



# *THE SPECTRUM*

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# **EDITORIAL TEAM**

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# VISION AND MISSION OF THE SCHOOL

## ABOUT SCHOOL

The **School of Electrical Engineering** at VIT University, Chennai was established in the year 2010. Since the inception of the institute, the department has developed a state-of-the-art infrastructure for teaching and research. The Smart Grid lab, for instance, is one of a kind in the country. The school has also signed an MoU with MSME, Govt. of India for collaborative works. SELECT has highly qualified and experienced faculty. The school offers Bachelor's program in Electrical and Electronics Engineering, and a PhD program. There are four major research groups: Power Systems, Power Electronics, Controls and Instrumentation and Electrical Machines and Drives. The research findings of these groups are published in several peer-reviewed International Journals every year. SELECT has always endeavoured to contribute significantly to the growth of technical education. There have been several workshops, seminars and guest lectures for faculties, students and research scholars of educational institutions from all over the country and abroad. Eminent professors from reputed Indian and Foreign Universities share their expertise with student and faculty here.

## VISION

- To offer an education in electrical engineering that provides strong fundamental knowledge, skills for employability, cross-disciplinary research and creates leaders who provide technological solutions to societal and industry problems.

## MISSION

- Provide personalized experiential learning in industry sponsored laboratories to prepare students in electrical engineering with strong critical thinking and employability skills.
- Foster design thinking, creativity and cross-disciplinary research with highly qualified faculty to create innovators and entrepreneurs in the broad area of electrical engineering.
- Collaborate with national and international partners to provide innovative solutions to societal and industry challenges.

# SST: A NEW BREED OF TRANSFORMERS

*By Phrashika R B(21BEE1275)*

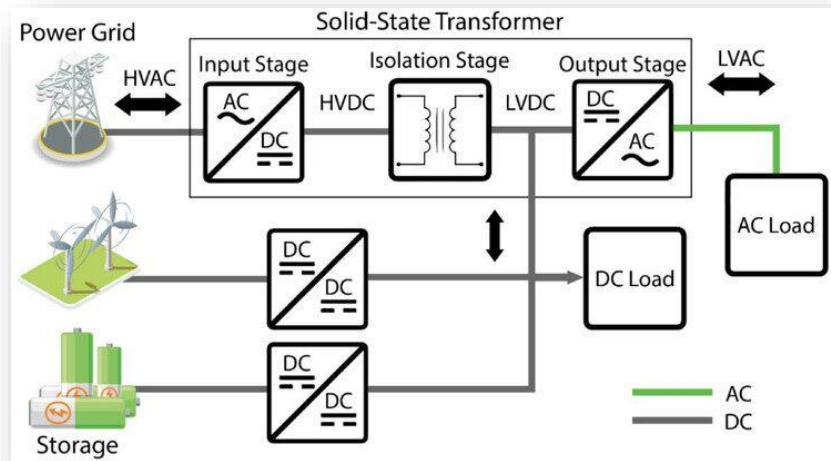
## What Is a Solid-State Transformer?

Unlike conventional transformers that rely on heavy iron cores and low-frequency operation, solid-state transformers (SSTs) use a multi-stage architecture and high-frequency transformers (HFTs) to achieve significant improvements in size, efficiency, and functionality.

Essentially, SST functionality relates on three core stages.

1. **Input Stage (AC-DC Conversion).** This stage converts low-frequency alternating-current (AC) into direct-current (DC), forming the foundation for high-efficiency power management. Wide-bandgap semiconductors like silicon carbide (SiC) and gallium nitride (GaN) are central to the process, offering reduced switching losses, enhanced thermal stability, and the ability to operate at higher frequencies. These innovations allow SSTs to achieve compact designs with enhanced power density. The input stage also provides reactive power compensation, which promises seamless integration with the grid and stabilizing power delivery under dynamic conditions.
2. **Isolation Stage (High-Frequency DC-DC Conversion).** In this stage, an HFT isolates and adjusts voltage levels between the high- and low-voltage sides. By leveraging advanced magnetic materials (such as ferrites and amorphous alloys), HFTs minimize core losses while maintaining high thermal stability and power density. Operating at frequencies ranging from tens of kilohertz to several megahertz, the HFT significantly reduces size and weight compared to traditional transformers, making it ideal for space-constrained environments like urban substations or offshore wind platforms.
3. **Output Stage (DC-AC Conversion).** This stage reconverts DC back into AC or retains it as DC, depending on the application. Supporting bidirectional power flow, the output stage enables seamless integration of distributed energy resources (DERs), energy storage systems, and renewable energy sources. Precise voltage and current regulation at this stage bolster grid stability and efficiency, positioning SSTs as intelligent nodes in modern grids.

