Critical POWER

Supplies ▪ Projects ▪ Support

UPS Electrical Design & Installation

Everything you need to consider for the design and installation of your uninterruptible power supply (UPS) system

Power when & where it matters

There are several crucial reasons why it is important to ensure your uninterruptible power supply (UPS) system is carefully designed and effectively installed:

- **It must be available and ready to kick in seamlessly in the event of a power failure**
- **It must work in alignment with the current on-site installations**
- **It must not interfere with other electrical equipment**
  - Particularly for industrial and healthcare installations where there may be critical equipment, such as medical and life support
- **It must adhere to relevant regulations and guidelines**
  - All electrical work within critical power installations has to be carried out by suitably qualified, certified and registered electrical engineers in accordance with local, national and organisational guidelines
  - In the UK, the latest applicable industry standards are The Institution of Engineering and Technology (IET) – BS 7671 IEE Wiring Regulations Seventeen Edition and Electricity at Work Regulations 1989

It all starts with a site survey

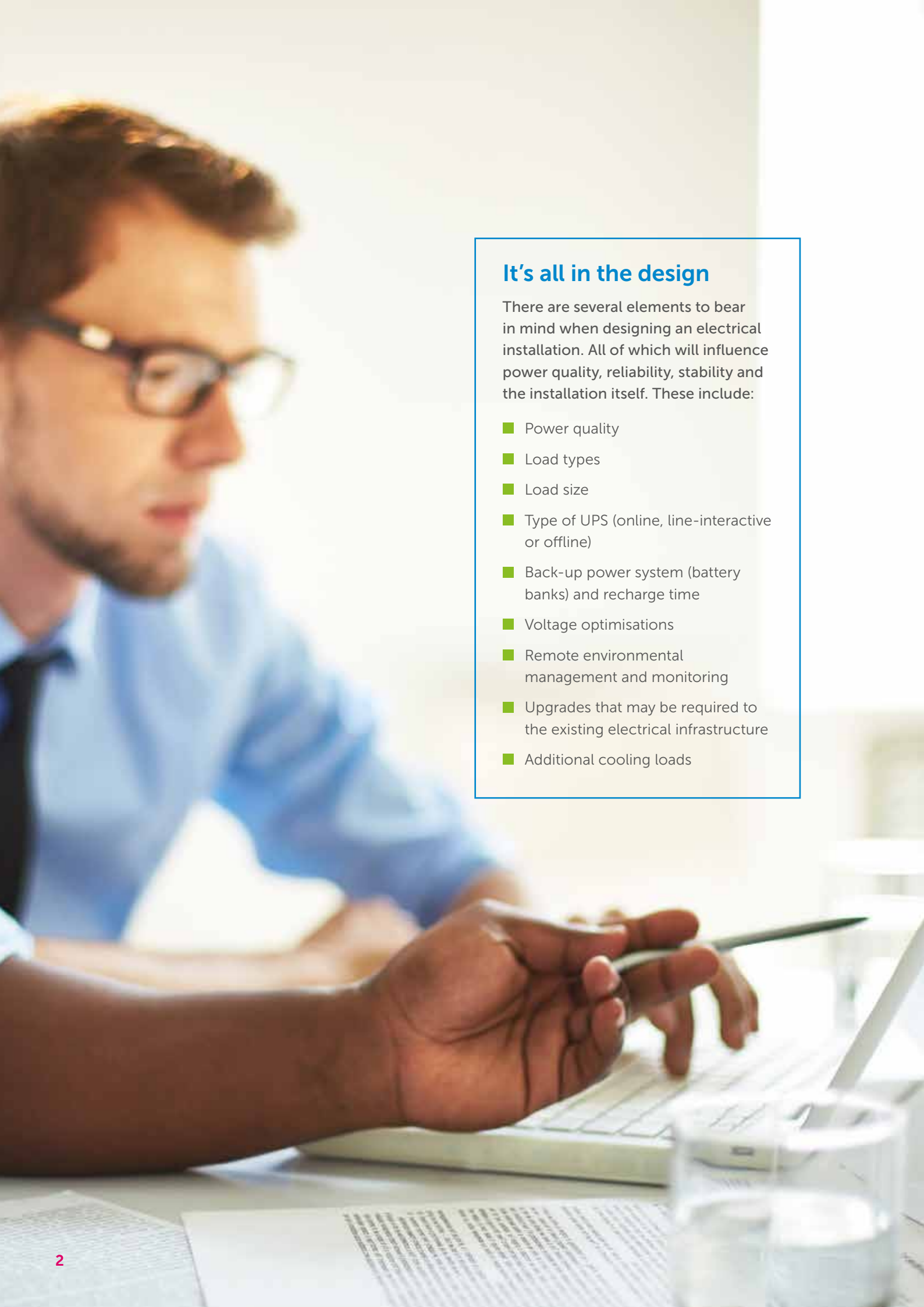
The pre-installation survey reveals all the details about the scope and complexities of the electrical work to be undertaken, including;

