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(54) Title: A MODULAR VOLTAGE SOURCE CONVERTER AND AN ENERGY SOURCE UNIT

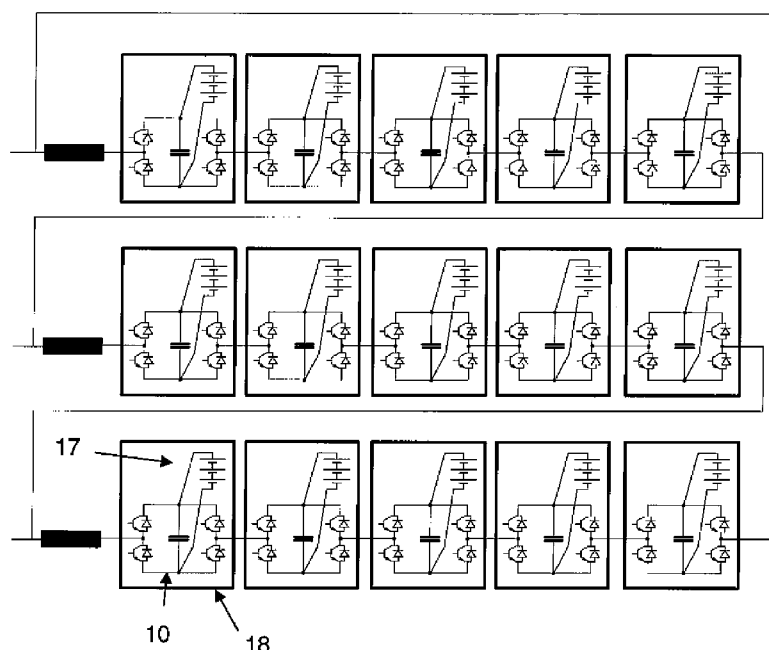


FIG. 5

(57) Abstract: The invention relates to a modular voltage source converter (VSC) comprising one or more phases (L1, L2, L3). Each of the phases comprises converter cell modules connected in series. At least one converter cell module in a phase is assigned a separate distributed energy source, wherein at least the energy source is accommodated in a separate housing. The invention further relates to an energy source unit comprising at least one energy source for converter cell modules of a voltage source converter.



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Title

A modular voltage source converter and an energy source unit

Field of the invention

- 5 The invention generally relates to the field of power compensation in a high-voltage power network, and in particular to a modular voltage source converter and to an energy source unit for a voltage source converter according to the preambles of the independent claims.

10 Background of the invention

Modern society relies heavily upon electricity. With deregulation and privatisation, electricity has become a commodity as well as a means for competition. Power quality, as a consequence, is coming into focus to an extent hitherto unseen. Disturbances emanating from any particular load will travel far, and, unless properly remedied, spread over the
15 grid to neighbouring facilities. A traditional way to deal with the problem of poor or insufficient quality of power distribution is to reinforce the grid by building new lines, installing new and bigger transformers, or moving the point of common coupling to a higher voltage level.

- 20 Such measures, however, are expensive and time-consuming, if they are at all feasible. A simple, straightforward and cost-effective way of power quality improvement in such cases is to install equipment especially developed of the purpose in the immediate vicinity of the source(s) of disturbance. As an additional, very useful benefit, improved process economy will often be attained enabling a profitable return on said investment.

25

Within flexible alternating current transmission systems (FACTS) a plurality of control apparatus are known. One such FACTS apparatus is the static compensator (STATCOM). A STATCOM comprises a voltage source converter (VSC) having an AC side connected to the AC network (transmission line) via an inductor in each phase. The DC side is
30 connected to a temporary electric power storage means such as capacitors. In a STATCOM the voltage magnitude output on the AC side is controlled thus resulting in the compensator supplying reactive power or absorbing reactive power from the transmission

line. With zero active power transfer, the voltage over the DC capacitors is constant when assuming that the converter losses are negligible. The VSC comprises at least six self-commutated semiconductor switches, each of which is shunted by a reverse or anti-parallel connected diode. A STATCOM apparatus with no active power source can only
5 compensate for reactive power, balancing load currents and remove current harmonics in point of common connection by injecting current harmonics with opposite phase.

By bringing together STATCOM and IGBT (Insulated Gate Bipolar Transistor) technologies, a compact STATCOM with reactive power compensation is obtained which
10 offer possibilities for power quality improvement in industry and power distribution. This performance can be dedicated to active harmonic filtering and voltage flicker mitigation, but it also allows for the compact STATCOM to be comparatively downsized, its footprint can be extremely small. The grid voltage profile may be controlled according to a given optimal characteristic, and the result is an enhanced grid capacity with a more stable,
15 strengthened and predictable behavior. One example where the compact STATCOM, has proven to be very useful is in the steel making industry. An electric arc furnace (EAF) is a piece of equipment needed to make steel products. For the grid owner and for the supplier of electricity, the EAF user is a subscriber to power, i.e. a customer, but in the worst case also a polluter of the grid.

20

An electric arc furnace is a heavy consumer not only of active power, but also of reactive power. The voltage drop caused by reactive power flowing through circuit reactances in the electrodes, electrode arms and furnace transformer becomes fluctuating in an erratic way. This is called voltage flicker and is visualized most clearly in the flickering light of
25 incandescent lamps fed from the polluted grid. The problem with voltage flicker is attacked by making the erratic flow of reactive power through the supply grid down into the furnaces decrease. This is done by measuring the reactive power consumption and generating corresponding amounts in the compact STATCOM and injecting it into the system, thereby decreasing the net reactive power flow to an absolute minimum. As an
30 immediate consequence, voltage flicker is decreased to a minimum, as well.