Compared to conventional transformers, SST designs notably include advanced features, including modular configurations, such as multilevel converters and dual-active bridges, which enhance scalability and operational flexibility. At the same time, integrated sensors and intelligent control algorithms can enable real-time monitoring, voltage regulation, harmonic filtering, and fault isolation. SSTs also support grid communication protocols, ensuring seamless integration with renewable energy systems and DERs. Notably, however, the functionality and applicability of SSTs depends significantly on their configuration, which determines their performance in various scenarios.



**One-Stage Configuration.** The design involves direct AC-to-AC conversion without a DC link. While cost-effective, lightweight, and suitable for basic voltage transformation, it lacks the advanced capabilities needed for reactive power compensation and renewable energy integration. The configuration may be ideal for applications in rural and industrial settings where simple step-down voltage conversion is necessary.

**Two-Stage Configuration.** Incorporates a DC link on either the primary or secondary side on either the high-voltage (primary) or low-voltage (secondary) side of the transformer, enabling more advanced functions. These include, for example, reactive power compensation, improved voltage regulation, and integration with DERs and energy storage. The configuration is better suited for electric vehicle (EV) fast-charging stations, where DC conversion is critical, and for renewable energy microgrids that need reliable voltage regulation and storage integration.

**Three-Stage Configuration.** Features dual DC links on both the high- and low-voltage sides. While complex and costly, this configuration provides the highest level of operational flexibility, bidirectional power flow, robust reactive power management, and seamless DER connection. Applications generally envisioned include urban substations, offshore wind platforms, and data centres, which generally need compact, efficient, and highly controllable power management.

# NATURE BIASED POWER GRID DESIGNS

*By Nikhil Nilam Langade (21BEE1196)*

Using biodiversity as a blueprint, researchers at Texas A&M University are examining ways to build more robust and resilient power grids.

## Unanticipated Threats to the Power Grid

Electrical power grids are susceptible to disruption by natural disasters or cyberattacks. The traditional approach to building a robust power grid is to anticipate disruptions and harden



aspects of the grid to meet these threats. The problem comes when unanticipated events threaten to bring down the entire grid.

Such was the case in Texas in February 2021 when a winter storm hit the region, setting record-low temperatures. The Electric Reliability Council of Texas (ERCOT), the body that

runs the Texas power grid, was unprepared for such cold extremes, as natural gas wells and pipelines froze, causing massive and systemwide power outages.

## Biological Resilience

The Texas A&M team noted that biological systems tend to be extremely resilient and are particularly resistant to unexpected occurrences. Typically, large-scale systems like power grids focus primarily on efficiency, favouring one power source.

A power grid based on a biological ecosystem achieves redundancy by adding different power sources and more power lines. This occurs in much the same way that fields and forests count upon a diversity of plant and animal species to build resiliency and the ability to adapt to unexpected assaults.

The goal of an electric power grid operator is to provide reliable service at the lowest possible cost—remediation and restoration are the primary strategies that are employed after a

power grid disturbance. Using the biological ecosystem approach builds in additional grid structures and functional adaptability to prevent a small problem from bringing down the entire grid.

Adding power sources to a grid primarily wind and solar renewables—and



incorporating large-scale battery energy storage already form major parts of the decarbonization of electric power systems nationwide. A diversity of power sources provides many of the same advantages as biodiversity in the

natural world.

## **Grid Resilience**

The technique used by the Texas researchers was to build a stringent mathematical model that allowed the optimization of power flow while considering ecologically based resilience. Various threat scenarios were investigated and have shown a strong connection between an ecosystem's resilience and a power grid's tolerance to resist threats.

The downside to building an ecosystem-based grid is that redundancy also adds cost. More power sources and transmission lines contribute to the costs of a grid. However, the price paid in human suffering and inconvenience when the grid becomes unstable or fails during a natural or man-made disaster is also significant.

The Texas A&M study estimated that in most cases, adding robustness through a biomimicry approach only costs an average of 5 percent more than building a traditional system but results in a power grid that can better tolerate unexpected and unpredicted disturbances. The ability of the grid to respond more robustly to disturbances also provides more time for grid operators to address problems through remediation and restoration of the system.

# MOSFET INNOVATIONS FOR AUTO ELECTRONICS

By ADITYA SINGH(22BEE1086)

The vehicle electrification reduces carbon footprints compared to traditional cars, but the increased electronics require more electrical power to operate, requiring a more extensive network of power supplies operating at high power density and efficiency.

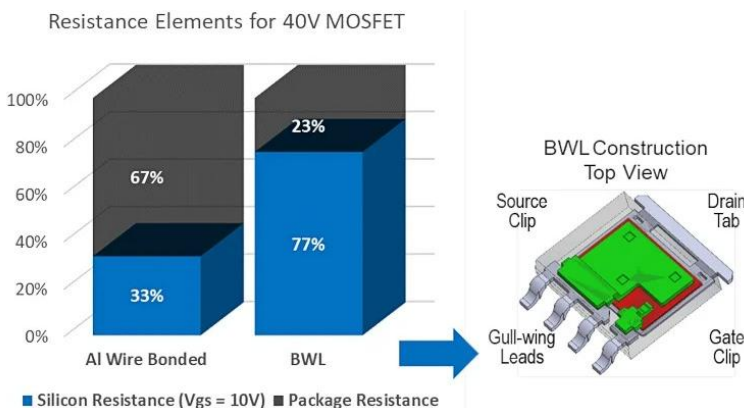
As MOSFETs provide critical switching functions in power management designs, choosing a device with an optimized balance of physical, thermal, and electrical attributes is critical to increasing power density. The latest innovations in power MOSFET packages elevate performance and provide ruggedness in extremely compact form factors.



