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Department of Electrical Engineering

TARANG

Technical Magazine 2019-20

Department Vision and Mission

VISION

To be a center of excellence in Electrical Engineering education to prepare professionally competent engineers with lifelong learning attitude for the accomplishment of ever-growing needs of society.

MISSION

- To prepare technically and professionally competent engineers by imparting quality education through effective teaching learning methodologies and providing stimulating environment for research and innovation.
- To develop professional skills and right attitude in students that will help them to succeed and progress in their personal and professional career.
- To imbibe moral and ethical values in students with concern to society and environment.

Program Educational Objectives (PEOs)

Graduates of the program will

- PEO I : Engage in design of system, tools & application in the field of electrical engineering & allied engineering industries.
- PEO II : Apply the knowledge of electrical engineering to solve problems of social relevance, pursue higher education & research.
- PEO III : Engage in lifelong learning, career enhancement & adapt to changing professional & societal needs.

EXECUTIVE DIRECTOR‘S MESSAGE:

Good things remain good only because they are always scant. I am glad to unfold this wonderful magazine as an appreciation of the admirable efforts put forth by the team. The effort taken to bring about content is appreciable. This is a productive technical material and subsidiary skill developing tool for the students. The release of this brilliant forth issue of the technical magazine “TARANG” has added the value of department. I also applaud the coordination & efforts behind the team to bring out this issue.

Hon. Shri Anil Bagane
Executive Director

PRINCIPAL MESSAGE:

We have been gifted with this blessed life. The program of society is mainly depend on many people who are working behind the scenes ,overtime round the clock planning things to the smallest. This technical magazine will be a medium to provide proper acknowledgement and respect to all of these effort and its results. This is only small step towards a long journey. This fourth issue of technical magazine should inspire all of us for a new beginning enlighten with hope , confidence and faith in each other In the road ahead for innovation work. It is expected that wide support for this mission will be provided through the reader’s valuable suggestions and comments…….Happy reading.

Dr. Sanjay A Khot
Principal

HOD’S MESSAGE:

I feel delight to introduced fourth issue of Technical Magazine prepared by department of Electrical Engineering. We at SITCOE promise of increasing the knowledge, enhancing the critical thinking, ability to change information into knowledge & power of analyzing the things technically of each & every individual of ever changing society through students.

Dr.K Hussain
Head of the Department

Faculty Editors Message:

Mr. Chandrashekhar S Patil

Electrical Engineering Department

Greetings from the Editorial members' board of the Technical Magazine "TARANG".Although that has been enduring in mind, it becomes real. It is truly an interesting and exciting experience. It is the snap shot of the various technologies and technological changes associated with Electrical Engineering. It among all of us. We would like to place. On record our gratitude and heartfelt thanks to all those who have contributed to make this effort in a successful one.

We profusely thank our Honorable Executive Director Shri Anil Bagane, Principal Dr. S A Khot and Head of Electrical Engineering Department Dr. K Hussain for giving support and encouragement and a free hand in this endeavour. This Technical Magazine will be a medium to provide proper acknowledgement and respect to all of those efforts and its results.

Student Editors Message:

(Mr.Shivkumar Jadhav)

Third Year Electrical Engineering

It's truly an interesting and exciting experience. This technical magazine was one such cherished work that had its roots in the persuasion. It would be a snap shot of the various activities and advancements in the field of Electrical Engineering Department.

This Technical Magazine will serve to reinforce and allow increased awareness about research activities. Interaction and Team Work among all of us, usually we fail to appreciate the good deeds of many people and activities that happen around us as we are engaged in irrelevant talks and assumptions. It could all change if we just pause to think of what is our contribution to the society.

CONTENTS

Edge Computing and AI

By: Biranje Diyva Dadaso (SE) Ms Patil Anagha Baban (SE)

Green waves reveals its latest AI chip, GAP9. Just like the previous generation, it is aimed at AI inferencing in systems at the very edge of the network.

Edge computing will increasingly become an integral part of the digital transformation phenomenon. The main benefits deriving from the use of these technologies are the reduction of processing latency, which allows real-time responses, and the saving of bandwidth, sending already processed and, therefore, smaller information to the data center.

Compared to Green Waves Technologies' currently shipping product, GAP8, the latest GAP9 reduces energy consumption by 5× while enabling inference on neural networks 10× larger. GAP9 is built on the same GAP architectural layout of the GAP8. Green Waves' GAP8 is the industry's first ultra-low-power processor designed to transfer high edge-processing capacity with particularly low costs and power consumption. It enables battery-powered artificial intelligence (AI) in internet of things (IoT) applications.

"There's a lot of interest at the moment in moving AI processing to the edge for applications such as ADAS, security cameras, robots, and phones," said Martin Croome, VP of marketing at Green Waves Technologies. "We are focusing on what we believe will be the next wave of edge devices, at what we call the very edge. These are the devices that are extremely power-constrained — for example, wearable's with very small rechargeable batteries that need weeks or months of battery life or sensors where power is unavailable or expensive to install. If you have to install cables to power a sensor, the cost of doing this is often many times more than the cost of the sensor itself. And then some sensors may be very distant from mains power. They might be in a middle of a field or something like that where getting power to them is almost impossible. You need to start having some other alternate power source, like PV panels or batteries with an extremely long life."

GAP8 is an IoT application processor based on the open-source RISC-V and PULP (Parallel Ultra-Low-Power Processing Platform) platforms. It is opening up new possibilities for the next generation of connected devices. GAP8 enables the cost-effective development of intelligent devices that capture, analyze, classify, and act on a fusion of rich data sources such as images, sounds, radar, infrared, or vibrations. GAP8 works from a few tens of mill watts in active mode to a few microwatts in sleep mode, so devices can last for years on a battery. GAP8 is optimized to perform a wide spectrum of image and audio algorithms, including convolutional neural network inference with extreme energy efficiency.

“In GAP8, our first product which is now in production, we’ve used the extensibility of the RISC-V instruction set architecture to improve the energy efficiency,” said Croome. “GAP8 has eight RISC-V cores in a cluster and then an extra ninth RISC-V core, which we use as a controller, a bit like an MCU for the chip. Signal-processing and machine-learning algorithms are good targets for parallelization in the cluster. If you parallelize a calculation on eight cores, you would hope to get as close as possible to eight times the work done. This factor is known as speedup. We have focused on getting very good speed up by implementing all of the task fork and synchronization primitives in hardware and a number of other optimizations. We then use the speedup that we achieve not to do more work, but to do the same amount of work at a lower clock speed. This, in turn, allows us to drop the voltage internally in the chip which gives us a quadratic power benefit. The chip integrates dynamic frequency and voltage control so we can save energy by continuously tuning the clock speed and voltage to the task that we are carrying out.”

