Importance of Supply´s Quality in a Calibration Laboratory

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Abstract.

In a calibration laboratory at the time of carrying out electrical measures of physics magnitudes, and upper reliability is required in order to get results of high precision. Within protections and security measures, some aspects must be considered as electrical, while another, as temperature and ambiental conditions, must not.

Focusing on electrical aspects we must have into consideration that the quality of the measure rested on a reliable power source.

An sabilized feed voltage ia a sign of quality and it can be obtained by two different ways. One of them is to get it from combined cycles, the other is to use an Uninterrupted Power Supply (UPS), since an UPS removes disturbances of the net, which could impede the correct measure and calibration of instruments.

In order to have a supply with requared quality, which means to have an stable voltage, both in permanent regime and in transitory regime, the use of UPS's becomes necessary and recomendable.

An special care must be have with micocuts, because these connections and disconnections cause anomalities in the sistem's operation, and the apearance of possible tips of voltage, which is not less important, UPS equipement are the ones that better conterac disturbances of the wave.

Key words

Power quality, voltage quality, short interuptions, voltage sag, UPS's

1. Introduction

Security is an important aspect to consider in the construction of electrical metrology laboratories, since the results must be the precise enough to be trustworthy. Within these safety measures, aspects like temperature, the environmental conditions in which the measures are taken, etc. are due to consider. But we are going to center in the electrical aspect, within which we will emphasize the earth, screenings or trustworthy power supplies necessity.

And it is in this last aspect on that we wished to deepen, due to the necessity of a stabilized voltage, for which combined cycles could be made or we will be able to use choppers or UPS for the stabilization of this feeding voltage and to eliminate the network disturbances that would prevent a correct measurement and calibration, for that reason in the calibration laboratory will be strictly necessary to obtain a great voltage stability because the equipment we will work with does not admit great voltage variations.

In addition to this, we must have special well-taken care of micro-cuts that will disconnect or cause anomalies in the system operation. It should also be considered that impulses (voltage tips) which will have to be avoid can appear.

All those problems, next to other factors like the frequency stability or the harmonic distortion, makes the use of UPS necessary and recommendable for this cases.

2. Problematic Of The Electrical System

In calibration laboratories, the equipment uses a three-wire system, corresponding to a phase, neutral and earth. The first two wires transport the energy and third one is connected to the metallic parts of the equipment for security reasons. In that kind of facilities, earth taking is important to consider.

Initially this one must derive to earth, current from any nature that can be originated due to isolation defects or atmospheric causes.

It is also necessary to consider the loss current that circulates around the earth line, due to a defect in a machine isolation or a radio frequency that is forwarded to earth in a filtering, and before arriving at earth is injected to another machine or equipment, so it causes

problems in the operation. This effect will be more accusing if the earth resistance is worst.

Some equipment and the level of protection offered.

Isolation Transformer
Equipped of electrostatic screen or winding by means of separating spool, it allows to obtain an important noise attenuation and parasitic effects. It does not solve voltage variations, cuts nor micro-cuts, since this conductor cannot be interrupted.

Ferroresonant transformer
They have a condenser in the output, in parallel with secondary coils, which provides a magnetic feedback and an output stabilization, but obtains very little yield.

Voltage regulator, Stabilizer
It offers solutions when the problem is based on network variations, nevertheless it depends in a great way on its characteristics, response time and regulation margin. It consists on the switching of different transformer plugging, in order to select the output required voltage. They can incorporate an isolation transformer, but they are incapable to solve cuts, micro-cuts and network frequency variations, since they do not contribute autonomy.

Network Conditioning
It is the combination of one isolation transformer with one network regulator. They can therefore be ferroresonant or electromagnetic. They obtain good results in opposite to variations and network parasitic effects, although they cannot do anything against cuts and frequency variations. The cost begins to be important.

Suppresor Filters
They are nonlinear elements that step down their impedance from a certain over-voltage, diverting the extra energy to other line with less impedance that one in the load or equipment to protect. A suppresor filter is not a deflection but absorption element. This kind of filters absorb part of extra energy, and therefore its absorption capacity must be considered, although the extra currents deflection, usually towards in a good earth conduction. It's in fact the way for protection.

Uninterruptible Power supply (UPS)
They are equipment which by their independent conception, allow to make provision even though network supply does not exist. They incorporate batteries and battery chargers for that provision and one wave modulator which changes the direct current, coming from the storage cells, in alternating current, of equal characteristics to the network, but exempts of the noise problems and variations that affect it. The most important benefits got from those equipment are:

- To isolate the load supplied from the network.
- To stabilize the output voltage and output frequency.
- To avoid tips and parasitic effects of the electrical network.
- To store energy in the batteries, which will provide it by a fixed period of time, if a power failure exists.