The latest innovations in power MOSFET packages elevate performance and provide ruggedness in extremely compact form factors.

## On-Resistance Minimization

Legacy transistor outline (TO) packages have provided proven solutions for powertrain applications that require power ratings from several hundred to thousands of watts. Products in



TO packages often use aluminium wires to connect the “source” of the MOSFET’s silicon to the terminals. This type of construction has its limitations, particularly for the latest technologies, which have very low R<sub>DS</sub>-Area.

For example, the most advanced 40 V device in a 7-pin D2PAK with Al wires will have a 33 % to 67 % split between silicon- and package-contributed resistance. Thus, the intrinsic limitation hinders the creation of better MOSFET products.

## Top-Side Cooled Packages

As the semiconductor industry continues reducing the  $R_{DS}$ -Area of technologies, the package also requires innovation to better complement the silicon. The new package constructions replace Al wires with bond-wireless (BWL) interconnection for surface-mount packages. In

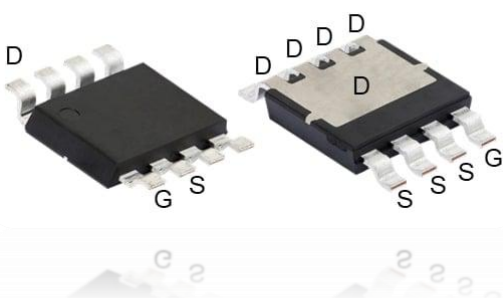
the BWL architecture, the source and gate of the MOSFET are connected to the terminals by two metal

clips. This dual-clip construction is optimized through finite element analysis to reduce stress on the die and leads while minimizing resistance and inductance.

Select powertrain applications that operate at high currents often need to utilize the metal enclosure or heatsinks to remove heat generated by the power loss of components. To

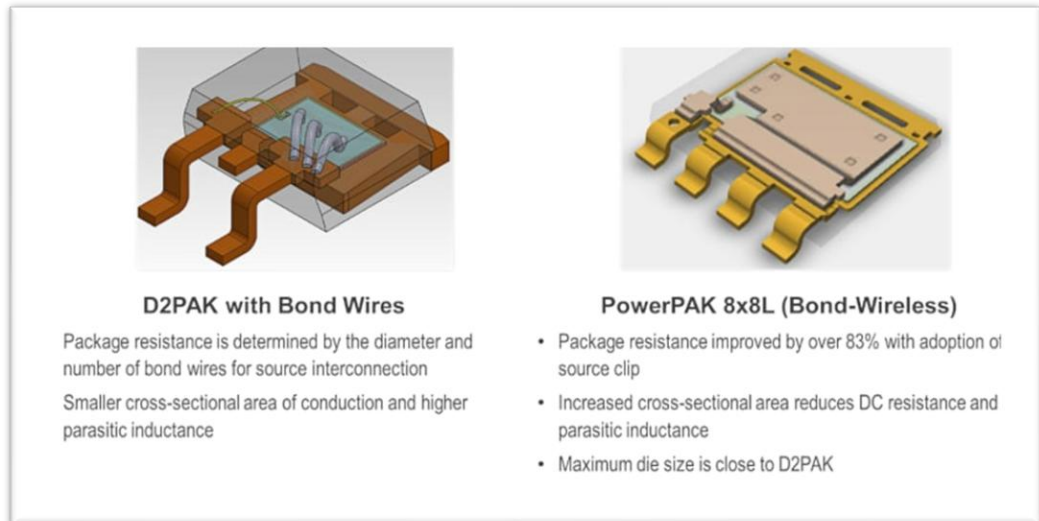
Bottom View

Top View



leverage such a thermal management design, the ideal MOSFET should have an interface with low thermal resistance to meet the heatsink. One solution is the latest PowerPAK 8 x 8 LR package, which provides a top-side cooled feature and is optimized for heatsinking. The drain pad is on the top of the encapsulation and provides a direct thermal path from

the top of the package to the heatsink, with thermal paste or gap filler at the interface. The heat can escape upward to the heatsink and is directed away from the PCB. As the dominant thermal path is the heatsink, the PCB handles less thermal transfer and can use smaller components, which ultimately lowers the PCB cost. As the heatsink takes away heat more efficiently, the system runs cooler and enables operation at a higher power density.



For most MOSFET packages with the drain on the bottom side, the heat will be pushed into the PCB through the drain pad and dissipated to the heatsink. This path includes several materials with thermal resistance in series. The PCB area of the MOSFET will also need vias to allow for thermal transfer.

