Description

This invention relates to uninterruptible power supplies (UPS).

A typical UPS is one in which a primary energy source (normally a commercial AC line) ad a reserve energy source (normally a battery voltage driven inverter) are both coupled to supply energy input to a energy coupling apparatus such as a transformer with two independent energy inputs. Each input is functional to supply power to a single output. In other arrangements the two sources of energy may be joined in series so that the primary source of energy charges the reserve source.

When power is being supplied from the reserve energy source, the UPS is disconnected from the commercial AC line by semiconductor electronic isolation switches located in the input line. Electronic isolation switches are normally used in place of mechanical switches in order to avoid the transients associated with the switching of mechanical switches. Should these electronic isolation switches fail in a shorted or conducting mode, power supplied by the reserve energy source may be fed back into the primary line source directly through the energy coupling apparatus. There generally is no indication of this switch failure until a current path is accidentally completed across the AC line permitting such current flow. This is a potential safety hazard which is often not apparent until such a current path is completed.

US Patent 4,104,539 discloses a power system in which a load is continuously supplied by two power sources; an AC commercial power source and an inverter power source energized by a battery floated off of a commercial AC line. A switching arrangement is provided to prevent reverse power flow from the inverter source into the AC commercial AC power source. To accomplish this objective a plurality of switches are provided, each responding to a specified condition of a particular AC line quality parameter such as frequency, voltage, current, etc. No specific provision is made however for discovering and responsing to the failure of one of the switches.

According to this invention there is provided a uninterruptible power supply as claimed in claim 1.

In a UPS system embodying the invention a backup input line isolation switch and its control circuit is operative, during operation of the reserve energy source portion of the power supply in supplying power to the output, to provide mechanical isolation between the primary energy source connected to the input line and the secondary energy source upon detection of a failure of an electronic isolation switch normally providing isolation between the input line and the secondary energy source. Detection of such a failure is accomplished by means of a dummy load which is connected in shunt across the input line. Its impedance is sized to permit a small low level of current flow, above normal leakage current levels permitted by a functioning semiconductor electronic line switch, if energy is reverse coupled from the reserve energy source via a failed electronic line switch without draining significant power from the primary energy source when the UPS is normally operative and deriving power from the primary energy source. A power flow direction sensing circuit detects the direction of power flow at the input to which the primary energy source is connected to the UPS and a control circuit responsive to the power flow direction sensing circuit disconnects the input from the primary energy source if reverse power flow is detected by activating a mechanical switch to disconnect the input from the primary energy energy source.

This arrangement isolates the reserve energy source and/or the output of the UPS, depending on the circuit topology, from the input AC line of the primary energy source by operation of a mechanical switch upon failure of the electronic switch ad hence prevents a coupling of energy from the reserve energy source to the primary energy source line in the event that any of the the electronic isolation switches should fail.

Brief Description of the Drawing

FIG. 1 is a detailed block and schematic diagram of a UPS including the mechanical backup line isolation switch and its control circuitry,

FIG.2 is a schematic diagram of an input line current sensing circuit used in an embodiment of the invention,

FIG.3 is a detailed block and schematic diagram of the control circuitry to determine current flow direction and operate the backup isolation switch located subsequent to the input of the UPS.

Detailed Description

A UPS embodying backup protection is shown in FIG. 1. The UPS shown is a parallel processing system with primary power derived from a commercial AC line connected to the AC input terminals 101 and 102 and reserve power from a DC voltage source (battery) 120 being connected to DC input terminal 121 which in turn is coupled to a charging rectifier 122 and an inverter circuit 123.

During normal operation of the UPS when the commercial AC is in its normal acceptable state, output power is fully derived from the primary energy source AC voltage supplied to input terminals 101,102. This primary energy input is coupled through a fuse 103, a mechanical isolation backup

switch 104, a filter circuit 105, and a current sensing winding 106 to two semiconductor electronic line switches 107 and 108 which are in turn coupled to an end terminal 109 ad a tap 110 of winding 111 of transformer 112. An output line 124 directly couples the end terminal 109 to an AC output terminal 126.