To parry the rapidly fluctuating consumption of reactive power of the furnaces, an equally rapid compensating device is required. This is brought about with the state of the art power electronics based on IGBT technology. With the advent of such continuously controllable semiconductor devices capable of high power handling, VSCs with highly
5 dynamic properties have become feasible into the 100 MVA range.

The function of the VSC in this context is a fully controllable voltage source matching the bus voltage in phase and frequency, and with an amplitude which can be continuously and rapidly controlled, so as to be used as the tool for reactive power control.

10

The input of the VSC is connected to a capacitor, which is acting as a DC voltage source. At the outputs, the converter is creating a variable AC voltage. This is done by connecting the voltages of the capacitor or capacitors directly to any of the converter outputs using the valves in the VSC. In converters that utilise Pulse Width Modulation (PWM), the input
15 DC voltage can be kept constant when creating output voltages that in average are sinusoidal. The amplitude, the frequency and the phase of the AC voltage can be controlled by changing the switching pattern.

In the compact STATCOM, the VSC uses a switching frequency greater than 1 kHz. The
20 AC voltage across the reactor at full reactive power is only a small fraction of the AC voltage, typically 15%. This makes the compact STATCOM close to an ideal tool for fast reactive power compensation.

For the compact STATCOM, the IGBT has been chosen as the most appropriate power
25 device. IGBT allows connecting in series, thanks to low delay times for turn-on and turn-off. It has low switching losses and can thus be used at high switching frequencies. Nowadays, devices are available with both high power handling capability and high reliability, making them suitable for high power converters. Instead of the IGBTs another possibility is to use Gate Turn-Off thyristors (GTOs), Integrated Gate Commutated
30 Thyristors (IGCTs), MOSFETs or any self commutated device.

As only a very small power is needed to control the IGBT, the power needed for gate control can be taken from the main circuit. This is highly advantageous in high voltage converters, where series connecting of many devices is used.

- 5 At series connection of IGBTs, a proper voltage division is important. Simultaneous turn-on and turn-off of the series connected devices are essential.

The converter topology for a compact STATCOM may be a two level configuration. In a two-level converter the output of each phase can be connected to either the positive pole
10 or the negative pole of the capacitor. The DC side of the converter is floating, or in other words, insulated relative to ground. The two-level topology makes two numbers of output voltage combinations possible for each phase on the AC-side. One such converter topology is shown in fig. 1.

- 15 The compact STATCOM described so far does only compensate for reactive power. The concept of DYNAPOW is to connect a battery energy storage to a compact STATCOM, and thus obtain an add-on feature to the existing compact STATCOM, which creates a platform for dynamic and active power compensation. The construction may be used e.g. as a spinning reserve and for compensating for fluctuating energy levels in the network.

- 20 The upper limit of the apparent power of the compact STATCOM is around 120 MVA. Since the maximum phase current is limited to approximately 1,8 kA, due to valve transistor current capability, the VSC must be connected to a high AC voltage and thus also the DC voltage of the VSC becomes high.

- 25 A high number of battery cells must be connected in series to match the DC voltage of the VSC. Moreover, to obtain the desired active power and duration of the energy storage, a number of battery strings must be connected in parallel. Note that only the converter DC voltage is controlled and that all the parallel-connected battery strings are connected to this controlled voltage. In Figure 3, the scheme of the DYNAPOW concept is shown, that
30 consists of a VSC and a battery energy storage connected to the DC-bus of the VSC.

There are several drawbacks for the DYNAPOW concept shown in figure 3, for example will a non optimal voltage be applied across the battery strings since the controller only adjusts the voltage over the DC capacitor. High short-circuit currents and power might arise as all battery strings are connected in parallel. A battery may start burning if
5 mistreated, and then the whole energy storage might be destructed.

The loop inductance of the VSC in figure 3 should be small in order to limit over voltages and to be able to switch as fast as possible in order to decrease the losses. Therefore, the VSC together with the DC capacitor should be built in a compact way to reduce the
10 commutation inductance, i.e., loop inductance.

An alternative to series connection of valve positions to achieve the necessary voltage rating is to connect converter cells in series. In this way smoother AC current and AC voltage waveforms are possible to obtain with lower switching frequency and minimal
15 filtering. One such arrangement is series connection of single phase full-bridge converters, which sometimes are referred to as chain-link cells.

A chain-link based converter comprises a number of series-connected cell modules, each cell comprising a capacitor, besides the valves. A chain-link cell module may consist of
20 four IGBT positions and a DC link Capacitor bank as shown schematically in figure 2. Each of the three VSC phases consists of a number of chain-link cells, here shown in series in the general diagram of figure 4 for a delta connected arrangement. The phases can also be connected in an Y-arrangement. The number of cells in series in each phase is proportional to the AC voltage rating of the system and can, for high AC voltage systems,
25 consequently include a large number of cells.

From the paper "Static VAr compensator (STATCOM) based on single-phase chain circuit converters", J.D. Ainsworth et al, IEE Proceedings 1998, it is known to replace the reservoir capacitors in each cell with a battery or other suitable energy storage component, giving the equipment the capability of providing real power to the AC system and removes
30 some of the above stated drawbacks with the concept of DYNAPOW.

Summary of the invention

The object of the present invention is thus to obtain an improved modular voltage source converter (VSC) that is able to dynamically provide active power for e.g. increased power quality management.

