

## APPARATUS FOR POWER SUPPLY SYSTEMS

### FIELD OF THE INVENTION

[0001] The present invention relates to control apparatus for power supply systems, to power supply systems comprising such control apparatus and to methods of operating the same.

### BACKGROUND TO THE INVENTION

[0002] Many power supply systems have undesirable fluctuations in their respective line voltages. For instance, in a power supply to an underground (subway), or a power supply from a wind turbine there are undesirable fluctuations. Demand, in the first case, and supply, in the second, vary. Such line voltage variation can cause degraded performance and uncertainty for power suppliers.

[0003] It is an aim of preferred embodiments of the present invention to overcome or obviate a problem of the prior art, whether referred to herein or otherwise.

### SUMMARY OF THE INVENTION

[0004] According to the present invention in a first aspect, there is provided a control apparatus for a power supply system operable at a fluctuating line voltage, the system further comprising an energy storage device, and the control apparatus further comprising a line voltage monitor and an energy storage device controller, wherein the control apparatus is configured whereby the energy storage device is at least partly discharged if the line voltage falls below a first predetermined voltage and the energy storage device is at least partly charged if the line voltage exceeds a second predetermined voltage and in which the first predetermined voltage is substantially lower than the second predetermined voltage.

[0005] Suitably, in the voltage region between the first and second predetermined voltages, the energy storage device is driven to a predetermined charge setting between a maximum charge setting and a minimum charge setting.

[0006] Suitably, the first and second voltages are determined relative to a mean line voltage. Suitably, the mean line voltage is determined by a time average over a predefined rolling time interval.

[0007] Suitably, an idle charge is defined with a positive idleness above the idlecharge and a negative idleness below the idlecharge, whereby in a region between the first predetermined voltage and the second predetermined voltage the energy storage device is neither charging nor discharging as the charge decreases until the charge reaches the negative idleness when it charges to a charge between the positive idleness and the negative idleness, preferably the idlecharge, and then neither charges nor discharges until the negative idleness is reached. In the case of a flywheel energy storage device, it will be coasting in this region.

[0008] Suitably, a third voltage below the first predetermined voltage defines a reduced discharge region between the first predetermined voltage and the third voltage, in which the energy storage device is discharged at a lower rate than in a discharge region in which the line voltage is lower than the third voltage.

[0009] Suitably, a fourth voltage above the second predetermined voltage defines a reduced discharge region between the second predetermined voltage and the fourth voltage, in which the energy storage device is charged at a lower rate than in a charge region in which the line voltage is higher than the fourth voltage.

[0010] Suitably, an energy storage device maximum charge is defined and a maximum charge idleness is defined below and in relation thereto, and the apparatus is configured whereby if the line voltage is above the second predetermined voltage, upon the energy storage device reaching maximum charge it is neither charged nor discharged until the energy storage device charge falls to the maximum charge idleness at which stage the energy storage device is charged.

[0011] Suitably, an energy storage device minimum charge is defined and the apparatus is configured whereby upon the energy storage device reaching the energy storage device minimum charge the energy storage device is neither charged nor discharged until the line voltage rises above the first predetermined voltage.

[0012] Suitably, the energy storage device is a flywheel. In this case charge of the flywheel is represented by speed thereof.

[0013] According to the present invention in a second aspect, there is provided a power supply system comprising a control apparatus according to the first aspect of the invention.

[0014] Suitably, the power supply system is for a transport system, preferably a rail transport system.

[0015] According to the present invention in a third aspect, there is provided there is provided a method of controlling a power supply system operating at a fluctuating line voltage, the system further comprising an energy storage device, and the control apparatus further comprising a line voltage monitor and an energy storage device controller, whereby the energy storage device is at least partly discharged if the line voltage falls below a first predetermined voltage and the energy storage device is at least partly charged if the line voltage exceeds a second predetermined voltage and in which the first predetermined voltage is substantially lower than the second predetermined voltage.

[0016] Suitably, in the voltage region between the first and second predetermined voltages, the energy storage device is driven to a predetermined charge setting between a maximum charge setting and a minimum charge setting.

[0017] Suitably, the first and second predetermined voltages are determined relative to a mean line voltage. Suitably, the mean line voltage is determined by a time average over a predefined rolling time interval.

[0018] Suitably, an idlecharge is defined with a positive idleness above the idlecharge and a negative idleness below the idlecharge, whereby in a region between the first predetermined voltage and the second predetermined voltage the energy storage device is neither charging nor discharging as the charge decreases until the charge reaches the negative idleness when it charges to a charge between the positive idleness and the negative idleness, preferably the idlecharge, and then neither charges nor dis-