The two line switches 107 and 108 are under control of the stored program control unit 130 which may comprise a microprocessor system. The control unit 130 monitors the quality of the AC input via lead 131 and when the AC input is fully acceptable it causes line switch 107 to conductively connect the input to the end terminal 109 of winding 111 which in turn is directly connected to the output terminal 126. During normal operation when the input AC voltage is satisfactory, the DC voltage source 120 is charged from the input AC voltage via winding 138 and rectifier charger 122. If the control unit 130 determines that the input voltage is substandard (i.e. a brownout), the line switch 107 is disabled and line switch 108 is enabled to connect the AC input to tap 110 of winding 111. This provides a voltage boost to the input AC voltage by means of the auto transformer formed by the subsection of winding 111 and provides an adequate signal at terminal 109 which is connected to the output 126.

If the input AC voltage falls to a low level where in a voltage boost is not sufficient to provide the desired output voltage level, power to the output is derived from the reserve DC voltage source 120. The supplied DC voltage is inverted into AC voltage by inverter 123 ad is coupled to input winding 113 of transformer 112.

During operation of the UPS from the reserve DC voltage source both line switches 107 and 108 are disabled to prevent the flow of energy from the reserve voltage source back into the primary AC energy source coupled to the input teminals 101 ad 102. Should either line switch 107 or 108 conduct, while supposedly in a turned off state, power flow from the reserve DC voltage source 120 into the primary AC source line creates a hazard that is not apparent until the AC source lines are accidentally conductively coupled.

In order to determine if either line switch 107 or 108 has failed, a dummy load 150 of fairly high resistance is connected across the input line just subsequent to the filter 105. This dummy load 150 has an impedance selected to permit a reverse current flow above leakage current values should any of the electronic isolation switches 107,108 fail shorted or conducting. This current flow is sensed by the power flow direction detector 151 and upon detection of a reverse current flow which is derived from the battery voltage source 120, a switch control circuit 152 responds by closing the relay switch 155. This particular arrangement uses output power to energize the relay coil 154 which in turn causes switch 104 to operate and disconnect the input from the primary AC source voltage at input terminals 101 and 102 by separating or opening the contacts of the mechanical switch 104.

The power flow detecting circuit is shown schematically in FIG.2 and includes a voltage sensing node 205 and a current sensing winding 206 connected in series with the input line switches 207 and 208. A secondary winding 266 is magnetically coupled to sensing winding 206 and is shunted by a resistor 267, two oppositely poled diodes 268 and 269 and a charge storage capacitor 270.

The dummy resistor 250 draws an AC current from the inverter upon failure of a line switch when power is suppled from the reserve voltage source. This current responsive to the reserve energy source flows through the current sensing winding 206. The secondary winding 266 applies a proportionate signal through an impedance 267 to develop a voltage waveform representative of the sinusoidal current which alternately charges the capacitor 270 to develop a voltage waveform at the output terminal 271. A voltage signal waveform is provided by node 205 to which lead 203 is connected. Diodes 268 and 269 are included to clamp the voltage across the secondary winding 266 and limit the power dissipated.

The phase relation between these voltage and current waveforms is utilized by the control circuitry of FIG. 3 to determine the diretion of power flow sensed by current sense winding 206 and voltage sense node 205. The current and voltage waveform signals are applied to the switch control circuit which is shown in block schematic in FIG.3. The sensed current and voltage signals are reconstituted into pulse signals by the square wave generators 381 and 382 respectively. The two square wave signals are phase compared in a phase comparator 384 whose output is applied to an averaging circuit 385 to derive a DC voltage level representative of the phase direction and magnitude difference. This DC voltage level is applied to a threshold comparator 386. If the voltage threshold is exceeded, indicating a reverse power flow, the relay coil 387 is de-energized by biasing transistor 388 off. Relay coil 387 when de-energized closes switch 155 (in FIG. 1) which in turn energizes the relay coil 156 (in FIG. 1) and enables operation of the mechanical backup switch 104.

Claims

1. An uninterruptible power supply comprising a first input (101,102) for accepting a primary source of energy, a second input (121) for accepting a reserve source of energy, an out-

switch 104, a filter circuit 105, and a current sensing winding 106 to two semiconductor electronic line switches 107 and 108 which are in turn coupled to an end terminal 109 ad a tap 110 of winding 111 of transformer 112. An output line 124 directly couples the end terminal 109 to an AC output terminal 126.

