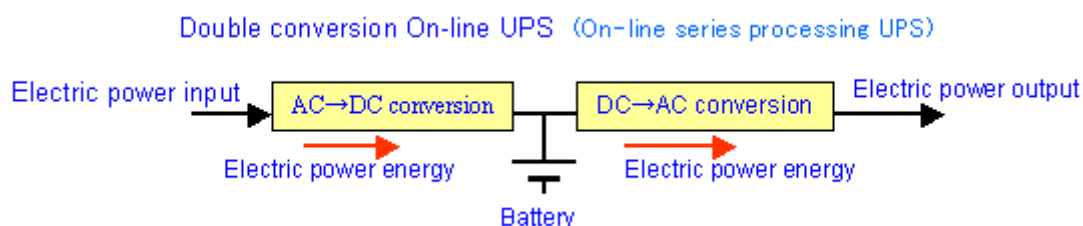


Comparison of the Parallel processing UPS vs. the Double conversion On-line UPS.

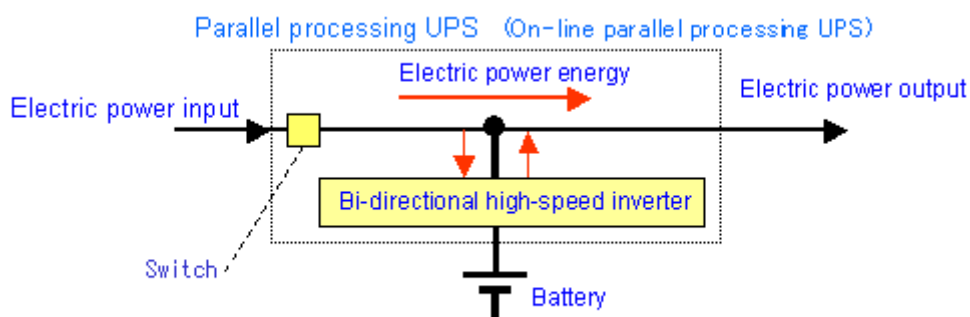
【1. General description】

The Double conversion On-line UPS to date, mainly used for the power sources of computers and other purposes, is the method that converts the electric power energy from the electric power company into direct current, then converts it into alternating current with the inverter again, and supplies it to the load. (See below)

This method converts the entire load power flow total twice and it makes power loss, but can provide ideal electrical output performance to protect power failure, voltage reduction and sudden surge noise arriving. This has been used up to the present time widely since about 1965, because for many years, no better design than this method has been developed in stability and quality of output power. This is also called the Double conversion On-Line power feeding method.



On the other hand, remarkable progress of LSI (Digital signal Processor, etc.) made the Parallel processing UPS put to practical use about 10 years ago. This design shown as below figure is the method to run the bi-directional inverter constantly in parallel state. This bi-directional inverter in parallel state monitors waveform and also corrects cobs at high-speed to normal conditions of electrical power. Using this UPS enables high-quality electrical power output against the case of power failure, momentary voltage drops and noise.



The switch is strong against overcurrent because the thyristor is used for it.

Using a single power converter results a significant reduction in energy losses, because the less amount of energy is converted in normal operation, also, the bi-directional inverter operates in a similar way to commercial power and parallel redundant operation. Therefore, this method is characterized by high reliability of the power feeding.

In the double conversion On-line method of the former, all of the electric power energy skewered semiconductor (IGBT) in the rectification part and the inverter part.

In the examples of the later method of the Parallel processing UPS, electric power energy doesn't pass through the semiconductors of the inverter unit on normal operation, high reliability of fewer troubles, such as failures of semiconductors on the electric path is characteristics of this UPS.

The above diagram of this method (See the above) is similar to the Standby UPS design as shown below. There is a worry that the noise passes through from the input side to the output side when the noise is arriving. However, as the above-mentioned, the bi-directional inverter in the parallel operation absorbs the noise at high speed, it doesn't pass through to the output side. (It was verified in 4kv surge noise experiment)

From a functional standpoint, this is the operation system that coordinates with commercial electric power as "Energy is from commercial electric power, quality is by an inverter". Thus, in this design, it is close to but not a same system as a general type of the Stand-by method UPS. Whether the bi-directional inverter process it constantly or not is the point of difference from the Stand-by method UPS.

