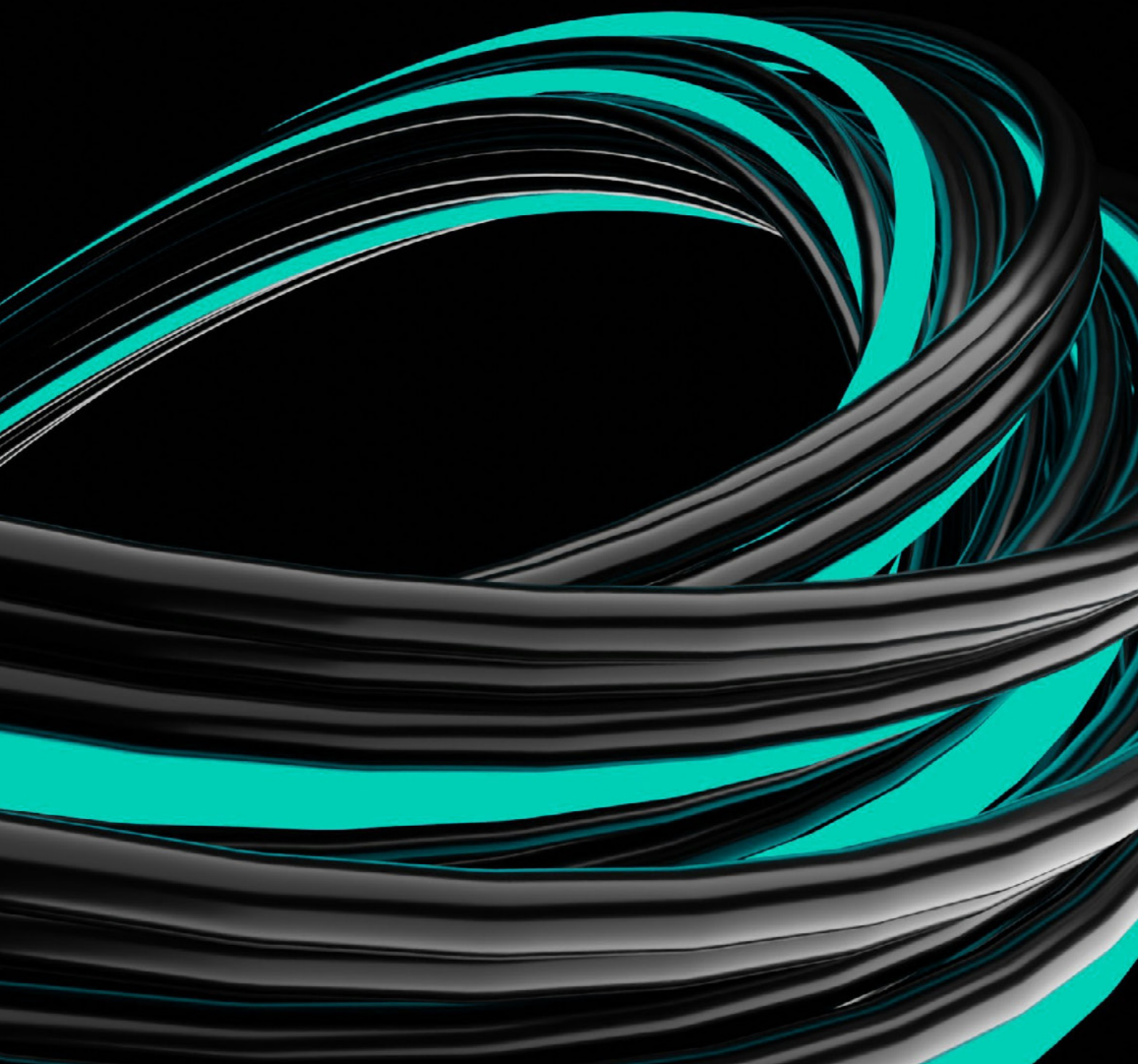
POWER GRID DISTURBANCES



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INTRODUCTION

Over 115 million unforeseen short and long-term power interruption were recorded on the Italian national electricity grid in 2020, that is more than 315,000 every day, with an average of 3.14 interruption per low-voltage user per year.[1]

You will certainly have already experienced data loss, interrupted services or even, in the worst cases, damaged equipment without knowing the cause that triggered these events.

The most known, and perhaps most obvious power disturbance, is an extended power interruption, better known as blackout; yet, are you aware of how many other anomalies, sometimes imperceptible, a power network can be subjected to?