### **The Takeaway—Smaller, Robust, and More Energy Efficient**

The new Power-PAK packages with BWL construction bring out the best of silicon and have lighter weight than devices in comparable TO packages. The resulting products increase efficiency and enable higher power density, so automotive electronic systems can be more energy efficient.

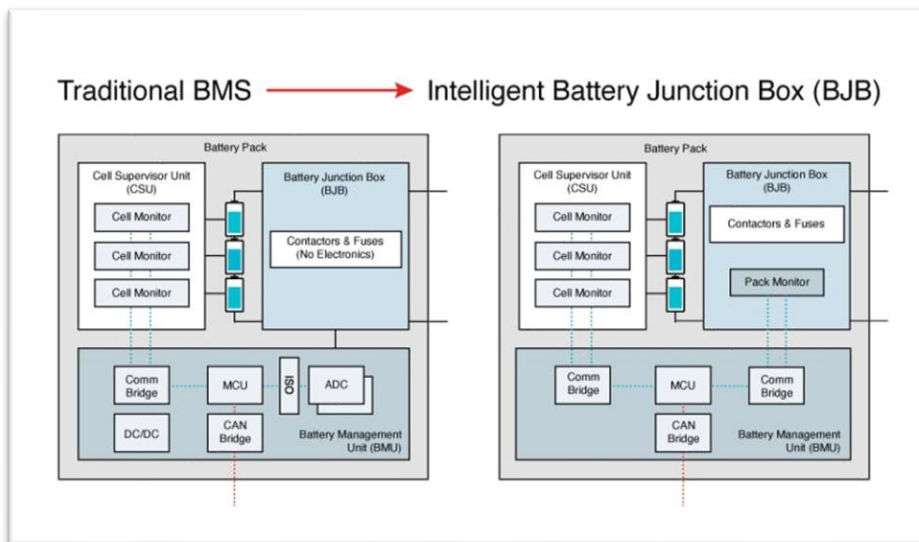
# INTELLIGENT BATTERY JUNCTION BOXES FOR BMS

By P HARINI(22BEE1154)

As electric vehicles become more popular, the challenge for automakers is to reflect true range while making vehicles more affordable. This means making the battery packs lower cost with higher energy densities. Every single watt-hour stored and retrieved from the cells is critical to extending the driving range.

The main function of a battery management system (BMS) is to monitor cell voltages,

pack voltages, and pack current. In addition, due to the high-voltage design of the BMS, insulation resistance measurement between the high-voltage and low-voltage domains is needed to catch defects in the battery structure and protect against



hazardous conditions.

## Over-Current Fault Detection and Protection

Detection and prevention of an over-current event are required in a BMS to prevent catastrophic damage that can occur to the battery pack in the event of a short circuit, exposed high-voltage terminal, or defective equipment. An over-current circuit integrated into the BJB unit will use the current sense information measured through the shunt resistor, hall-effect sensor, and the battery pack monitor. This measurement is then processed and compared to a threshold inside the battery pack monitor while the same has the capability of signalling an over-current event through dedicated outputs, which will be used to enable a fuse-driver to blow the high-voltage separator (pyro-fuse).

## **Voltage and Current Synchronization**

Voltage and current synchronization is the time delay to sample the voltage and current between the pack and cell monitors. These measurements are mainly used for calculating the state of charge and state of health through electro-impedance spectroscopy (EIS). Calculating the impedance of the cell by measuring the voltage, current, and power across the cell enables the battery management system to monitor the instantaneous power of the car.

The cell voltage, pack voltage, and pack current must be time synchronized to provide the most accurate power and impedance estimations. Taking samples within a certain time interval is called the synchronization interval. The smaller the synchronization interval, the more precise the power estimate or the impedance estimate. The more accurate the state-of-charge estimation, the more accurate the remaining mileage drivers get.

## **Synchronization Requirements**

Next-generation BMS will require synchronized voltage and current measurements in less than 1 ms, but there are challenges in meeting this requirement. These battery monitors also support delayed ADC sampling to compensate for the propagation delay when transmitting the ADC start command down the daisy-chain interface.

## **Remote Device Communication Support**

Another benefit of the intelligent BJB is the streamlined data communication by using the versatile daisy-chain interface not just for battery pack and battery cell monitor devices but also remote devices like EEPROM memory or any type of sensors that are placed in the modules with different physical placement in the vehicle. In this case, the pack and monitor device also acts as an interface translator offering I2C or SPI data to be transferred through the daisy-chain interface, eliminating wires and cabling harnesses and, in turn, reducing the overall EV weight.