The hierarchical architecture allows very low power operation by combining a series of highly autonomous intelligent I/O peripherals for connecting external devices. A cluster of eight cores with an architecture optimized to execute vector and parallelized algorithms combined with a specialized convolution neural-network accelerator (HWCE). All cores and peripherals can be switched in power, voltage, and frequency as required. DC/DC regulators and clock generators with ultra-fast reconfiguration times are integrated to optimize power management. Cluster and HWCE cores share access to a memory area and instruction cache. Multiple DMAs allow for fast, low-power, standalone transfers between memory areas. A memory protector is included to allow applications to run safely on GAP8.

The new GAP9 adds security features for AES128/256 cryptography and full support for floating-point arithmetic across all cores based on an innovative transprecision floating-point unit capable of handling floating-point numbers in 8, IEEE 16, BFloat16, and IEEE 32-bit precisions with support for vectorization. GAP9 handles sophisticated neural networks such as Mobile Net V1 with ease processing a 160 × 160 image with a channel scaling of 0.25 in just 12 ms with a power consumption of 806 µW/fps. GAP9 provides 20× increase of effective memory bandwidth compared to GAP8, enabling significant improvements in detection accuracy by simultaneously analyzing streams of data from multiple different sensors such as images, sounds, and radar (Figure 1).

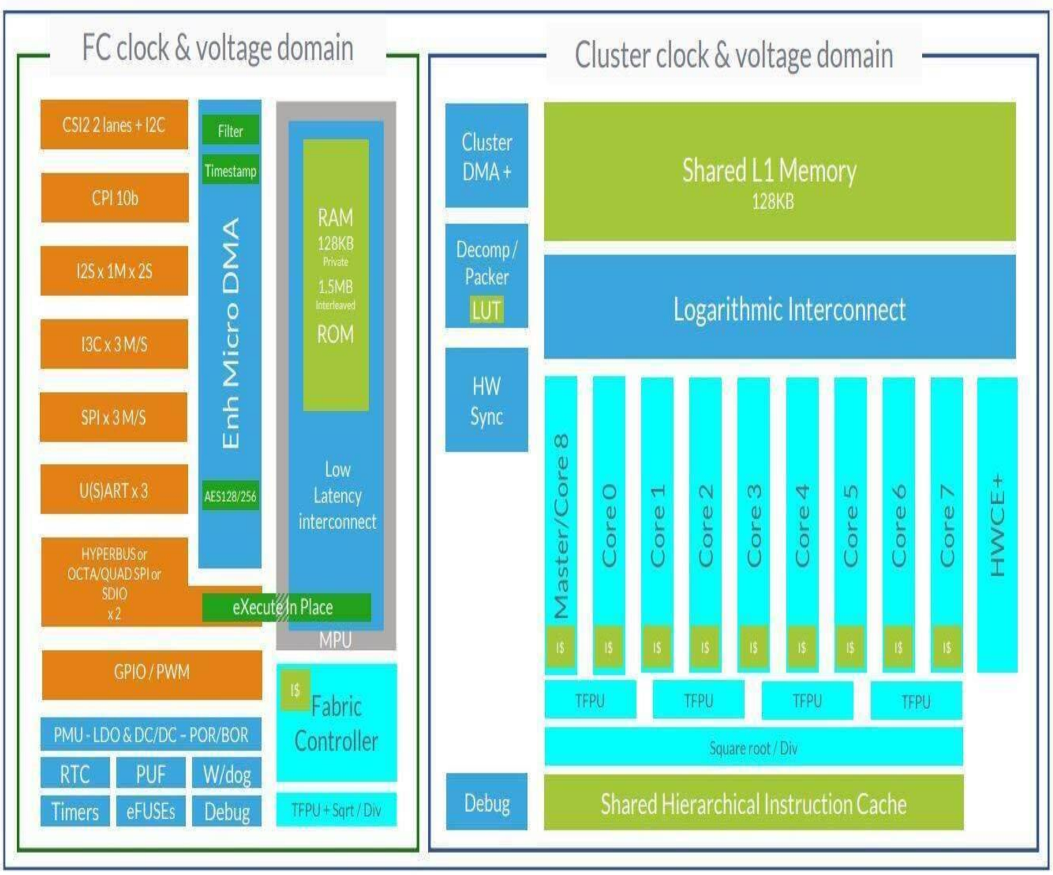


Figure 1: Block diagram of GAP9

"GAP9 enables a new level of capabilities for embedding combinations of sophisticated machine learning and signal processing capabilities into consumer, medical, and industrial product applications," said LoicLietar, CEO of Green Waves Technologies. "The GAP family provides product designers with a powerful, flexible solution for bringing the next generation of intelligent devices to market.

"We don't heavily use some kind of very esoteric architectural approach to accelerate just convolutional neural networks (CNNs) because we believe that that market is moving so fast. Every month there's a thousand new papers on the neural network space. And we want to make sure that we're able to accelerate all of those new things that are coming out this year and next year and not be something that's focused on last year's best idea. So we have a convolution hardware accelerator, which helps reduce energy consumption in some cases, but generally, architecture is programmable."

Face Identification has attracted a lot of press relating to uses in security applications, and it is implemented using a Squeeze Net-based CNN. CNNs are a family of neural networks widely used in computer vision and, more generally, with data that have spatial relationships. The CNNs follow an architecture at levels, typically non-cyclical.

Face Detection can be activated using passive infrared (PIR) techniques to reduce power consumption further when no face is present. Once detected, the algorithm emits the coordinates of the detected image appropriately resized in an image of 128 × 128 pixels. This image is the input for the face identification CNN. The output of the CNN is the signature of 512 parameters (16-bit size) of the detected face.

To speed up time to market, Green Waves Technologies has designed the GAPuino board to facilitate the implementation of GAP8. The GAPuino can be used as a replacement for a standard Arduino Uno board and can be connected to most Arduino Uno compatible 3.3-V or 5-V shields. By adding an Arduino communication shield (BlueTooth, WiFi, LoRa, etc.), it is possible to prototype complete IoT applications with AI on battery-powered devices quickly (Figure 2).

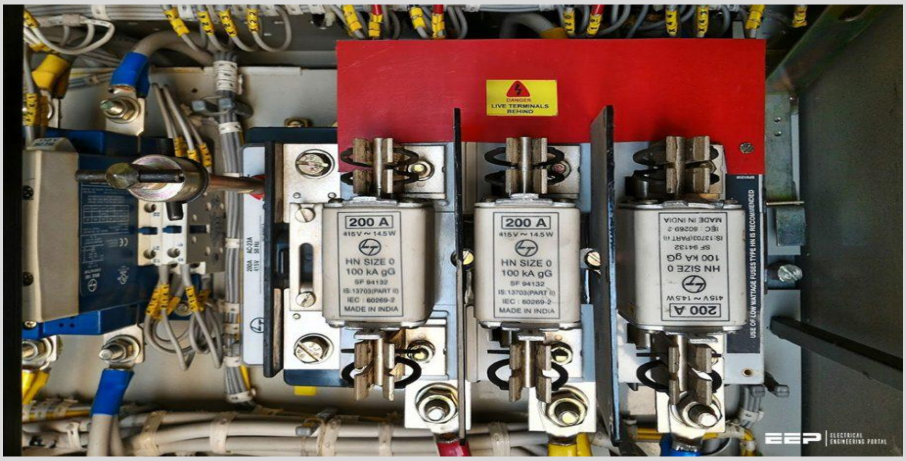
Figure 2: GAPuino

Several accessories are available such as the module with the B&W low-power QVGA camera and a sensor board that adds an articulated set of sensors including four digital microphones for audio applications. For GAP8 processors, there is also a complete SDK, which includes a RISC-V GCC/GDB chain tool with extensions for additional processor instructions, tools for the MCU side with two operating systems (PULP OS and the Mbed OS port on RISC-V/GAP8).

