

## METHOD AND DEVICE FOR CONTROLLING VOLTAGE

THE PRESENT INVENTION relates to a voltage control device for electrical equipment.

Many sites such as commercial premises, e.g. shops and  
5 offices, operate a range of electrical equipment such as  
fridges, cool-rooms, freezers, and computer equipment. Most of  
this equipment is rated to operate at 230V AC.

However, the electricity supply to such sites can vary  
dramatically between 200V AC and 250V AC, and in many  
10 instances the electricity is supplied towards the higher of  
these two extremes.

If the electricity is supplied at a voltage higher than  
the rated voltage of an item of electrical equipment, a number  
of problems can occur. Firstly, excess electricity is consumed  
15 resulting in increased costs. Secondly, additional heat and  
losses are generated in the equipment, which can lead to  
premature equipment failure. Thirdly, electrical equipment  
may be damaged by excess voltage surges.

It can therefore be appreciated that the direct use  
20 of such a variable electricity supply has a number of  
disadvantages.

The invention seeks to provide a solution to this  
problem.

According to one aspect of the present invention  
25 there is provided a voltage control device for connection to  
an electrical supply having an alternating supply voltage, the  
device comprising:

- an input for connection to the electrical  
supply;
- 30 an output having an output voltage;
- comparator means for comparing the output  
voltage with a predetermined voltage and generating a  
comparison signal; and
- adjustment means to increase or decrease the  
35 output voltage in response to the comparison signal, said  
adjustment means being connected to the

input and output such that

the output voltage is maintained substantially at the predetermined voltage unless the variable alternating supply voltage falls below the predetermined  
5 voltage.

Preferably, the adjustment means comprise means to delay the onset of the rise of output voltage within a half-cycle.

Conveniently, the adjustment means comprise means to  
10 delay the onset of the rise of output voltage within both half-cycles.

Advantageously, the delay in the onset of the rise of output voltage within one half-cycle is controlled independently of the delay in the onset of the rise of output  
15 voltage within the other half-cycle.

Preferably, the adjustment means comprise a thyristor module.

Conveniently, the thyristor module comprises an antiparallel pair of thyristors.

20 Advantageously, the adjustment means comprise means to reduce the amplitude of the output voltage within a half-cycle.

Preferably, the adjustment means comprise means to reduce the amplitude of the output voltage within both half-cycles.

Conveniently, the reduction of the output voltage within  
25 one half-cycle is controlled independently of the reduction in the amplitude of the output voltage within the other half-cycle.

Advantageously, the means to reduce the amplitude of the output voltage comprise a variable AC transformer.

30 Preferably, the device further comprises a bypass switch across the means to adjust the output voltage.

Conveniently, the device further comprises means to vary the predetermined voltage.

Advantageously, the device further comprises a display for  
35 displaying set-up parameters and operating information.

Preferably, the device is powered by the input voltage.

Conveniently, the device is for connection to a single phase voltage.

Advantageously, the device is for connection to a  
5 multiple phase voltage.

Preferably, the multiple phase supply voltage is a three phase voltage.

According to another aspect of the present invention, there is provided a method of controlling an alternating voltage  
10 comprising the steps of:

providing a device having an input which has an input voltage, said input being connected to an electrical supply having an alternating supply voltage;

an output having an output voltage;

15 comparing the output voltage with a predetermined voltage to generate a comparison signal;

effecting adjustment of the output voltage by increasing or decreasing the output voltage in response to the comparison signal such that the output voltage is maintained substantially at the  
20 predetermined voltage unless the variable alternating supply voltage falls below the predetermined voltage.

Preferably, adjustment of the output voltage comprises delaying the onset of the rise of output voltage within a half-cycle.

25 Conveniently, the adjustment of the output voltage comprises delaying the onset of the rise of output voltage within both half-cycles.

Advantageously, the delaying of the onset of the rise of output voltage within one half-cycle is controlled  
30 independently of the delaying of the onset of the rise of output voltage within the other half-cycle.

Preferably, the delay in onset of rise of output voltage is caused by a thyristor module.

Conveniently, the thyristor module comprises a pair of  
35 antiparallel thyristors.