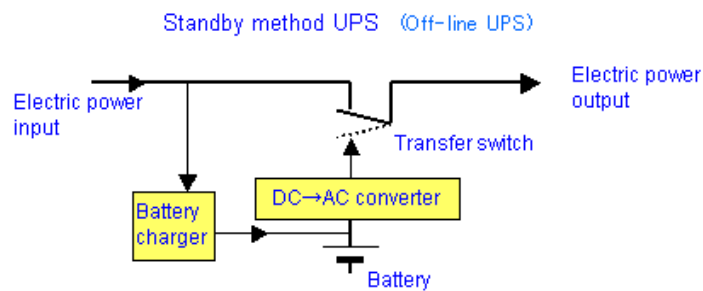
Needless to say, when power outage, this parallel processing UPS will output perfect electric power and cover shut-off moment without distortion.

In this design, operation efficiency at normal time is 97% (98% in AC400V type); it is quite high and enables to reduce the cost of the commercial electric power (Contribute to the CO2 reduction). Also, it can make the electric power charge of an air conditioner reduce because of fewer heat generating.

As described previously, electric power energy at normal operation doesn't pass through the semiconductors (IGBT) of the inverter unit in this design, and inrush current has strong characteristics. This method is used a lot in fields such as not only telecommunication and large-scale computer field but also in fields of semiconductor fabrication equipments and precise machine tools where the transformers and the power equipments, etc. exist together.

Note: In general, "Standby method UPS" is the method that let the unprocessed electric power output at normal operation, the inverter only starts with the transfer switch that is set to output the

electric power from the inverter when power fails. (See the figure below.)



The standby method UPS is not actively implemented for the systems that require a high quality and reliability, because when transferring the switch to the inverter, instantaneous interruption is caused for 4 -10 msec. Also the inverter unit still has a concern regarding the warranty of its operations, as it has to wait for a long period of time such as several months over to several years until electric power outage happens, it makes components reliability reduce. (Excepted from the comparison in this booklet)

【2. Comparison of output electric power quality】

(2.1) Quality of the Double conversion on-line UPS

As described before, the Double conversion online UPS is the system that regenerates AC electric power in inverter units, therefore output voltage is able to maintain constant frequency even if input voltage fluctuates. Enables to output quality waveform with fewer distortion.

Frequency is set to synchronize with the phase of commercial electric power (commercial synchronized operation) so that it is equivalent quality of commercial electric power. When inputting through a simple electric generator or this kind of machine that fluctuates frequency, operation will be changed to asynchronous operation in order to maintain output frequency constantly.

As described about this method, this UPS can output high quality electric power, but has a disadvantage at power attenuation since the system consumes energy by converting the entire load power flow twice even if the good quality commercial power is provided.

(2.2) Quality of the parallel Processing UPS

(Hereinafter, called "The Inverter parallel processing method")

In the Inverter parallel processing method, when the voltage and frequency are within the normal range, this UPS doesn't convert the electric energy, and its bi-directional inverter unit that is connected constantly in parallel processes waveform such as removing noise to output high quality electric power.

The normal range can be freely defined with this UPS in using detection setting. The possible setting range is from $\pm 1\%$ to 10% in the rated voltage. To ascertain whether output voltage/frequency are within the setting range or not, reference waveform in the UPS is always compared with them. The bi-directional inverter unit will output the power only when they exceed the setting range. If the setting width of voltage/frequency range is narrowed, the number and time of output power feeding from the bi-directional inverter unit will be increased.

Components that require precision in alternating voltage/frequency such as the magnetic drums were used for early computers. Modern computers and server needn't those components. Moreover, it is now designed to meet the UL/E/NSI (European standard) and JIS, also the operation guarantee is covered within the range of voltage rating $\pm 10\%$. Therefore, output voltage of UPS now can be sufficiently satisfied by a certain range of width.

Sales representative of UPS manufacturers often appeal that "The Double Conversion On-Line UPS can output high precision voltage than other design UPS" as the advantage of that. However, in fact, the distance of wiring from UPS to the loading apparatus causes voltage reduction so that the voltage of each of loading apparatus becomes not constant state.

Thus, whatever the Double conversion On-Line method or the Inverter parallel processing method, as long as the electric power quality of the apparatus in load side such as telecommunications equipment can provide stable operation, it suffices.

In fact, the allowable output power voltage range width of the Inverter parallel processing method UPS (20 – 300Kva, 450 units) were preset between $+10\%$ to -8% , and then, they were operated in domestic and abroad by 2010 since 2002. As a result, no issue has arisen including the loading apparatus side.