5

It is a further aim to provide a new building component for a modular VSC, based on chain-link technology, to further enhance the flexibility of the VSC to meet various demands.

10 The above-mentioned object and aim are achieved by modular VSC comprising one or more phases (L1, L2, L3). Each of the phases comprises converter cell modules connected in series to each other. At least one converter cell module in a phase is further assigned a separate distributed energy source, wherein at least the energy source is accommodated in a separate housing.

15

The invention also relates to an energy source unit comprising at least one energy source for converter cell modules of a voltage source converter (VSC) comprising one or more phases (L1, L2, L3). Each of the phases comprises converter cell modules connected in series to each other. The energy source unit further comprises a separate housing to

20 accommodate at least the at least one energy source.

By using a modular (e.g. chain-link) converter topology together with an energy source that is distributed into several small energy supplies, the converter cell modules can be dispersed and each converter cell module may be placed in or near a housing, which
25 contains at least one small energy source. The housing may be fire-proof, e.g. a fire cell, which will prevent a fire to spread and also minimize the damage if a part of the energy source fails and starts to burn.

Another advantage by distributing the converter and the energy supplies is that different
30 technologies may be used for different converter cell modules.

The modular VSC with energy sources may be used for example to control the voltage on the network (e.g. a transmission network, a sub transmission network or a distribution network), by consuming or injecting reactive and active power to the network.

- 5 Preferred embodiments are set forth in the dependent claims.

Short description of the appended drawings

Figure 1 illustrates a prior art two-level static compensator.

Figure 2 illustrates a cell module of a chain-link voltage source converter.

- 10 Figure 3 illustrates the concept of DYNAPOW with voltage source converter and battery energy storages.

Figure 4 illustrates a chain-link converter connected in delta.

Figure 5 illustrates a distributed chain-link converter connected in delta together with distributed energy sources according to one embodiment of the invention.

- 15 Figure 6 illustrates a phase of a distributed chain-link converter together with distributed energy sources according to one embodiment of the invention.

Figure 7 illustrates one embodiment according to the invention.

Detailed description of preferred embodiments of the invention

- 20 Figure 1 illustrates a prior art two-level static compensator 1 without any transformers to step down the power network voltage. The static compensator 1 comprises a voltage source converter (VSC) 2 connected at its DC side to a capacitor 3 and at its AC-side to a power network 8, also denoted grid.

- 25 The conventional two-level VSC 2 comprises three phase-legs P1, P2, P3 (the phases are denoted L1, L2, L3 when describing the present invention), each phase-leg consisting of two series-connected valves. The two valves of phase-leg P1 are indicated at reference numerals 9a, 9b. Each valve 9a, 9b in turn comprises a transistor with an anti-parallel diode, or rather, in order to manage high voltages, each valve comprises a number of series-connected transistors, for example IGBTs, each IGBT having an anti-parallel diode.

The VSC 2 is connected to the grid 8, in figure 1 comprising a three phase network, via a phase reactor 4, via an optional starting resistor 5 connected in parallel with a switch 6 and via an AC circuit breaker 7 in each phase. A starting resistor 5 may be used in series with each converter phase, if the energizing current is too high for the converter. Each phase
5 comprises such phase reactor, circuit breaker and if needed starting resistor together with switch. The respective phases are connected to the middle point of the respective phase-leg P1, P2, P3, i.e. connected between the respective valves as illustrated in the figure. It is possible to reduce the number of components by equipping (if needed) only two of the phases with the starting resistor connected in parallel with the switch. Only one phase is
10 described in the following in order to simplify the description, but it is understood that the phases are similar.

When the grid-connected VSC 2 is to be energized and started, the circuit breaker 7 is switched so as to provide a current path from the grid 8 through, if needed, the starting resistor 5, the phase reactor 4, and through the diodes of the VSC 2 so as to charge the
15 capacitor 3. When the capacitor voltage has reached a predetermined level, the starting resistor 5 is short-circuited by closing the parallel-connected switch 6. As the starting resistor 5 is short-circuited, the capacitor voltage will increase a bit more and when it is high enough, the valves of the VSC 2 are deblocked and start to switch. The capacitor voltage is then controlled up to its reference value.

20 The starting resistor 5 is provided in order to protect the diodes of the VSC 2 from being damaged by a too high and/or too long-lasting current surge, which could occur upon closing the AC circuit breaker 7 without the use of the starting resistor 5.

The stress put on the valves, and in particular the diodes, of the VSC 2 depend on several factors, for example the size of the DC-side capacitor 3, the size of the phase reactors 4
25 and on the voltage levels of the power network 8.

Figure 2 illustrates one converter cell module, also denoted converter link or chain-link cell module, of a modular converter applicable in the present invention. The cell module
10 may comprise four valves 11, 12, 13, 14, each valve including a transistor switch, such as an IGBT. In the following an IGBT is used as an example, but it is noted that other

semiconductor devices could be used, for example gate turn-off thyristors (GTOs), Integrated Gate Commutated Thyristors (IGCTs), MOSFETs or any self commutated device. A free-wheeling diode, also denoted anti-parallel diode, is connected in parallel with each IGBT. The diode conducts in the opposite direction of the IGBT. The valves 11, 12, 13, 14 are connected in an H-bridge arrangement with a capacitor unit 15. One example of a chain-link cell module VSC is shown in figure 4, here connected in delta. The VSC may of course instead be connected in Y. A starting resistor together with a switch may be added in each phase of the delta- or Y-connected converter cell module VSC to reduce stress of the diodes in the converter cell modules during energizing.