Eight Fuse Characteristics You Must Consider When Designing Protection Circuits

By Ms. Shinde Gouri Balkrishna (SE) Ms. Geetanajali Swami (TE)

Fuses were the first type of protection to be used, and they still have a place in numerous applications. Although they do not have the flexibility of adjustment and resetting capacity of a circuit breaker, they are nevertheless reliable, high performance devices in terms of their ability to break very high short-circuit currents.



Eight fuse characteristics you must consider when designing protection circuits:

The fuse cartridge is inserted in the circuit to be protected. If there is an overcurrent, the circuit is broken automatically by fusing of the conductive fuse element, which is specially rated, inside the cartridge.

The silica in the body of the cartridge absorbs very high energies by fusing and vitrification. Unlike a circuit breaker, the fuse cartridge is destroyed by the fault and must be replaced. Fuse cartridges comply with standard IEC 60269-1. They come in various shapes and sizes. In low voltage electrical installations cylindrical cartridges and blade type cartridges are mainly used, with ratings ranging from 0.5-1250 A.

Fuse cartridges are fitted in isolating switches, fuse carriers or simply on bases.

Table of contents:

9. Cylindrical cartridge fuses gG and aM types
10. Blade cartridge fuses gG and aM types

Fuse characteristics:

1. Fuse Type:

Fuses are identified by 2 letters, according to their application category. In low voltage installations **gG** and **aM fuses** are mainly used.

gG cartridges:

gG cartridges are for general use and they protect the circuits against **low and high overloads** and, of course, against **short circuits**. gG cartridges are marked in black.

aM cartridges:
aM cartridges are used with **electric motors** and they protect against high overloads and short circuits. They are calculated to resist certain temporary overloads (starting a motor).

These cartridges must therefore be used **together with a thermal protection device to protect against low overloads**. aM cartridges are marked in green.

2. Rated currents and voltages:

The rated current can cross a fuse indefinitely, without triggering either fusing or any excessive temperature rise. The rated voltage is the voltage at which this fuse can be used. Let's explain the meanings of the letters used for the application categories.

Figure 1 – Fuse ratings (example)

The first letter indicates the main operation:

- **a (associated)** – The fuse must be associated with another protection device, because it cannot break faults below a specified level. It provides short-circuit protection only.
- **g (general)** – It breaks all faults between the lowest fusing current (even if it takes 1 hour to melt the fuse elements) and the breaking capacity. It provides short-circuit and overload protection.

The second letter indicates the category of equipment to be protected:

- **G** = Protection of cables and conductors
- **M** = Protection of motor circuits
- **R** = Protection of semiconductors
- **S** = Protection of semiconductors
- **Tr** = Protection of transformers
- **N** = Protection of conductors according to North American standards
- **D** = Time-delay fuse for protecting motor circuits according to North American standards

3. Conventional Non-fusing and Fusing Currents

You should differentiate two conventional currents: non-fusing and fusing.

Conventional non-fusing current (Inf) – This is the current value that the fuse cartridge can withstand for a conventional time without melting.

Conventional fusing current (If) – This is the current value that causes the fuse cartridge to fuse before the conventional time has elapsed.

Ratings (A)	Inf Non-fusing current	If Fusing current	t Conventional time
In ≤ 4	1.5 In	2.1 In	1 h
4 < In ≤ 10	1.5 In	1.9 In	1 h
10 < In ≤ 25	1.4 In	1.75 In	1 h
25 < In ≤ 63	1.3 In	1.6 In	1 h
63 < In ≤ 100	1.3 In	1.6 In	2 h
100 < In ≤ 160	1.2 In	1.6 In	2 h
160 < In ≤ 400	1.2 In	1.6 In	3 h
400 < In	1.2 In	1.6 In	4 h

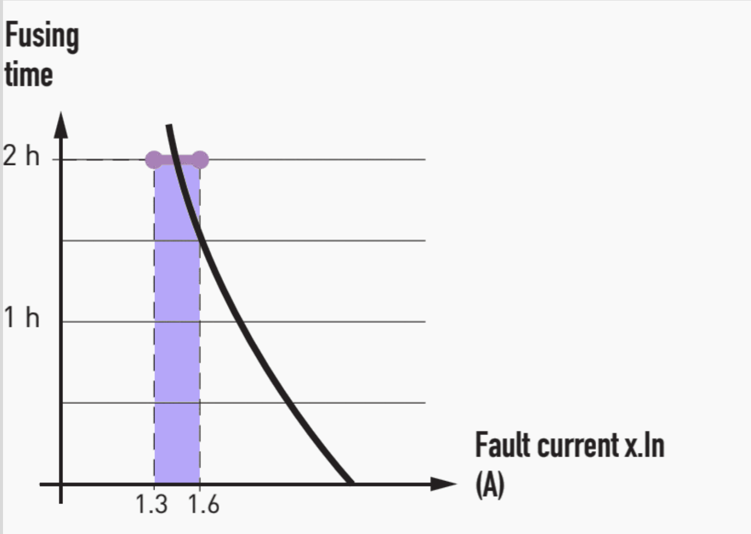


Figure 2 – Fusing time / Fault current

In the above example (100 A gG cartridge):

- Conventional time = **2 h**
- Inf = **1.3**
- If = **1.6 In**

4. Operating zone

The operating zone defined by the standards is used to determine **the operating time of the fuse** according to the current crossing it. It is important to know the operating characteristics of the fuse in order to calculate the discrimination of the various protective devices installed in series.

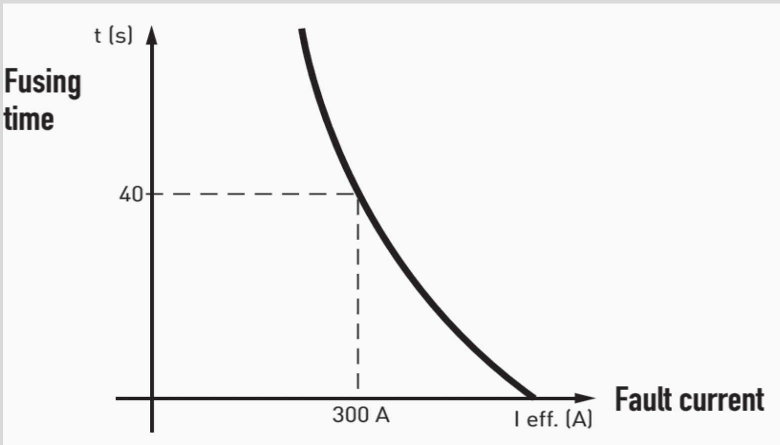


Figure 3 – Fuse operating zone

For a 100 A, **22 × 58 gG cartridge**, an overload of **300 A** will melt the cartridge in 4**0 s**.

