CLAIMS

[Claim 1]

A cross current suppression control device which suppresses a cross current in a power conversion circuit in which inverter units are connected in parallel to a direct current voltage source, the cross current suppression control device comprising:

a gate delay command value calculation block that operates once at a half switching cycle so as to calculate a rising gate delay command value and a falling gate delay command value;

a rising delay adding section that adds the rising gate delay command value to a gate command value or a voltage command value; and

a falling delay adding section that adds the falling gate delay command value to the gate command value or the voltage command value,

wherein the rising delay adding section and the falling delay adding section are provided for each phase of each inverter unit,

wherein the gate delay command value calculation block includes

a proportional amplifier that multiplies a deviation between an inverter unit output current command value and an inverter unit output current detection value by a gain,

the deviation being obtained as a cross current;

an integral amplifier to which the cross current is input by a first switch which is turned on whenever each switching element is turned on or off and when a logical result of a sign of the inverter unit output current detection value and a sign of the gate command value is true; and

a second switch that receives a signal from the integral amplifier and is turned on by the sign of the inverter unit output current detection value, and

wherein outputs from the proportional amplifier and the second switch are added together, and thus the rising gate delay command value and the falling gate delay command value are output.

[Claim 2]

A cross current suppression control device which suppresses a cross current in a power conversion circuit in which inverter units are connected in parallel to a direct current voltage source, the cross current suppression control device comprising:

a gate delay command value calculation block that operates once at a half switching cycle so as to calculate a rising gate delay command value and a falling gate delay command value;

a rising delay adding section that adds the rising gate delay command value to a gate command value or a voltage command

value; and

a falling delay adding section that adds the falling gate delay command value to the gate command value or the voltage command value,

wherein the rising delay adding section and the falling delay adding section are provided for each phase of each inverter unit,

wherein the gate delay command value calculation block includes

a proportional amplifier that multiplies a deviation between an inverter unit output current command value and an inverter unit output current detection value by a gain, the deviation being obtained as a cross current;

an integral amplifier that is provided so as to correspond to each switching element and to which the cross current is input by a first switch which is operated by the sign of the inverter unit output current detection value; and

a second switch that receives a signal from the integral amplifier and is operated by the sign of the inverter unit output current detection value, and

wherein outputs from the proportional amplifier and the second switch are added together, and thus the rising gate delay command value and the falling gate delay command value are output.

[Claim 3]

The cross current suppression control device according to claim 1 or 2, wherein, when an absolute value of the cross current is equal to or smaller than a set value, the proportional amplifier outputs zero, and the integral amplifier stops being updated, and

wherein, when the absolute value of the cross current is equal to or greater than the set value, a value obtained by subtracting the set value from the absolute value is input to the proportional amplifier and the integral amplifier.

[Claim 4]

The cross current suppression control device according to any one of claims 1 to 3, wherein the inverter unit output current command value is a value obtained by dividing an inverter output current detection value by the number of inverter units.

[Claim 5]

The cross current suppression control device according to any one of claims 1 to 3, wherein the inverter unit output current command value is an output current detection value of another certain inverter unit.

[Claim 6]

The cross current suppression control device according to any one of claims 1 to 5, wherein, when the inverter unit output current detection value is equal to or smaller than a set value, the proportional amplifier outputs zero, and the

integral amplifier stops being updated,

wherein, when an absolute value of the inverter output current detection value is equal to or greater than the set value, a value obtained by subtracting the set value from the absolute value is input to the proportional amplifier and the integral amplifier, and

wherein proportional integral calculation is performed so that the deviation between the inverter unit output current command value and the inverter unit output current detection value becomes zero, and a value obtained by adding a proportional integral calculation result and outputs from the proportional amplifier and the second switch together is used as the gate delay command value,~~.~~

~~[Claim 7]~~

~~The cross current suppression control device according to claim 6,~~ wherein effective values of the inverter unit output current command value and the inverter unit output current detection value are used for the proportional integral calculation.