When constructing VSCs it is of major importance that the inductance is kept as low as possible at the DC-side to reduce voltage transients when switching and to keep down the switching losses. However, on the AC-side inductance is needed to limit the current and to filter the current wave form.

The present invention relates to a modular VSC comprising one or more phases (L1, L2, L3), wherein each of the phases comprises converter cell modules 10 connected in series to each other. At least one converter cell module 10 in a phase is assigned a separate distributed energy source 17, wherein at least the energy source 17 is accommodated in a separate housing 18. One embodiment is schematically illustrated in figure 6, where a phase of the modular VSC is shown. Here it is only the energy source 17 that is accommodated in the housing 18, and the converter cell module 10 is situated outside in close vicinity to the housing 18. Accordingly, at least one converter cell module 10 in a phase is capable of generating active power, and the converter cell module 10 with assigned energy source 17 may be placed together at distant places, separate from the other converter cell modules 10 in a phase. This is an advantage compared to having the energy supply for active power generation at a common place, as then there will e.g. be a need for long cables to connect converter cell modules 10 to energy sources. The housing 18 is preferably provided with connection means to connect the energy source 17 to the converter cell module 10.

According to one embodiment, two or more converter cell modules 10 in a phase are assigned a separate distributed energy source 17 each, wherein at least two of the separate distributed energy sources 17 are accommodated in a common separate housing 18. Thus, several energy sources may be placed in the same housing, whereby the housing 18 then
5 preferably is provided with connection means to connect the energy sources 17 to the converter cell modules 10.

According to a further embodiment, also the at least one converter cell module 10 in a phase assigned a separate energy source 17 is accommodated in the separate housing 18.
10 Thus, a compact building block with active power compensation capabilities for a VSC is achieved that simplifies the building of a modular VSC. One example of this embodiment is illustrated in figure 5, where all the phases of the modular VSC are shown. It is further important to keep loop inductance low inside the converter cell module 10. However, between the cell modules 10, the size of the inductance does not matter. Therefore, the
15 converter cell modules 10 may be placed distant to each other. The converter cell modules 10 may hence be accommodated in the same separate housing 18 as the assigned separate energy source 17. The housing 18 is then preferably provided with connection means to connect the converter cell module(s) 10 to e.g. other converter cell modules 10, or another housing 18. In the example shown in figure 5, all cell modules 10 in a phase are each
20 assigned a separate distributed energy source 17 and are accommodated in separate housings 18, together with their assigned separate distributed energy source 18.

According to a further embodiment, also the two or more converter cell modules 10 in a phase, assigned distributed energy sources 17 accommodated in the common separate
25 housing 18, are accommodated in the same common separate housing 18. Thus, different constellations of building blocks with active power compensation are possible.

According to a still further embodiment, the housing 18 also accommodates at least one converter cell module 10 without assigned energy source(s) 17. It is thus possible to have
30 one housing 18 accommodating e.g. two converter cell modules 10 with assigned distributed energy sources 17, together with three other converter cell modules 10 without assigned distributed energy source 17. Many other constellations are of course possible

within the scope of the invention defined by appending claims. The converter cell modules 10 in the housing 18 are connected in series, and the housing 18 advantageously comprises connecting means for connecting to other converter cell modules 10 etc.

- 5 Advantageously, the housing(s) 18 is/are fire-proof. By having fire-proof housings 18, the energy sources 17 are shielded from fire starting outside of the housings 18. If a fire starts inside the housing 18, other equipment in the modular VSC will be shielded from the fire by the housing 18, and the risk of destroying more active energy sources 17 etc of the modular VSC in case of fire is much reduced. The fire-proof housing 18 may be made in a
- 10 material that is heat-resistant, such as metal, hard metal or any other kinds of fire- and heat-resistant material.

- Thus, by using a modular (e.g. chain-link) converter topology, which is displayed in figures 2 and 4, together with an energy source that is divided into several small energy
- 15 sources 17, the converter cell modules 10 can be dispersed and each converter cell module 10 can be placed in or near each fire cell, which contains the small energy source, as illustrated according to the examples in figure 5 and 6.

- Preferably, the distributed energy source(s) 17 of a phase constitute the total active power
- 20 demand of that phase. Consequently, an active power source that matches the DC voltage of the converter cell module 10 is obtained. Due to the possibility to distribute both the converter cell modules 10 and the total energy source, a more flexible and safer module-based VSC with active power compensation is achieved, than prior known VSC with e.g. the DYNAPOW concept. Costs for building the modular VSC with active power
- 25 compensation may also be reduced, as converter cell modules 10 with energy sources 17 accommodated in a housing 18 may be mass produced with standard components. No single large energy source has to be tailor made for the VSC, which is not easily expanded if the VSC is to be enlarged in capacity. The footprint of the VSC may also be optimized or customer designed and more easily handled, as the cell modules 10 and assigned
- 30 separate energy sources 17 may be placed at more distant locations than before, as the inductance between the cell modules 10 does not have to be kept low.

The two- or three-level VSC used in the DYNAPOW concept results in high dv/dt switching in the converter and the DC side must be grounded to avoid capacitive stray currents between the battery strings and the ground. The DC side grounding results in high level harmonics on the AC side and therefore a transformer must be used to trap the harmonics. The module-based VSC is a multi-level converter that produces low amounts of dv/dt and little harmonics and therefore the capacitive stray currents between the energy sources 17 and the cell modules 10 are very small and no special grounding arrangement is necessary.