[1] ARERA, Indicators related to power interruptions for the year 2020

The term **power disturbance** refers to a change in power supply (voltage, current or frequency) that interferes with the normal operation of electrical equipment.

SOURCE OF POWER DISTURBANCES

Power problems can o**riginate from the electrical grid** itself, as transmission lines extend over thousands of kilometres and are subjected to weather events such as lightning, snow, ice and flooding.

However, these disturbances can also be generated **locally** by equipment failures, road accidents, construction work, high ignition loads or faulty distribution components, as well as by common background electrical disturbances.

Our activities are now increasingly dependent on a **continuous and quality power supply**, for this reason, being familiar with power disturbances is the first step to understand what solution can be adopted to prevent and protect against any downtime and / or damage to equipment.

TERMINOLOGY

Many different terms, sometimes even inappropriate, are often used to describe power anomalies, creating some confusion and complexity in understanding and effectively resolving these issues.

To overcome this problem, the **IEEE** (Institute of Electrical and Electronics Engineers) has developed the **IEEE 1159-2019 Standard**: "*IEEE Recommended Practice for Monitoring Electrical Power Quality*".

This Standard uniquely identifies the different power supply problems, possible causes and their consequences, thus allowing a common terminology to be used to report problems to professionals experienced in the field.

OUR FOCUS

In this study, we present some of the power supply problems included in the IEEE Standard; in particular, we will focus on all those **problems that can be solved promptly through a UPS solution**.

As contemplated by the IEEE standard, the problems have been divided into different categories according to the waveform:

1. **Transient Disturbances**

2. **Interruptions**

3. **Sags / Undervoltages**

4. **Swells / Overvoltages**

5. **Waveform distortions**

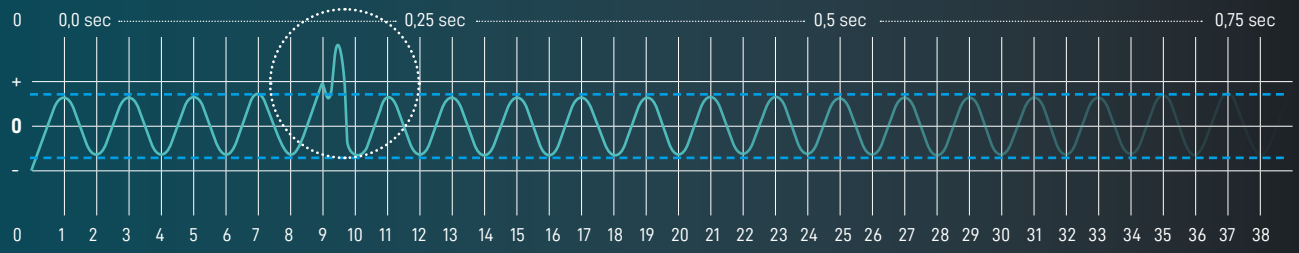
6. **Voltage fluctuations**

1. TRANSIENT DISTURBANCES

Transient disturbances are potentially the most harmful events and are in turn divided into two sub-categories: **impulsive** and **oscillatory**.

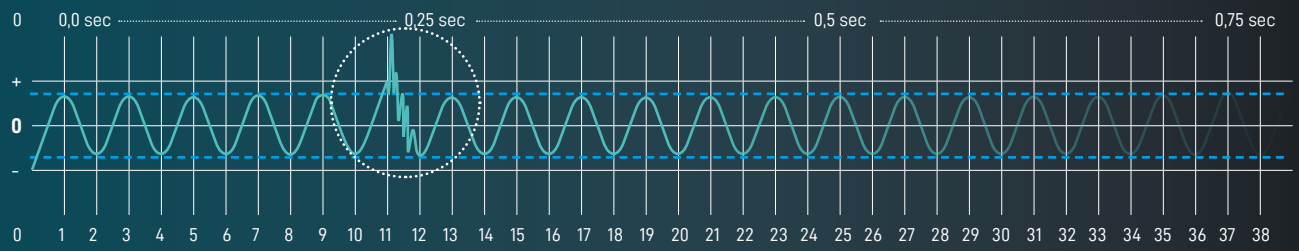
TRANSIENT IMPULSIVE DISTURBANCES

Transient impulsive disturbances are high peak events that increase voltage and/or current levels in a positive or negative direction. Causes of impulsive transients include lightning, poor-quality earthing, switching inductive loads, repairing faults in the power plant, and electrostatic discharges. The latter are sufficient, for example, to irreversibly damage the motherboard of a common computer.



