DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

ASANSOL ENGINEERING COLLEGE
ESTD 1998

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INSTITUTE'S VISION

To emerge as a centre of excellence in technical education, offering best of the teaching and learning by creating ambience for advanced level of education and research to serve the society.

DEPARTMENT'S VISION

To aspire to become a department which can provide value-based quality education, foster research and innovation and to groom the students to be globally competent.

INSTITUTE'S MISSION

IM-1: To create an ambience for advanced level of teaching and learning process.

IM-2: To generate new ideas by engaging in cutting-edge research and technology.

IM-3: To initiate collaborative projects which offer opportunities for long term interaction with industry and academia.

IM-4: To develop intellectual human potential for serving the society according to the regional, national and global needs.

DEPARTMENT'S MISSION

DM-1: To Create an outcome-based teaching learning process to increase the creativity and innovativeness of the students and to face the challenging world.

DM-2: To motivate students and promote research and development culture among students, so that they can choose it as an optional career.

DM-3: To provide ethical and value-based education by promoting activities addressing the societal needs Editorial board.

MESSAGE FROM HOD, ECE

Dr. Chittajit Sarkar
HEAD OF DEPARTMENT
ELECTRONICS & COMMUNICATION ENGINEERING

Welcome to the department of Electronics and Communication Engineering, Asansol Engineering College. Our institution boasts a robust undergraduate program in Electronics & Communication Engineering, granting B. Tech degrees. Additionally, we provide opportunities for postgraduate studies through our M. Tech program. Each year, we admit 120 students into our B. Tech program and 13 students into the M. Tech program.

Every child possesses innate genius, and if a child isn't grasping knowledge through conventional teaching methods, perhaps it's time we adapt our approach to match their unique learning style. With this principle in mind, we've developed our teaching methodology. Our objective is to offer an outstanding platform for aspiring hardware and software engineers, equipping them to meet the ever-evolving demands of the modern industry. Our department takes pride in its commitment to academic excellence, innovation, and fostering a dynamic learning environment. As the Head of the Department, I am honored to lead a community of dedicated faculty and enthusiastic students who share a passion for knowledge and growth. Here at Electronics and Communication Engineering, we strive to provide a comprehensive educational experience that combines rigorous academic programs with practical applications. Our faculty members are not only experts in their respective fields but also mentors who are deeply invested in students' success. They are committed to nurturing students' intellectual curiosity and helping them to achieve academic and career goals.

Undergraduate students are actively encouraged to engage in a wide range of research initiatives through the Students Innovation Centre (SIC). The creation of an IEEE student chapter focused on Microwave Theory and Technology – Society further promotes and supports students in their pursuits within this field.

EDITORS' MESSAGE

It gives us immense pleasure to present to you the latest edition of our Electronics and Communication Engineering Department magazine, ELECTROSPARK. This magazine is a humble attempt to showcase the vibrant spirit, creativity, and technical brilliance of our students and faculty.

In an era where technology is evolving at an unprecedented pace, the field of Electronics and Communication remains at the heart of innovation. From the advancement of communication systems to the development of embedded technologies, our department continues to make remarkable strides in both academics and research.

This edition features a blend of technical articles and creative expressions. Each contribution reflects the passion, dedication, and intellectual curiosity of our community.

We extend our heartfelt thanks to all the students, faculty members, and contributors who have made this magazine possible. Special appreciation goes to the editorial team for their unwavering commitment and teamwork. We hope you find this edition informative, inspiring, and reflective of the dynamic world of ECE.

Warm Regards,
Shibram Paramanik, Anushka Trvedi, Prince Kumar, Somnil Neogi, Kaustav Biswas, Subhadeep Maity, Ananya Ghosh, Nilanjan Dutta
Editors, ELECTROSPARK
Department of Electronics & Communication Engineering
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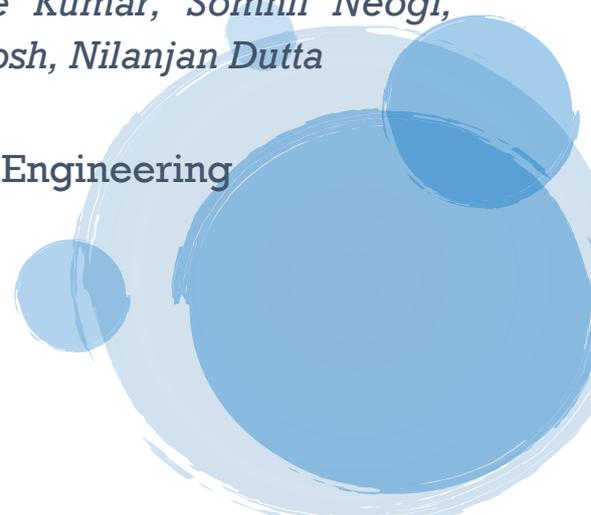
EFFICIENCY IN EV CHARGING IS CRUCIAL FOR WORLDWIDE ELECTRIFICATION

SOMNIL NEOGI, KAUSTAV BISWAS
2nd YEAR, ECE

It's critical to minimize on-road charging periods and increase driver convenience for EVs to be efficient. Range anxiety can be lessened and the desire for electric car use can be increased globally with the planning of the charging infrastructure. The network for charging electric vehicles must be quick, affordable, secure, strong, trustworthy, and adaptable. In fact, the infrastructure for charging vehicles must offer a sufficiently adaptable network to produce, store, transport, and distribute the energy required for the global transition to electrification. Power semiconductor technology is crucial in this regard and to achieving this objective globally. It makes EV charging more practical, affordable, and sustainable. In truth, electric vehicle chargers that are quick and effective are necessary on the current market.

Semiconductor technology will provide grid managers more flexibility to manage and improve energy infrastructure by imagining an all-electric future. Thousands of electric vehicles connecting at once and placing tremendous energy demands on the power distribution network constitute the key scenario. For instance, most commuters must manage their charging requirements at the same time.

GaN technology is a smart technology for charging EVs

More EVs can be on the road at once if EV charging is done more quickly. This is a crucial factor for prospective EV purchasers who want comfort and accessibility, safety and confidence regarding the range and the accessibility of charging stations, as well as the time needed to recharge their cars and resume driving.

State-of-the-art technologies will play a significant role in ensuring the correct travel requirements. Integrated processing technology with integrated processors, such as real-time microcontrollers, works seamlessly with isolated gate drivers and fully integrated gallium nitride (GaN) power devices to increase the efficiency and speed of the charging process. GaN power devices maximize power density, efficiency, reliability, and cost advantages. Gallium Nitride (GaN) integrated circuits can be used in various applications, such as telecommunications, servers, motor drives, and laptop adapters, but especially in onboard chargers for electric vehicles. GaN transistors switch much faster than silicon MOSFETs, potentially achieving much lower switching losses.
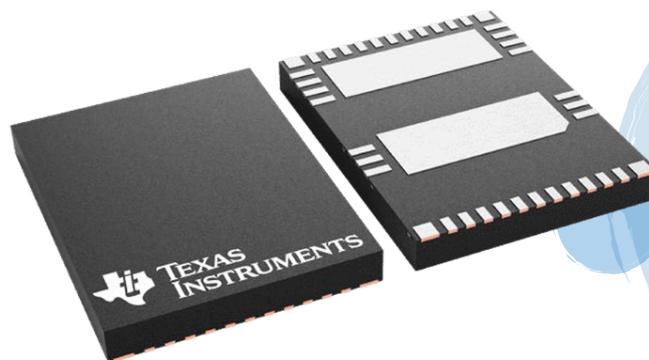
GaN enables faster and more energy-efficient charging. Due to its ability to operate at higher switching frequencies in multi-level power supply topologies, Gallium Nitride technology enables faster and more efficient charging than traditional silicon-based materials. As a result, design engineers can make smaller magnets in power systems, reducing the cost of components that use copper and other raw materials. Multi-level topologies can be more efficient, which reduces the power required for heat dissipation or cooling. GaN effectively triples the power density of the power supply or power management system in applications such as electric vehicle onboard chargers, electric vehicle charging stations, and energy storage systems. This leads to faster charging designs and smaller system sizes and lowers total costs for EV owners. The capacity of DC fast charging stations has increased significantly over time. Where the standard was once 150 kilowatts, we are now seeing charging capacities of 350kW and beyond, and improvements will surely continue as time goes by as we look for new and more efficient, and better-performing power solutions. As a result, EVs will recharge faster, which will help ensure that chargers are no longer a critical element for automotive electrification. At scale, optimal power distribution and load sharing are key to ensuring the charging infrastructure is flexible enough during peak usage. Semiconductor device technology may allow for greater flexibility in managing power distribution through smart energy metering that simplifies charging.

