

PRESENT STATUS AND TECHNICAL TRENDS OF UNINTERRUPTIBLE POWER SYSTEMS

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1. FOREWORD

Japan's industrial and social structures are rapidly changing from production centered, hardware and export oriented type to an information-network society aimed at a rich society based on the accumulation of social capital (especially completion of the information infra-structure) and individual and total harmony.

Against this background, there is the advanced development of individual technology as technical seeds and diversification (including globalization) of market needs and price and the development of a new business concept corresponding to these is demanded by the industrial world. The indispensable problem in reaching this individual and total harmony is the information orientation of industry and current society is said to be facing an "information-network society".

An information-network society cannot be established unless the system supporting it does not operate at high reliability and is not trusted by the people who use it. For this reason, not only communication equipment and computers, but their installation environment, power supply system, and everything else must be reliable and economical. For this, total reliability which includes the operating management reliability beside not merely high reliability devices, is necessary.

As a consolidated electrical machinery manufacturer, Fuji Electric initiated research and development of high reliability power supply systems at the same time as the appearance of computer and has contributed to the construction of the current information-network society.

Fuji UPS business has "creation of high reliability together with the customer" as its philosophy and recognizes its mission is not only the technical development, manufacture, and supply of UPS alone, but total cooperation from planning to after-sale service and the supply of the optimum solution.

Based on this business philosophy, Fuji Electric not only improved the performance of the UPS, but was also quick to take up the problem of computer as its load and also solved power supply side problems for UPS and made much know-how available to users and fulfilled its role as a leading manufacturer.

This special issue introduces the present status of Fuji UPS. We hope that it provides users with an understanding and further guidance.

2. UPS ROLE AND NEED

2.1 Social system and reliability

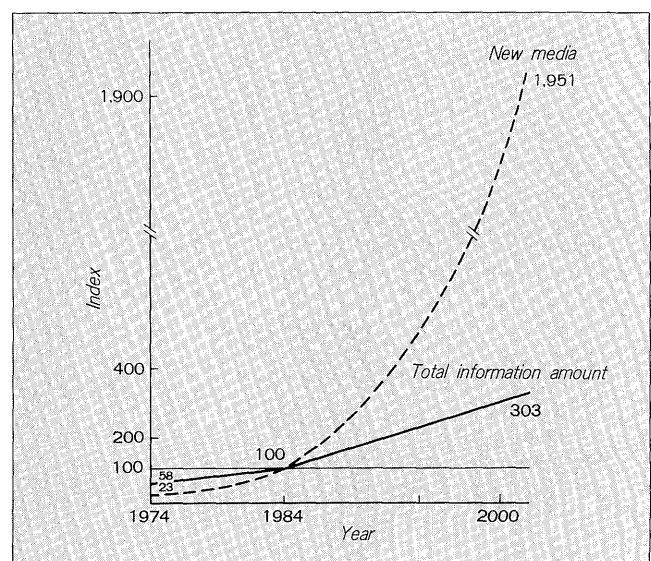
The development of computer and communication technology is making large changes in our daily life. The most significant items of these can be taken by considering the big changes in

- (1) realization of a cashless society
 - (2) realization of reliable and speedy information interchange
 - (3) realization of various automation
- Systems which solve problems by rationalization by artificial intelligence, etc. are forecast for the future.

Viewing these techniques socially, the background behing the development of our society by using such new techniques is fairness and achievements amply trusted could be shown to the world.

The future information interchange amount of Japan forecast summarized by the National Land Agency is shown

Fig. 1 Information interchange amount forecast



in Fig. 1. The information interchange amount increased rapidly after the 1980's and Japan is in the midst of the information-oriented age and a future rapid increase is also forecast.

When the reliability of these information systems is considered, the computer and other information machines having a high reliability is, of course, important. However, the environment in which this computer is installed and especially the computer power supply, are indispensable. Even an instantaneously power failure will cause a computer to stop and a UPS must supply stable power to the computer even if the utility power fails.

2.2 Utility power quality and UPS

It goes without saying that when the electricity is cut off, a computer will stop, but the quality of the electricity needed for a computer to operate stably is more stringent

than that required by other devices. Figure 2 shows the relationship between computer allowable voltage fluctuation and voltage fluctuation duration. Power within this allowable range must be supplied and quality electricity is demanded.