5. Breaking Capacity

The breaking capacity must be **at least equal to the prospective short-circuit current** that may occur at the point at which the fuse is installed. The higher the breaking capacity, the more capable the fuse of protecting the installation against high intensity short circuits.

HBC (High Breaking Capacity) fuses limit short circuits that could reach more than 100 000 A rms.

6. Limitation Curve

The limitation of the current can vary according to the conditions of the short circuit (intensity, cos ϕ, short-circuit starting angle ψ). The limitation curves of cartridges represent the maximum limited current values that can be achieved under the most unfavorable conditions.

Example

For a prospective short circuit of 10 000 A rms (or 10 kA rms) in view of the maximum asymmetry of the current, the short circuit could reach a theoretical maximum value of **2.5 × Irms, i.e. 25 kA peak**.

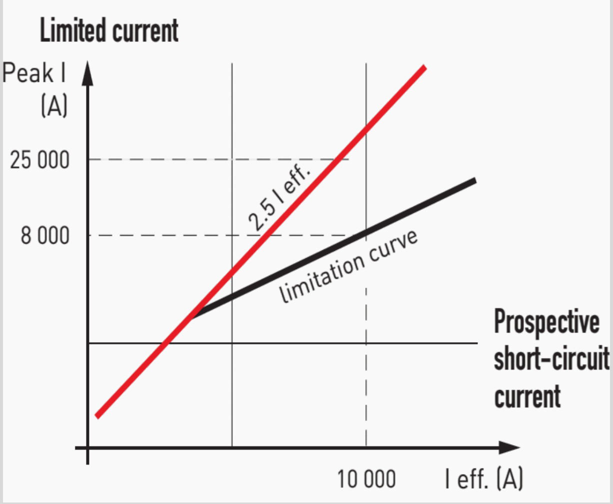


Figure 4 – Fuse limitation curve

The 100 A gG cylindrical fuse cartridge limits the first current wave to 8 000 A peak, i.e. approximately 30% of the prospective maximum value. The destructive electrodynamic effects are therefore reduced by a factor of 10 ($(8\ 000/25\ 000)^2$) of the maximum value.

The higher the prospective short-circuit current, the higher the limitation ratio. For example, for a 100 000 A rms short circuit, i.e. 250 000 A peak, the 100 A gG cartridge limits this current to 15 000 A peak, i.e. limitation to 6% of the prospective maximum current and limitation to 0.36% of the prospective maximum electrodynamic effects.

Importance of the limitation capacity

A short circuit is dangerous, both in terms of its electrodynamics effects and its thermal effects:

The destructive electrodynamics effects depend on the square of the peak current reached during the short circuit, and cause mechanical damage to the insulation of the conductors.

The destructive thermal effects depend on the thermal energy dissipated during the short circuit, and could burn the insulation of the conductors. Fuse cartridges limit both these effects as much as possible.

7. Limited Thermal Stress

A short circuit triggers the release of a **considerable amount of energy**. The fuse cartridge limits this energy to a much lower value, conventionally known as the limited thermal stress, expressed in A^2s.

Why must the thermal stress be limited?

If the energy released by the short circuit is not limited, it can quickly lead to total or partial destruction of the installation. Thermal stress is governed by two main parameters:

- **Cos ϕ:** the lower this is, the greater the energy
- **Voltage:** the higher the voltage, the greater the energy

Fuse cartridges significantly limit this energy. For example, for a **10 kA** rms asymmetrical short circuit at 230 V, cos ϕ = 0.1, would develop if there were no cartridge, on several current waves. For the first wave only, the thermal stress could reach 4 000 000 A^2s. Under the same fault conditions, a **100 A gG cartridge** would limit the thermal stress to **78 000 A^2s**, i.e. 1.95% of the value on the first wave of the prospective current only.

Difference between pre-arcing and arcing thermal stresses

A fuse breaks a short circuit in two stages: pre-arcing, then arcing. Let's say a word about each stage:

The pre-arcing thermal stress corresponds to the minimum energy necessary for the fuse element of the cartridge to start melting. It is important to know this thermal stress in order to determine the selectivity on a short circuit between several protection systems in series.

The arcing thermal stress corresponds to the energy limited between the end of pre-arcing and total breaking.

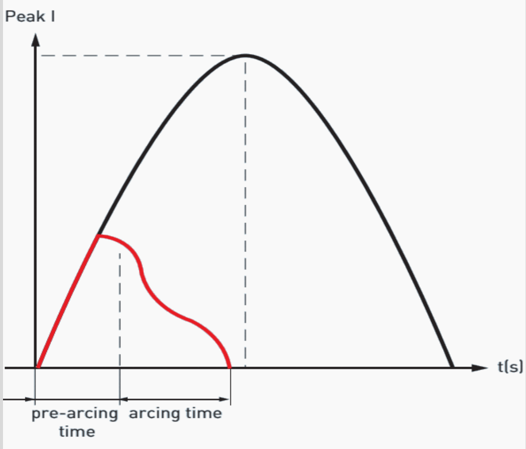


Figure 5 – Difference between pre-arcing and arcing thermal stresses

The sum of the arcing and pre-arcing thermal stresses gives the total thermal stress.

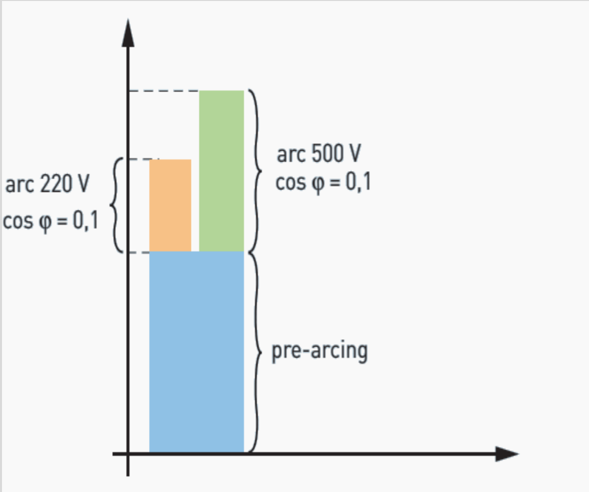


Figure 6 – Total thermal stress

8. Selectivity

A current generally crosses a number of protection devices in series. These devices are calculated and distributed according to the various circuits to be protected. There is selectivity when only the device protecting the faulty circuit operates.

Example

Only the **25 A** cartridge has operated on a fault occurring on the line it is protecting. If the **100 A** cartridge, or even the **400 A** cartridge, had also operated (incorrect selectivity), the whole installation would have gone down.