Bidirectional charging of electric vehicles

New technologies are being studied to simplify recharging based on semiconductors and portable chargers. In this regard, another determining design parameter for electrified cars is the size of portable DC chargers. When you want to increase system efficiency, size is extremely important. Reducing the size of portable DC chargers, such as a wallbox DC charger, can lead to large gains and better cost-effectiveness. Wallbox DC chargers can help make electric vehicles (EV) more affordable by offering chargers at different power levels based on customers' charging needs, facilitating real-time energy monitoring and grid connections. Smaller and lighter charging stations have more flexibility and allow network operators to deploy them in different places more easily. The presence of more portable systems such as DC wallboxes also brings more convenience to the home for EV owners who want to recharge or power their home when needed.
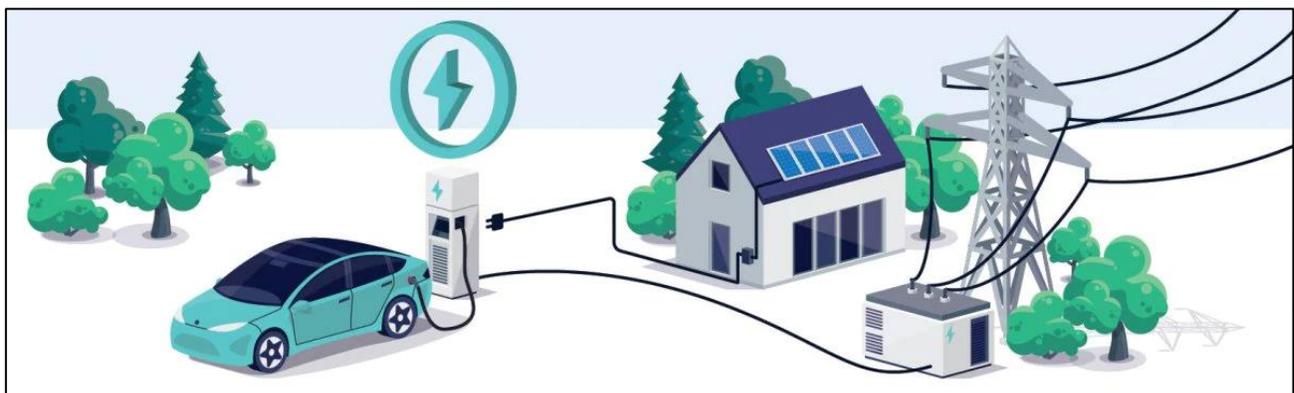
REVOLUTIONIZING TRACKING WITH LoRaWAN TECHNOLOGY

ANANYA GHOSH, SUBHADEEP MAITY

1st YEAR, ECE

In the continuously growing domain of the Internet of Things (IoT), uninterrupted connectivity and efficient data transmission are of utmost importance. In the field of asset tracking, there has been a persistent challenge to find a solution that provides a wide range, user-friendly interface, and cost efficiency. Conventional solutions such as Bluetooth Low Energy (BLE) trackers and 4G/LTE trackers possess inherent constraints. However, a new technology called the SenseCAP T1000 Tracker has been developed by Seeed Studio with an ongoing Kickstarter Campaign. It utilizes LoRaWAN technology to offer advanced features for accurate and dependable tracking in different scenarios.

Bluetooth Low-Energy (BLE) trackers, although suitable for tracking over short distances, are not effective for long-range tracking. Consider the scenario where you are trying to find your wallet on the second floor while you are on the ground floor. In this situation, the range of a standard Bluetooth Low Energy (BLE) tracker may not be adequate. In contrast, 4G/LTE trackers provide superior network coverage, but their transmission costs are high, and they have limited capabilities for expanding their range. As a result, they are not suitable for remote or expansive areas such as mountain trails, mining sites, or ski resorts. SenseCAP T1000 Tracker overcomes the mentioned constraints through the utilization of LoRaWAN technology.

SenseCAP T1000 Tracker

The T1000 has a small physical size, similar to a credit card, allowing it to easily fit in a pocket or be attached to valuable items. However, what distinguishes it are the functionalities it provides and the obstacles it successfully tackles.

The T1000 Tracker offers accurate positioning capabilities over large geographical regions, encompassing both indoor and outdoor environments, including extremely isolated areas. This technology impacts industries that necessitate dependable tracking in difficult conditions.

Seamless indoor and outdoor positioning refers to the ability to accurately determine the location of an object or person both inside and outside of a given space. This is achieved through the use of advanced technologies such as Global Navigation Satellite Systems (GNSS), Wi-Fi, Bluetooth.

The T1000 Tracker is integrated with GNSS, Bluetooth, and Wi-Fi technologies to provide uninterrupted positioning capabilities both indoors and outdoors. This adaptability is crucial for situations where assets move between enclosed and open areas, guaranteeing a reliable and precise tracking process.

Comprehensive data collection refers to the systematic gathering and recording of a wide range of information from various sources. This process involves the collection, organization, and storage of data in a structured manner for several applications.
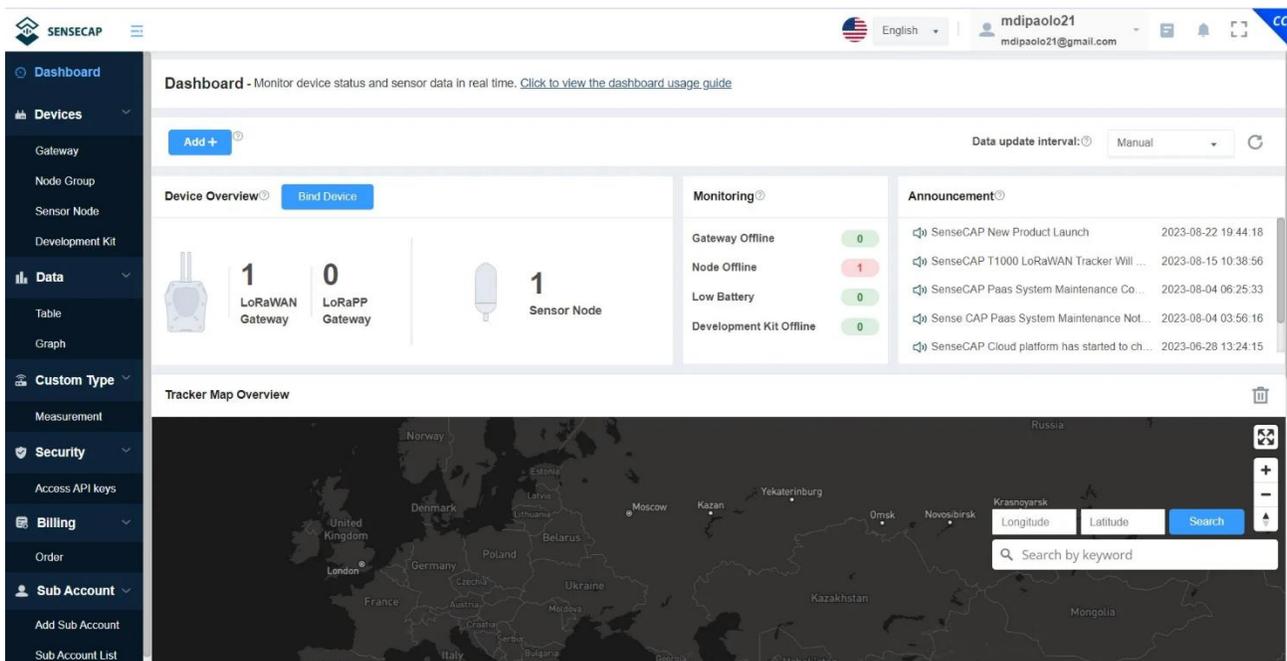
In addition to basic location tracking, the T1000 Tracker gathers key data including temperature, luminosity, and motion. This data is highly valuable for ensuring compliance, conducting quality control, and optimizing logistics processes.

Ensuring safety is of utmost importance, the T1000 Tracker incorporates essential features such as an emergency button and an integrated buzzer. During emergency situations, the tracker will transition into SOS mode. In this mode, it will continuously transmit data updates to the platform and activate the buzzer to alert individuals in close proximity. This functionality has the potential to mitigate the loss of life and offer prompt aid during crucial circumstances.

One notable feature of the T1000 Tracker is its utilization of LoRaWAN technology for communication purposes. This results in reduced communication expenses in comparison to cellular networks such as 4G/LTE. The cost-effectiveness of LoRaWAN enables widespread commercial implementation, facilitating opportunities for diverse industries.

The T1000 Tracker is designed to endure extreme environmental conditions. Featuring an IP65 waterproof rating and an operational temperature range of -20°C to 60°C (-4°F to 140°F), this device is capable of withstanding harsh conditions, rendering it appropriate for applications in sectors such as agriculture, logistics, and outdoor activities.

Utilizing the LoRaWAN network infrastructure, the T1000 Tracker leverages the extensive coverage of LoRaWAN services across more than 160 countries. The widespread accessibility enables the potential for international tracking and monitoring.

By utilizing LoRaWAN technology, it overcomes the constraints of conventional trackers, offering a wide coverage area, accurate positioning, comprehensive data gathering, and additional features. The T1000 Tracker paves the way for innovation in industries ranging from logistics and agriculture to emergency response and outdoor activities, thanks to its robust features, durability, and cost-effectiveness.

Unveiling the SenseCAP M2 Gateway

The SenseCAP M2 Multi-Platform LoRaWAN Gateway is a solution that provides connectivity, extensive coverage, and user-friendly operation. Developed with the aim of enhancing multiple industries such as agriculture, urban development, and others, this gateway enables the exploration of novel opportunities for establishing streamlined and intelligent networks. Let's explore the essential characteristics and advantages that make the SenseCAP M2 Gateway an essential tool for constructing a LoRaWAN network.