Regarding precision of frequency, both of the former one and the later one are set to synchronize with the phase of commercial electric power (commercial synchronized operation) so that it is equivalent quality of commercial electric power, there is no difference between them.

In future selection of UPS, not only for the traditional type of the Double conversion On-Line UPS, but also the effort of re-engineering technique considering the modern operating conditions such as telecommunications equipments including reduction of electric power loss (electric power charge) would be needed to put the thought into total optimization.

[3. Comparison of passage of noise]

(3.1) Passage of noise in the Double-conversion On-Line UPS

In this method of UPS, AC input is converted into DC, and then DC is converted back into AC. Therefore, some consider that if the noise comes to the input power, it doesn't affect any of the output power. But from this point of view, Normal mode type is different from Common mode type in input noise.

Normal mode noise comes piling up between electric power lines same as the alternating current voltage. This noise, for example, is generated when the phase advanced capacitor switches in the high voltage terminal.

"Common mode noise" is that to be generated between electric power lines and the earth by thunderbolt, and arrive piling up to each of electric power lines in-phase (Common mode).

In the former case, Normal mode noise doesn't pass through the Double conversion on-line UPS. In the later case, Common mode noise passes through this method UPS. If the Double conversion on-line UPS were replaced with an equivalent circuit, semiconductors (IGBT) in a rectifier unit and semiconductors in an inverter unit would be capacitors. Thus, in a condition of those two capacitors in tandem arrangement, high frequency content of common mode noise can pass through it. A storage battery has high impedance on high-frequency content so that it is not able to absorb high-frequency noise content.

Common mode noise will be stopped entering in the input side by the arrester, but the arrester cannot prevent the noise that is less than 600V of clamp voltage. To prevent invasion by that, an electric transformer is installed in the input side of the UPS. Actually, in most of cases, an electric transformer is used for receiving voltage in the building; therefore, it performs to block that noise so that setting of the extra transformer is not necessary. However, in the complicated-wiring large-scaled building, it may not identify an arriving pathway of that noise, there is an example that a transformer is installed in input side of the UPS.

(3.2) Passage of noise in the Inverter parallel processing UPS

As described above, in this UPS design, the noise of the input side seems to pass through to the output side straight away. In fact, that doesn't go through to the output side because the bi-directional inverter that performs high-speed processing in constantly parallel drowns out the noise.

Common mode noise will pass through the arrester that is less than 600V of clamp voltage as well as The Double conversion on-line method UPS. High-frequency content of

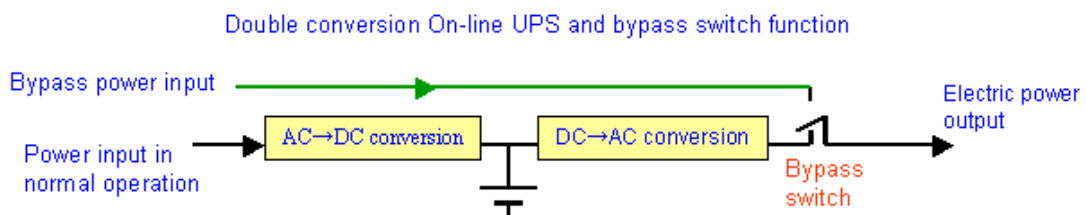
common mode noise passes through, because the AC switch unit of this method will become a transformer at a high-frequency equivalent circuit. It is possible to block that as well as the Double conversion on-line UPS by installing a transformer.

As observed above, it was experimentally verified that there is no difference in the passage of noise between both of those methods of UPS. (It was verified in 4kv surges of impressed voltage test)

【4.Comparison of reliability】

(4.1) Reliability of The Double conversion on-line UPS.

As mentioned previously, in this method, the electrical power energy is output passing through the rectifier unit and the inverter unit to the load. Thus, there are semiconductors (IGBT) on the way of the passage of electric power, once failure of semiconductors or over-current occurs, the inverter unit is stopped. In order to continue to output the electrical energy, the “Bypass switch” is set up in the input side of the inverter unit. (See the below figure)