TRANSIENT OSCILLATORY DISTURBANCES

Transient oscillatory disturbances are sudden changes in the state of voltage and/or current both positive and negative. The power signal varies very quickly, alternately increasing and decreasing. Oscillatory disturbances usually disappear over a cycle (short oscillation). These disturbances occur when an inductive or high-capacity load, such as a motor or storage capacitor, is turned off.



2. INTERRUPTIONS

An **interruption** is defined as the complete loss of supply voltage or load current. Depending on the duration, the interruption is classified as instantaneous, momentary, temporary or sustained.

INSTANTANEOUS
0,5 to 30 cycles

MOMENTARY
30 cycle to 2 seconds

TEMPORARY
2 seconds to 2 minutes

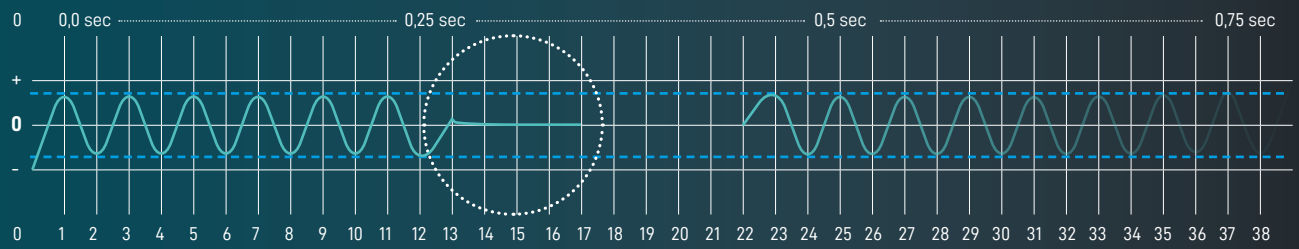
SUSTAINED
Greater than 2 minutes

INTERRUPTIONS

Possible causes may be: lightning, damage caused by wild animals, falling trees, car accidents, destructive weather events, equipment failures or just the tripping of a circuit breaker.

An interruption of any duration may result in damage of different magnitudes, such as loss of data and information, or damage to electronic equipment.

Even more serious problems can arise for industrial users who often have to bear not only the costs of damage to work equipment but also the costs associated with downtime, cleaning, and restarting operations.



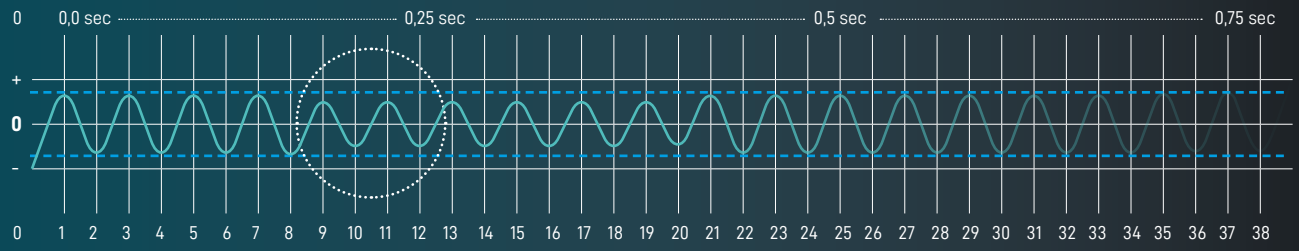
3. SAGS AND UNDERVOLTAGES

A **sag** is a reduction in AC voltage at a certain frequency that can last from 0.5 cycles to one minute. Extended voltage sags are usually referred to as **undervoltages**.

VOLTAGE SAGS

Voltage sags may be caused by faults or by the ignition of high load machines that entail a significant reduction of the voltage within the circuit.

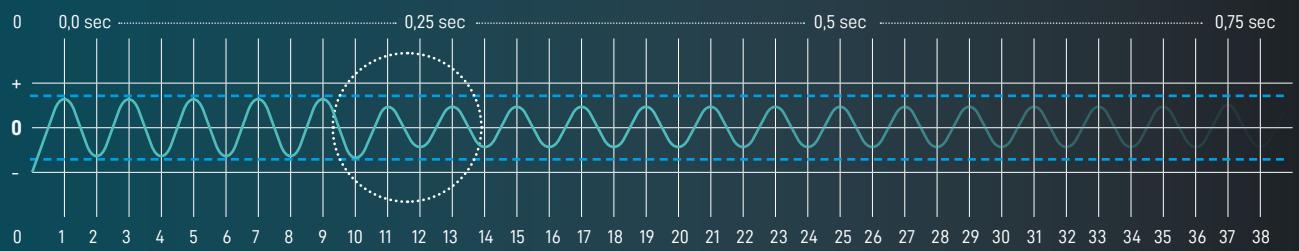
Unlike the aforementioned disturbances, the damage caused by voltage sags is not immediately obvious, but becomes evident over time with damaged equipment, errors in industrial processes or damaged data.