The SenseCAP M2 Gateway is a LoRaWAN gateway that is designed to support a wide range of global LoRaWAN frequency plans, specifically ranging from 865 MHz to 923 MHz. The adaptability of this technology allows for seamless incorporation into a wide range of applications, including intelligent infrastructure, precise agricultural practices, and environmental surveillance systems. Due to its extensive coverage and strong signal output, the gateway serves as the fundamental component for establishing a resilient and dependable LoRaWAN network.

The gateway's compatibility with various network servers supporting LoRaWAN technology, such as AWS, TTN, and ChirpStack via the Packet Forwarder / Basics™ Station mode, enhances its flexibility and utility. This adaptability empowers users to seamlessly integrate the gateway into their existing infrastructure, facilitating smoother operations and reducing setup complexities.

The process of configuring the SenseCAP M2 Gateway is straightforward due to the inclusion of the SenseCAP Local Console within its design. Users can easily configure the device through a web interface that is accessible via both Wi-Fi AP and Ethernet connections. This optimized configuration process enhances the speed of deployment, enabling users to quickly establish their networks.

To enhance deployment reliability and efficiency, the gateway supports Power-over-Ethernet (PoE). This feature eliminates the need for an extra power supply cable, simplifying installation and reducing clutter. PoE enables users to power the gateway through an Ethernet connection, streamlining the setup process while maintaining a high level of reliability.

The performance of the SenseCAP M2 Gateway is achieved through the utilization of the mature hardware solution MT7628 and Semtech SX1302 baseband Long Range chip. This combination of advanced components enhances the gateway's ability to maintain consistent and dependable connectivity, regardless of whether it is using Cellular, Wi-Fi, or Ethernet internet connections.

With a user-friendly web interface, users can swiftly configure the gateway, and both SenseCAP Portal and SenseCAP Local Console provide efficient monitoring and management capabilities. This robust suite of tools ensures operational excellence and empowers users to maintain their networks with ease.

HOW EV BATTERIES ARE BUILT
ANIMESH KUMAR SHAW
2nd YEAR, ECE

As the market forecasts a constant increase in sales of electric vehicles over the next decade, a number of government initiatives addressing climate change involve the elimination of fuel-powered vehicles. Electric rechargeable batteries, the fundamental structure for using sustainable and renewable energy, are driving the expansion of EVs. EVs utilize powertrain batteries that provide energy to all engine components so that they can operate as expected.

The production of EV powertrain batteries has proven to be detrimental to the environment, but sadly, only a handful of automakers are treating the issue seriously. Lithium and its derivatives are the components used to manufacture these batteries. Among these variations are cobalt nickel, manganese, and a number of other substances. The dominant material on the market is cobalt manganese, which is utilized by numerous electric vehicle manufacturers. In contrast, Tesla utilizes a mixture of lithium, cobalt, and manganese. A few automakers are developing a new cobalt-free powertrain; however, cobalt remains an essential mineral without which it will be challenging to manufacture EV powertrains.

The widespread use of lithium-ion batteries in portable consumer electronics such as smartphones and laptops. Due to their greater energy density than lead-acid or nickel-metal hydride batteries, they are also utilized in electric vehicles.

This advantage enables automotive manufacturers to develop smaller batteries without sacrificing storage capacity. Li-ion batteries also exhibit a high power-to-weight ratio, high energy efficiency, high-temperature performance and low self-discharge. Additionally, the various parts of Li-ion batteries can be recycled, making them an environmentally friendly choice. The next section explores the workings of a basic Li-ion battery.

How does a Li-ion battery work?

Li-ion batteries operate on the principle of electrochemical reactions, whereby the transfer of electrons occurs between two electrodes, one of which is negatively charged while the other is positively charged. The electrodes are immersed in a conductive electrolyte, facilitating the movement of charged ions between them.

Li-ion battery charging

Li-ion cells have intercalation compounds characterized by a crystalline structure with layers that allow the migration or deposition of lithium ions. When charging a Li-ion battery, the ions travel from the positive to the negative electrode as they intercalate and await the next discharge cycle.

The latest generation of batteries exhibits enhanced ion mobility, enabling faster charging without the associated risk of overheating. In response, chipmakers have developed an array of integrated solutions for Li-ion battery management that simplify the design of chargers. These companies now offer silicon that enables engineers to design products capable of taking advantage of the accelerated charging rates during the constant-current phase.

Li-ion battery discharging

During discharging, ions move from the negative electrode to the positive electrode via a liquid electrolyte, while electrons flow from the negative electrode to the positive electrode through an external circuit that delivers power to electronic devices. The combination of ions and electrons at the positive electrode results in lithium deposition. Once all the ions have returned to the positive electrode, the battery is fully discharged and requires recharging.

During the discharging process in EVs, the battery's stored energy is depleted, and the voltage of the battery decreases as the electric current flows from the battery to the motor. The rate of discharging depends on the power demand of the motor and the battery's capacity, which determines the amount of energy that can be delivered before the battery requires recharging. Efficient battery discharging is essential for optimizing the range and performance of EVs.

Li-ion battery expression

The battery-charging equation is expressed in relation to the battery capacity. It depends on the numerical value of the rated battery capacity in ampere-hours and the time at which this value is declared. The equation is defined as:

$$I = M \times Cn$$

Where I is the charge or discharge current in amperes, M is the multiplication factor of C, C is the numerical value of rated capacity in ampere-hours and n is the time in hours at which C is determined.

What are the industry standards for developing EV batteries?

Currently, the industry standard for developing EV batteries involves utilizing Li-ion technology, which has undergone significant advancements over the past 30 years. While these batteries provide superior energy density compared with other technologies, they require precise control of recharging processes and appropriate packaging. At present, Li-ion technology is considered the optimal choice for achieving a combination of capacity, recharging flexibility and durability.
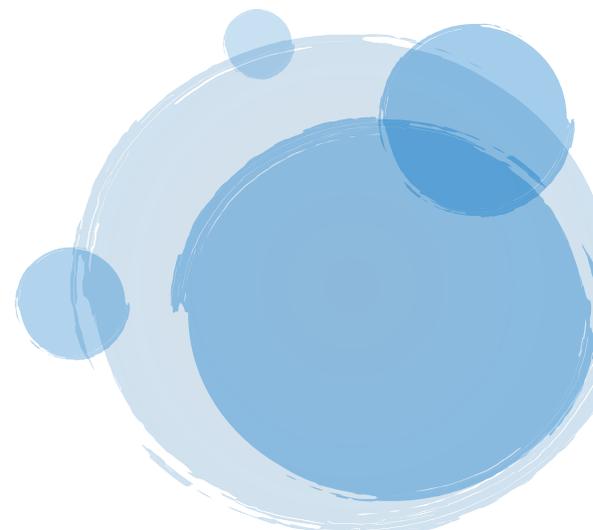
DESIGN OF LOW POWER TRANSFORMER – LESS POWER SUPPLIES

SANA SHAMS, NIPPU KUMAR
1st YEAR, ECE

It is frequently advantageous to employ a transformer-less power supply solution to provide the required supply to low-power circuits.

In fact, it is possible to convert the input AC voltage into DC voltage without the use of large, expensive, and bulky transformers if the load current is only a few tens of milliamps. An alternative without a transformer is also less expensive, lighter, and has a smaller footprint. Transformer-less power supplies are categorized into two groups: capacitive and resistive, depending on the kind of circuit. We will now look at each type of circuit's features, how to assess the power of the electronic components involved, and what safety precautions to take.

Transformer-less capacitive power supply

Figure shows the schematics of a transformer-less capacitive power supply. The formulas that allow you to determine the values of the required components are provided below. The AC mains voltage's line and neutral are denoted by L and N, respectively, while the output voltage and current are denoted by V_{OUT} and I_{OUT}, respectively. Resistor R_1 and C_1's reactance both serve to reduce the inrush current, which might potentially cause damage to the components. D_2 is a typical silicon diode with the task of rectifying the AC voltage, whereas D_1 is a Zener diode that offers a steady reference voltage.
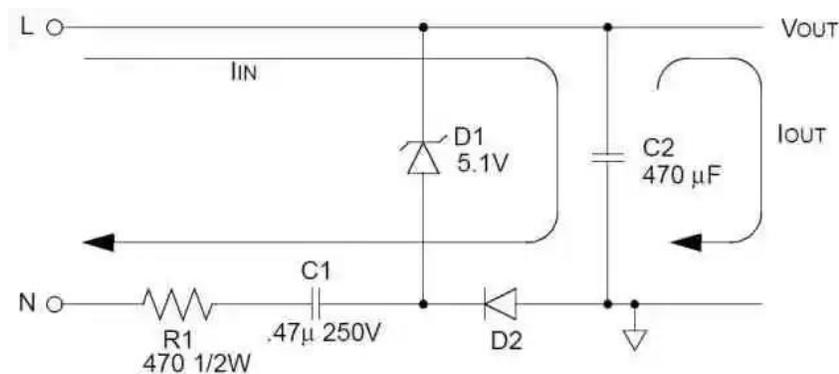
The voltage on the load remains constant as long as the output current I_{OUT} is less than or equal to the input current I_{IN}, the value of which can be calculated as:

$$I_{IN} = \frac{\sqrt{2V_{RMS}} - V_Z}{2\left(\frac{1}{2\pi f C_1} + R_1\right)}$$