3. Primary Knowledge About UPS

In the design of the sources, notice that they are not built self-sufficient in addition to their necessities to make them more powerful and perfect in their functions, so that it is much more usual to find in all activity areas that correct operation is absolutely depending on the supply of their units and reference instruments.

Fig. 1 Outside view of an UPS system

Once the study in static UPS is centered, it is necessary to talk about existing configurations, which means the general disposition of the modules (rectifying, battery, inverter, filters, switch, etc…) that compose the UPS and operation strategy. Those two aspects determine the UPS and the strategy of operation. Based on them we determined the most important characteristics of UPS like reliability, yield and weight, independently of the concrete solutions adopted to make every block.

4. UPS Types

Classic UPS is composed basically of a rectifier that feeds a battery from network and an inverter. This one feeds the critic load through an static switch. The load can directly be fed from network by means of a static switch (by-pass).

4.1.On-Line UPS
The load is normally fed by the rectifier-inverter line, the network switch or by-pass disconnects the inverter load and connects it to the network, any cut or micro-cut is replaced by batteries. The wave modulator provides an output voltage whenever an stabilized output is guaranteed. It does not exist transference Network-UPS

nor UPS-Network, since the wave modulator is permanently working and providing energy to the output.

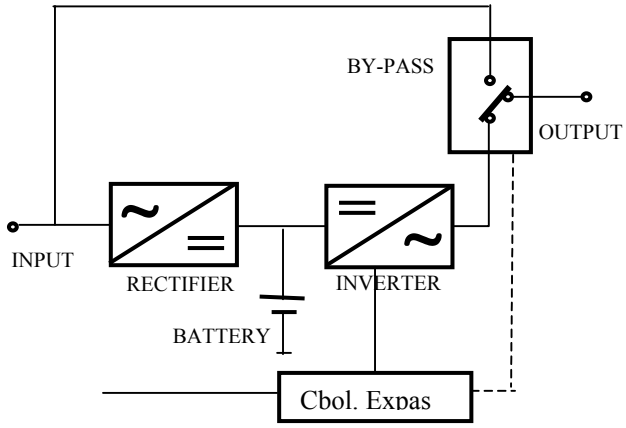

Fig. 2 On Line UPS system (basic composition)

4.2.Off – line UPS

These systems are made with the purpose of reducing costs, the base is to protect only in case of necessity, the network feeds the normal load and the wave modulator only works in case of failure of network or excessively low or high network, by means of the action of the switch. We could say, that the network is controlled within an interval of maximum and minimum voltage, and therefore the load that we are feeding, will have to support the voltage limits to which the equipment takes part.

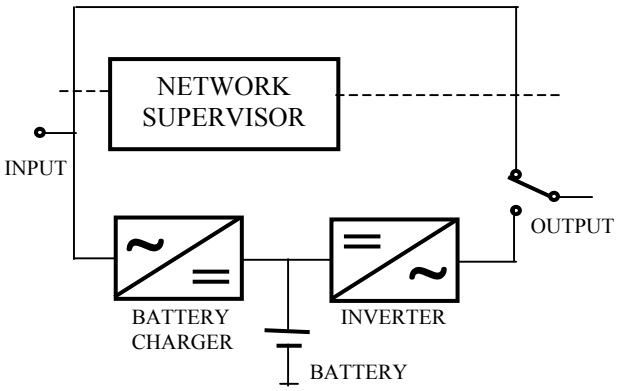

Fig. 3 Off Line UPS system (basic composition)

4.3.Mono and Multifunctional blocks UPS

In these systems, a same circuit makes several basic electrical functions. The most usual case is the use of the inverter circuit as a battery charger in the presence of network. This can be obtained controlling the voltage and phase of the waves generated by the inverter respect to the network. It is usual to integrate functions of stabilization and inverter or battery wave modulator in a same block network absence.

4.4.Mono and Multimodule UPS

Two modules in parallel usually are arranged when the required security of operation is not reached with one single module, constituted by rectifier, battery, inverter and switch, or when the load power is of higher than 2000 kVA. With this system it is possible to obtain high MTBF (Mean Time Between Failures) systems and comfortable repair.

4.5. Off-line variants to improve and be similar to the Online one.

The Off-line topology is the most economic and in many cases sufficient, but it is not the better for a total protection. Off-line UPS, is useful, only in places where the network is stable and the protection to make is for momentary provision cuts.

