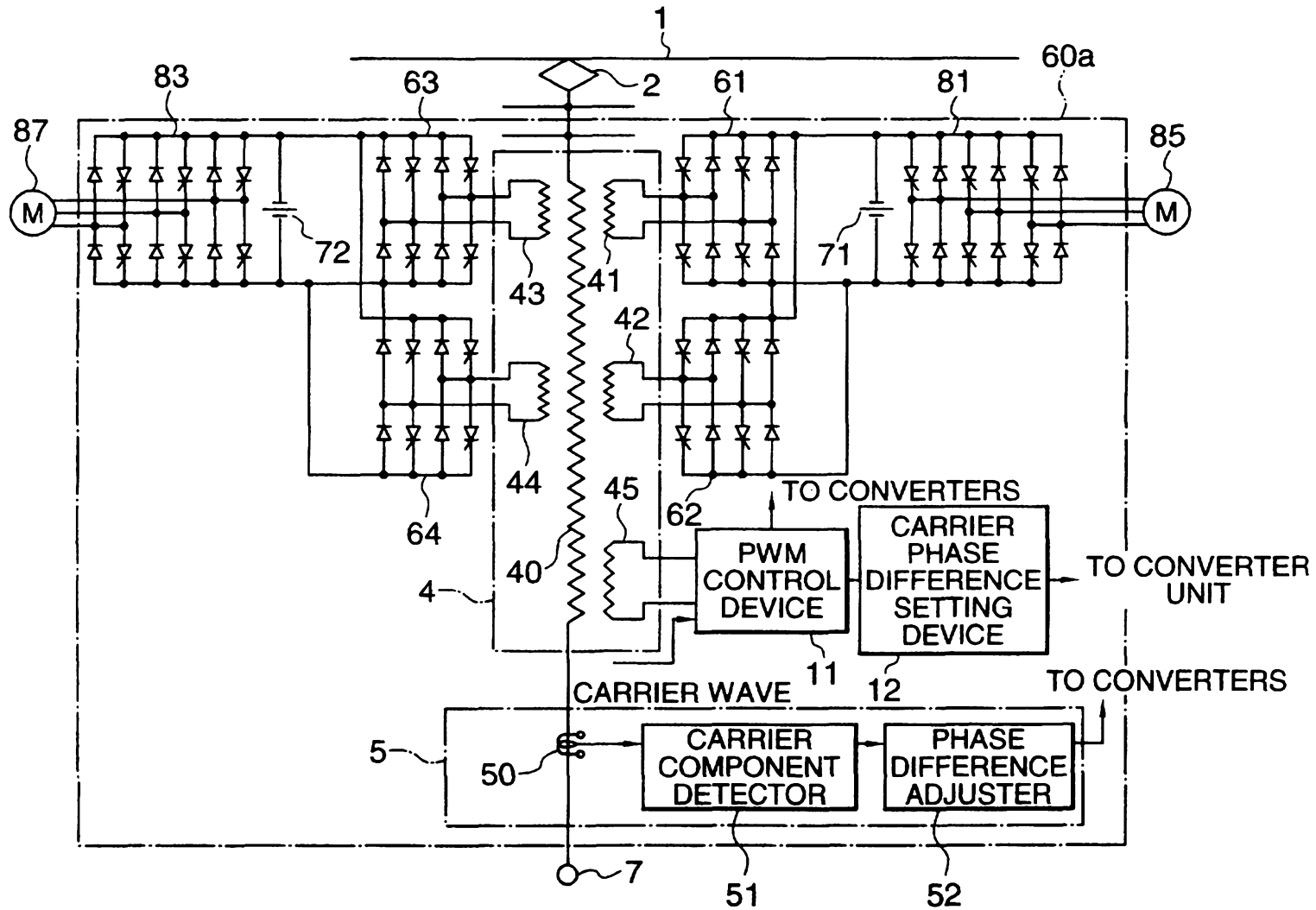


FIG. 3

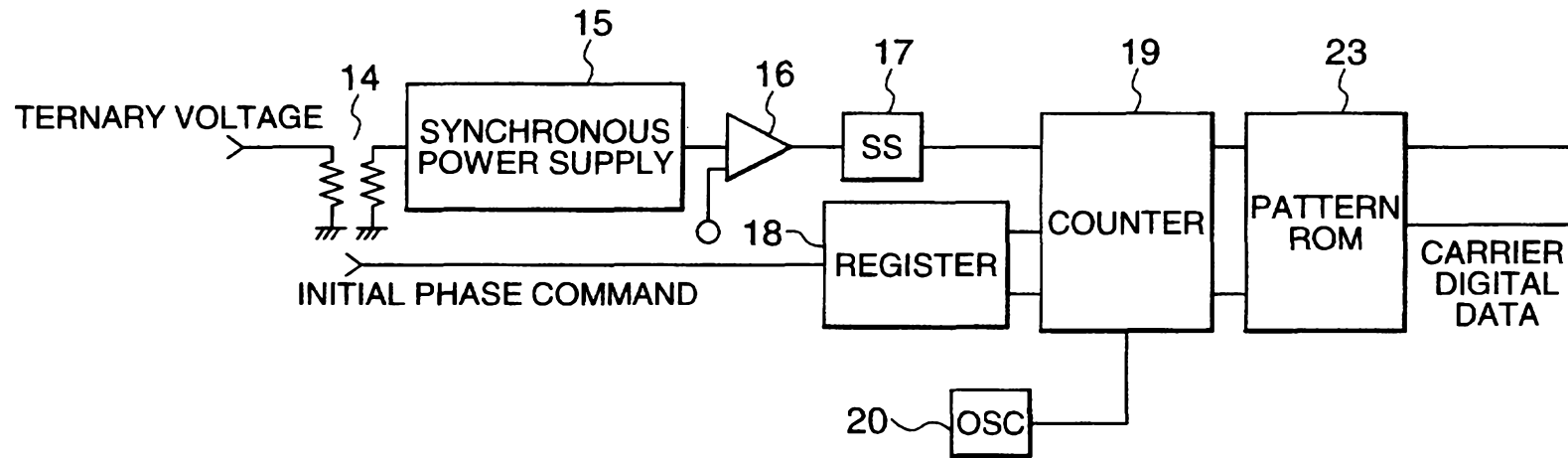


FIG. 4

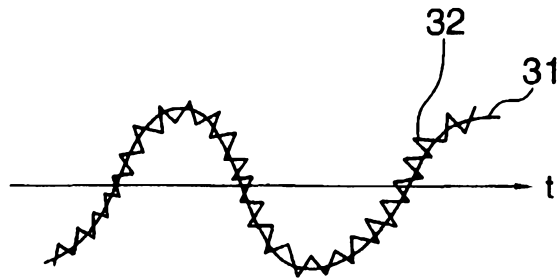


FIG. 5

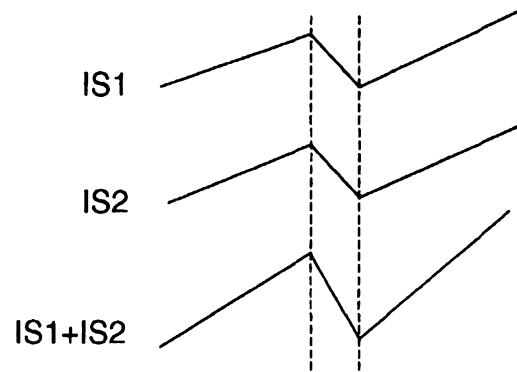