UNDERVOLTAGES

Undervoltages are defined as events in which a reduction in AC voltage occurs over an extended period of time.

Undervoltages may cause motors to overheat and lead to non-linear load failures, such as the power supply to the computer.

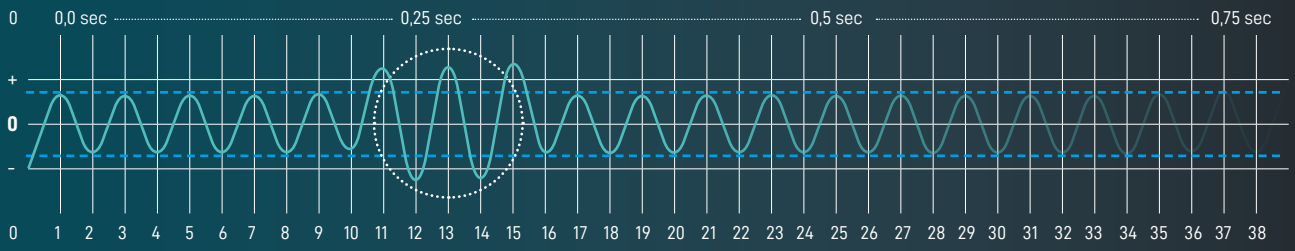


4. SWELLS AND OVERVOLTAGES

The **swell** is the opposite of the voltage dip, i.e. an increase in AC voltage that can last from 0.5 cycles to 1 minute. Extended sags are usually referred to as **overvoltages**.

SWELLS

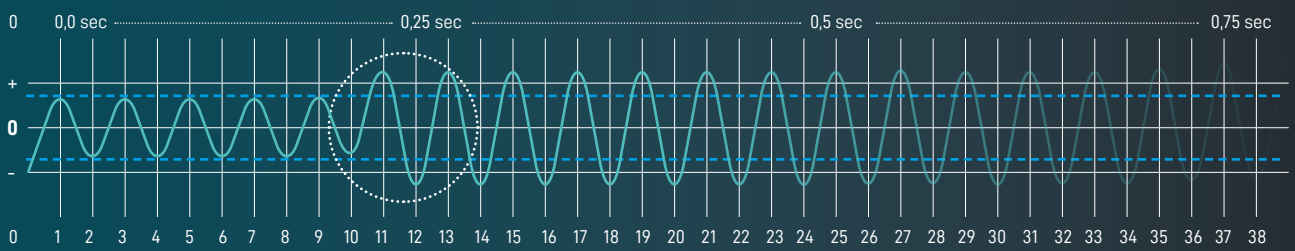
The peak can be caused by high impedance neutral connections, high and sudden load reductions, single-phase failures on a three-phase system. The most common consequences are data-saving errors, phenomena such as the flickering of the lighting system, damage to semiconductors in electronic devices, and damage to insulating material. As with voltage sags, sags may not be obvious until the effects are ascertained.



OVERVOLTAGE

An overvoltage can be defined as an extended peak.

Overvoltages occur in those areas where the power transformer socket settings are incorrectly configured and the loads have been reduced; they are more frequent, for example, in areas that experience high-traffic in certain seasons.

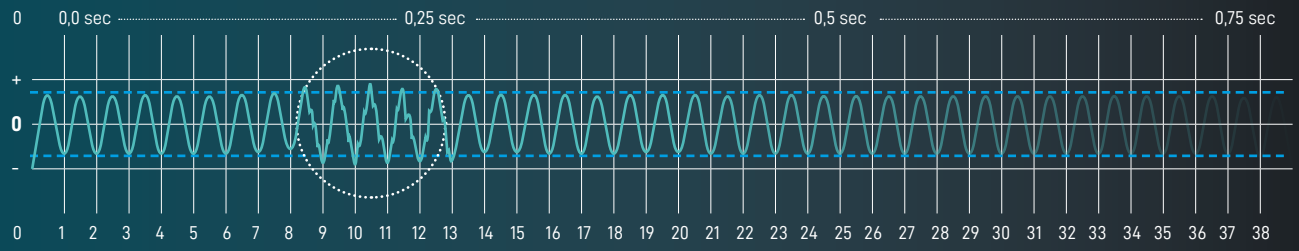


5. WAVEFORM DISTORTIONS

Waveform distortions are very common disturbances and can be of different types; the **interharmonics** and the **notching** disturbance presented below are among those that can be solved through the use of a UPS system.