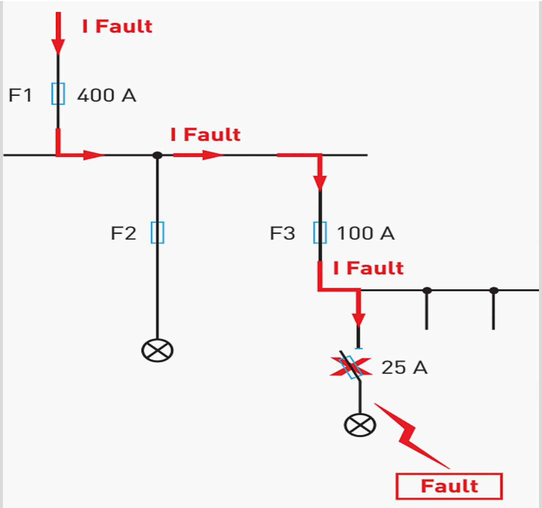


Figure 7 – An example of fuse selectivity

9. Cylindrical cartridge fuses gG and aM types

Rupture capacity curves:

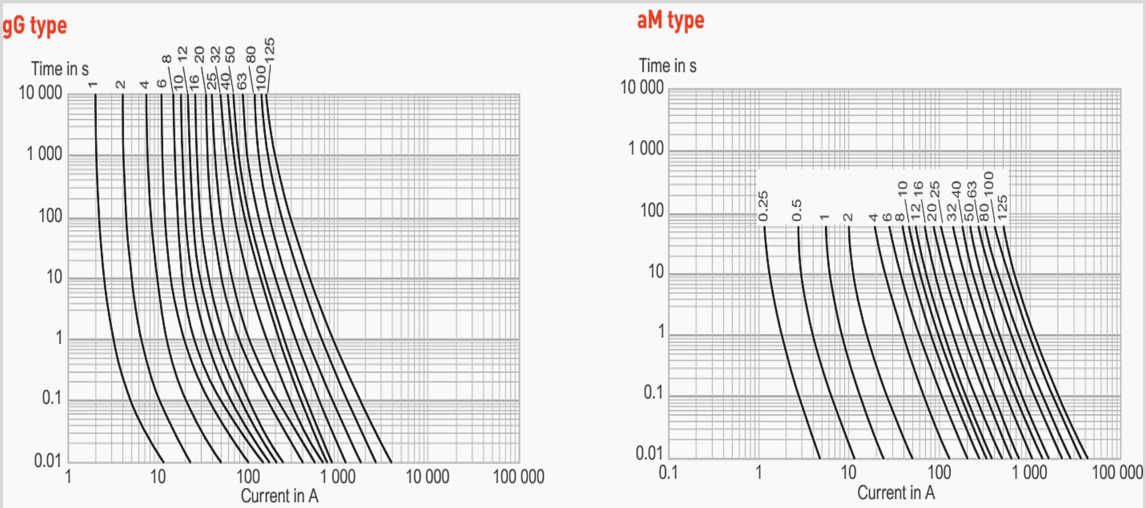


Figure 8 – Rupture capacity curves for cylindrical cartridge fuses gG and aM types

Thermal stress (∫i²dt)

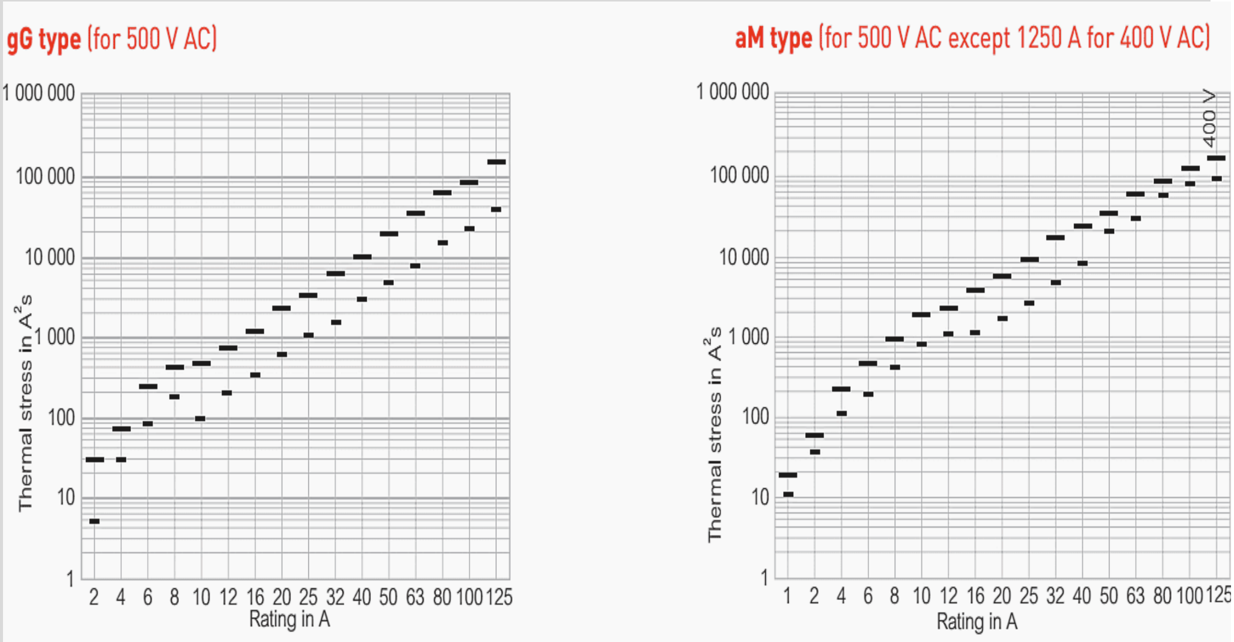


Figure 9 – Thermal stress (∫i²dt) for cylindrical cartridge fuses gG and aM types

Limitation curves:

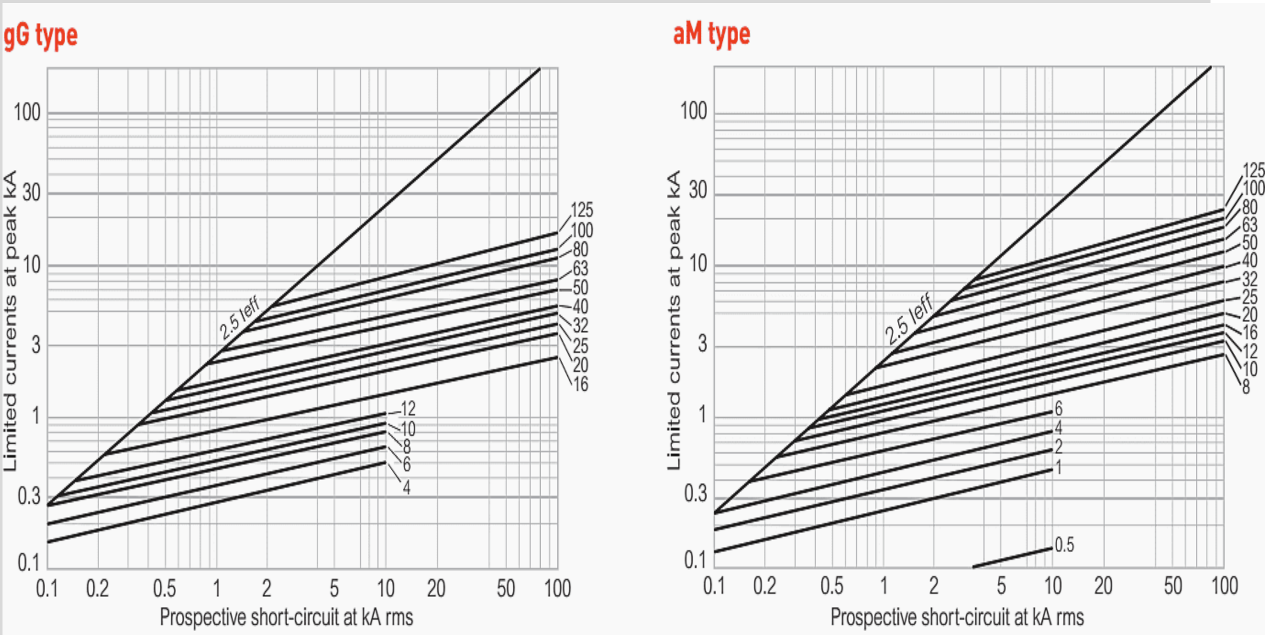


Figure 10 – Limitation curves for cylindrical cartridge fuses gG and aM types

10. Blade cartridge fuses gG and aM types

Rupture capacity curves

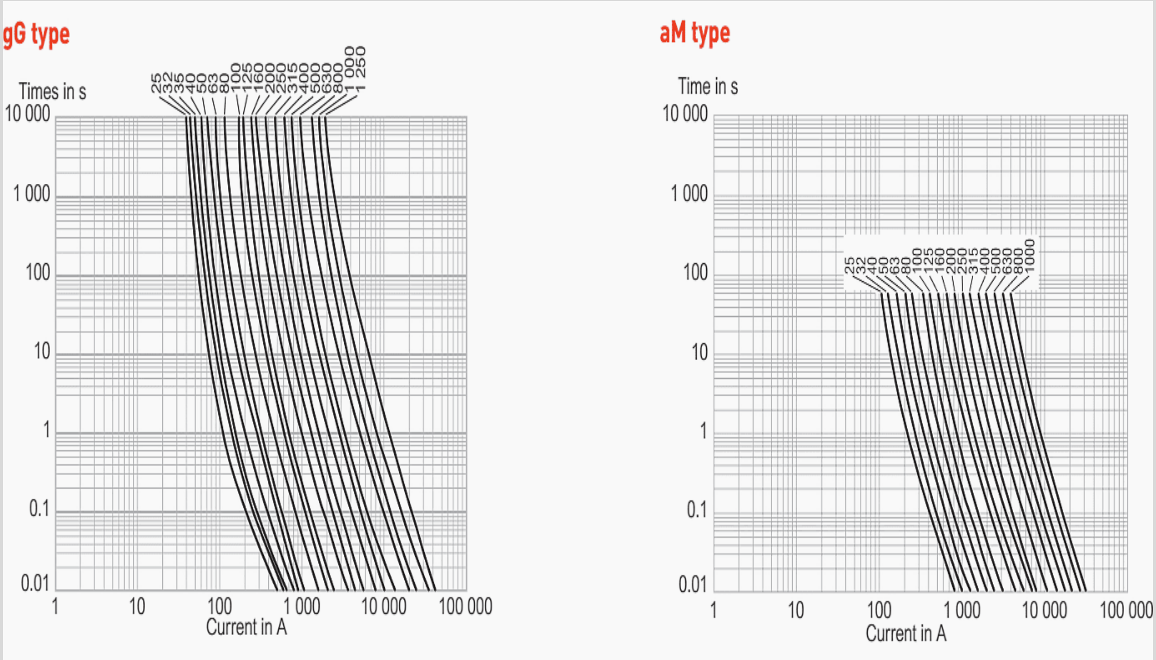


Figure 11 – Rupture capacity curves for blade cartridge fuses gG and aM types

Thermal stress (∫i²dt)

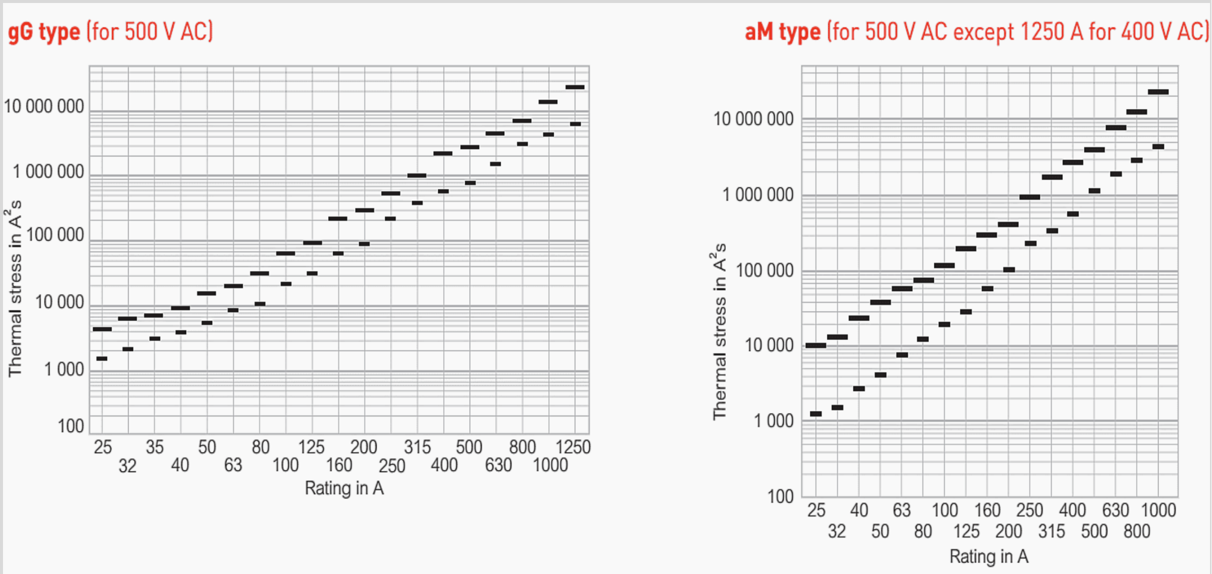


Figure 12 – Thermal stress (∫i²dt) for blade cartridge fuses gG and aM types

Limitation curves

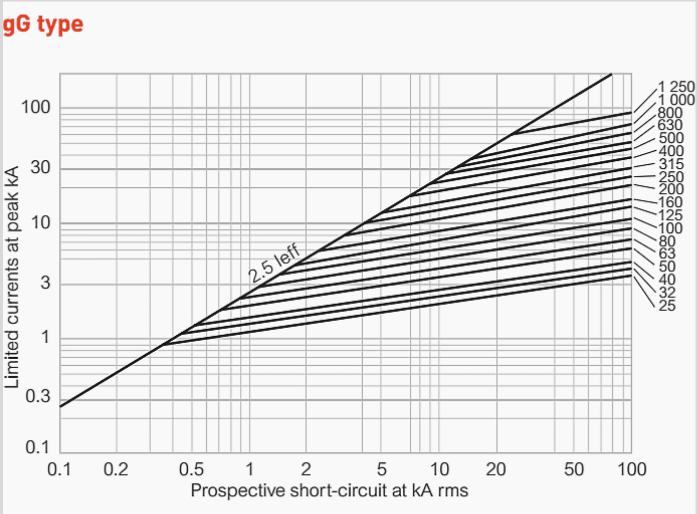


Figure 13 – Limitation curves for blade cartridge fuses gG and aM types

How far is a lightning?