For Japan, long-term power outages, including announced power outages due to work by electric power company, etc., have been almost eliminated by the efforts of electric power companies to improve supply reliability. However, when viewed from the computer, there are cases when the quality of electricity is insufficient, even in this state. That is, around us momentary power outages due to lightning and short-term power outages and voltage drops until the faulty power line is disconnected when a fault occurs, and the momentary voltage drop which is generated when a load requiring a large inrush current is started remain despite the efforts of the electric power companies.

These are important problems which are rocking the foundation of our country, which is aimed at an information-network society, and are no longer subjects for electric power companies and our country is undertaking their countermeasures centered about the Resources and Energy Agency. Protecting a computer system against unexpected power outages by connecting a UPS to the computer system is recommended as this countermeasure.

From such a background, the production of UPS of Japan is increasing rapidly. Figure 3 shows the production of UPS of 10kVA and greater. The recent growth rate is especially noticeable. These targets can be assumed a barometer of the advance of the information-network society of Japan.

Fig. 2 Computer voltage allowable range

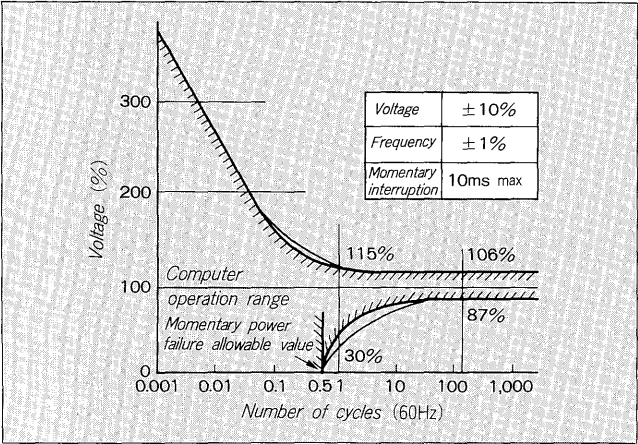
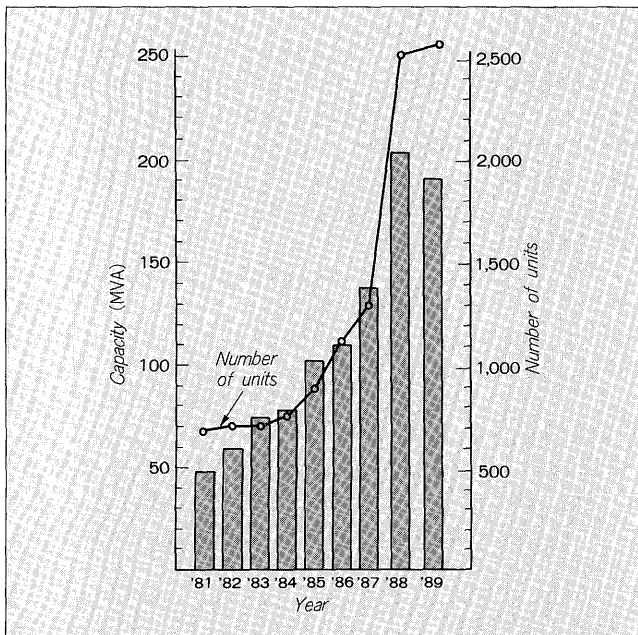


Fig. 3 UPS delivery record (10 kVA or larger)



3. UPS TOPICS AND TECHNICAL TRENDS

The state of use of UPS was discussed above. However, there is an infinite variety of computer systems from small systems for personal computers to large computer systems for giant computer centers for city banks, large security companies, and government organizations. Their power requirements is expanding to the 0.1 to 15,000kVA range.

The functions, performance, and specifications demanded of these UPS are also diverse, and the best product must be supplied. For example, the mini UPS is used in applications in which the supply of power cannot be interrupted (for example, automated factory and communication facility control, etc.) and only within the work time, such as OA, etc. When planning the introduction of a UPS into these facilities, the best type must be selected according to the importance of UPS and simple selection is unsuitable.

Table 1 shows the Fuji UPS series.

A wide product series capable of meeting expansion of UPS application and diverse needs are provided and the best model series are available. Fuji Electric's approach is introduced.