According to one embodiment, the distributed energy source 17 is a Li-Ion battery. This embodiment is advantageous, as the Li-Ion battery has high performance characteristics. As the Li-Ion battery may start burning if mistreated, it is important to prevent that a fire in a single distributed energy source 17 starts to spread to the other energy sources 17. By accommodating the distributed Li-Ion batteries in separate fire-proof housings 18, this risk is much reduced. According to another embodiment, the distributed energy source 17 is any of a battery of another type than the Li-Ion battery, a fuel-cell, a solar panel system, a hydroelectric power system or a wind turbine.

Other suitable energy sources may also be possible to use in conjunction with the converter cell modules 10.

According to one embodiment, the distributed energy sources 17 are different kinds of energy sources. Thus, one distributed energy source may be a Li-Ion battery, the second a fuel cell, the third a solar panel system etc. The modular VSC may thus be used together with different kinds of energy sources when needed, and e.g. does not have to rely on a single distributor of energy sources.

In one embodiment, each of the converter cell modules 10 comprises four valves 11, 12, 13, 14 arranged in a full-bridge connection. This embodiment is shown in the figures 2, 5 and 6. According to another embodiment, each of the converter cell modules 10 comprises two valves 11, 14 arranged in a half-bridge connection. This embodiment is a variant that is not exemplified in the figures, as the other essential features of this embodiment of the invention are the same as in the full-bridge connection embodiment.

Advantageously, each valve 11, 12, 13, 14 in the converter cell modules 10 comprises an insulated gate polar transistor (IGBT) with an anti-parallel diode. Other devices such as Gate Turn-Off thyristors (GTOs), Integrated Gate Commutated Thyristors (IGCTs),
5 MOSFETs or any self commutated device may thus be used.

The present invention further relates to an energy source unit 19 comprising at least one energy source 17 for converter cell modules 10 of a voltage source converter (VSC) comprising one or more phases (L1, L2, L3), wherein each of the phases comprises
10 converter cell modules 10 connected in series to each other. The energy source unit 19 further comprises a separate housing 18 to accommodate at least the at least one energy source 17. Consequently, an energy source unit 19 is obtained that is easily placed at various locations, and that has a footprint that is relatively small.

15 Preferably, the separate housing 18 is provided with connection means to connect the at least one energy source 17 to converter cell module(s) 10. The energy source 17 is advantageously connected in parallel with the capacitor unit 15, as shown in figure 6. In a further embodiment, the separate housing 18 is adapted to also accommodate at least one converter cell module 10. The separate housing 18 is then preferably provided with
20 connection means to allow connection to other housings 18 or converter cell modules 10 etc. By pre-making the housing 18 to accommodate at least one converter cell module 10, the choice of having the converter cell module 10 inside the housing 18 or outside can be made at a later time. According to one embodiment, the separate housing 18 is adapted to accommodate five converter cell modules 10 and two energy sources 17, wherein the two
25 energy sources 17 are connected to one of the five converter cell modules 10 each. This embodiment is illustrated in figure 7.

Thus, a building component for a modular VSC is obtained, that is pre-sized and wherein the parts matches each other, i.e. the energy source 17 matches the converter cell module
30 10, in the building component. Different building components are then easily build together to form a compact STATCOM that may compensate for both reactive and active power. The STATCOM is may thus be built according to different power demands.

- Advantageously, the housing 18 of the energy source unit 19 is fire-proof. By having a fire-proof housing 18, the energy source(s) 17 inside the housing is/are shielded from fire starting outside of the housing 18, and other parts of the construction outside the energy source unit 19 are shielded from fire starting inside the housing 18. Accordingly, a building block to build up a compact STATCOM with both reactive and active power compensation is obtained, wherein the risk that a fire in an energy source 17 destroys large parts of the energy source is greatly reduced.
- 10 Preferably, the at least one energy source 17 is a Li-Ion battery. As explained above, Li-Ion batteries have high performance characteristics, making this embodiment advantageous. It is then advantageous to have fire-proof housings. According to another embodiment, the at least one energy source 17 is any of a fuel-cell, a solar panel system, a hydroelectric power system and a wind turbine. Other suitable energy sources may also be possible to use in conjunction with the converter cell modules 10.

The present invention is not limited to the above-described preferred embodiments. Various alternatives, modifications and equivalents may be used. Therefore, the above embodiments should not be taken as limiting the scope of the invention, which is defined by the appending claims.

Claims

1. A modular voltage source converter (VSC) comprising one or more phases (L1, L2, L3), each of said phases comprising converter cell modules (10) connected in series to each other,
5 characterized in that at least one converter cell module (10) in a phase is assigned a separate distributed energy source (17), wherein at least said energy source (17) is accommodated in a separate housing (18).
- 10 2. A modular voltage source converter according to claim 1, wherein two or more converter cell modules (10) in a phase are assigned a separate distributed energy source (17) each, wherein at least two of the separate distributed energy sources (17) are accommodated in a common separate housing (18).
- 15 3. A modular voltage source converter according to claim 1, wherein also said at least one converter cell module (10) in a phase assigned a separate energy source (17) is accommodated in said separate housing (18).
4. A modular voltage source converter according to claim 2, wherein also the
20 two or more converter cell modules (10) in a phase, assigned distributed energy sources (17) accommodated in said common separate housing (18), are accommodated in the same common separate housing (18).
5. A modular voltage source converter according to claim 3 or 4, wherein said
25 housing also accommodates at least one converter cell module (10) without assigned energy source(s) (17).
6. A modular voltage source converter according to any of the preceding claims, wherein said housing is fire-proof.
- 30 7. A modular voltage source converter according to any of the preceding claims, wherein the distributed energy source(s) (17) of a phase comprises the total active

power demand of that phase.