Where V_Z is the Zener voltage, V_{RMS} is the RMS value of the input AC voltage, and f is its frequency. The minimum value of I_{IN} shall match the load power needs, while its maximum value shall be used to choose the right power rating for each component. The output voltage V_{OUT} can be calculated as:

$$V_{OUT} = V_Z - V_D$$

Where V_D is the forward bias voltage on D_2 (0.6–0.7 V for a regular silicon diode). As for R_1, it is advisable to select a component with at least twice the power with respect to the theoretical value P_{R1} given by:

$$P_{R1} = I^2 \times R = (V_{RMS} \times 2\pi f C_1)^2 \times R_1$$

The capacitor C_1, which gives its name to this type of circuit, should be selected with a voltage at least double that of the AC mains (for example, 250 V in the U.S.). Diode D_1 shall have at least twice the power with respect to the theoretical value given by the following formula:

$$P_{D1} = I \times V_Z$$

The same applies to the power of the diode D_2, where the constant voltage value 0.7 V can now be used in place of V_Z. For C_2, an electrolytic capacitor is typically used, with voltage at least twice that of V_Z.

The main advantages of the capacitive solution, compared to a transformer based one, lie in the reduced size, weight, and costs. Compared to the resistive-type solution, presented in the next paragraph, this circuit allows you to obtain a higher efficiency level. The disadvantages are the lack of insulation from the AC input voltage and a higher cost than the resistive solution.

Transformer-less resistive power supply

In a transformer-less resistive power supply, again, the output voltage V_{OUT} remains constant as long as the current I_{OUT} is less than or equal to the input current I_{IN}. However, the difference is that now the inrush current limitation is performed only by resistor R_1. The output voltage V_{OUT} can be calculated using the same formula as the capacitive power supply, while the input current I_{IN} can now be obtained by applying the following formula:

$$I_{IN} = \frac{\sqrt{2V_{RMS}} - V_Z}{2R_1}$$

As in the previous case, the components must be selected with a power value at least double that of the theoretical one, which can be calculated by applying Ohm's law (P = R × I_2 for resistor R_1 and P = V × I for diodes D_1 and D_2). The electrolytic capacitor C_2 must be sized as in the capacitive case.

The resistive power supply has the advantage of having reduced size and weight compared with the transformer-based circuit and represents the absolute cheapest solution. Even in this case, however, there is no insulation from the AC mains and efficiency is lower than the capacitive scheme.

ENHANCING INTERSATELLITE COMMUNICATION LINKS WITH SDRs

ANUSHKA TRIVEDI
3rd YEAR, ECE

The field of radio astronomy has experienced remarkable advancements in recent years, largely due to the integration of satellite-based technologies. Satellites equipped with software-defined radios (SDRs) have revolutionized the way we explore and understand the universe. In particular, the feasibility and optimization of using SDRs for intersatellite communication links have emerged as a crucial area of study. This involves investigating modulation schemes, multiple access techniques and routing algorithms for reliable and efficient communication between satellites. Additionally, the need for high-channel–count and high-bandwidth SDRs cannot be understated in enabling these advancements.

Satellites equipped with SDRs offer numerous advantages for intersatellite communication links. First, SDRs provide the flexibility to adapt to changing communication requirements, allowing for the efficient utilization of the limited resources available in space. In the context of intersatellite communication, this flexibility is vital, as it enables satellites to adjust their transmission parameters dynamically. Modulation schemes play a pivotal role in optimizing the use of available bandwidth. By exploring different modulation schemes, such as amplitude shift keying, frequency shift keying and quadrature amplitude modulation, researchers can determine the most suitable techniques for achieving high data rates and minimizing interference, thereby enhancing the reliability and quality of intersatellite communication.

Furthermore, multiple access techniques are critical for facilitating simultaneous communication between multiple satellites. In satellite networks, where multiple satellites are deployed to perform coordinated tasks or cover a wide area, efficient multiple access schemes are essential. The utilization of time-division multiple access or frequency-division multiple access schemes enables efficient sharing of the communication channel, ensuring that each satellite can transmit and receive data without significant interference. SDRs provide the necessary flexibility to implement these multiple access techniques, allowing for seamless coordination and data exchange among satellites in a network.

Routing algorithms also play a vital role in optimizing intersatellite communication links. Efficient routing algorithms ensure that data is transmitted through the most optimal path, considering factors like link quality, available bandwidth and power constraints. For instance, a routing algorithm may prioritize high-quality links with strong signal strength and low interference for critical data transmission. By employing intelligent routing algorithms, SDR-based satellite systems can maximize the utilization of available resources and ensure reliable communication across the network.

To achieve the ambitious goals of satellite-based radio astronomy, high-channel–count and high-bandwidth SDRs are essential. Radio astronomy requires the collection and processing of vast amounts of data simultaneously from multiple sources in the electromagnetic spectrum. The availability of high-channel–count SDRs enables the reception and processing of data from various celestial sources, expanding our understanding of the universe. This means that the SDRs should be capable of handling multiple simultaneous channels, allowing astronomers to monitor and analyze multiple celestial objects or different frequencies simultaneously.

Moreover, the need for high-bandwidth SDRs arises from the desire to capture a wide range of frequencies for detailed analysis. The electromagnetic spectrum encompasses a vast range of frequencies, each carrying unique information about celestial objects and phenomena. High-bandwidth SDRs allow for the capture of a broader frequency range, providing researchers with a more comprehensive view of the universe and enabling the discovery of new phenomena. By covering a wide frequency range, SDRs facilitate the detection and study of various astrophysical phenomena, such as pulsars, quasars, cosmic microwave background radiation and spectral lines emitted by interstellar gas.

The integration of SDRs in satellite-based radio astronomy offers immense potential for advancing our understanding of the cosmos. By studying the feasibility and optimization of intersatellite communication links, researchers can unlock new avenues for exploration and discovery. Modulation schemes, multiple access techniques and routing algorithms serve as the building blocks for reliable and efficient communication between satellites, ensuring seamless collaboration and data exchange. Additionally, the availability of high-channel–count and high-bandwidth SDRs plays a crucial role in capturing and processing the vast amounts of data required for comprehensive radio astronomy research.

As technology continues to evolve, the integration of SDRs in satellite-based radio astronomy will undoubtedly lead to groundbreaking discoveries and new insights into the mysteries of the universe. The ongoing advancements in SDR capabilities and the optimization of intersatellite communication links promise to push the boundaries of radio astronomy and redefine our understanding of the cosmos. By harnessing the power of SDRs, astronomers can embark on a new era of exploration, where the vastness of space and the intricacies of celestial phenomena are unraveled like never before.
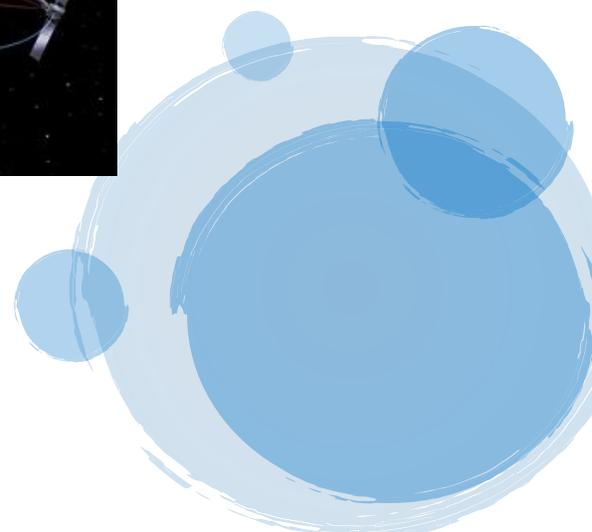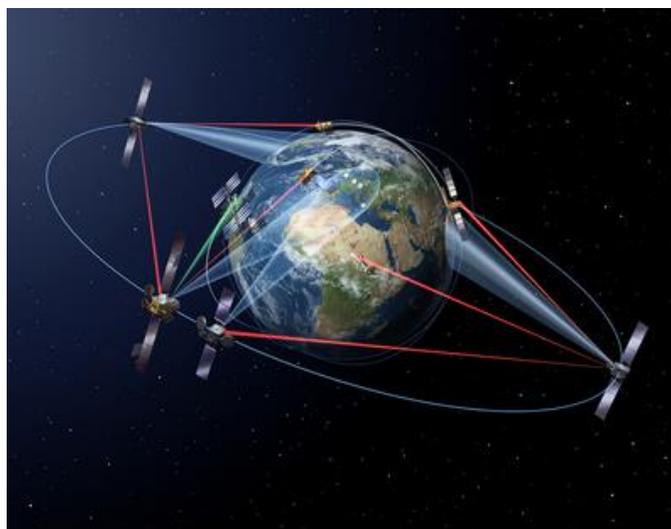
THE CRUCIAL ROLE OF A GATE DRIVER

NILANJAN DUTTA, PRIYANSHU CHATTERJEE
1st YEAR, ECE

All power circuits primarily use switching devices made of silicon carbide and gallium nitride. Although such devices produce superior working speeds, high voltages, processed currents, and low power dissipation, designers frequently neglect to focus on the associated gate driver in favor of focusing solely on the devices themselves.