- Type of electrical loads
- Power quality issues
- Harmonics
- Whether it is a high, medium or low voltage installation
- Electrical distribution set up
- Breaker sizes already on site and their discrimination

Scoping the electrical work

The extent and complexity of the electrical work involved depends upon the size and intricacy of the installation, but typically includes:

- Cable installation (from AC mains power source to UPS; from the UPS output to a distribution system, between the UPS and battery set generator and/or other alternative power sources)
- Installation of additional power sockets or fused spurs
- Upgrading supply ratings, cable and distribution boards
- Installing electrical switchgear panels and maintenance bypasses
- Running alarm cables to remote panels or network connection points



It's all in the design

There are several elements to bear in mind when designing an electrical installation. All of which will influence power quality, reliability, stability and the installation itself. These include:

- Power quality
- Load types
- Load size
- Type of UPS (online, line-interactive or offline)
- Back-up power system (battery banks) and recharge time
- Voltage optimisations
- Remote environmental management and monitoring
- Upgrades that may be required to the existing electrical infrastructure
- Additional cooling loads

Protecting the power continuity

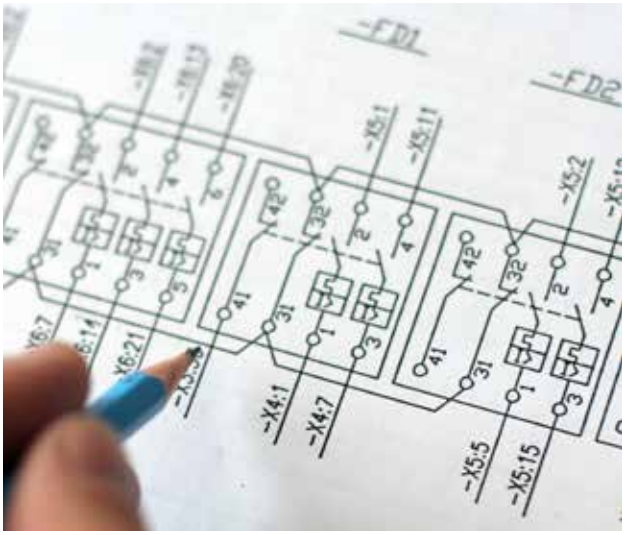
Protection discrimination is how two or more protective devices within a supply circuit are coordinated to ensure any loads that develop a fault (overload, short-circuit or earth), are quickly removed without disruption to other loads.

The implementation of a suitable discrimination path for each section is critically important to ensure the supply conductors of each device are individually protected. This is in order to:

- Protect the UPS themselves
- Protect the critical loads attached to them

Importantly, this process involves:

- Choosing the right solution from the range of suitable devices available
  - Fuses, circuit-breakers or Residual Current Devices (RCD)
- Recognising the different rating, suitability and operating characteristics, such as the speed of response and the types of circuit-breakers available which may be rated the same, but react differently in overload conditions
  - For example, a 20A circuit-breaker may disconnect within 0.1 seconds with an overload current of just 100A, whereas another type of 20A circuit-breaker may not trip until it receives a current of 400A
- Understanding the ultimate need of the devices
  - Robust circuit-breakers, that can sustain higher overloads for longer periods are recommended for loads with high inrush currents, such as some types of UPS (transformer-based) and motor loads/motor machinery
  - More responsive circuit-breakers are suitable for sensitive equipment such as computer and telecom loads
  - While ensuring nuisance tripping at start up, is prevented