The two line switches 107 and 108 are under control of the stored program control unit 130 which may comprise a microprocessor system. The control unit 130 monitors the quality of the AC input via lead 131 and when the AC input is fully acceptable it causes line switch 107 to conductively connect the input to the end terminal 109 of winding 111 which in turn is directly connected to the output terminal 126. During normal operation when the input AC voltage is satisfactory, the DC voltage source 120 is charged from the input AC voltage via winding 138 and rectifier charger 122. If the control unit 130 determines that the input voltage is substandard (i.e. a brownout), the line switch 107 is disabled and line switch 108 is enabled to connect the AC input to tap 110 of winding 111. This provides a voltage boost to the input AC voltage by means of the auto transformer formed by the subsection of winding 111 and provides an adequate signal at terminal 109 which is connected to the output 126.

If the input AC voltage falls to a low level where in a voltage boost is not sufficient to provide the desired output voltage level, power to the output is derived from the reserve DC voltage source 120. The supplied DC voltage is inverted into AC voltage by inverter 123 ad is coupled to input winding 113 of transformer 112.

During operation of the UPS from the reserve DC voltage source both line switches 107 and 108 are disabled to prevent the flow of energy from the reserve voltage source back into the primary AC energy source coupled to the input teminals 101 ad 102. Should either line switch 107 or 108 conduct, while supposedly in a turned off state, power flow from the reserve DC voltage source 120 into the primary AC source line creates a hazard that is not apparent until the AC source lines are accidentally conductively coupled.

In order to determine if either line switch 107 or 108 has failed, a dummy load 150 of fairly high resistance is connected across the input line just subsequent to the filter 105. This dummy load 150 has an impedance selected to permit a reverse current flow above leakage current values should any of the electronic isolation switches 107,108 fail shorted or conducting. This current flow is sensed by the power flow direction detector 151 and upon detection of a reverse current flow which is derived from the battery voltage source 120, a switch control circuit 152 responds by closing the relay switch 155. This particular arrangement uses output power to energize the relay coil 154 which in turn causes switch 104 to operate and disconnect the input from the primary AC source voltage at input terminals 101 and 102 by separating or opening the contacts of the mechanical switch 104.

The power flow detecting circuit is shown schematically in FIG.2 and includes a voltage sensing node 205 and a current sensing winding 206 connected in series with the input line switches 207 and 208. A secondary winding 266 is magnetically coupled to sensing winding 206 and is shunted by a resistor 267, two oppositely poled diodes 268 and 269 and a charge storage capacitor 270.

The dummy resistor 250 draws an AC current from the inverter upon failure of a line switch when power is suppled from the reserve voltage source. This current responsive to the reserve energy source flows through the current sensing winding 206. The secondary winding 266 applies a proportionate signal through an impedance 267 to develop a voltage waveform representative of the sinusoidal current which alternately charges the capacitor 270 to develop a voltage waveform at the output terminal 271. A voltage signal waveform is provided by node 205 to which lead 203 is connected. Diodes 268 and 269 are included to clamp the voltage across the secondary winding 266 and limit the power dissipated.

The phase relation between these voltage and current waveforms is utilized by the control circuitry of FIG. 3 to determine the diretion of power flow sensed by current sense winding 206 and voltage sense node 205. The current and voltage waveform signals are applied to the switch control circuit which is shown in block schematic in FIG.3. The sensed current and voltage signals are reconstituted into pulse signals by the square wave generators 381 and 382 respectively. The two square wave signals are phase compared in a phase comparator 384 whose output is applied to an averaging circuit 385 to derive a DC voltage level representative of the phase direction and magnitude difference. This DC voltage level is applied to a threshold comparator 386. If the voltage threshold is exceeded, indicating a reverse power flow, the relay coil 387 is de-energized by biasing transistor 388 off. Relay coil 387 when de-energized closes switch 155 (in FIG. 1) which in turn energizes the relay coil 156 (in FIG. 1) and enables operation of the mechanical backup switch 104.