The role of gate driver

SiC and GaN MOSFETs are not the only static components in a good power circuit. The gate driver is another component that comes before the electronic switches and ensures the right amount of energy is used to drive them optimally. In fact, sending a square or rectangular wave straight to the component's gate terminal is insufficient. The driving signal, on the other hand, needs to be precisely timed to deliver the correct potentials to ensure that the oscillations are appropriate for the different components, minimizing parasitic elements, and as nearly canceling the power losses as possible. As a result, the designer must complete the project in relation to the circuit from the viewpoint of the ultimate load while researching and developing a top-notch gate driver that can drive the power components as efficiently as possible.

A non-optimal driver not only determines significant power losses but often, the imperfect synchronizations cause an anomalous operation of the circuit, with the possible destruction of the MOSFETs. They are voltage-controlled devices, and the gate is their control terminal, which is electrically isolated from the device. A voltage must be applied to this terminal through a specially dedicated driver to make a MOSFET work.

The gate terminal of a MOSFET is, for all intents and purposes, a non-linear capacitor. Applying a charge on the gate capacitor brings the device to the "on" state, allowing the flow of current between the drain and source terminals. Instead, the discharge of this capacitor puts it in the "off" state. To make a MOSFET work, a voltage higher than the threshold voltage (VTH) must be applied between the gate and the source, which is the minimum voltage at which the capacitor is charged, and the MOSFET goes into conduction. Usually, a digital system (microcontroller, or MCU) is insufficient to activate the device, so an interface, precisely the driver, is always required between the control logic and the power switch.

One of the main functions performed by the gate driver is that of the level translator. However, the gate capacitor cannot charge instantaneously; it takes a while for it to fully charge. In this time, albeit very short, the device works with high current and voltage, dissipating high power in the form of heat. Unfortunately, this energy is unused and constitutes a loss of power. The transition from one state to another must therefore be extremely fast to minimize the switching time and to reduce this time, it is necessary to facilitate a high current transient to quickly charge the gate capacitor. Figure 1 concerns the response of a SiC MOSFET, used as an electronic switch, and shows the most important signals at the various nodes during a transient, and in particular:

- The "V (pulse)" signal at the top represents the PWM wave that powers the system. It is an ideal rectangular signal with a frequency, in this case, of 100 kHz. It is a perfect signal.

- The "V (gate)" signal represents the actual signal present on the gate terminal. As you can see, its trend is irregular, as the gate capacitance is not linear and its voltage reaches its maximum level after a few moments, which is the time necessary for the capacitor to charge to its maximum capacity. This interval is dictated by the time constant RC and, in this case, is about 150 ns.

- The "I (load)" signal represents the current flowing through the load and the drain terminal. Initially, it is low when the MOSFET is open and then reaches the maximum level when the MOSFET is closed. This sequence is repeated indefinitely. Note that the switching is not immediate and instantaneous but follows that of the gate voltage.

- The "V (drain)" signal shows the trend of the VGS voltage and, obviously, is in phase opposite to the current and always follows the charging speed of the gate capacitor.

- The last graph shows the power dissipated by the MOSFET (VDS × ID) and, in correspondence with the rising and falling edges of the driving signal, it presents high harmful peaks. This is the loss of power, a factor that a gate driver must minimize as much as possible.
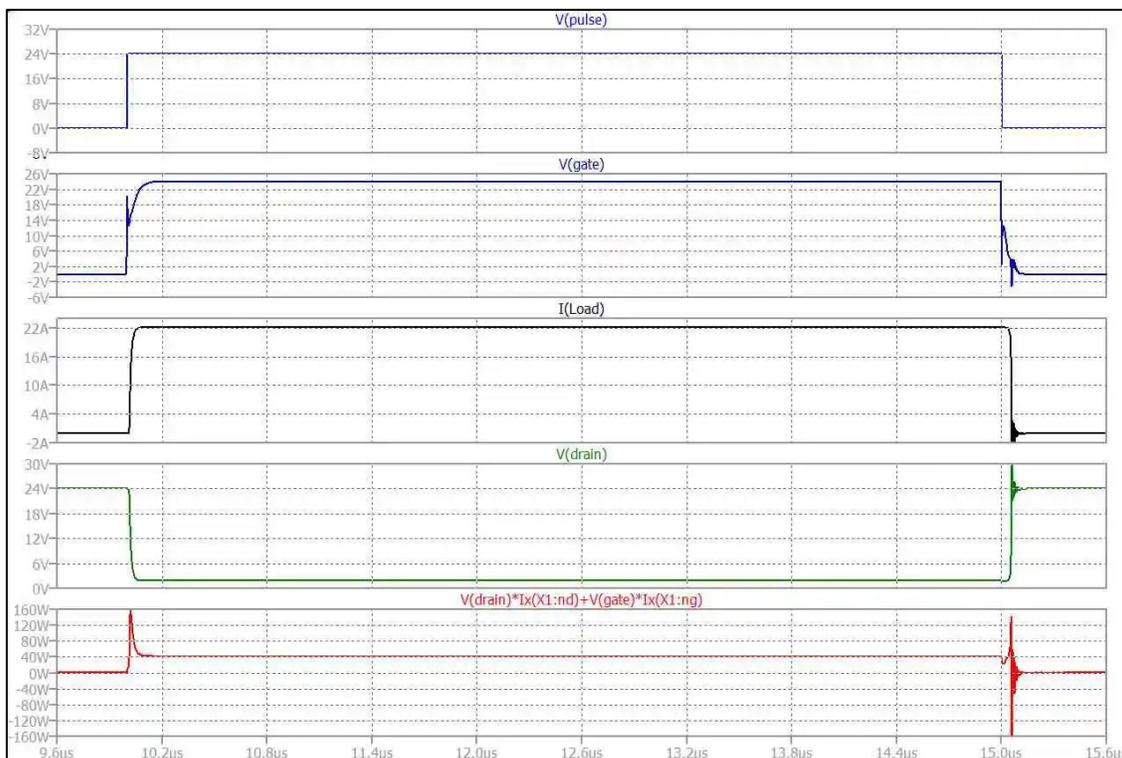
THE DIGITAL GRID AND RENEWABLE ENERGY ARE THE FUTURE OF SUSTAINABLE ENERGY

UTSAV CHATTERJEE, PRASENJIT MONDAL
2nd YEAR, ECE

The output of renewable energy sources, such as wind and solar, has climbed by 18% since last year, according to the U.S. Energy Information Administration. From 2023 to 2027, the US renewable energy market is anticipated to grow at a CAGR of more than 6%. This suggests that the production of renewable energy in the US is on the rise gradually. Furthermore, according to the government's energy tracker, wind, solar, and hydropower will generate 22% of the nation's electricity by the end of the year. That is higher than nuclear power at 19% and coal at 20%.

Electric vehicle adoption is anticipated to account for 60% of all worldwide new car sales by 2030 as renewable technologies advance. According to a recent prediction, there would be 26.4 million people living there by 2030. Another significant change is the decline in demand for oil-fired furnaces, boilers, cooking stoves, and water heaters in the gas business. These have been replaced by induction cookers and high-efficiency electric heat pumps. This might lead to a reduction in carbon dioxide emissions of up to 3 gigatons, an important development in light of the United States' 2035 carbon emission targets.
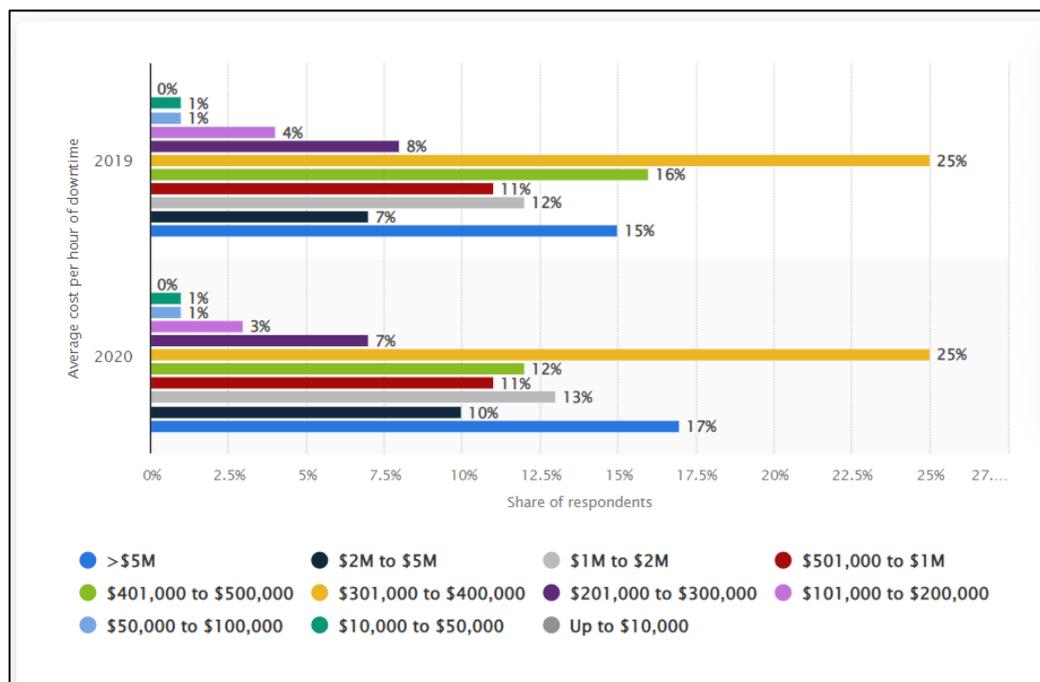
With all this increase in the adoption of electrically powered machines, the grid faces much load. U.S. electricity consumption is projected to be increased by as much as 30% by 2050. This significant increase in demand requires a reliable power grid. The power grids were built long ago considering a supply would come from centralized, dispatchable fossil fuel generators. But in modern times, these generators are replaced by solar panels and windmills, which leads to electricity generation dependent on the sun and wind. Without grid innovation and modernization, the whole system will eventually fail and may result in catastrophic power failures.