Although the Off-line topology is much more economic that the On-line one, its benefits and characteristics, is far from being effective to protect critical systems from an electrical provision point of view, for that reason, variants are introduced to the Off-line basic structure, in order to improve its technical characteristics and therefore benefits, trying to approach the On-line one at the cost of the Off-line.

5. UPS Reliability

As the purpose of the UPS is to eliminate electrical supply cuts to a critical load, its operation security or reliability is very important. The more common is to suppose the UPS is composed of well-known reliability functional blocks (rectifier, inverter, etc…) and to deduce from them the full equipment reliability.

The comparative valuation of some UPS configurations as opposed to others, maintains its use even with appreciable differences in the granted beginning blocks reliability, so that the comparison criteria pretended to establish are not reduced, although, evidently, the absolute values of the systems reliability parameters depend on the ones assigned to the blocks.

5.1. Monofunction blocks UPS reliability the main responsible of the UPS reliability is the inverter, the rectifier has little influence. The MTBF of the system, 8,000 hours, is insufficient for most applications.

5.2. Multifunction blocks UPS reliability

The existence of a network switch improves enormously the UPS reliability. In a normal null degree redundancy case (a module of the load power or superior), the switch changes the MTBF of 8,000 hours to 190,000 hours.

Supposed On-line UPS with switch or Off-line UPS can continue supplying the load by battery-inverter while the network feeding circuits are repaired. This supposes a careful electrical and mechanical design.

In order to finish, we will speak of the optimal reliability. The way to determine with exactitude the indispensable optimal MTBF to the feeding of a critical load consists of evaluating in economic terms the cost that suppose the cuts of feeding plus the financing of UPS based on the of

this one MTBF. The minimum cost takes place for an optimal MTBF.

6. Adopted Solutions

Once identified the disturbance and only if this one cannot be eliminated in origin, it must be resisted by means of the installation of conditioning or suitable UPS. Sometimes to have the sufficient security of as is the disturbance criticizes in the feeding of a load is not simple and requires long and tedious periods of observation with the help of instruments and talent. Depending on the power consumed by the load and the cost that original its badly operation or shutdown, if the disturbance this identified surely, cannot be economic in the long run to install UPS that conditioning the simplest one since these equipment, in their more complex versions, eliminates all the types of disturbances.

7. UPS Selection

7.1. CRITERIA ABOUT UPS NECESSITY

7.1.1. Economic Criteria
- Profitability regarding to a shutdown at application running..
- Reliability of supply provided by electrical network.
- Required Power.
- battery load time.
- MTBF (average time between failures) and MTTR (Mean Time To Repair).

7.1.2. Technical Characteristics
- To analyze if a cheaper equipment can make the required function.
- To make the most profitable configuration.
- Yield Necessity.
- The UPS must work with the disturbances of our network.

7.1.3. Installation facilities
- Size, weight and occupied space.
- Installation difficulty
- Noise Level (acoustic).
- Aux. conditioned air systems necessity.

7.1.4.Maintenance and norm
- Manufacturer responsibility (guarantees, manual…).
- Rapidity of answer.
- Personal adapted.
- To fulfill the demanded legal requir.

7.2.CRITERIA FOR UPS SELECTION

7.2.1. Power that consumes the totality of the System

It must be obtained by a consumptions sum of each element, either by means of indication of characteristics plate, or by consumption measurement. The sum of the watts, of each element would give directly the UPS model to use, since we indicate the active power (W).

7.2.2. Electrical problems to solve and surroundings application

Once the UPS power necessity is known, we will have to consider the electrical surroundings in which it will be due to locate and the problems of the same nature that affect the system and must be solved by the UPS. We indicate an aid graph, of the necessary topology election.

TABLE I. - Problems and recomended solutions

ELECTRICAL PROBLEM	*SURROUNDINGS*	*RECOMMENDED UPS*
Network cuts	Urban areas	Off-line
Network variations	Urban areas	Off-line + Boost
Usual alterations	Urban areas	Off-line + Stabilizer
Usual alterations	Industrial areas	Off-line + Stabilizer
Problems of electrical noise machinery connection, arc welding	Industrial areas	Online

8. Electrical Characteristics

- Referring to the wave modulator:
  - Output voltage stability
  - Harmonic distortion.
  - Permissible power factor.
  - Peak Factor.
  - Permissible overload and form of protection.
  - Wave form.
  - Frequency stability.

- Referring to the batteries charger (ON - LINE) or to the system (Off-line).
  - Input voltage
  - Load current.

- Referring to batteries
  - Autonomy.
  - Number and Type of battery

- Referring to the Bypass
  - By-pass or possibility of this one.
  - Electrical isolation.