Advantageously, adjustment of the output voltage comprises reduction of the amplitude of the output voltage

within a half-cycle.

Preferably, adjustment of the output voltage comprises reduction of the amplitude of the output voltage within both half-cycles.

5        Conveniently, the reduction of the output voltage within one half-cycle is controlled independently of the reduction in the amplitude of the output voltage within the other half-cycle.

Advantageously, the reduction of the amplitude of the  
10 output voltage is caused by a variable AC transformer.

Preferably, the predetermined voltage is varied.

Conveniently, the supply voltage is a single phase voltage.

Advantageously, the supply voltage is a multiple phase  
15 voltage.

Preferably, the multiple phase voltage is a three-phase voltage.

Also, there is disclosed a voltage capping device for connection between an AC electrical supply having one or more  
20 phases and at least one item of electrical equipment comprising:

a) an electronic switch for each phase of AC electrical supply, in use between the AC voltage supply and the equipment, to vary the voltage delivered in each half-  
25 cycle of the AC mains supply,

b) output voltage measuring means to measure the voltage between the switch output and the equipment,

c) comparator means to compare the voltage as measured by the output measuring means with a predetermined  
30 voltage value, and

d) control means to control the electronic switch, as dependent on signals received from output measuring means and comparator means, to ensure the voltage delivered to the equipment is substantially equal to said predetermined voltage  
35 value.

Preferably the electronic switch consists of a thyristor module that varies the time a voltage is delivered by delaying the onset of each rise in voltage for each half-cycle. Preferably the thyristor module is a pair of thyristors placed back to back.

Preferably a bypass switch is provided across each electronic switch.

Preferably the capping device is powered from the AC electrical supply.

10 Preferably a display is provided to display set-up parameters and operating information.

Preferably means are provided to vary the predetermined voltage value.

An embodiment of the invention will now be described with 15 reference to the accompanying drawings in which:

Figure 1 shows a circuit diagram;

Figure 2 shows a thyristor module formed from two back to back thyristors;

Figure 3 shows a graph of one complete AC cycle as 20 altered by a device of the invention; and

Figure 4 shows a graph of input voltage and output voltage for a device of the present invention.

Referring to Figure 1 there is shown a circuit diagram of a voltage capping device 1. The device 1 is connected 25 between an AC electrical supply having three phases P1, P2, P3 and an item of three phase electrical equipment represented by L1, L2, L3.

Device 1 has three electronic switches THY1, THY2, THY3 between each phase P1, P2, P3 of the electrical supply and the 30 equipment L1, L2, L3 respectively to vary the time a voltage is delivered for each half-cycle of the AC mains supply. Switches THY1, THY2, THY3 are each a thyristor module formed by a pair of thyristors placed back to back as shown in Figure 2. This arrangement is also known as an antiparallel pair of 35 thyristors. Thyristors are also known as silicon-controlled

rectifiers, or SCRs.

Each thyristor module varies the time a voltage is delivered by delaying the onset of each rise in voltage for each half-cycle as described below. Switches THY1, THY2, THY3 5 can be bypassed using bypass switches S1, S2, S3 controlled either by means of a master bypass switch SW1 or automatically in the event of a fault, operating a bypass contactor control circuit 2.

An output voltage sensor 3 provides a measuring means to 10 measure the voltage between each switch output THY1, THY2, THY3 and the equipment L1, L2, L3.

A comparator means is provided by a comparator circuit 4 to compare the voltage as measured by the output voltage sensor with a predetermined voltage value as varied and set 15 by voltage output set-points V1, V2, V3.

A thyristor control means 5 is provided to control the switches THY1, THY2, THY3, as dependent on signals received from output voltage sensor 3 and comparator circuit 4, to ensure the voltage delivered to the equipment L1, L2, L3 is 20 substantially equal to the predetermined voltage value as varied and set by voltage output set-points V1, V2, V3.

A display 6 is provided to display set-up parameters and operating information.

The control device 1 is powered from a power supply unit 25 7 fed from the AC electrical supply P1, P2, P3.