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The curse of harmonics

Electrical systems naturally get busier, as more equipment is added into already overcrowded distribution systems. The result is an increase in harmonic pollution, the attributes of which need to be considered from the outset, including:

- The variation of permitted harmonic limits depending on whether the supply is high, medium or low voltage
- A high voltage network is likely to have low impedance, which allows a larger harmonic content load to be connected
- In the EU, the electrical supply industry is required to meet EN 50160 – Voltage Characteristics of Electricity Supplied by Public Distribution Systems and it includes guidelines on harmonic voltage distortion
- In the UK, permitted harmonic levels are also specified in G5/4-1

The influence of power factor

Some electrical equipment (particularly older devices) have poor power factor, which means their load is out of phase with the voltage waveform of the electrical supply. So, what does this mean?

- System inefficiencies
- Additional demands on supply connections and peripheral equipment, such as cabling, conductors, transformers and distribution boards
- The closer the input power factor of the UPS is to Unity (1), the lower the amount of reactive power generated and the more efficiently the UPS system will run
- Installation of passive harmonic filters can improve things, but because of the way in which a phase-controlled rectifier operates, performance will remain load related

Cable sizing & installation

Failure to select and specify the correct type and size of cabling in UPS installations can result in overheating, fire risk and premature failure. It is therefore important to:

- Select the best method of installation, alongside the most optimum routing
- Install the same cable sizes for input and output
- Select the right cable to provide continuous full thermal current rating
- Use a site survey to reveal the length of cable required, what voltage drop should be catered within the project specification and what size lugs are required

Ensuring downstream protection

Downstream protection must be right for the type of UPS and how it operates: normal operation with mains power supply present or battery operation with no mains power supply present.

Normal mains operation

With mains power supply present, any fault or short-circuit on the UPS output will result in the load being transferred to the bypass. This will allow the full capacity of the mains power supply to clear the downstream fault. Once cleared, the UPS will transfer the load back to the inverter and resume normal operation.

Battery operation

When no mains power is present, a fault condition on the UPS output will result in an energy restriction in an attempt to clear the fault. Once cleared, the UPS will continue supplying the loads from the battery set. If however, the UPS does not have enough power to clear the load, it will shut down in order to protect itself and any connected downstream loads. This is referred to as 'current limiting'. So, awareness of the type and current rating of downstream devices is important, in order to ensure discrimination occurs during both modes of operation. There are several options for downstream protection:

- **Galvanic isolation** – how this is set up depends upon where the isolation transformer is installed, with which type of online UPS and whether it has a single or dual input supply
  - Transformerless UPS require two isolation transformers on the input side to provide complete neutral separation
- **Maintenance bypasses** – there are various types of maintenance bypass available, including internal and external
  - For UPS below 5kVA, external bypasses are typical and usually have an additional automatic transfer facility
- **Surge protection** – on mains 1 and 2 (as chosen through discussions with the client)
- **Lightning protection** – modern buildings typically cover this requirement, but it should also be covered in the site survey

Parallel systems connection

A parallel capacity UPS can be installed with either a single or dual input power supply, but the overall rating must be adequate enough to supply the parallel UPS irrespective of operation (capacity or redundancy). Key things to consider are:

- The AC supply must be rated to the maximum input current of each UPS module, multiplied by the total UPS units in the system
- Within a parallel redundant UPS configuration, the supply rating can be the same as that used for a parallel capacity system or equal to the total current required by each of the individual UPS modules (plus 10% to allow for charging and system losses)
- Cables in a parallel UPS system should be:
  - Sized in accordance with the rating for each UPS module to which they are connected (input cables)
  - Rated to either the supply or the maximum output power available from each UPS module (output cables)
  - The same length (for both input and output cables) to ensure an even power distribution

Dual input connection – fed by unique breakers or linked?

UPS resilience is further increased through the common practice of using dual AC power sources, rather than single. Why use dual input connection?