By: Mr. Sarthak Koli (BE), Mr. Bharamgonda Shubham R (TE)

Sometimes it's really useful to measure the distance between us and the lightning during a thunderstorm. This measurement allows understanding if the thunderstorm is approaching or moving away. The calculation could be done manually or by using a chronometer, but we want to build a simple electronic circuit to the perform the measurement.

Thunders and Lightning:

The thunder is a strong noise caused by a lightning which, depending on its nature and the distance from the observer, can manifest itself as a sharp and powerful blow or as a low and prolonged roar. Thunders and lightning occur in the same place, but the speed of light and of sound is very different, therefore the two events are perceived in various moments, as shown is the figure 1.

Figure 1: thunders and lightning are not perceived at the same moment, since their speed is different

The rumble of thunder follows the glow of lightning, because light travels at a greater speed than sound. The two electrical quantities are the following:

- the speed of Light is 299,792,458 meters in a second;
- the speed of Sound in the air is only 331 meters in a second.

There is a very big difference between the two speeds. The glow of a lightning is seen immediately, whatever the distance from the observer. You can calculate by hand the distance of a thunderstorm this way: after you see a flash of lightning, count the number of seconds until you hear the thunder. Divide the number of seconds you count by 5 to get the number of miles or by 3 to get the number of kilometers. For example, if you count 8 seconds from the lightning to the thunder, the thunderstorm is 1.6 miles or 2.6 kilometers far.

Logic Diagram:

As shown by the diagram in figure 2, the system consists of the following logical parts:

- The central unit, equipped with a microcontroller and its firmware, the display LCD and the buttons to simulate the lightning and the thunders. This unit is completely independent and it works very fine;
- The external sensors as optional parts of the circuit. They automate the process of detection of lightning's and thunders. They must be built with electronic components. If you want more independence but more complexity, you can build them yourself.

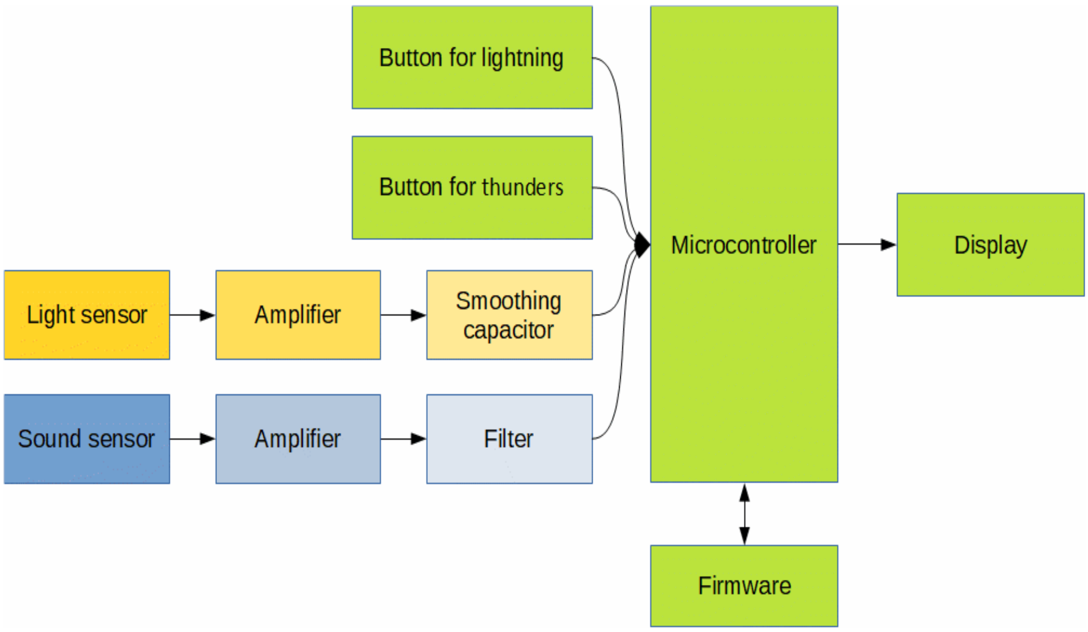


Figure 2: Flowchart of the system

Main System:

The main system is a stand-alone circuit that works without external add-ons. It's the simplest solution to measure the distance of a thunderstorm. It works manually indeed you have to press the first button when a lightning occurs and to press the second button when you hear a thunder. The system calculates the time between the two pressing and, then, the distance of the thunderstorm. We can see the electric schematic in figure 3.