NERC's recent assessment about more than two third of America is under the threat of total blackout. Power failures and blackouts are highly undesirable for places such as hospitals and businesses. According to a 2020 survey, a power downtime could cost up to $301,000 per hour or more, depending on the businesses.

Modernizing the Grid with Microgrid and IoT

Microgrid is a group of interconnected loads and distribution of energy resources within clearly defined electrical boundaries that can act as a single controllable entity concerning the main grid. A microgrid can connect and disconnect from the grid to operate in grid-connected or "island mode".

There are many benefits of microgrids, one of these is that microgrids can be built in phases. This allows the electric grid to grow as per business demands and thus leaves the scope for development in the future. Microgrids also ensure a continuous supply of electricity, this can be done by operating the microgrid in island mode. This mode isolates the microgrid from the main grid and sustains itself with self-generated electricity. This feature is a secure option against cyber-attacks, extreme weather conditions, or physical attacks. The microgrid can generate revenue by reducing peak voltages, participating in the demand response market, and by frequency regulation services.

Demand response programs incentivize electricity users to reduce their electricity consumption during times of high demand, such as during heat waves or extreme weather events. By being part of a microgrid, users can adjust their electricity usage. At times users can also sell the excess electricity they saved back to the grid, potentially generating revenue. Lastly, a microgrid can provide frequency regulation services to the broader grid. Electricity grids need to maintain a stable frequency, and microgrids with energy storage capabilities can help stabilize the grid by injecting or withdrawing electricity as needed. Grid operators may pay microgrid owners for these frequency regulation services, providing another potential revenue stream.

Another aspect of grid modernization is using technologies that allow distributed energy resources (DERs) to even out power flows. DERs, such as solar panels or energy storage systems, can generate or store electricity locally, helping to balance the supply and demand on the grid. This can help improve the overall reliability and stability of the power grid. Metering infrastructure is also an important part of grid modernization. Advanced metering technologies can provide more accurate and timely information about customers' electricity usage, allowing for more precise billing and better customer service.
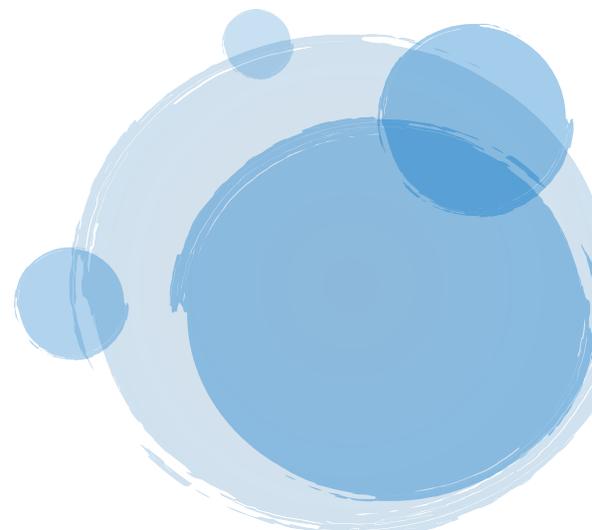
SIMPLIFYING THE ANALOG AND MIXED – SIGNAL IC DESIGN PROCESS

PRATYUSH BISWAS, NIHAL BARANWAL
1st YEAR, ECE

Analog and mixed-signal (AMS) circuit design typically involves designing components like amplifiers, filters and data converters, which can be complex and time-consuming, often requiring manual design expertise and iterations.

This article is focused on the revolutionary approach to the design of AMS circuits developed by Agile Analog. This U.K.-based semiconductor company simplifies and accelerates this process with its scalable platform.

By automating parts of the design process, Agile Analog makes the analog design more accessible to a broader range of engineers, including those without extensive expertise in analog circuit design. The main goal is to enable faster and more reliable development of analog ICs, crucial for various applications, including telecommunications, automotive, consumer electronics and internet-of-things devices.

"At Agile Analog, we have designed a customizable analog IP generator," said Chris Morrison, Agile Analog's director of product marketing. "Composa, our internal software tool, can automatically generate an analog IP based on the initial seed, the customer requirements and the PDK from the foundry.

"This makes us process-agnostic, meaning we can use our solution in any process, quickly generating fully verified analog circuits for any process and compliant with the customer's exact requirements," he added.

12-bit ADC IP

In February 2023, Agile Analog announced agileADC, the first customizable and process-agnostic 12-bit ADC IP (Figure 1). With sample rates of up to 64 MSPS and a signal-to-noise ratio of 70 dB, the agileADC, a conventional charge-redistribution SAR ADC, achieves 12-bit resolution. It has an integrated reference generator and a selectable multiplexer that accommodate up to 16 input channels. Each input channel can be set up to accommodate differential or single-ended inputs and be buffered or unbuffered. There are several options for digital output formats, including APB and TileLink interface options.
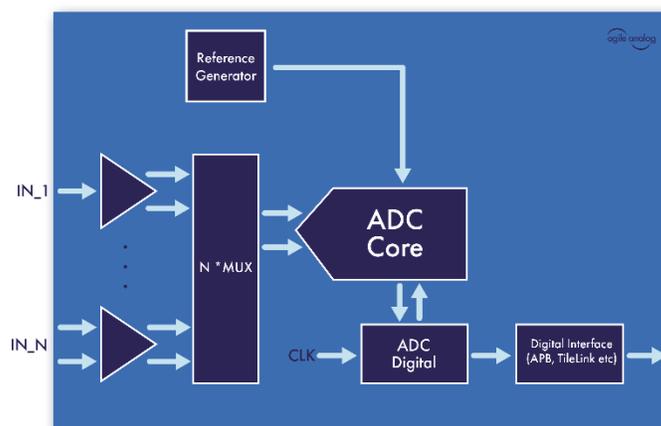
The agileADC can be customized to meet the power, performance and area requirements particular to the customer's project. The number of inputs and bits and the sampling rate can also be configured.

"What makes our solution different from others in the market is the customization we offer customers," Morrison said. "Customers come to us with their exact requirements, and we can meet them. With our Composa tool, we can design the exact circuit the customer needs."

That also means the whole circuit is optimized and no extra power or area is burnt to get what is needed in the design.

## Digitally wrapped analog IP

Recently, Agile Analog launched an innovative, digitally wrapped analog IP subsystem that significantly reduces the analog IP integration effort, time and costs.

This solution covers various analog subsystems, including power management, PVT sensing and sleep management. By enabling the IP to be dropped directly into a digital design flow and connected via a conventional peripheral bus, such as AMBA APB, these innovative, digitally wrapped subsystems considerably minimize the effort necessary to integrate many analog IPs into any ASIC.

The subsystems (Figure 2) are simple to comprehend and manage because they have the same appearance as a typical block of digital IP and have the expected standard interfaces. Time to market, expenses and risk are significantly decreased as a result. The agilePMU for power management, agilePVT for PVT sensors and agileSMU for sleep management are the first three subsystems the business is introducing.

Agile Analog handles all the analog-to-digital and mixed-signal boundary verification needs, which is another significant benefit for the user. As a result, the client design and verification times are greatly shortened, the design process is made less risky, the cost of licensing mixed-signal design tools is decreased and integration is simpler. Customers can now add analog product features to differentiate them without needing expensive toolchains and specialized AMS engineers.