8. A modular voltage source converter according to any of the preceding claims, wherein each distributed energy source (17) is a Li-Ion battery.

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9. A modular voltage source converter according to any of claims 1 to 7, wherein each distributed energy source (17) is any of a battery, a fuel-cell, a solar panel system, a hydroelectric power system or a wind turbine.

10 10. A modular voltage source converter according to any of the preceding claims, wherein each of said converter cell modules (10) comprises four valves (11, 12, 13, 14) arranged in a full-bridge connection.

11. A modular voltage source converter according to any of claims 1 to 9,
15 wherein each of said converter cell modules (10) comprises two valves (11, 14) arranged in a half-bridge connection.

12. A modular voltage source converter according to any of claim 10 or 11
20 wherein each valve (11, 12, 13, 14) comprises an insulated gate polar transistor (IGBT) with an anti-parallel diode.

13. Energy source unit (19) comprising at least one energy source (17) for
converter cell modules (10) of a voltage source converter (VSC) comprising one or more
phases (L1, L2, L3), each of said phases comprising converter cell modules (10)
25 connected in series to each other,
c h a r a c t e r i z e d i n that the energy source unit comprises a separate housing (18) to
accommodate at least said at least one energy source (17).

14. Energy source unit (19) according to claim 13, wherein said separate housing
30 (18) is provided with connection means to connect said at least one energy source (17) to
converter cell module(s) (10).

15. Energy source unit (19) according to any of claim 13 or 14, wherein said separate housing (18) is adapted to also accommodate at least one converter cell module (10).

5 16. Energy source unit (19) according to claim 15, wherein said separate housing (18) is adapted to accommodate five converter cell modules (10) and two energy sources (17), wherein said two energy sources (17) are connected to one of said five converter cell modules (10) each.

10 17. Energy source unit (19) according to any of claims 13 to 16, wherein said housing (18) is fire-proof.

18. Energy source unit (19) according to any of claims 13 to 17, wherein said at least one energy source (17) is a Li-Ion battery.

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19. Energy source unit (19) according to any of claims 13 to 17, wherein each of said at least one energy source (17) is any of a battery, a fuel cell, a solar panel system, hydroelectric power system and a wind turbine.

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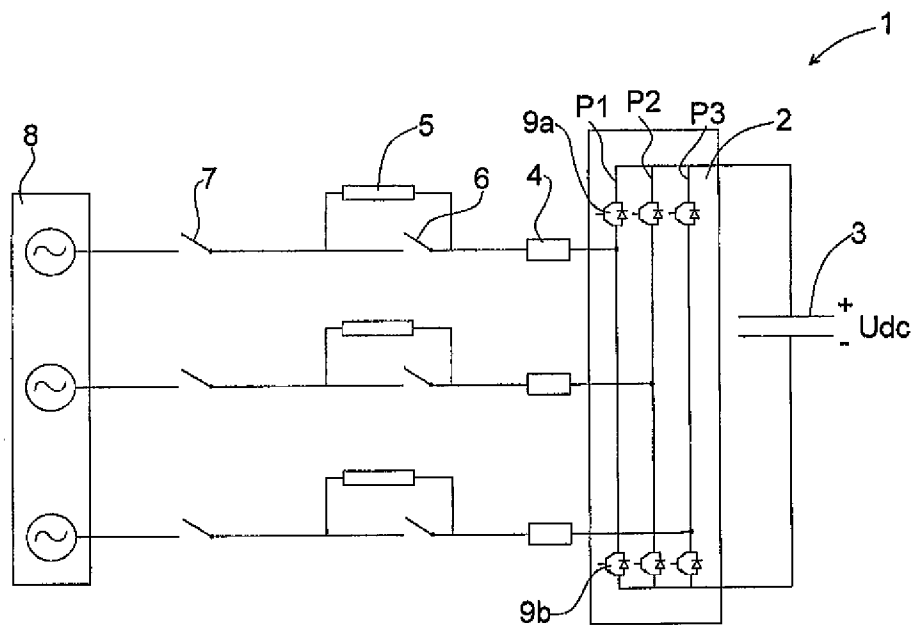