Claims

1. An uninterruptible power supply comprising a first input (101,102) for accepting a primary source of energy, a second input (121) for accepting a reserve source of energy, an out-

* C L M S *

put (125,126) for accepting a load to be energized, a power transformer (112) comprising first and second input windings (111 and 113) for receiving energy from the first and second inputs and capable of coupling energy from the second input to the first input, a primary semiconductor disconnect switch (107) for decoupling the first input from the first input winding of the power transformer when energy is being supplied to the load from the second input winding, characterized by a backup mechanical disconnect switch (104) for disabling energy flow from a reserve energy source connected to the second input into the first input, a dummy load (150) connected across the first input connected for facilitating a current flow supplied from the second input through the primary semiconductor disconnect switch at a current level greater than a leakage current of the primary semiconductor disconnect switch, and current direction sensing circuitry comprising current sensing circuitry (106) connected between the dummy load and the primary semiconductor disconnect switch, voltage sensing circuitry (206) connected between the dummy load and the primary semiconductor disconnect switch, signal phase comparison circuitry (384) for ascertaining a phase relation between signals detected by the current sensing circuitry and the voltage sensing circuitry to determine a direction of current flow, averaging circuitry (385) responsive to the signal phase comparison circuitry, and threshold circuitry (386,387,388) responsive to the averaging circuitry and connected to activate the backup mechanical disconnect switch.

2. A power supply as claimed in claim 1 wherein the current sensing circuitry comprises a transformer having a primary winding (206) connected between the dummy load and the primary semiconductor disconnect switch, and a secondary winding (266), a capacitor (270), a rectifier (268,269) connected to charge the capacitor from the secondary winding, and a lead (271) to connect the capacitor to the signal phase comparison circuitry.

3. A power supply as claimed in claim 1 or 2 wherein an end terminal (109) of the first input winding is directly connected to the output, and there is provided a second semiconductor disconnect switch (108) for coupling the input to a tap (110) of the first input winding, the second semiconductor disconnect switch being activated to conduct if a signal at the input is to be amplified, and control circuitry for enabling flow of energy from the second input winding upon failure of the second semiconductor disconnect switch.

Patentansprüche

1. Unterbrechungsfreie Stromversorgung mit einem ersten Eingang (101, 102) zum Anschalten einer primären Energiequelle, einem zweiten Eingang (121) zum Anschluß einer Reserveenergiequelle, einem Ausgang (125, 126) zum Anschluß einer zu versorgenden Last, einem Leistungstransformator (112), der eine erste und eine zweite Eingangswicklung (111 und 113) zur Aufnahme von Energie vom ersten und zweiten Eingang besitzt und Energie vom zweiten Eingang zum ersten Eingang koppeln kann, und einem primären Halbleitertrennschalter (107) zur Entkopplung des ersten Eingangs von der Eingangswicklung des Leistungstransformators, wenn Energie von der zweiten Eingangswicklung zur Last geliefert wird,
gekennzeichnet durch:
einen mechanischen Reservetrennschalter (104) zur Abschaltung des Energieflusses von der an den zweiten Eingang angeschlossenen Reserveenergiequelle in den ersten Eingang,
eine Blindlast (150), die über den ersten Eingang geschaltet ist und einen von dem zweiten Eingang gelieferten Strom über den primären Halbleitertrennschalter mit einem Wert fließen läßt, der größer als ein Leckstrom des primären Halbleitertrennschalters ist,
eine Stromrichtungs-Fühlschaltung mit einer Stromfühlschaltung (106), die zwischen die Blindlast und den primären Halbleitertrennschalter geschaltet ist,
eine Spannungsfühlschaltung (206), die zwischen die Blindlast und den primären Halbleitertrennschalter geschaltet ist,
eine Signalphasenvergleichsschaltung (384), die eine Phasenbeziehung zwischen den durch die Stromfühlschaltung und die Spannungsfühlschaltung detektierten Signalen feststellt, um die Stromflußrichtung zu bestimmen,
eine Mittelwert-Bildungsschaltung (385), die auf die Signalphasenvergleichsschaltung anspricht, und
eine Schwellwertschaltung (386, 387, 388), die auf die Mittelwert-Bildungsschaltung anspricht und so geschaltet ist, daß sie den mechanischen Reservetrennschalter aktiviert.