INTERHARMONICS

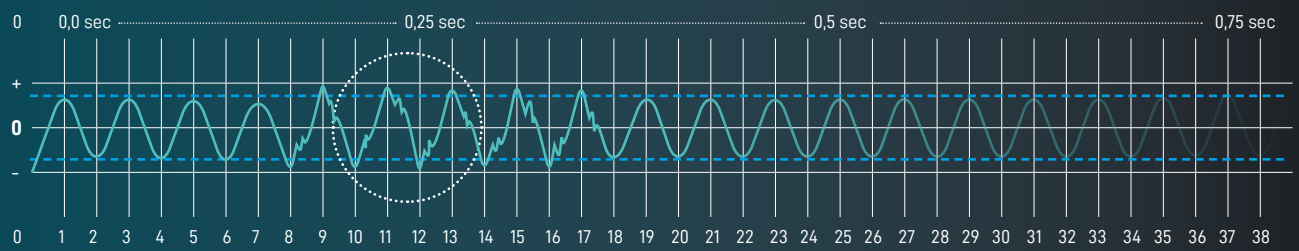
These wave distortions are usually caused by a signal introduced into the supply voltage by electrical equipment such as static frequency converters, induction motors, and devices for the formation of electric arcs. These disturbances can occur especially in large industrial complexes, such as cement plants or mining plants. The flickering of monitors or lights, and communication interference are the typical effects of this phenomenon.



NOTCHING

it is a periodic disturbance caused by electronic devices, such as variable speed drives, lighting regulators and arc welding machines during normal operation.

This disturbance is similar to the impulsive transient but, as it is characterized by a periodicity of ½ cycle, it is classified as an abnormality of waveform distortion.