[Claim 7~~8~~]

The cross current suppression control device according to any one of claims 1 to 5, wherein, when the inverter unit output current detection value is equal to or smaller than a set value, the proportional amplifier outputs zero, and the integral amplifier stops being updated,

wherein, when an absolute value of the inverter output current detection value is equal to or greater than the set value, a value obtained by subtracting the set value from the absolute value is input to the proportional amplifier and the integral amplifier, and

wherein proportional integral calculation is performed so that the deviation between the inverter unit output current command value and the inverter unit output current detection value becomes zero, and a value obtained by adding a proportional integral calculation result and outputs from the proportional amplifier and the second switch together is used as the gate delay command value~~The cross current suppression control device according to claim 6~~,

wherein absolute current mean values per cycle of a fundamental wave of the inverter unit output current command value and the inverter unit output current detection value are used for the proportional integral calculation.

[Claim 8~~9~~]

The cross current suppression control device according to any one of claims 1 to 7~~8~~, wherein, when an absolute value of the inverter output current is smaller than a threshold value, the integral amplifier stops being updated.

[Claim 9~~10~~]

The cross current suppression control device according to any one of claims 1 to 8~~9~~, wherein the gate delay command

value calculation block is operated at a peak of a carrier triangular wave.

[Claim 10~~1~~]

The cross current suppression control device according to any one of claims 1 to 8~~9~~, wherein the gate delay command value calculation block is operated when the gate command value changes.

[Claim 11~~2~~]

The cross current suppression control device according to any one of claims 1 to 10~~1~~, wherein each of the inverter units is a multi-level inverter.

[Claim 12~~3~~]

The cross current suppression control device according to ~~any one of~~ claim~~s~~ 9~~10 to 12~~, wherein the integral amplifier stops being updated in a case where the number of times of switching is not one during a half cycle of the carrier triangular wave.

[Claim 13~~4~~]

The cross current suppression control device according to any one of claims 1 to 11~~2~~, wherein a gate command is output without adding delay thereto when an initial value of the integral amplifier starts to be set during a test operation of the power conversion circuit,

wherein, during the test operation of the power conversion circuit, in a state in which a switching element

of an inverter unit which is out of a delay time measurement target is turned on, a pulse-ON command is output to a switching element of a delay time measurement target inverter unit, a closed circuit is formed of the two switching elements and a cross current suppression reactor, time after a gate signal is set to an ON state until a differentiation result of the inverter unit current detection value exceeds a threshold value and time after the gate signal is set to an OFF state until the differentiation result of the inverter unit current detection value is equal to or smaller than the threshold value are measured in the delay time measurement target inverter unit, and the measured times are used as initial values of the integral amplifier, and

wherein, when an operation state of the power conversion circuit is changed from the test operation to a normal operation, a value of the integral amplifier is reset, and the initial value is input to the integral amplifier.

[Claim 14~~5~~]

The cross current suppression control device according to claim 13~~4~~, wherein, during the test operation of the power conversion circuit, as a current detector used to detect an inverter unit current detection value, a current detector of a specific inverter unit is used in all inverter units.

[Claim 15~~6~~]

The cross current suppression control device according

to any one of claims 134 or ~~to~~ 145, wherein, during the test operation of the power conversion circuit, a direct current voltage of the delay time measurement target inverter unit is set to be lower than during a normal operation when a delay time is measured.

[Claim 167]

The cross current suppression control device according to any one of claims 134 to 156, wherein, during the test operation of the power conversion circuit, among switching elements other than the turned-on switching element of the delay time measurement target inverter unit, a positive side voltage of a gate driving circuit for a switching element of one of the ~~an~~ inverter units is lowered, and voltage drop of the switching element is set higher than during the normal operation.

[Claim 178]

The cross current suppression control device according to any one of claims 1 to 123, wherein a PWM carrier frequency is increased in a specific period after the power conversion circuit starts to operate or a total output current of the inverter units exceeds a current threshold value.