3.1 Installation site limitations and suitability

In the past, the computer was usually installed in a

Table 1 Fuji UPS series

Series	Output capacity (kVA)					Output phases	Output frequency (Hz)	Inverter element	Input phases	Rectification system	Output voltage control	Installation site	Remarks
	1	10	100	500	1,000								
Mini UPS	MUPS-V					Single	50/60	MOSFET	Single	Single-phase, full wave	Instantaneous value	Office	General use
	MUPS-VS					Single	60/60	MOSFET	Single	PWM rectification	Instantaneous value	Office	General use
Medium size UPS	600-021					Single	50/60	MOSFET	DC	—	Instantaneous value	—	Instrumentation use
	500-145					Single	50/60	BJT	Three	12 pulse rectification	Average value	—	Advanced functions type
	600-043					Single	50/60	MOSFET	Three	3-phase full wave	Instantaneous value	CPU room	High performance type
	500-165					Three	50/60	BJT	Three	12 pulse rectification	3-phase batch average value	—	Advanced functions type
	600-063					Three	50/60	MOSFET	Three	3-phase full wave	3-phase individual instantaneous value	CPU room	High performance type
	500-095					Three	400	BJT	Three	12 pulse rectification	3-phase batch average value	—	400Hz
Large UPS	500-155					Single	50/60	BJT	Three	12 pulse rectification	Average value	—	Advanced functions type
	500-175					Three	50/60	BJT	Three	12 pulse rectification	3-phase batch average value	—	Advanced functions type
	600-077					Three	50/60	IGBT	Three	PWM rectification	3-phase individual instantaneous value	CPU room	High performance type

special air conditioned room and the UPS was installed in a exclusive electric room. However, with the advance of computer miniaturization and distributed processing, the number of computers used in an office environment is increasing and power supplies are also diversifying to office installation, etc. Fuji Electric emphasizes these installation environments and offers office installation, computer room installation, and power room installation models to meet this need.

The office installation type was made quieter by using a high speed-switching modulation method and was made smaller and lighter weight, including the battery, so that there is no loss of the pleasant environment of the office. Erroneous operation prevention, etc. even for daily operation by a unspecified number of people was planned by using a novel digital panel system design.

For the computer room installation type, installation safety countermeasures were taken and installation was simplified by using a cubicle type sealed battery. Noise was reduced and operation and maintenance were also simplified.

For a large UPS, installation in the computer room, etc. is basically difficult and it is installed in a special electric room as in the past. These systems are designed for facility expandability, greater protection against surges from utility power receiving, central monitoring facility, and enhancement of the interface for remote monitoring.

3.2 Computer affinity

The advance of control power supply technology has been accompanied by an increase in the number of switching power supplies used as computer internal power supplies. As a result, the power which flows in the computer is distorted due to such nonlinear load with many harmonics and not what is conventionally considered AC sine wave current.

Particularly, the power supply of small computers has a single-phase input. The crest factor of this power supply is normally more than 2.4. Therefore, for a small single-phase UPS, a current with a large amount of this distortion flows and even kVA consideration is insufficient. The Fuji Electric single-phase UPS can withstand a current with a crest factory of 2 or more.

The equipment of a computer system which is connected to a medium or small 3-phase UPS have a small capacity. Their power supply often has a single-phase input and normally, those are distributed to three phases. Therefore, in this capacity range, the necessity to withstand currents with a high crest factor is increasing though they are 3-phase machines. Fuji Electric supplies a series which satisfies this need. The 600 Series, in particular, uses MOSFET and IGBT and performs high frequency modulation and features good characteristics.

Power supplies for large computers mainly have a 3-phase input. Their crest factor is about 1.7 and distortion

is comparatively small and a current with a crest factor as high as the large UPS used with it is unnecessary.

When a UPS passes a current with this high crest value distortion, the output voltage waveform is distorted and causes erroneous operation of the computer power failure detector and other trouble and a loss of stability.

3.3 High reliability and serviceability

Fuji UPS development was conducted with quality and reliability as the chief aims. This is determined by the UPS itself and is recognized not as a production product, but rather as an insurance product.

The quality, including design quality, of the Fuji UPS is amply controlled. Their actual failure rate as a system is extremely low and is several million hours by MTBF. Its reliability can be said to be very high. The background of this is not only the reliability of the parts, but also improvement of the reliability of their functions as a system.

However, there are failures due to external causes, erroneous operation, etc. and improvement of operator-friendliness from the standpoint of human engineering, harmonization with the load, and other improvements are necessary in the future.