# WAVE ENERGY TECHNOLOGY: FUTURE RENEWABLE ENERGY

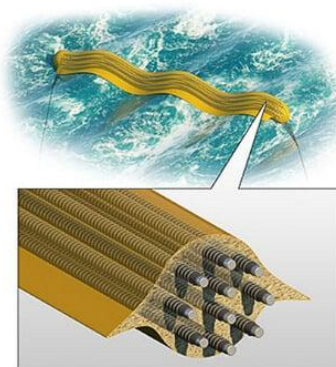
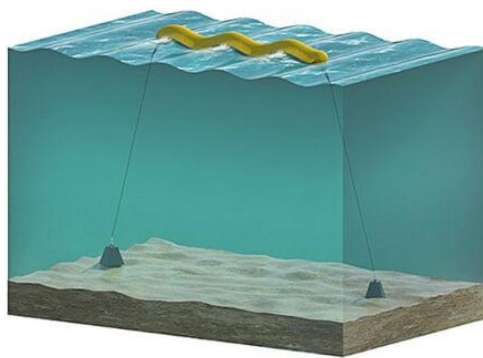
By SHASHWAT MISHRA(22BEE1264)

Unlike other ocean energy-harvesting solutions, which consist of one energy-harvesting module, the DEEC-Tec domain is unique in combining many individual energy converters to create a larger structure. One primary advantage of this architecture is that using an array of tiny converters makes the structure more flexible. With a flexible geometry, the DEEC-Tec system can bend and conform to different shapes, allowing it to interact with an energy source across its entire structure.

These flexible ocean wave energy converters are often referred to as flex-WECs. With the ability to be built into numerous shapes—snakes, balloons, paddles—flex-WECs increase the potential for substantial marine energy generation because more of the device can be used to extract energy from ocean wave movement. The individual energy converters that create flex-WECs generate energy through movement in the structure, which is possible because the DEEC-Tec-based devices are built without mechanical joints. Wherever water movement causes the dynamic structure to deform (twist, bend, or move), energy can be harvested from the deformation at that location.

## Stronger Than Traditional Wave Energy Designs

Traditional wave energy converters experience their own construction, maintenance, and cost challenges. In water, the structures are under constant stress from wave pressure. While this is great for harnessing energy, with only one converter, there is a greater risk of damage or failure because the force



isn't spread out. To minimize this, the structures are often built with inflexible steel frames. Unfortunately, the materials can be costly and not sustainably procured, in addition to raised costs for regular maintenance to fix operational failures.

DEEC-Tec concepts used in the Flex-WECs design, on the other hand, have a natural redundancy and robustness because of the many small transducers used to build the structure. Here, the wave forces are distributed across all elements, leading to lower pressure per element and a lower risk of failure. Additionally, the failure of a single converter or group of converters does not automatically create a failure of the whole Flex-WECs structure.

Because of these improved properties, the materials and assembly costs of the domain are relatively low. They are mostly made from common polymers and fabricated in a simple roll-to-roll process. The simple design also allows for the structure to be easily maintained, installed, or stored, depending on need or to avoid damage from ocean storms.

DEEC-Tec can also be used as a sensor within the structure, decreasing maintenance schedules by tracking real-time information from the transducers.

## **Future Renewable Energy Generation Possibilities**

Because DEEC-Tec generates energy through dynamic movement and can be combined to create a larger structure, the domain could also be used to make fabrics, barriers, and building structures. This dramatically expands the range of use for DEEC-Tec-based energy-converting structures. The resilience and flexibility of the DEEC-Tec domain open it up to create new possibilities for generating renewable energy.

The NREL team has made many advancements in the DEEC-Tec domain and still recognizes the challenges they face with the design. Proper materials are necessary to mitigate fatigue, determine optimal geometry structure, and enhance power conversion efficiency. They are optimistic these challenges will be solved.

# UNLEASHING THE POWER OF IOTs IN HEALTHCARE

By MANU GEORGE JOHN (21BEE1018)

The everyday challenges we face from our aging population with multiple chronic illnesses are ubiquitous worldwide. The medical, lifestyle, and personal health needs of aging populations will continue to burden our healthcare resources. Fulfilling these challenges requires a focus on empowering populations to self-manage their health through health innovation to improve well-being and attenuate health resource burden. This is where the IoT (Internet Of Things) comes into the picture.

## What Is IOT And Why Healthcare?

The Internet of Things (IoT) is a system of wireless, interrelated, and connected digital devices that can collect, send, and store data over a network without requiring human-to-human or human-to-computer interaction. It promises many benefits to streamlining and enhancing our healthcare delivery to proactively foresee health issues and diagnose, treat, and monitor patients both in and out of the hospital.

IoTs have been a topic of global interest over a couple of decades. However, the healthcare industry has just begun to understand its tremendous potential and usefulness. IoTs have recalibrated the healthcare industry with

their endless applications in the structure. The enactment of IoT in healthcare started with its adoption of remote patient monitoring for the retraction of data from bedside devices which can help physicians and nurses make better medical decisions and reduce human interactions, thereby eliminating error rates. In response to the novel COVID-19 pandemic, many government leaders and decision-makers are implementing policies to deliver healthcare services using this technology and it is now becoming increasingly important to understand how established and emerging IoT technologies can support health systems to deliver safe and effective care.