FIG. 6

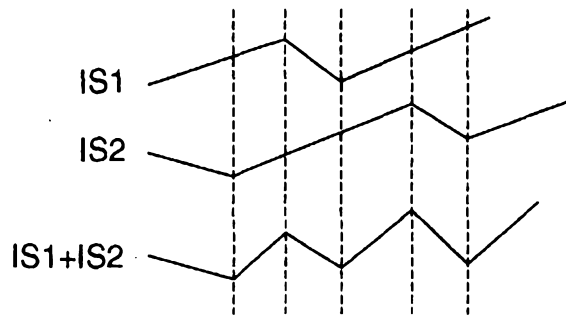


FIG. 7

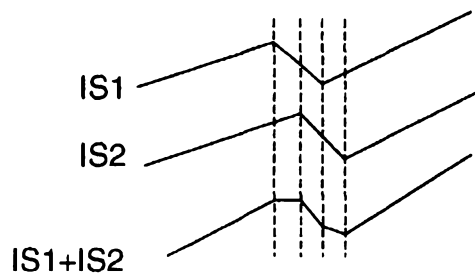


FIG. 8

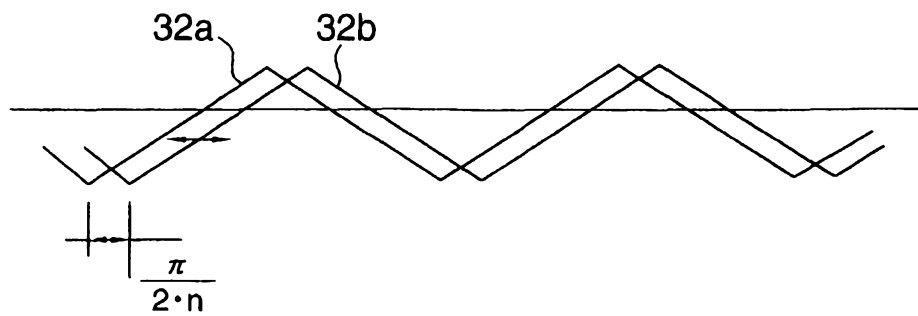


FIG. 9

