Simulating the grids of the future today

Energy grids are changing as more renewable sources come onto the network, which can cause voltage fluctuations and other problems. Test engineers are looking to deploy more advanced AC source power supply units to ensure the reliability and resilience of future systems and equipment. In this article, TDK-Lambda explores how the grid of the future can be simulated at present.

References

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Energy grids are changing as more renewable sources come onto the network, which can cause voltage fluctuations and other problems. Test engineers are looking to deploy more advanced AC source power supply units to ensure the reliability and resilience of future systems and equipment.

The adoption of renewable energy continues to accelerate globally as power systems become cleaner and more sustainable as part of the ongoing battle against climate change.

Recent statistics from the International Energy Agency (IEA) reflect the pace of this incredible transition. The world added 50% more renewable energy capacity in 2023 than in 2022, reaching almost 510 gigawatts (GW), and the next five years will see the fastest growth yet. The shift to renewable sources is taking place in all key regions, including Europe, China, and the United States, with wind and solar representing the majority of the new capacity.

However, while integrating more renewable energy into global power grids is to be welcomed, it presents some challenges, specifically regarding grid supply. The uncertain nature of wind and solar has been shown to cause problems such as voltage spikes, frequency fluctuations and harmonic distortions. These conditions can significantly impact the performance and reliability of a broad range of grid-connected devices, including inverters, uninterruptible power supplies, electric vehicle chargers, industrial machinery and consumer electronics. Grid instability is a serious concern across multiple industries, and engineers must pay much consideration to the resilience of connected equipment in a more electrified world.

Simulating real-world conditions for device resilience

So, how do engineers ensure that the latest systems and equipment can cope with more regular fluctuations in grid conditions? The answer lies in using next-generation programmable AC source power supply units (PSUs), which can simulate and test AC power conditions. These devices have become more versatile and user-friendly in recent years, allowing engineers to perform a broader range of simulations and tests with more precision, accuracy, repeatability and control. AC source PSUs have become indispensable in product development, validation and compliance testing under AC conditions, leading to improved reliability and performance.

Let us look in greater detail at various grid conditions that programmable AC source PSUs can simulate. Firstly, voltage fluctuation is one of the most commonly occurring impacts associated with the increased integration of renewable sources into the grid. Poor regulation of output from a wind turbine at low or high wind speeds can cause significant fluctuations in the voltage supplied to the grid. The connection and disconnection of heavy motor loads from industrial machinery, elevators, or other power-hungry equipment can exacerbate these conditions.

Voltage fluctuations can vary considerably and can be more than ±10% of the nominal voltage, and fluctuation duration and frequency can also differ. These variances can cause various performance issues for grid-connected systems and devices, including equipment damage and degradation, data loss and corruption, and operational interruptions of industrial or medical equipment. AC source PSUs can accurately recreate various voltage fluctuations in highly controllable conditions, helping to validate the robustness and compliance of devices through the development of effective mitigation strategies.

Distortions – where the AC waveform becomes non-sinusoidal – represent another set of conditions that AC source PSUs can recreate. The increased presence of renewable energy sources can introduce more opportunities for harmonic distortion if not correctly managed. For example, many solar panels and wind turbines use inverters to convert the generated DC power into AC power that can be supplied to the grid. Inverters are non-linear devices and can introduce harmonic distortion into the power system if improperly designed or filtered. The distributed nature of renewable energy and the more complex interaction of different devices can also cause distortion effects.

Also, some electrical devices such as switch mode power supplies, IT equipment, LED lighting, and welding machines can create non-linear loads – which can introduce harmonic distortions. Again, AC source PSUs can effectively simulate distortion and harmonic conditions, allowing engineers to test and validate the performance of devices under these conditions.

Many other conditions can also be simulated. These include transients, a short-term effect where the voltage or current changes rapidly due to factors such as lightning strikes, arcing, contact bounce or removal of large load, and interruptions, where the voltage or current varies from the nominal for mS or seconds, i.e., simulating a mains insulator flashover. It can also include frequency variations, where the frequency differs from the nominal frequency for one or more cycles, e.g., simulating a diesel generator. Ultimately, with AC source PSUs, test engineers can recreate just about any conditions appearing on the grid in a precise, accurate and repeatable manner.

User-friendly and flexible designs meet engineers' needs

But if those are some of the high-level performance parameters, what about factors such as usability and ease of operation of AC source PSUs? These are also critical considerations for time-pressed test engineers whose work often takes place within compressed product development cycles. Therefore, the latest testing devices must be intuitive and interoperable, allowing test engineers to integrate them into testing operations quickly and easily with minimum set-up times.

Flexibility is, therefore, key. Test engineers want to be able to pre-program standard profiles or perform custom simulations for different scenarios with AC source power supplies, with optional embedded test profiles pre-programmed and field-upgradeable. For grid-connected systems, these include IEC61000-4-11 and 13, and IEC61000-4-14, 17, 27, 28, 29, 34 9, as well as the ability to perform harmonic analysis. If an individual has programming expertise, they should be able to quickly and easily "pre-program" the above, other standards or any other input condition they would like to subject the unit or device to test.

Another useful capability is combining multiple units to create one-phase or three-phase applications, enhancing flexibility and precision. At all times, the resolution and accuracy of the simulated supply voltage must be guaranteed. By ensuring high accuracy and low total harmonic distortion, the latest generation of AC source PSUs makes it possible to produce a very pure input sinusoid. Therefore, the device under test has no noise or disturbances. Also, when simulated disturbances are added, it can be done precisely.

Test engineers also want their AC source power supplies to have more of a look and feel of consumer devices, with modern materials reducing weight without compromising durability, making them easier to move and handle. Desired features also include intuitive graphical user interfaces, in multiple languages, with clear and simple layout using icons and visual cues to facilitate ease of use. They also increasingly prefer capacitive touchscreens rather than knobs and buttons, with multi-touch capabilities like those found in smartphones and tablets. These functions all improve efficiency and flexibility.

Conclusion: ensuring reliability in a renewable energy future

AC source PSUs will play an essential role in ensuring devices connected to future grids comprising a greater mix of generating technologies will operate correctly and reliably. Major applications will likely include grid-connected inverters, energy storage systems, onboard electric vehicle chargers, industrial equipment, and military applications requiring ultra-rigorous testing and approvals. That means potential use cases will be spread across multiple sectors, including aerospace, automotive, industrial, and defence.

In each case, next-generation AC source PSUs will enhance the role of test engineers, helping them work flexibly, efficiently and creatively as part of multi-discipline teams. The intuitive design and high efficiency of these devices can also positively affect sustainability – saving energy, reducing operational temperatures, and reducing running costs.

In summary, programmable AC power is pivotal in ensuring that devices connected to future grids operate correctly and reliably. Without these devices, achieving a net-zero future would be challenging.

However, by deploying and using AC source PSUs, test engineers can help build resilient systems, paving the way for sustainable and dependable energy – now and in the future.