Well, for all the purposes and requirements, IoTs have just begun to pave their path and are employed as a practice among doctors and patients, changing the conventional way of treating illness. With the increase in the global population, the number of chronic diseases, and costlier services, the healthcare industry has long lost hope. To its rescue came the IoTs in the form of X-rays, followed by patient monitoring units and then Hospital meters which will reduce the major workload with operations and patient care.

IoT in healthcare have been embedded with current procedures, mainly with context to remotely monitoring patients in real-time, collecting data, and transferring them to end connectivity, which assists patient flow automation and enables data movement, vital information analysis, etc. IoTs have reduced regular medical check-ups to be more patient and home-centric than hospital-centric approaches. They are making health care much more efficient and avaricious by equipping objects with sensors to monitor their external environment.

### **Future Scope for IOT Driven Healthcare**

The revolutionary futuristic IoTs are on their way to marking their footprints with the help of breakthrough innovations and ideas. Some of the highly anticipated advancements include upgrades in sensor technologies, improvements in systems to gather and process data, and integration of artificial intelligence technologies in healthcare.

In terms of improving the existing implementations, research studies are in progress to enhance the usability and connectivity capabilities required in various areas of healthcare. Low-power operation is one of the essential characteristics focused on by researchers who are trying to utilize energy-harvesting systems with the help of ultra-low-power voltage converters. Moreover, the rise of artificial intelligence (AI) and its alliance with IoT is one of the critical aspects of digital transformation in modern healthcare. AI, along with sensor technologies from IoT, can lead to better decision-making. Advances in connectivity through artificial intelligence are expected to promote an understanding of therapy and enable preventive care that promises a better future.

## BASIC FRAMEWORK OF UHVDC

*By Yash Singh(21BEE1159)*

An era of soaring energy demands and decarbonized energy systems calls for efficient and economical power transmission. Hence, Ultra High Voltage Direct current (UHVDC) have emerged as a transformative solution for long-distance power transmission, reshaping the landscape of electrical grids. UHVDC systems can operate at voltages beyond the conventional limits, and their ability to transport electricity across vast distances with minimal losses makes them indispensable in a future that strives for sustainability.

At its core, UHVDC converts alternating current (AC) to direct current (DC) at the transmitting end using high-power electronic devices like thyristors or Insulated Gate Bipolar Transistors (IGBTs). The direct current is then transmitted over long distances with minimal losses. At the receiving end, the DC is converted back to AC for distribution to the grid.

AC lines have been the standard for decades due to the ease at which high voltages can be converted to low voltages depending on demand. Its disadvantage lies in that a sizable proportion of power is consumed in alternating the current. For any given voltage, an AC system has roughly double the losses of a DC system.

UHVDC systems use fewer materials than AC, as they require three slightly larger wires, while AC systems use six conducting wires. DC systems also need less aluminium and, hence, carry less weight. It also enhances grid stability through advanced control mechanisms and stabilizes heavily strained AC grids. The technology allows for dynamic power flow control, providing flexibility and strength in managing the electrical grid. It facilitates efficient electricity sharing between regions, optimizing global energy resources. This capability is crucial for harnessing renewable energy from remote locations and delivering it to high-demand areas. Hence, an interconnected power system is established across regions and countries. While UHVDC systems require substantial initial investments, their lower transmission losses contribute to reduced environmental impact over the long term. The efficiency gains align with global efforts to create more sustainable and resilient energy infrastructures.

In 2010, China became the first country to adopt UHVDC to meet the relentless demand for electricity. UHVDC can provide up to 10 gigawatts to power nearly 20 million Chinese homes. The growing efficient grid in China proves that the best places for UHVDC to take root are the bigger countries that are capable of generating large amounts of power and need to deliver it to cities over great distances.

# CHAOS IN POWER CONVERTERS: EFFECTS, AND SOLUTIONS

*By Gopika S (21BEE1241)*

Chaos in power converters refers to unpredictable, nonlinear behaviour that occurs in the electrical system, often causing system instability, erratic performance, and potentially leading to component failure. Power converters, which are used to convert electrical energy from one form to another (e.g., AC to DC or DC to AC), are typically designed to operate in a stable, predictable manner. However, due to their complex dynamics, they can exhibit chaotic behaviour under certain conditions.

Understanding chaos in power converters is crucial for ensuring their reliability and performance in practical applications. This article explores the causes of chaos, the effects it can have on power converter operation, and potential solutions to mitigate or avoid chaotic behaviour.

## What is Chaos in Power Converters?

In the context of power converters, chaos refers to a type of dynamic behaviour that is highly sensitive to initial conditions and leads to seemingly random or irregular fluctuations in output. Even though the system may be governed by deterministic equations (i.e., the system is predictable if all parameters are known), small variations in initial conditions or system parameters can lead to vastly different outcomes. This phenomenon is commonly referred to as deterministic chaos.