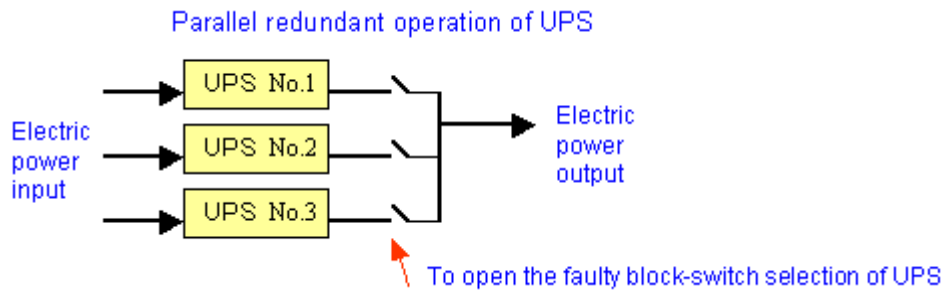


In the Double conversion on-line method UPS, certainty operation in the bypass pathway switch is always a bottleneck of reliability. It is important to execute confirmation tests to confirm its certainty periodically, however, once this UPS is in operation, those tests are not executed in the most of fields actually, because there are some difficulty to get the load side users' approval for that.

As the result of that, there is a rare case that can be seen, such as 0.2 – 0.5 ms instantaneous interruption, or power output halt, because underlying defects in the bypass-switch-unit are not recognized previously.

In order to increase reliability of this method UPS, when using the electric power supply for a large-sized computer and so on, UPS units are composed by multiple-connected in parallel formation for parallel redundant operation.

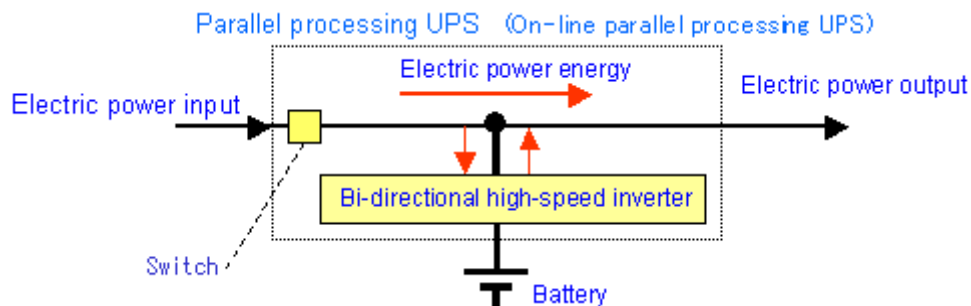
In parallel redundant operation system in a normal operation, all of UPS units are operated in parallel, but when a failure occurs in any of UPS units, the UPS units with failures are separated by switch over from the current operation, and the rest of them will keep supplying the necessary electric power output. (See the below figure)



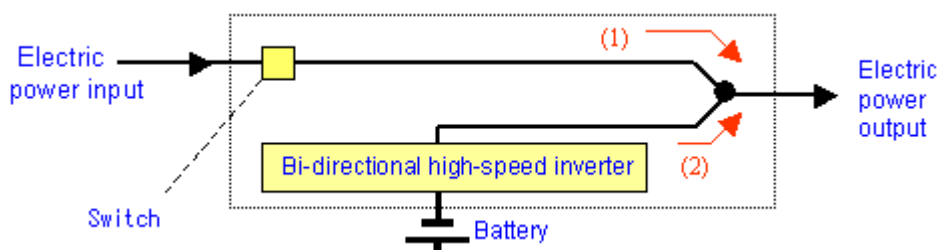
In parallel redundant operation system, precise synchronization between voltages and frequencies are needed in UPS units each other. It depends on that success or failure of the control systems at parallel redundant operation, and it greatly affects to its reliability. To prevent the control system from decreasing of reliability, this control system is not executed under the one common-base circuit but controlled individually as each of UPS units.

(4.1) Reliability of the Inverter parallel processing UPS

As mentioned before, semiconductors (IGBT) that are vulnerability against over-current exist on the way of the passage of electric power in the Double conversion on-line method UPS. In the examples of the Inverter parallel processing UPS, electric power energy doesn't pass through the semiconductors of this Inverter parallel processing method UPS, and also, small number of the component parts and so on decreases failure rate than the former example, as one of characteristics of this UPS. And the commercial power and the bi-directional inverter are functioning like parallel redundant operation, moreover, there is no bypass switch that would be a bottleneck. Therefore they make its reliability increase.



When a figure is changed, will see that the output stands for two systems of (1) and (2).