FIG. 1

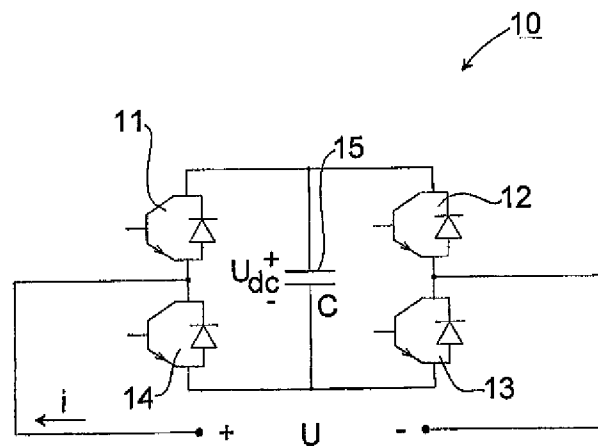


FIG. 2

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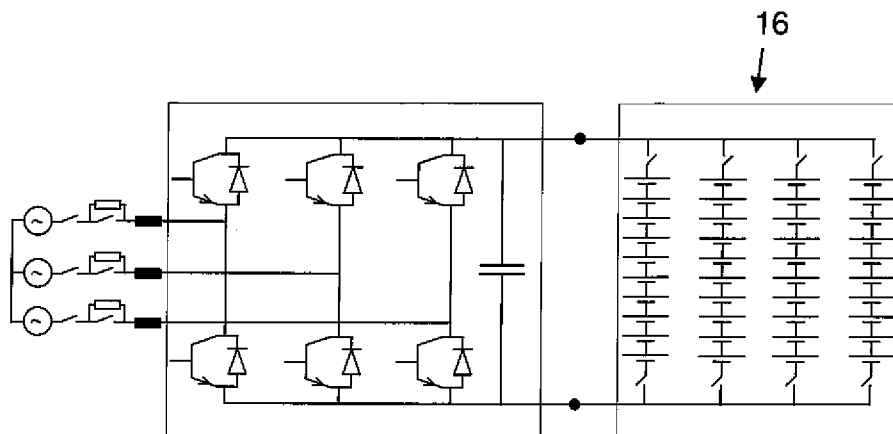