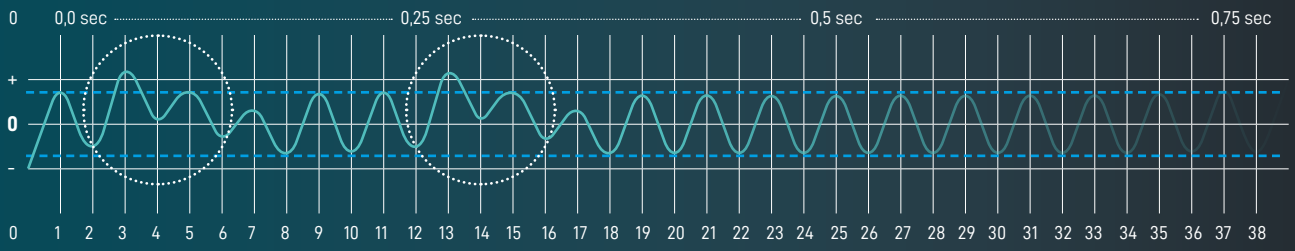
6. VOLTAGE FLUCTUATIONS

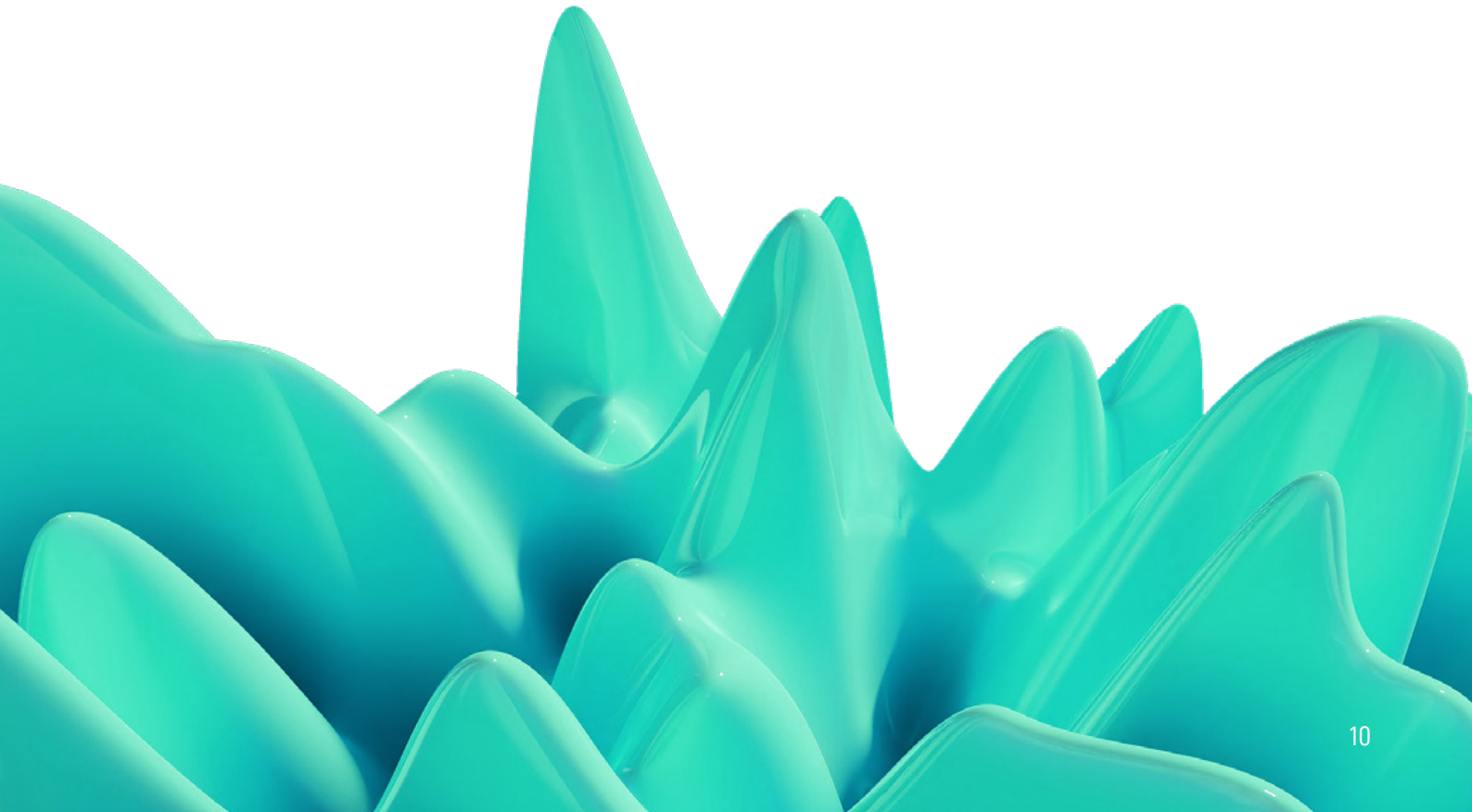
Since voltage fluctuations are fundamentally different from the rest of the waveform anomalies, they are placed in their own category.

VOLTAGE FLUCTUATIONS

This is a repetitive variation of the voltage waveform or small random voltage changes. They are normally in the range of 95% to 105% of the rated voltage.

Any load that shows significant current variations may cause voltage fluctuations. The flickering of incandescent bulbs is one the most common effects of this problem.





CONCLUSIONS

At the beginning of this document, we mentioned the **high frequency with which power disturbances occur daily**, resulting in damage, inconveniences, and delays that inevitably result in losses and costs to be borne.

In fact, it is estimated that **75% of the damage to electronic equipment is directly or indirectly due to power defects**.

According to an IBM study, this percentage rises to 80% in the case of computer systems, where the effects may concern both the hardware, causing damage and breakage to the structure of the microcircuits, and the software, causing errors in the interpretation of data that pass-through circuits and giving rise to program malfunctions.

The increasing complexity of technology means that equipment damage results in ever-increasing costs.

Even **the shortest power disturbance can have terribly high costs**, up to several thousand Euro.

Every company should try to **reduce** as much as possible the **risk of downtime**; for this reason, knowing the electrical environment and the susceptibility of the equipment to power supply disturbances is really very important, as well as being equipped with the right countermeasures.

THE SOLUTION

One of the most effective methods to ensure a continuous and quality power supply is **to choose a suitable UPS system**, which can protect the loads affected by any power disturbance.

In fact, the UPS interposes itself between the mains and the utilities, providing the load with a continuous and quality power supply, regardless of the state of the mains, thus guaranteeing a reliable and disturbance-free supply voltage, which is within tolerances compatible with the requirements of electronic equipment.

Investing in a UPS system means protecting our work tools and guaranteeing their long-term durability, ensuring a clean and continuous voltage that allows our work to continue without interruptions.

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