Once the failure occurs in the Double conversion on-line method UPS, “switch-over” operation will be executed for that. On the other hand, in the Inverter parallel processing method UPS, the failure units are operated to “separate”. Thus, if compare “switch-over” with “separate”, the latter is simple as operation, and also there is more excellent in the certainty than “switch-over”.

Also, in the Parallel inverter processing method UPS has “Normality acknowledgement function” that can output the electric power from the bi-directional inverter without stopping the commercial electric power input. This function retains the reliability of the UPS because its autonomous working checks normality acknowledgement function periodically.

In the actual field to retain the reliability of the UPS is not influenced by its methods or relative merits of composition but greatly depending on whether operation checks for the case of the outage are executed periodically or not.

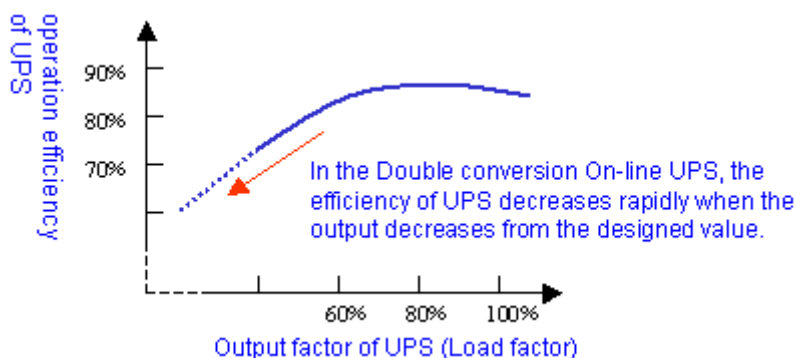
If more reliability is required, the UPS is operated by parallel redundant formation as well as the Double conversion On-line method UPS.

In addition, if the Inverter parallel processing method UPS is used under the bad output conditions like the commercial power supply voltage often fluctuates, to increase the capacity of the storage battery should be considered because the time length of output electricity in inverter side would be longer.

【5.Comparison of operation efficiency】

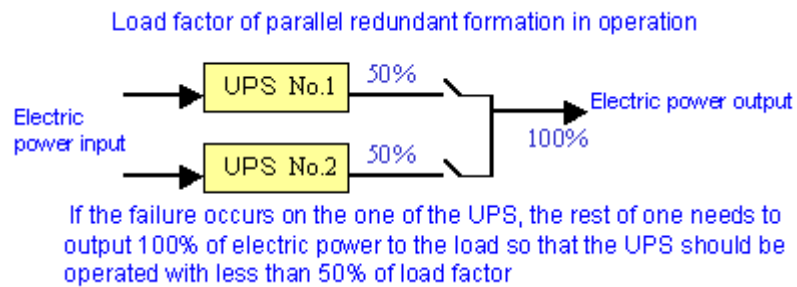
(5.1) Operation efficiency of the Double conversion On-line UPS.

As previously mentioned, the Double conversion On-line method UPS converts commercial power supply twice. Therefore, the best operation efficiency is limited to 92-93%; even it is the latest design. This value is the best figures under the condition of that 80-90% of rated load power output. When this load factor decreases to 60% and 50% or lower, operating efficiency will be down rapidly. (See the below figure)



When the UPS is operated by parallel redundant formation to increase the reliability, each UPS should be operated with less than 50% of load factor. Because if the failure occurs on

the one of the UPS, the rest of one needs to output 100% of electric power to the load.



Though parallel redundant formation makes reliability of UPS increase, operation efficiency will be decreased greatly and also power attenuation will be caused. In order to reduce those loss, set about 3 to 4 UPS in parallel redundant operation and so on, not for 2 UPS, because load factor of each UPS will be increased.

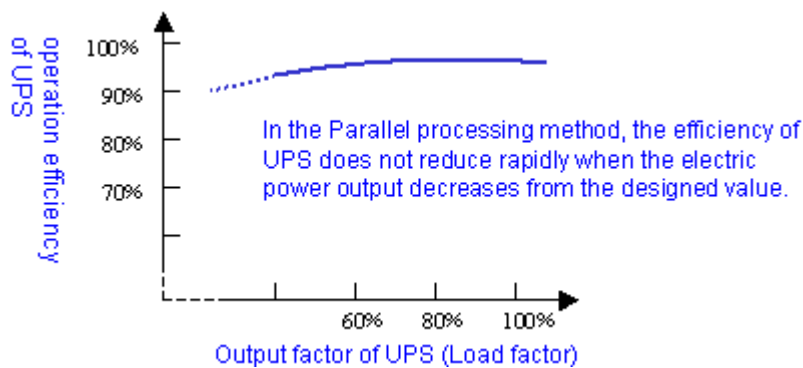
(5.1) Operation efficiency of the Inverter parallel processing UPS

In this method, a reduction in energy losses doesn't occur when the commercial electrical power is in normal status, because that power is not converted.