FIG. 3

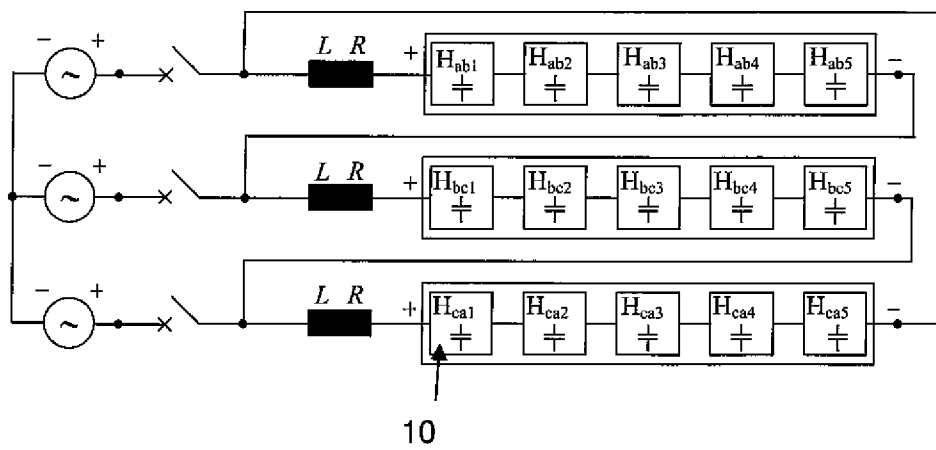


FIG. 4

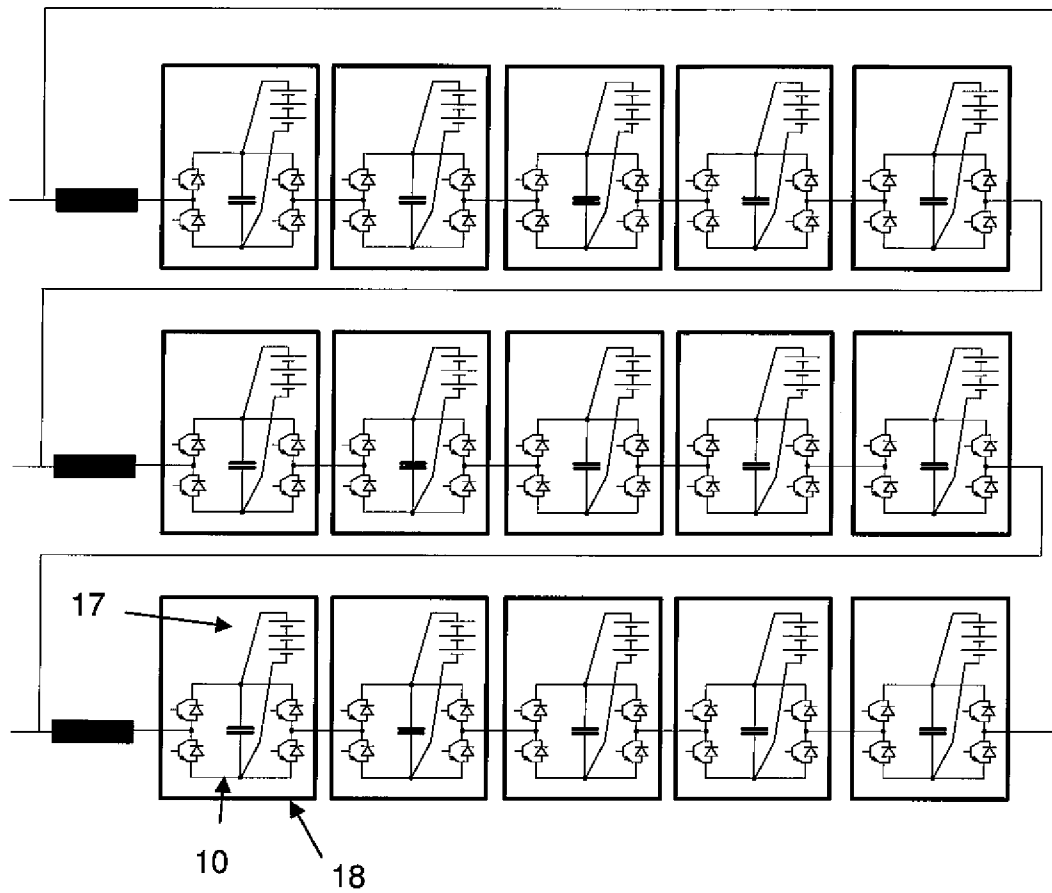


FIG. 5

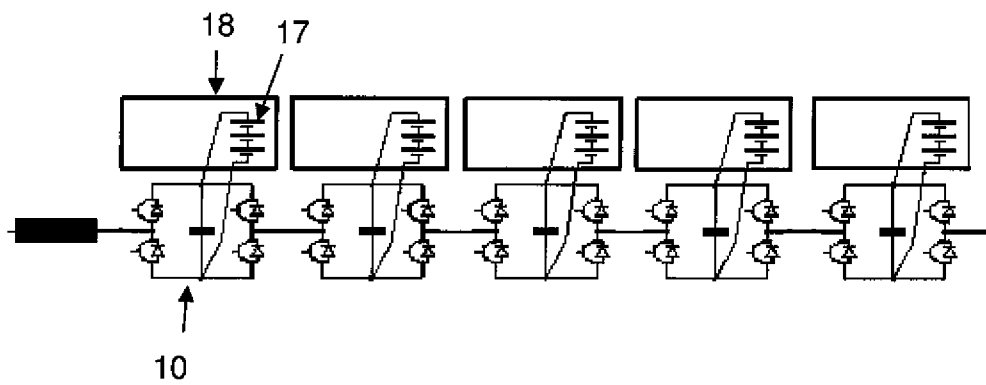


FIG. 6

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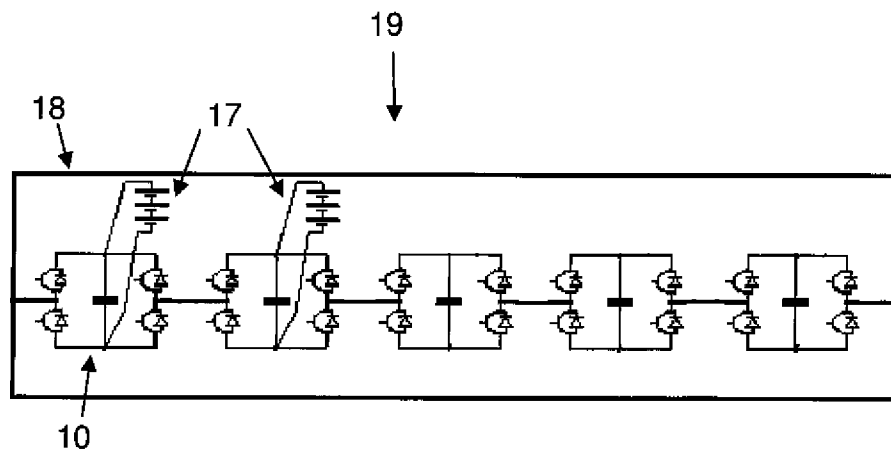


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/052887

A. CLASSIFICATION OF SUBJECT MATTER INV. H02M1/32 ADD. H02J3/18 H02J3/32		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) H02J H02M		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practical, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	AINSWORTH J D ET AL: "Static VAR compensator (STATCOM) based on single-phase chain circuit converters" IEE PROCEEDINGS: GENERATION, TRANSMISSION AND DISTRIBUTION, INSTITUTION OF ELECTRICAL ENGINEERS, GB, vol. 145, no. 4, 15 July 1998 (1998-07-15), pages 381-386, XP006011181 ISSN: 1350-2360 cited in the application figures 2,5 page 385, left-hand column, paragraph 12 ----- -/--	1-19
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : *A* document defining the general state of the art which is not considered to be of particular relevance *E* earlier document but published on or after the international filing date *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) *O* document referring to an oral disclosure, use, exhibition or other means *P* document published prior to the international filing date but later than the priority date claimed *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. *Z* document member of the same patent family		
Date of the actual completion of the international search 6 July 2009		Date of mailing of the international search report 16/07/2009
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Kail, Maximilian

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/052887

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JIH-SHENG LAI ET AL: "Multilevel Converters-A New Breed of Power Converters" IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS, IEEE SERVICE CENTER, PISCATAWAY, NJ, US, vol. 32, no. 3, 1 June 1996 (1996-06-01), XP011022014 ISSN: 0093-9994 figures 6,7 page 513, left-hand column, paragraph 2	1-19
X	DE 93 12 174 U1 (VARTA BATTERIE [DE]) 7 October 1993 (1993-10-07) claim 1	13
A	WO 2008/074274 A (SIEMENS AG [DE]; SCHRIEK UWE [DE]) 26 June 2008 (2008-06-26) page 1, line 1 - page 3, line 3 page 3, line 29 - page 4, line 3 page 4, line 31 - page 5, line 7 page 5, lines 22-26	1-19
A	ANONYMUS: "Elektrische Betriebsräume / Electrical Service Rooms"[Online] June 2008 (2008-06), pages 1-9, XP002532110 Retrieved from the Internet: URL: http://notstrom.gaz-accu.com/uploads/media/GVI.pdf [retrieved on 2009-06-15] page 7, paragraph 1	1-19
A	KIYOKAWA I ET AL: "UPS with an electric-energy storage function using VRLA batteries" INTELEC 2003. 25TH. INTERNATIONAL TELECOMMUNICATIONS ENERGY CONFERENCE. YOKOHAMA, JAPAN, OCT. 19 - 23, 2003; [INTELEC. INTERNATIONAL TELECOMMUNICATIONS ENERGY CONFERENCE], TOKYO, IEICE, JP, vol. CONF. 25, 19 October 2003 (2003-10-19), pages 808-813, XP010675329 ISBN: 978-4-88552-196-6 page 810, left-hand column, last paragraph	1-19

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Information on patent family members

International application No

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