Power supplies of up to several thousand kVA are not uncommon as one system, but many load devices are connected to such a system and the load side failure rate increases by that much and this can affect the UPS. Therefore, overall reliability is improved by grouping the load side and configuring a redundant system for each branch circuit.

In computers and other systems which require a UPS, the number of systems which are difficult to stop is gradually increasing. For this, a redundant system, etc. is used so that reliability becomes sufficiently high. However, to maintain reliability, amply maintenance management is necessary. Therefore, when planning a system, study from the standpoints of both reliability and serviceability is necessary. Especially, for a small UPS, there are many cases where this study is insufficient and there is the possibility that something taken lightly may remain as a source of calamity.

Fuji Electric can supply mini UPS, etc. with improved serviceability. Enhancement of maintenance management in the operating state is also being demanded and a micro-computer is being installed in the UPS so that the internal status can be diagnosed and monitored. This is developing into a remote maintenance system using a communication line.

3.4 Affect and countermeasures of harmonic current against substation and generating facilities

The harmonic current component which flows out from the advance of power electronics is a type of pollution. This becomes a problem because it distorts the utility voltage waveform. This restriction is studied also. The UPS also passes harmonics to the power supply side, the same as other power electronics devices. Fuji Electric has used the

12 pulse rectifier, generating very little harmonics, as a pioneer since 1984. This system has gained public favor. A PWM rectifier has been realized and is being supplied as a new system replacing the 12 pulse rectifier. This system not only suppresses harmonics, but since it also reduces the uneffective power at the same time, and the incoming power capacity is small. The affect of these harmonics is diverse, but for the customer introducing the UPS, the emergency generator is affected directly. For a 6 pulse rectifier UPS, because of the limitation of the equivalent reverse current by the harmonics, an emergency generator of at least double the UPS capacity must be provided. On the other hand, for the 12 pulse rectifier, UPS supplied by Fuji Electric, an emergency generator of only the same capacity of the UPS rating be supplied and, overall, the UPS has no affect on the incoming power facility and reliability is high and it is economical.

3.5 UPS systems

UPS systems are roughly classified into on-line system and off-line system (SPS). The off-line system normally supplies utility voltage directly to the load and when a power outage occurs, switches without any interruption. This system features little normal kW loss, good efficiency, etc. However, there are also utility power supplies unexpected, and completely uninterrupted switching to inverter supply for all disturbances and supplying stable power to the load is impossible and there are limits on its reliability. Because of this, the on-line system which can supply more stable power is used generally.

3.6 Trend of power semiconductors for UPS

When shifting from the thyristor to a self-quenching element, there was a dispute between power transistor and gate-turn-off (GTO) thyristor, but the easily controlled power transistor highly reliable and can be modulated by a high frequency has become the mainstream.

The background for this is given as improvement of the product quality of the element itself, clarification of the safe operation range, and establishment of a protection system, etc. as application technology. Fuji Electric, has supplied transistor UPS of up to several hundred thousand kVA. It is no exaggeration to say that the number of transistor failures has been so small as to be almost nonexistent.

To make equipment smaller and more advanced, practicalization of elements which can be high frequency modulated, that is, MOSFET, IGBT, etc., is progressing. New control algorithms aimed at the high-speed of these elements and making the equipment itself intelligent are being researched.

These power semiconductor elements have various advantages and disadvantages. The same element does not support everything and it is estimated that discrimination is possible by the economical and technical effects obtained by this.

Fuji Electric is practicalizing an office type UPS using these elements. These systems are forecast to be rapidly improved and become popular in the future.

4. CONCLUSION

Fuji Electric has provided many UPS to the market and has supported the raising of the curtain of today's information-network age. The UPS market growth rate is high and the number of UPS manufacturers is that much larger and products are being diversified and the market competition is also very severe.

The attitude taken consistently by Fuji Electric is the "supply of the most reliable UPS". This is also an eternal subject. Therefore, at times, systems were developed with such care as thought to be too conservative and at other times, revolutionary system were developed and customer valuation was requested. Fortunately, the posture and

achievements of Fuji Electric are evaluated from each customer and we are grateful for obtaining a position as an industry leader.

The UPS is indispensable for the development of the information-network society. From the standpoint of improvement of the reliability as an entire system, further strengthening of undertaking this topic is fully realized. Not only the quality of devices, but also the suitability of the plan is considered to be a big key to improved reliability. Fuji Electric is accumulating much know-how in this area also. In the future, we will consider the optimum solution together with the customer.