- Generals
  - Type of ventilation, temperature, yield.

9. Design Of A System Of Integral Protection

For the design and installation of elements or integral protective equipment at the designing time, the electrical

installation of an industrial calibration laboratory, we will have to know in first instance the vulnerability the equipment to protect. It is necessary not to forget that the factors that usually affect the correct electric behavior and electronic systems, are: regulation, transitory, harmonic, earth and energy cuts. In our case, the first, fourth and fifth ones, will be resolute by means of the UPS application. The fourth factor or earth, will depend on the construction of the same one, it is recommendable to use an exclusive earth taking for critical equipment and another one for machinery. For the transitory factor, because of their nature and given the great magnitudes that can get to reach, it is not sufficient the application of UPS, as safety measure it is necessary to also apply to Suppresor Filters.

The transport and distribution line

The energy quality problems and those ones caused by their defect, are consequence of electronics evolution and more particularly of their integration. It increases the exhibition of the user to electrical disturbances and sensitivity of the equipment. All those effects can be joined in five issues: regulation, transitory, harmonic, land and power shutdowns.

Regulation

They are slow variations in the voltage or frequency, which can be able from some cycles to some hours. We will make difference between 3 elements involved at the regulation: "swells" or tips, which are slow growth of the voltage, they can reach values up to 20% of nominal value and they can be able for seconds. Voltage shutdown of short time called "sags", are usually caused by starting of motors, since these ones can spend up to twenty times their nominal value during the starting. Voltage shutdowns of long time called "brownouts", are caused by overload in the electrical network at an important area. Although the electronics equipment usually support the effects of the regulation during short time, the immediate effect is the reduction of the utility life due to generated overheats.

Transitory

The transitory ones are short time high voltages and high currents. It is considered as transitory one issue of time less than 1ms of high voltages and currents. The involved frequencies run from kHz to hundreds of MHz. According to studies published, the origin of transitory reveals that 35% of them are due to natural phenomena (lightning) and 65% ones are caused by connection of reactive loads (motor, fluorescent etc.). The ESD are other important origin of transitory, due to the artificial fiber used like carpets, dresses,... One transitory can affect on several ways, for example a logic circuit can receive one transitory and not be destroyed by it, that information can be read wrong by the logic circuit, so it will cause a logical fault. One repetition of the effect in

the same circuit can destroy it by overheat, so there will not appear the causes of the destruction.

Harmonic effects

The harmonic effects are caused by the integration of multiple frequencies, mainly coming from power supplies. Usually they are increased by the consumption of non-linear loads like switched power supplies. The uneven harmonic effects are the most usual, starting the margin of frequencies at 180 Hertz up to 1 kHz. The most usual troubles of the harmonic effects are unexpected flows in the electrical systems, high currents in wires of neutral and important losses in transformers. The magnetothermal will not reach either their usual benefits, taking place firings before than the expected time. Looking for one solution or better an attenuation of that kind of troubles, it is necessary to talk about the oversize of the neutral, necessity of K factor transformers, necessity of line disruptors instead of magnetothermal and filters. The UPS use is also an important element to consider, since usually they include an active filter, for the change of non-linear loads into linear ones.

Earth

Regarding to the earth taking, we must consider two effects regarding: the first one is the referen1ce, which consists of assuring that several equipment stay at the same voltage; the second one is the security regarding to electrical discharging and fire risks. In absence of a common earth reference, the connected equipment can be affected by logical failures or damages in the communication lines can be happen. The earth reference is obtained through impedance zero which is given by the national electrical mains. So only one earth point is the best solution for the equipotentializing of the electronic instruments in the metrology laboratory. The electrical isolation is also the best solution for data transmission lines.

Energy cuts

There exist 4 possibilities of energy cuts: micro-cuts less than 1 cycle, falls greater than 1 cycle, momentary falls less than 1 minute, slow falls greater than 1minute. The main causes usually are: starting of great motors, line defects or switching defects in the electrical network coming from the own company. In case of micro-cuts, we will depend on the power supply characteristic (reserve time) to affect or not to the laboratory equipment. The energy cuts are zeros of network greater than 300ms, so it will cause the total unemployment of the equipment at non-controlled way. The only solution to this kind of troubles is the use of UPS.

The following table II summarizes different troubles and solutions

TABLE II. - Troubles and solutions

	High Voltage protection	Filter	Stable equipments	UPS
Regulation	----	----	Yes	Yes
Transitory	Yes	Yes	----	Yes
Noise	----	Yes	----	Yes
Harmonic effects	----	----	----	According to Characteristic
Energy cuts	----	----	----	Yes

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