"With our digitally wrapped analog IP subsystems, the customer doesn't have to consider the analog design," Morrison said. "Customers can integrate and verify it as if it were a digital IP because we'll have done all of the mixed-signal verification for them."
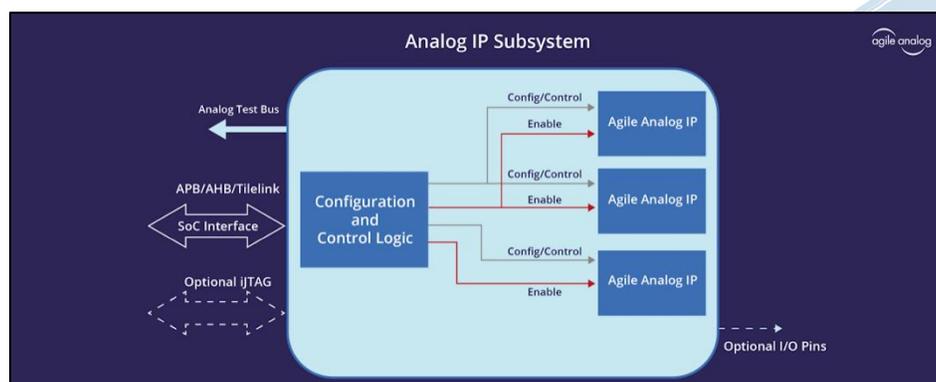
A subsystem's IP-building components are all drawn from Agile Analog's library of adaptable analog IP. While sitting within the overall digital wrapper, this enables each block within the subsystem to be tailored to the customer's particular requirements.

The digitally wrapped subsystems, like all Agile Analog IPs, are foundry- and process-independent, and each design is tailored to the unique PDK of the customer. By eliminating redundant analog functions, lowering design-rule–checking demands and improving interconnects, IP integration within a subsystem further improves the customer's design. These result in a smaller area, reduced power usage and improved noise immunity.

"One of the main issues at the moment is that there is a real shortage of skilled analog engineers," Morrison said. "Skilled analog engineers are hard to find for companies, while the rate of innovation is really high.

"When a company buys standard IP from a company like ours, it frees up their precious analog engineers to develop the truly differentiating IP that sets their product apart from the competition," he added.

The agilePMU Subsystem, which includes a power-on-reset, several low-dropout regulators and a related reference generator, is an effective and highly integrated power management unit (PMU) for systems-on-chip (SoCs)/ASICs. The agilePMU Subsystem is made to guarantee minimal power usage while offering the best power management capabilities.

For on-chip monitoring of a device's physical, environmental and electrical properties, the agilePVT Sensor Subsystem is a low-power integrated macro comprising process, voltage and temperature sensors and a related reference generator.

The agileSMU Subsystem is an integrated macro that uses little power and contains all the crucial IP blocks needed to manage an SoC coming up from sleep mode safely. It contains several low-power comparators that can be used to start the wakeup process, a programmable oscillator for low-frequency SoC operation and a power-on-reset that offers a reliable startup reset to the SoC.

"We also have some IPs for preventing side-channel attacks," Morrison said. "A clock attack sensor, voltage glitch sensor and temperature sensor are combined to prevent people from executing physical side-channel attacks."

Agile Analog has just announced that it has taken this further by bundling a set of these subsystems into a complete analog IP subsystem for RISC-V applications. The initial subsystem includes all the analog IP required for a typical battery-powered IoT system, including a PMU, sleep management unit and data converters. This unique, process-agnostic, customizable and digitally wrapped analog IP subsystem will help solve many of the issues that SoC designers currently encounter, as it pairs with a RISC-V core to form a complete solution.

"What we're doing with these subsystems is trying to take away that analog design pain," Morrison said. "We're giving our customers what looks just like a digital IP block that drops straight into their design flow."

WHY CAR POWER SUPPLIES ARE REPLACING 12V WITH 48V

SHIBRAM PARAMANIK

3rd YEAR, ECE

As the number of electric vehicles rises, manufacturers are switching from 12 V to 48 V power supplies as their preferred power source. Higher voltages provide more driving force for power systems while weighing less and costing less to wire. The conventional 12-V system is no longer adequate for all of the electronics in current autos because they all require more electricity. The main justification is that 12-V systems require a lot higher current to provide the same amount of electricity.

Ohm's law also favors a 48-volt power supply

Let's say you need to supply power to a car's starter motor. The following static and dynamic features could be present:

- Supply voltage: 12 V
- Rated current: 40 A
- Rated power: 480 W
- Nominal average impedance: 0.3 Ω
- Inrush current: 150 A
- Inrush power: 1,800 W
- Inrush impedance: 0.08 Ω

Without considering the high inrush current (which, however, has the greatest impact on the thickness of the electrical wires), a 12-V battery must temporarily provide the motor with a current of 40 A in order for it to rotate with high torque. The battery and the motor itself are subjected to a significant energy demand totaling several thousand joules. The electrical cables in the system must be sufficient and have a big cross-sectional area to support this level of current flow and prevent them from overheating and posing a fire risk (see corresponding schematics in Figure). The calculations above are supported by Ohm's law, which also includes the following key formulas:

$$V = R \cdot I$$
$$P = V \cdot I$$

The two formulas give rise to other inverse relationships, which make it possible to calculate the resistance as well as the current, having the other known values. Returning to the motor example, a continuous current of 40 A is a fairly large value, which must be handled safely. Starting from the nameplate data of the example motor, the following relationships can be solved:

$I = P/V = 480/12 = 40$ A
$R = V/I = 12/40 = 0.3$ Ω

The minimum cross-sectional area of a power cable to pass this value of current is 6 mm², but inrush current must also be included, so the minimum recommended cross-sectional area rises to about 35 mm².
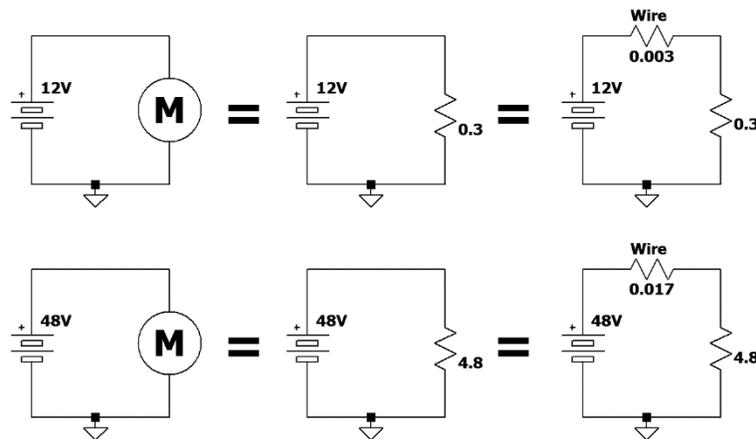
There are special charts that motorists can use together with their trusted electrician. If the power supply were 48 V, the situation would be completely different, as for the same power consumption, the current flowing through the cables would be much lower. Raising the supply voltage from 12 V to 48 V decreases the current flowing through the circuit, and the cables can be safely sized with much smaller diameters. This makes wiring lighter and more affordable.

Simulation of cable temperature

With the data calculated above, it is now possible to simulate the use of different sections of electrical cables to power the above motor with voltages of 12 V and 48 V. The purpose is to find out, for the same power, whether the wiring undergoes a drastic increase in temperature, using the two voltages. For the simulation, only engine operation at steady state (and not at inrush) is considered.
Please note that the resistance value of an electric cable is as follows:

$$R = \frac{\rho \cdot l}{A} = \frac{l}{\sigma \cdot A}$$

With the powers dissipated by electric cables, at various operating conditions, several F.E.M. simulations can be carried out to calculate, in principle, the temperatures they can reach. When an electric current flows through a conductor, some of the energy is converted into heat by the Joule effect, and the heat generated is dissipated into the surrounding environment. This temperature depends on several factors, such as electrical resistance of the conductor, current, exposed surface area and ambient temperature. The general conditions of thermal simulation F.E.M. are as follows:
- Ambient temperature: 27°C
- Thermal conductivity of copper: 395 mW/(mm/°C)

The use of a 48-V power supply is becoming increasingly common in modern automobiles. This is because a 48-V electrical system also results in 15% energy savings compared with 12-V systems. Although the design of 48-V systems is more challenging, the electronic components are smaller and lighter, which can lead to improved vehicle performance and efficiency.

MONOLITHIC LINEAR VOLTAGE REGULATORS

HRITIK VISHWAKARMA, SNIGDHA MAJI
1st YEAR, ECE

Monolithic, or integrated, linear voltage regulators make it possible to build a stable power supply with a small number of parts, saving both time and space. Additionally, a lot of the modern devices on the market incorporate cutting-edge features like short-circuit, overvoltage, and overcurrent protection. Since they were first used, linear regulators have dominated the power supply industry—at least until switching technology appeared. They continue to be employed in many applications, particularly low-power ones, due to their simplicity. Efficiency is the primary constraint on linear regulators since the lower it is, the bigger the disparity between the input and output voltages.