Figure 3 is a graph showing voltage over time. Line 8 illustrates the waveform of a normal single phase of AC supply (e.g. from P1). Each thyristor switch THY1, THY2, THY3 is controlled to vary the time a voltage is delivered by delaying 30 the onset of each rise in voltage for each half-cycle, as shown by line 9 so as to reduce the waveform amplitude resulting in a lowering of the effective RMS voltage. Increasing the delay causes the waveform amplitude (and hence RMS voltage) to decrease and reducing the delay causes the 35 waveform amplitude (and hence RMS voltage) to increase.

The control device 1 thus uses its voltage sensor 3 to sense the output voltage of the switches THY1, THY2, THY3, and this voltage value is then adjusted up or down, by delaying the conduction through thyristors THY1, THY2, THY3, depending on whether the voltage value is below or above the predetermined value, as varied and set by voltage output set-points V1, V2, V3.

This is done by setting a threshold value for the input voltage 8 to reach before the thyristor module allows the output voltage 9 to change from zero. This results in a delay 10 in the first half-cycle and a delay 11 in the second half-cycle of the output voltage 9. The delay 10 and the delay 11 could be controlled independently and may not have the same value.

15 The device thus moderates and controls the variable alternating supply voltage to give a smoothed and consistent output voltage at a predetermined value. If the supply voltage drops below the predetermined voltage value, then the output voltage will drop below the predetermined value accordingly.

20 A person skilled in the art will appreciate that a similar voltage-controlling effect could be achieved by advancing the return to about zero of the output voltage in each half-cycle. In this embodiment, the device varies the time a voltage is delivered by advancing the return to about zero of the output voltage for each half-cycle. Increasing the advance causes the waveform amplitude (and hence RMS voltage) to decrease and reducing the advance causes the waveform amplitude (and hence RMS voltage) to increase. The output voltage in the half-cycle returns to zero ahead of the input voltage by a certain amount of time.

Also, the output voltage could be adjusted by lowering the amplitude of the output voltage within each half-cycle. This would lead to a lowering of the output RMS voltage. Again, the output voltage in one half-cycle could be controlled independently of the other half-cycle. This could

be achieved by using a variable AC transformer.

A combination of these methods of adjusting the output voltage may be used. For example, the output voltage may be delayed in the first half-cycle and advanced in the second half-cycle. Alternatively, the output voltage may be delayed in the first half-cycle and reduced in the second half-cycle.

Figure 4 shows the result of a trial run of a device according to the invention which delays the rise of the output voltage in each half-cycle. The trial was run over a period of about 20 hours from 14:10 on one day to 10:29 on the following day. The device used contained a Semikron SKKT162 thyristor module and the voltage was measured with a Yokogawa power analysing meter model WT110. The top line shows the supply input voltage over a period of around 20 hours. The bottom line shows the corresponding output voltage produced by a device of the invention. Although the input voltage varies dramatically over this period over almost a 10 volt range, the output voltage remains consistently within about 1 volt of the predetermined voltage value of 235 volts.

It will thus be seen that the control device of the invention can be used to maintain a voltage supply at a constant level at or below a predetermined value.

In practice, the predetermined value can be set at the rated voltage of electrical equipment L1, L2, L3 so that excess electricity is not consumed resulting in increased costs, and so that additional heat and losses are not generated which can lead to premature equipment failure. This also helps to prevent damage to electrical equipment due to excess voltage surges.

The invention may take a form different to that specifically described above. For example instead of one item of three phase electrical equipment L1, L2, L3, the L1, L2, L3 could represent more than one item of three phase equipment or three separate single phase electrical circuits or a combination. Also the control device may be used with

single-phase electricity, in which case the control device would have only one electronic switch to control one or more items of single phase electrical equipment.

Further modifications will be apparent to those skilled  
5 in the art without departing from the scope of the present invention.