- It protects against a single point of failure, as it allows the rectifier and bypass to be supplied from separate sources, possibly different sub-stations
- Transformer-based UPS are supplied with dual input terminals as standard
- With transformerless UPS, it is slightly different as the rectifier and bypass supplies require a common neutral connection
  - These can still be installed with a dual input, but supplied from the same source, but this is a factory fit option and not standard

Earthing & bonding for UPS and battery racks

To protect equipment (and the installation itself) from overheating, premature failure and fire risk, it is mandatory that live conductors are protected from overloads, short-circuits and earth faults. The earthing and bonding of UPS equipment depends upon the type of electrical supply installed. There are four common types:

TN-C-S – the most common, which uses Protective Multiple Earthing (PME) where neutral and earthed protective conductors are combined in part of the system

TN-C – in which neutral and earthed conductors are combined throughout the system and this type also uses PME

TN-S – in which the neutral and earthed conductors remain separate throughout

TT – in which neutral is earthed at the power source, but the electricity supplier does not provide an earthed protective conductor

It is inadvisable within UPS systems to connect the output neutral to the incoming earth. If neutral-to-earth connection is required, an isolation transformer should be installed on the UPS output.

Earthing & bonding for generators

It is important that care is taken around neutral connections, as UPS and generators rely on breaking the neutral when switching to and from the generator supply. Therefore, the UPS must be capable of withstanding a break in supply neutral during changeover. This can be addressed by operating either a switching mechanism or a make-before-break method.

Switching mechanism

This common form of switching mechanism uses two individual, but electrically interlocked contactors, and is:

- Controlled by the AMF (Automatic Mains Failure) panel, to select between incoming mains power or generator output
- Relatively inexpensive, but not necessarily the best, particularly for installations requiring a fixed neutral between changeover, as it is slow and could take several cycles for the change to occur

Make-before-break contact method

This system is better and ensures the neutral stays fixed during changeover and can include installing an isolation transformer to maintain a fixed neutral, helping to address harmonic problems.

24x7 Power does not just happen, the team at Critical Power Supplies make it happen."

UPS & generators

The UPS and generators must be compatible and suitably matched in terms of sizing, in order for:

- The generator to be able to accept the UPS loads
- The UPS (rectifier and static bypass supplies) to operate with and synchronise to the output of the generator
- The generator and UPS to interface for control purposes
  - Cable runs may be needed for both the electrical and communications signals (for example, to make a connection between the UPS, generator and AMF panel, which may be monitored remotely)

Electrical testing & certification

Hard wired UPS systems require electrical testing and certification, carried out by certified electrical contractors. Testing regimes will vary in accordance with the size and scope of each installation, but they could include Earth fault loop impedance testing.

Downstream distribution and left and right PDUs both on UPS or only one and the type of PDU required as there are three types.

- Basic
- Monitored
- Managed

Metered PDUs should be a bare minimum to ensure the load supported by the PDU does not exceed the supply breaker size, otherwise overloading could pull the breaker open, consequently dropping the load without notice.

Assured power protection for business continuity

The whole point of a UPS is to ensure that when the mains power goes off, everything critical remains operational. Get the electrical design and installation wrong and you could end up with no power protection at all. Get it right and you could ensure power continuity, increased efficiency and save many thousands of £s in electricity bills.

A site survey is vital; knowing what you are working with at the outset is a great starting point. After that, it's a case of making sure you understand the technology you are working with, have the experience to make it work and know what is needed. The importance of expertise in this area cannot be overstated. At Critical Power, we offer the experience, knowledge and qualifications to get the job done, and get it done cost-effectively.

Critical Power is a specialist provider of power protection and energy management products and services. We understand the vital need for sustainable uptime, optimised energy consumption and power continuity in today's business environments.