Chaotic behaviour in power converters can manifest as:

- Voltage or current oscillations: Unpredictable variations in the output voltage or current.
- Spikes or dips: Sudden, large variations in voltage or current that can stress components.
- Non-periodic behaviour: Output that does not settle into a steady-state value, which may cause power instability.

## Causes of Chaos in Power Converters

Several factors can lead to chaotic behaviour in power converters. Some of the primary causes include:

### 1. Nonlinearities in the System

Power converters are nonlinear systems, meaning their output is not directly proportional to their input. Nonlinear behaviour in components like semiconductor devices (MOSFETs, IGBTs, diodes) or magnetic components (inductors and transformers) can contribute to chaotic dynamics. Nonlinearities in the control algorithm (e.g., pulse-width modulation or PWM) can also lead to irregularities in the converter's output.

## 2. Feedback Loop Instabilities

Power converters often use feedback mechanisms (such as voltage or current feedback) to regulate their output. If the feedback loop is poorly designed or tuned, it can lead to oscillations or instability. For instance, if the feedback gain is too high or if there are delays in the feedback response, it can cause underdamped or overdamped systems that are prone to chaotic oscillations.

## 3. Control Strategies

The control strategy employed in a power converter plays a significant role in its stability. For example, PWM control, which is commonly used in DC-DC converters and AC-DC converters, can lead to chaotic behaviour if the modulation frequency and switching ratios are improperly chosen.

## 4. Parameter Variations and Perturbations

Power converters can be sensitive to changes in operating conditions, such as input voltage fluctuations, load changes, or temperature variations. Small variations in parameters (e.g., inductance, capacitance, or resistance) can have a disproportionate effect on system behaviour. These perturbations can shift the system from stable operation into chaotic behaviour.

## 5. High-Frequency Switching and Parasitic

At high switching frequencies, parasitic elements such as parasitic capacitance and inductance in the circuit layout can become more significant. These parasitics can interact with the switching operation and cause unwanted oscillations, leading to chaotic behaviour. Additionally, the switching transients themselves can introduce noise and instability into the system.

## 6. Coupling Effects

In complex power conversion systems, components can interact with each other in ways that induce chaos. For example, in multi-phase converters or multi-stage converters, interactions between phases or stages can lead to synchronization issues or chaotic coupling. Similarly, electromagnetic interference (EMI) between components or circuits can disturb the operation of the converter and lead to instability.

## **Effects of Chaos in Power Converters**

When chaos occurs in a power converter, it can have several detrimental effects on the system's performance and reliability, including:

1. **Instability in Output:** Chaotic behaviour can lead to unstable voltage and current waveforms, making it difficult to maintain the desired output for the load. This can cause equipment to malfunction or operate inefficiently.

2. **Component Stress and Damage:** The unpredictable spikes and oscillations associated with chaotic behaviour can put excessive stress on components, especially sensitive ones like capacitors, semiconductors, and inductors. Over time, this stress can lead to premature component failure.
3. **Increased Harmonics:** Chaotic oscillations in the power converter can generate high levels of harmonics in the output waveform, which can interfere with other equipment, reduce power quality, and lead to inefficiencies.
4. **Reduced Efficiency:** Instability and chaotic oscillations can decrease the overall efficiency of the power conversion process, as the system may not operate in an optimal manner. This inefficiency results in wasted energy and increased operating costs.
5. **Potential for System Shutdown:** In extreme cases, chaotic behaviour can cause the power converter to malfunction to the point where it may shut down entirely, leading to downtime and loss of productivity.

## **Mitigating Chaos in Power Converters**

While chaos in power converters can be a serious issue, there are several approaches that engineers can take to mitigate or prevent it:

### 1. Improved Control Design

- **PID control optimization:** Fine-tuning the proportional-integral-derivative (PID) control parameters can help stabilize the feedback loop and prevent oscillations that could lead to chaos.
- **Adaptive control:** Adaptive control algorithms can dynamically adjust the controller parameters in real-time to compensate for changes in the system, reducing the risk of instability.

### 2. Feedback Loop Tuning

- Proper tuning of the feedback loop is essential to avoid instability.
- 3. **Use of Higher Switching Frequencies**
- Higher switching frequencies can help reduce low-frequency oscillations that may contribute to chaotic behavior. However, this must be balanced with the need for effective thermal management, as higher switching frequencies can increase heat generation.

### 4. Damping Mechanisms

- Damping networks (such as resistive elements) can be introduced into the circuit to reduce the oscillatory behavior and prevent chaotic feedback loops. Damping also helps mitigate high-frequency oscillations and spikes.

## 5. Resonance Avoidance

- Careful selection of switching frequencies and harmonics is important to avoid resonance effects that can lead to instability. Designers should ensure that the switching frequency of the converter does not coincide with the resonant frequencies of circuit components.

## 6. System Simulation and Modelling

- Before physical implementation, power converters should be simulated to assess their behavior under various conditions. This can help identify potential regions of chaos and instability, allowing engineers to address these issues in the design phase.