## CLAIMS

1. A voltage control device for connection to an electrical supply having an alternating supply voltage, the  
5 device comprising:  
    an input for connection to the electrical supply;  
    an output having an output voltage;  
    comparator means for comparing the output voltage with  
    a predetermined voltage and generating a comparison signal;  
10 and  
    adjustment means to increase or decrease the output  
    voltage in response to the comparison signal, said adjustment  
    means being connected to the input and output, such that  
    the output voltage is maintained substantially at the  
15 predetermined voltage unless the variable alternating supply  
    voltage falls below the predetermined voltage.
2. A device according to claim 1 wherein the adjustment  
means comprise means to delay the onset of the rise of output  
voltage within a half-cycle.
- 20 3. A device according to claim 2 wherein the adjustment  
means comprise means to delay the onset of the rise of output  
voltage within both half-cycles.
4. A device according to claim 3 wherein the delay in  
the onset of the rise of output voltage within one half-cycle  
25 is controlled independently of the delay in the onset of the  
rise of output voltage within the other half-cycle.
5. A device according to any preceding claim wherein  
the adjustment means comprise a thyristor module.
6. A device according to claim 5 wherein the thyristor  
30 module comprises an antiparallel pair of thyristors.
7. A device according to claim 1 wherein the adjustment  
means comprise means to reduce the amplitude of the output  
voltage within a half-cycle.
8. A device according to claim 7 wherein the adjustment  
35 means comprise means to reduce the amplitude of the output

voltage within both half-cycles.

9. A device according to claim 8 wherein the reduction of the output voltage within one half-cycle is controlled independently of the reduction in the amplitude of the output voltage within the other half-cycle.

10. A device according to any of claims 7 to 9 wherein the means to reduce the amplitude of the output voltage comprise a variable AC transformer.

11. A device according to any preceding claim further comprising a bypass switch across the adjustment means.

12. A device according to any preceding claim further comprising means to vary the predetermined voltage.

13. A device according to any preceding claim further comprising a display for displaying set-up parameters and operating information.

14. A device according to any preceding claim which is powered by the input voltage.

15. A device according to any preceding claim for connection to a single phase voltage.

16. A device according to any of claims 1 to 14 for connection to a multiple phase voltage.

17. A device according to claim 16 wherein the multiple phase supply voltage is a three phase voltage.

18. A method of controlling an alternating voltage comprising the steps of:

providing a device having an input, said input being connected to an electrical supply having an alternating supply voltage and an output having an output voltage;

comparing the output voltage with a predetermined voltage to generate a comparison signal;

effecting adjustment of the output voltage by increasing or decreasing the output voltage in response to the comparison signal such that the output voltage is maintained substantially at the predetermined voltage unless the variable alternating supply voltage falls below the predetermined

voltage.

19. A method according to claim 18 wherein adjustment of the output voltage comprises delaying the onset of the rise of output voltage within a half-cycle.

5 20. A method according to claim 18 wherein adjustment of the output voltage comprises delaying the onset of the rise of output voltage within both half-cycles.

21. A method according to claim 20 wherein the delaying of the onset of the rise of output voltage within one half-  
10 cycle is controlled independently of the delaying of the onset of the rise of output voltage within the other half-cycle.

22. A method according to any of claims 18 to 21 wherein the delay in onset of rise of output voltage is caused by a thyristor module.

15 23. A method according to any of claim 22 wherein the thyristor module comprises a pair of antiparallel thyristors.

24. A method according to claim 18 wherein adjustment of the output voltage comprises reduction of the amplitude of the output voltage within a half-cycle.

20 25. A method according to claim 24 wherein adjustment of the output voltage comprises reduction of the amplitude of the output voltage within both half-cycles.

26. A method according to claim 25 wherein the reduction of the output voltage within one half-cycle is controlled  
25 independently of the reduction in the amplitude of the output voltage within the other half-cycle.

27. A method according to any of claims 24 to 26 wherein the reduction of the amplitude of the output voltage is caused by a variable AC transformer.

30 28. A method according to any of claims 18 to 27 wherein the predetermined voltage is varied.

29. A method according to any of claims 18 to 28 wherein the supply voltage is a single phase voltage.

30 30. A method according to any of claims 18 to 28 wherein  
35 the supply voltage is a multiple phase voltage.

31. A method according to claim 30 wherein the multiple phase voltage is a three-phase voltage.

32. A voltage control device substantially as hereinbefore described with reference to and/or as shown in 5 the accompanying drawings.

33. A method of controlling voltage substantially as herinbefore described with reference to and/or as shown in the accompanying drawings.

34. An electrical device comprising a voltage control 10 device substantially as hereinbefore described with reference to and/or as shown in the accompanying drawings.