2. Stromversorgung nach Anspruch 1,
bei der die Stromfühlschaltung einen Transformator mit einer Primärwicklung (206) aufweist, die zwischen die Blindlast und den primären Halbleitertrennschalter gelegt ist, und mit einer

Sekundärwicklung (266), einem Kondensator (270), einem Gleichrichter (268, 269), der so geschaltet ist, daß er den Kondensator aus der Sekundärwicklung auflädt, und einer Leitung (271), die den Kondensator mit der Signalphasenvergleichsschaltung verbindet.

3. Stromversorgung nach Anspruch 1 oder 2, bei der ein Endanschluß (109) der ersten Eingangswicklung direkt mit dem Ausgang verbunden ist und ein zweiter Halbleitertrennschalter (108) vorgesehen ist, der den Eingang mit einer Anzapfung (110) der ersten Eingangswicklung verbindet, wobei der zweite Halbleitertrennschalter leitend gesteuert wird, wenn ein Signal am Eingang verstärkt werden soll, und bei der eine Steuerschaltung vorgesehen ist, die den Energiefluß von der zweiten Eingangswicklung bei einem Ausfall des zweiten Halbleitertrennschalter ermöglicht.

Revendications

1. Une alimentation secourue comprenant une première entrée (101, 102) destinée à être connectée à une source d'énergie primaire, une seconde entrée (121) destinée à être connectée à une source d'énergie de réserve, une sortie (125, 126) destinée à être connectée à une charge à alimenter, un transformateur de puissance (112) comprenant des premier et second enroulements d'entrée (111 et 113) pour recevoir de l'énergie à partir des première et seconde entrées, et capable de transmettre de l'énergie de la seconde entrée vers la première entrée, un interrupteur de déconnexion à semiconducteurs primaire (107) pour déconnecter la première entrée vis-à-vis du premier enroulement du transformateur de puissance, lorsque de l'énergie est fournie à la charge à partir du second enroulement d'entrée, caractérisée par un interrupteur de déconnexion mécanique de secours (104) qui est destiné à empêcher la circulation d'énergie vers la première entrée à partir d'une source d'énergie de réserve connectée à la seconde entrée, une charge fictive (150) connectée aux bornes de la première entrée et connectée de façon à permettre la circulation d'un courant fourni par la seconde entrée, à travers l'interrupteur de déconnexion à semiconducteurs primaire, avec un niveau de courant supérieur à un courant de fuite de l'interrupteur de déconnexion à semiconducteurs primaire, et un circuit de détection de direction de courant, comprenant un circuit de détection de courant (106), connecté entre la charge fictive et l'interrupteur de déconnexion à semiconducteurs primaire, un circuit de détection de tension (206) connecté entre la charge fictive et l'interrupteur de déconnexion à semiconducteurs primaire, un circuit de comparaison de phase de signaux (384) destiné à déterminer une relation de phase entre des signaux qui sont détectés par le circuit de détection de courant et le circuit de détection de tension, pour déterminer une direction de circulation du courant, un circuit de calcul de moyenne (385) qui fonctionne sous la dépendance du circuit de comparaison de phase de signaux, et un circuit à seuil (386, 387, 388) qui fonctionne sous la dépendance du circuit de calcul de moyenne et qui est connecté de façon à activer l'interrupteur de déconnexion mécanique de secours.

2. Une alimentation selon la revendication 1, dans laquelle le circuit de détection de courant comprend un transformateur ayant un enroulement primaire (206) connecté entre la charge fictive et l'interrupteur de déconnexion à semiconducteurs primaire, et un enroulement secondaire (266), un condensateur (270), un redresseur (268, 269) connecté de façon à charger le condensateur à partir de l'enroulement secondaire, et un conducteur (271) qui est destiné à connecter le condensateur au circuit de comparaison de phase de signaux.

3. Une alimentation selon la revendication 1 ou 2, dans laquelle une borne d'extrémité (109) du premier enroulement d'entrée est directement connectée à la sortie, et dans laquelle il existe un second interrupteur de déconnexion à semiconducteurs (108) qui est destiné à coupler l'entrée à une prise (110) du premier enroulement d'entrée, le second interrupteur de déconnexion à semiconducteurs étant activé de façon à conduire si un signal présent à l'entrée doit être amplifié, et un circuit de commande qui est destiné à permettre la circulation d'énergie à partir du second enroulement d'entrée en cas de défaillance du second interrupteur de déconnexion à semiconducteurs.

* C L M S *