## 7. Robust Design and Fault Tolerant Systems

- Power converters should be designed with robustness in mind, ensuring they can handle varying operating conditions without slipping into chaos. Incorporating redundancy and fail-safes can help maintain operation in the event of instability.

## **Conclusion**

Chaos in power converters, while not a common occurrence, can be a serious issue that affects their performance, reliability, and longevity. By understanding the causes of chaos — including nonlinearities, feedback instabilities, and perturbations — engineers can design power converters with better stability and robustness. Proper control strategies, tuning, and system design can mitigate the effects of chaos, ensuring that power converters function reliably even under challenging conditions.

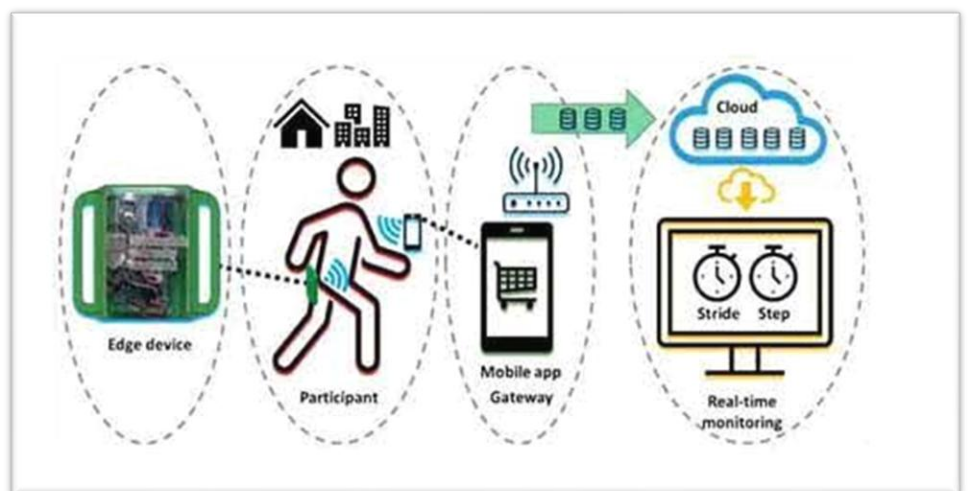
# WEARABLE GAIT TECHNOLOGY

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Instrumented gait analysis plays a crucial role in clinical assessment and rehabilitation. Gait analysis can identify impairments, guide the development of effective rehabilitation programs, and inform strategies to improve overall function and quality of life. Specifically, instrumented approaches can better inform how individuals can walk with greater comfort and reduced pain.

Inertial sensors-based wearables, such as accelerometers, collect high-resolution data over prolonged periods—resulting in data that is expensive to store and time-consuming to process. Equally, streaming inertial data to a base station (like a smartphone) has its own challenges, such as high bandwidth requirements and high-power consumption.

In an article published in IEEE Sensors Journal, researchers present a novel wearable edge device that overcomes those challenges by utilizing edge computing. The developed edge device can collect and process raw



data on the device and then only transfer the extracted gait characteristics to the cloud via a mobile phone connection for real-time monitoring. In the processing stage, the developed edge device detects walking/gait bouts and extracts step and stride durations, without requiring data storage and offline processing. Results suggest that the edge device is suitable for instrumenting gait in real-time and has the potential to be used continuously beyond the laboratory.

## Utilizing Edge Computing Technology

Edge computing refers to the decentralization of computing power from the cloud/computer/mobile device to the edge of the network, where data are collected and processed closer to the source. Such an approach enables faster and more efficient processing of data, as well as reduced latency and bandwidth requirements. Furthermore, processing raw data directly on the device without data transmission minimizes the risk of inaccurate results due to data loss.

Researchers introduce a low-cost edge device as a viable alternative to time-consuming and computationally complex gait analysis. The proposed edge device addresses the described challenges by leveraging artificial intelligence (AI) models with a previously validated software-level algorithm.

Specifically, the proposed edge device can identify walking bouts and perform a real-time gait analysis to quantify steps and stride durations beyond the laboratory.

This low-cost device can operate for up to three days and requires a smartphone with Bluetooth and Internet connectivity to transmit data to a cloud platform using a mobile application available in the current digital markets. According to the researchers, edge computing can facilitate decentralized data processing, whereby raw data are collected and processed on edge devices.

This computing technique alleviates limitations related to raw data transmission, such as data loss, and offers real-time feedback capabilities for users. Furthermore, the proposed approach suggests a solution to privacy concerns by allowing individuals and organizations to maintain greater control over their data and minimize the risk of data leakage as raw data are processed and deleted on the device.

The system can better reflect gait in habitual environments by capturing data in naturalistic settings. If a participant forgets to wear the sensor, a researcher can identify this through real-time analysis and then inform the participant. The system also minimizes the risks associated with data privacy and data loss as raw data are processed and deleted on the edge device.