The efficiency trend as a function of the VOUT/VIN ratio is shown in Figure. When the V_{OUT}/V_{IN} ratio leans toward 1, the best outcomes are attained. Because extra energy is lost as heat when output and input voltages range noticeably, it is also vital to offer suitable thermal management solutions.
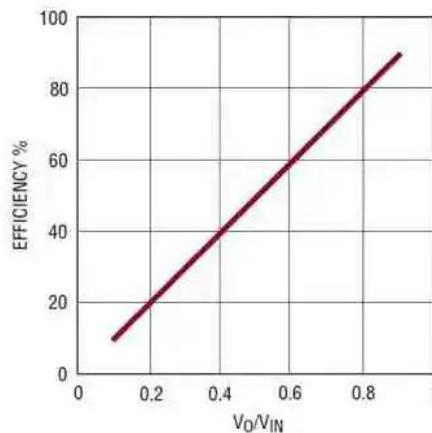
The dropout voltage, or the difference between the input voltage and the output voltage, is a crucial component of every linear regulator. The input voltage should never drop below 6.5 V, for instance, in the case of a regulator with an output voltage V_{OUT} of 5 V and a dropout voltage $V_{DROPOUT}$ of 1.5 V. The following list of some of the most well-liked linear regulators on the market includes their key characteristics and application circuits.

78xx and 79xx series

The 78xx series of monolithic linear regulators (for positive voltages) and 79xx (for negative voltages) are among the longest-lived on the market. With a wide range of output voltages VOUT and input voltage VIN up to 40 V, these regulators can deliver an output current of up to 1 A, with plastic or metallic package depending on the model. Regulators include internal circuits for thermal and short-circuit protection.

The dropout voltage, depending on the model, varies between 1.7 V and 2.5 V.

By using a center-tapped transformer, the two circuits based on 78xx and 79xx linear voltage regulators can be easily combined, creating a dual power supply (for instance, 12 V and −12 V).

LM1117

We have decided to include in our selection this regulator and not the LM317 (very popular in past years) because, compared with the latter, LM1117 has a lower dropout voltage (1.2 V at the maximum deliverable current of 800 mA) and it is more suitable for generating a 3.3-V output voltage (widely used by today's microcontrollers). The LM1117 is available both in the version with fixed output voltage (1.8 V, 2.5 V, 3.3 V, and 5 V) and in the version with variable output voltage, adjustable through a pair of external resistors.

The LM1117 has integrated features for current limiting and thermal shutdown, as well as an internal Zener diode, which ensures an accuracy of the output voltage of ±1%. Although not strictly necessary, it is advisable to insert at the output a tantalum capacitor of at least 10 μF to improve stability and transient response. The regulator can also be used to generate a negative output voltage.

LT3080

The LT3080 is a low-dropout (up to 350 mV) linear regulator with output voltage adjustable between 1.2 V and 36 V, maximum current equal to 1.1 A, and accuracy up to 1%.

An important feature of the LT3080 is that it can be parallelized in such a way as to obtain a greater output current and improve thermal management.
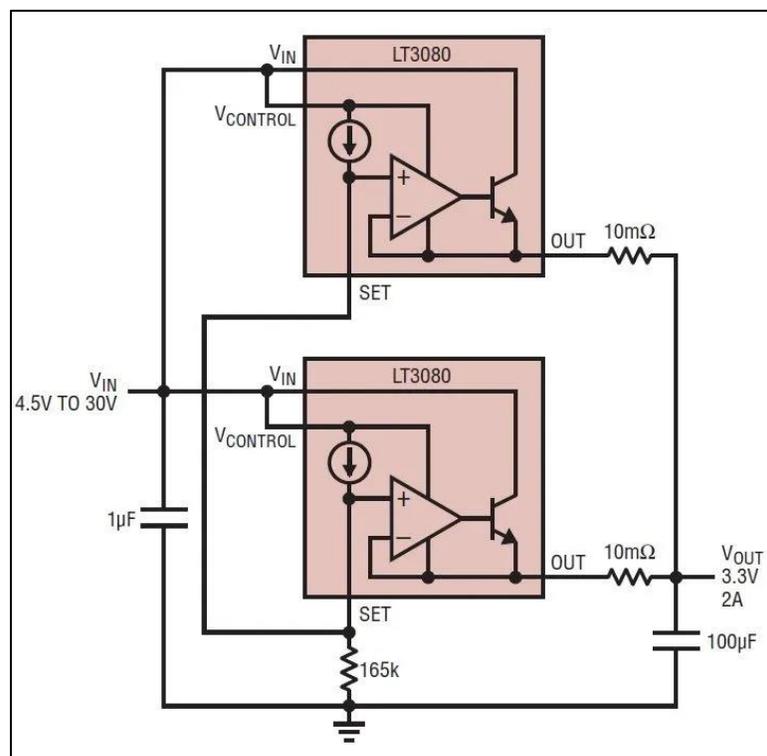
THE DRAWBACKS OF LITHIUM-ION BATTERIES

PRINCE KUMAR
2nd YEAR, ECE

Lithium is a silvery-white metal known mainly for its use in battery production. It's found in computers, cellphones and electric vehicles. Despite the fact that it powers green energy and reduces people's reliance on fossil fuels, it's not without its flaws, and we should be conscious of how much we use. Here's why we shouldn't become too dependent on lithium-ion batteries.

Obtaining lithium is a dirty process

Lithium is used to produce batteries that will reduce fossil-fuel usage, but its extraction can damage the soil and contaminate the air.

In South America, people extract lithium from huge salt flats and use a staggering 500,000 gallons of water to produce one ton of lithium. This extreme water usage has negative effects on human populations and local wildlife.

In China and Australia, people mine lithium in the form of a mineral called spodumene. They then process it at extremely high temperatures, which uses a lot of energy, and leach it with acid to extract the lithium.

Then it must be made into batteries. A full 77% of the world's Li-ion batteries are produced in China, a process fueled by coal. This means creating Li-ion batteries is not an environmentally sustainable process.

Li-ion batteries are sensitive to temperature

One unfortunate property of Li-ion batteries is that they're prone to combustion if they get too hot, and they contain all the necessary elements for self-sustaining a fire. It's another reason why we shouldn't become too dependent on Li-ion batteries.

They're hard to recycle

It's true that lithium-based batteries can be recycled, thereby reducing the dependency on mining, but it's not easy to do. They're designed with energy efficiency in mind, not their end-of-life processes, so people who work at recycling centers say they're difficult to recycle. The internal components are welded together and hard to take apart.

Furthermore, many countries aren't yet equipped to recycle batteries like this en masse, so a large percentage of the batteries ends up in landfills. This is set to become a huge problem as the popularity of EVs explodes.

With EVs becoming increasingly common, scientists need to figure out an efficient way to recycle Li-ion batteries to reclaim the metal from them. The alternative is to expand mining operations.

THE AUTOMOTIVE RE-MARKETING REVOLUTION

RISHI PRASAD, SOURAV PASWAN
1st YEAR, ECE

The automotive market is experiencing an unprecedented crisis due to an explosive mix of lack of new and now also used cars, the energy crisis, the pandemic, the push towards electrification and emergence of eCommerce models. All these different elements are adding pressure on a key sector for the Italian and global economy: the automotive sector.

As the old adage goes, within every crisis there is opportunity and despite the complex period, there is no shortage of success stories in this sector. In fact, more and more dealers are harnessing the intelligence provided by data derived from multiple sources such as sensors, mobility data, Big Data and the IoT to revolutionize the acquisition and sales model of used vehicles, helping them to create new revenue sources. Thanks to the data collected and analyzed by technology, it is in fact possible to increase liquidity and earnings from automotive re-marketing, enabling specialized operators to make informed and timely decisions.

Personalization unlocks new opportunities in Automotive Re-Marketing

The solutions currently used by dealers are, however, only a starting point of a wider revolution. In fact, the tools typically in use are rather standardized and do not exploit the growing amount of data available with to AI and Machine Learning. Contamination with external platforms and data makes it easier for these tools to offer an accurate price estimate.

Recently, together with its partners, Air-Connected Mobility has started developing the concept of a new approach to re-marketing, based on the combination of experienced professionals and technology. Starting from the key idea that all useful information must be brought together in a single platform so that it can be analyzed, it follows that the digitization and automation of processes is essential not only to save time, but above all to facilitate and speed up the entire decision-making process. In the dealership specifically, technology needs to offer tailored solutions in addition to vehicle pricing support, offering an enabling tool that supports professionals throughout the entire re-marketing cycle, from stock acquisition to positioning.

Tech and the dealership

Faced with a constant increase in used vehicle value and price lists, technology can help the dealer take a strategic approach and make targeted tactical choices such as which vertical publications to optimize, where to source the product across multiple channels and how to evaluate the product in the short term by balancing rotation, attractiveness, margins and positioning.

Technology can offer the dealer critical support on all re-marketing processes, starting from collection and sales price decisions. Thanks to the technology it is now possible to determine the attractiveness of the product on the basis of sales and offers on the market by analyzing hundreds of sources in just a few seconds. Tech also allows the dealer to evaluate the out-ins rotation of the product according to the market and to easily analyze national, regional and provincial market. The data is then purged of duplicate ads linked to promos, eliminating the statistical queues linked to promotions and optimizing the price according to company strategy.

The accuracy of the data provides immediate, accurate data, with very fast response times and pricing processing, but people will still play a key role. In fact, technology is a tool to support – never to replace – internal expertise, confirming that digital tools integrate and strengthen internal skills, enhancing the work of the re-marketing team. Thanks to a rich set of market indicators such as demand, supply, liquidity, absorption, stock, etc., dealers can focus on positioning and competitive analysis, guaranteeing all-round operational efficiency.