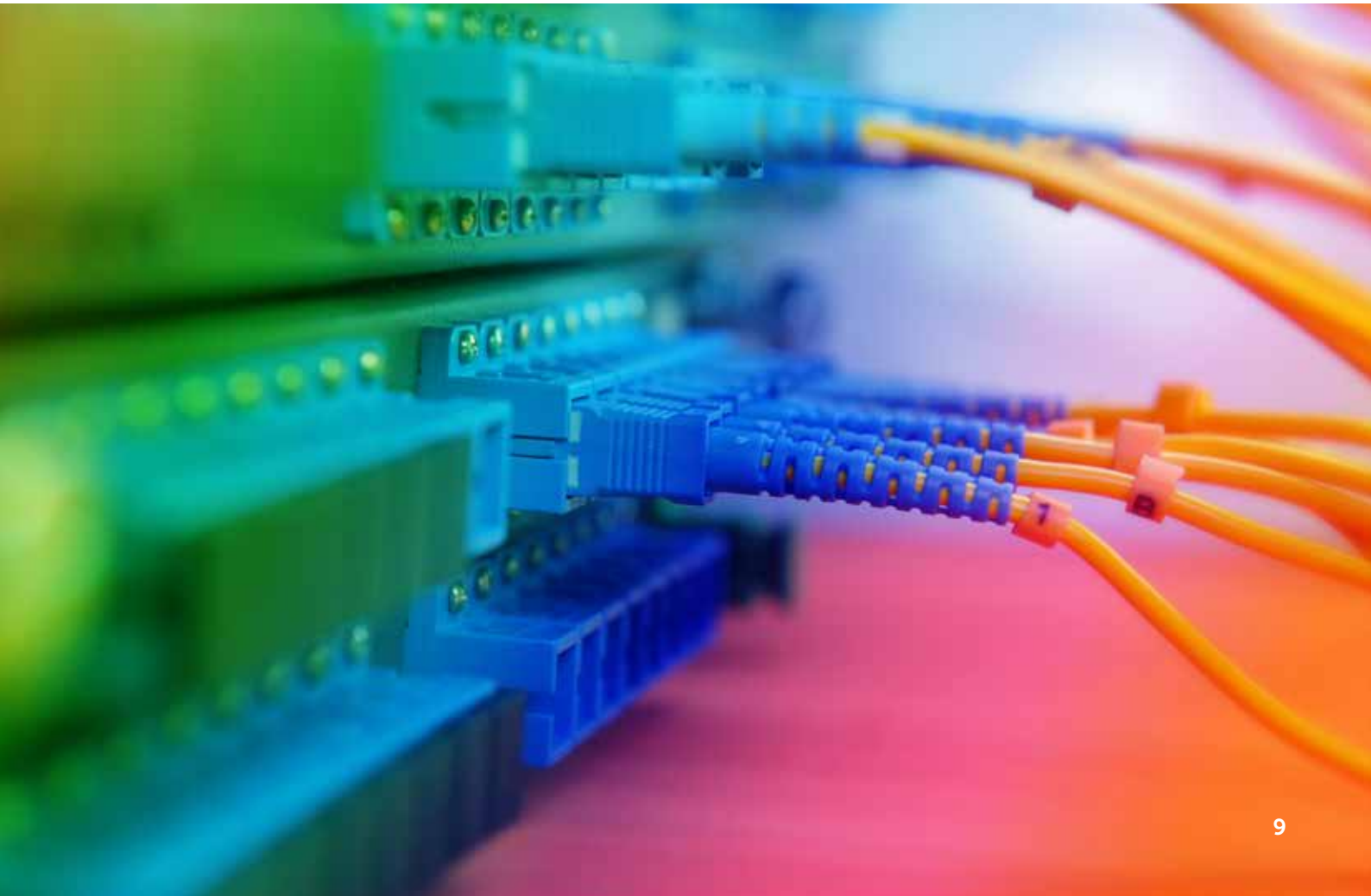
Manufacturer independent and accredited – we take the time to design and choose the right solution for your UPS electrical installation whatever your industry:

- Health
- IT
- Industrial
- Marine
- Military
- Retail
- Telecommunications

Accreditation & compliance

Recognising that our customers often operate in highly regulated industries in which accreditation is a legal requirement; we too are certified to work under these strict directives. This means you can rest assured our staff, suppliers, products and services comply with the latest standards and regulations, so your own regulatory compliance remains intact.

If you require any further information, or would like an informal chat about critical power continuity, standby power or power protection systems in general, get in touch.



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