The bi-directional parallel inverter in operation by means of the constant floating state consumes quite small electric power, since they only works for waveform processing, or battery charging operation for the storage battery and so on.

As the result of that, operation efficiency of this method will be reach 97-98% in this method of UPS, it can be quite-high value.

In this method of UPS, its operation efficiency is not affected by decrease of the load factor, even if it reduces to less than 60% and 50% or lower, because it has no converter power loss. Therefore, there is the feature of this UPS with small reduction in operation efficiency (electric power energy loss increase) when it is operated in parallel redundant formation.



【6.Summary】

In Uninterruptible-power-supply (UPS), literally meaning, the function of “Uninterruptible” is the most important function. Thus, reliable electric power supplies (reliability of the power feeding) at outage is the highest priority condition than anything else.

The Double conversion On-line method UPS provides CVCF function, thus, its high accuracy level of voltage and frequency are often appealed. However, this is commercial synchronized operation run by commercial power, therefore, there is no higher precision of frequency of commercial power than that.

Also, quality of electric voltage in Japan is entirely satisfactory because the electric power companies supply the electric powers under its “rules and regulations”. It makes no quality issue. The primary purpose of the UPS is that “Stable electric power supplies at electric outage”. Therefore, it is not a voltage & frequency regulator.

“Stable electric power supplies at electric outage of UPS” is necessary to maintain until that UPS is removed. It is important to execute the power failure operation examinations including the function of the storage battery regularly for that.

When examinations are not executed, it is impossible to maintain the status of “No power failure” as a top priority condition for a long period of time, even if the method theory of UPS is discussed. Reliability is maintained in this Inverter parallel processing method UPS over a long period of time because a regular power failure operation examination is ensured by the automatic operation.

Many of people who have been engaged in “The Double conversion On-line method UPS” business for many years often conclude that the best choice of UPS must be “The Double conversion On-line method UPS”.

Probably, their study and knowledge about the Inverter parallel processing method UPS (Parallel Processing) is not enough yet.

It might be verbose description but the quality of a commercial electric power of Japan is steadier than that of the age when the Double conversion on-line UPS developed. Thus, neither the power failure nor the voltage decreases are caused mostly at the operating time. Loss of power caused in the Double conversion on-line UPS method doing the electric power conversion twice even if the quality of commercial electric power is excellent is not desirable.

The Double conversion on-line UPS method is effective in the region where the voltage and the frequency variation are frequently generated and it continues long. It is important to choose the method of UPS according to what power supply circumstances in each region. (The UPS described in reference (6) is prepared for the region where the power supply

circumstances are bad).

Unfortunately, the small size UPS less than 20kva by the Inverter parallel processing method UPS have not developed yet. The UPS in this area (single-phase current) is expected further progress in development. The global environment protection is pressing need.

It is necessary to work on re-engineering according to the development of the equipment on the load side, and to attempt the total optimization including the loss. It would be greatly appreciated if many people could review the Inverter parallel processing method (Parallel Processing) UPS. From a special maker's standpoint that have developed the Double conversion on-line method UPS since 1965's, we also recommend that method (The Inverter parallel processing) for users.

Eight years has passed since the Inverter parallel processing method UPS was implemented in 2002. Several hundreds of the UPS with the scales of 20 – 300 KVA have been operating. The result of more reliability has been obtained than the Double conversion on-line method UPS.

This UPS is used for a lot of various purposes such as servers of IT equipment, and also, for precision machine factories where voltage inverters or inductive load etc. are mixed because they are strong in the overload momentarily.

Our product that can correspond to the three-phase four-wire system of a global standard has been operating as a large-scale computer for “Shanghai World Financial Center” in Shanghai. (SANPUS-E33A Redundant operation 300KVA)

SANYO KOGYO CO., LTD. / SANYO DENKI Group company

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Input voltage 55 -150VUL, Usable in the area of frequency fluctuation 40 - 120 Hz,
Standard/FCC on-specification product

http://db.sanyodenki.co.jp/techrepo_e/24e/index.html