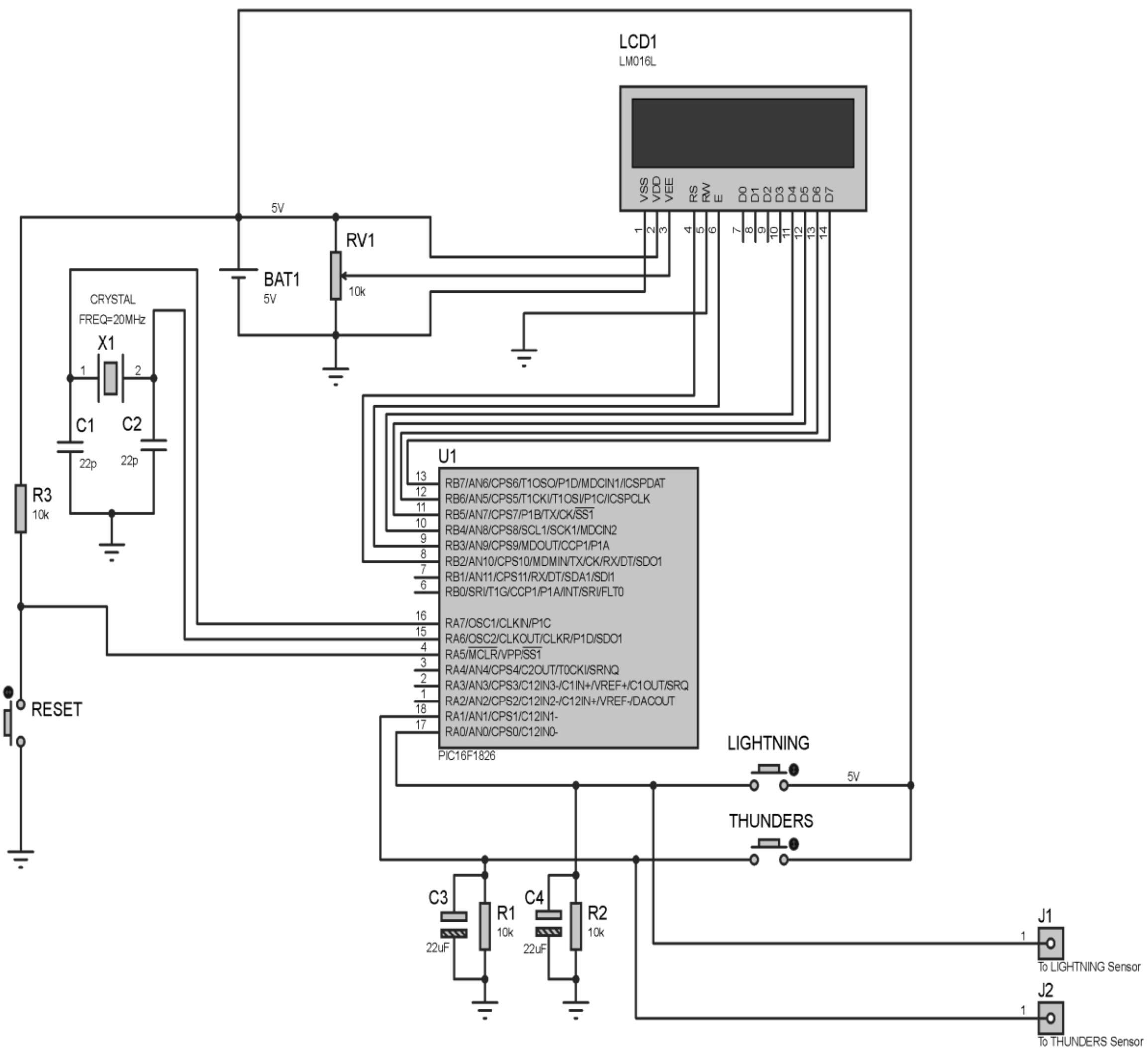


Figure 3: The fully working basic electrical schematic of the thunderstorms calculator

The central brain of the system is a 16F1826 microcontroller, but you can use any type of MCU. Its oscillation is performed thanks to the ceramic capacitors of 22pF and to the crystal of 20 MHz. The button "LIGHTNING" must be pressed when you see a lightning in the sky. The button "THUNDERS" must be pressed when you hear the thunder. PORTA0 and PORTA1 digital input ports are connected to the ground by two pull-down resistors (R1 and R2), that ensure a low digital level if the buttons are not pressed. The C3 and C4 electrolytic capacitors smooth the input signal, if it's very short or irregular (see figure 4).

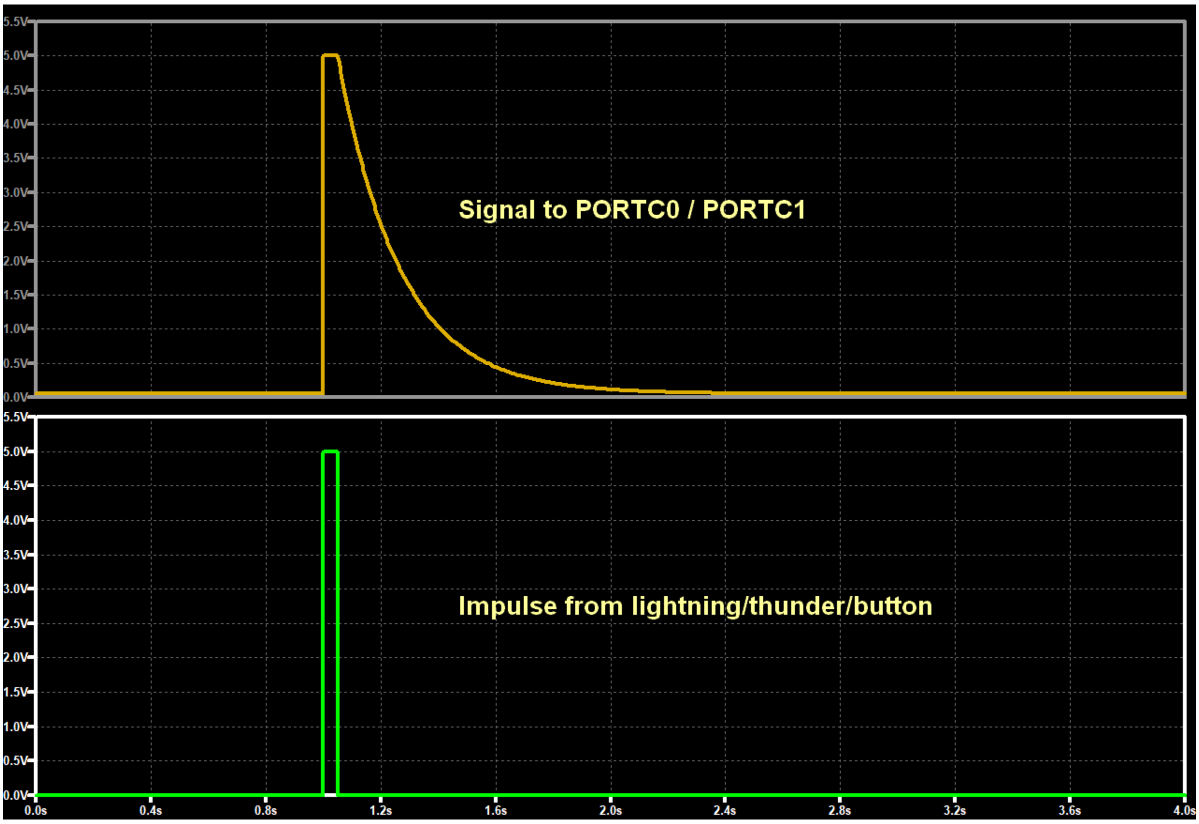


Figure 4: C3 and C4 act a debounce on the input signal

Then, the MCU calculates the distance of the thunderstorm and shows the results on an LCD. It uses only 4 data lines for its connection to the microcontroller. The RV1 potentiometer (or trimmer) allows setting the correct contrast of the display and it cannot be omitted. J1 and J2 are external connections, used to to automate the process of detection of lightning's and thunders. You can connect circuits and sensor to these terminals (see below in the article). The "Reset" button restarts the whole process when pressed.

Firmware and Flowchart:

The firmware of the microcontroller is written in Basic language with Proton compiler. No License Key is required to use PIC16F1826, and you can download it and compile for FREE. Obviously you can use any languages and any compilers. As you can see in figure 5, the firmware is divided in several parts. The first portion contains the declaration of the device used, the symbols, the variables and the setting of ports. The second portion waits for a lightning, checking the PORTA.0. A message on the display warns about this. The third portion waits for a thunder, counting the elapsed tenths of seconds and showing them on the display. The last portion performs the calculation of the distance of the thunderstorm (in meters), showing it on the display.

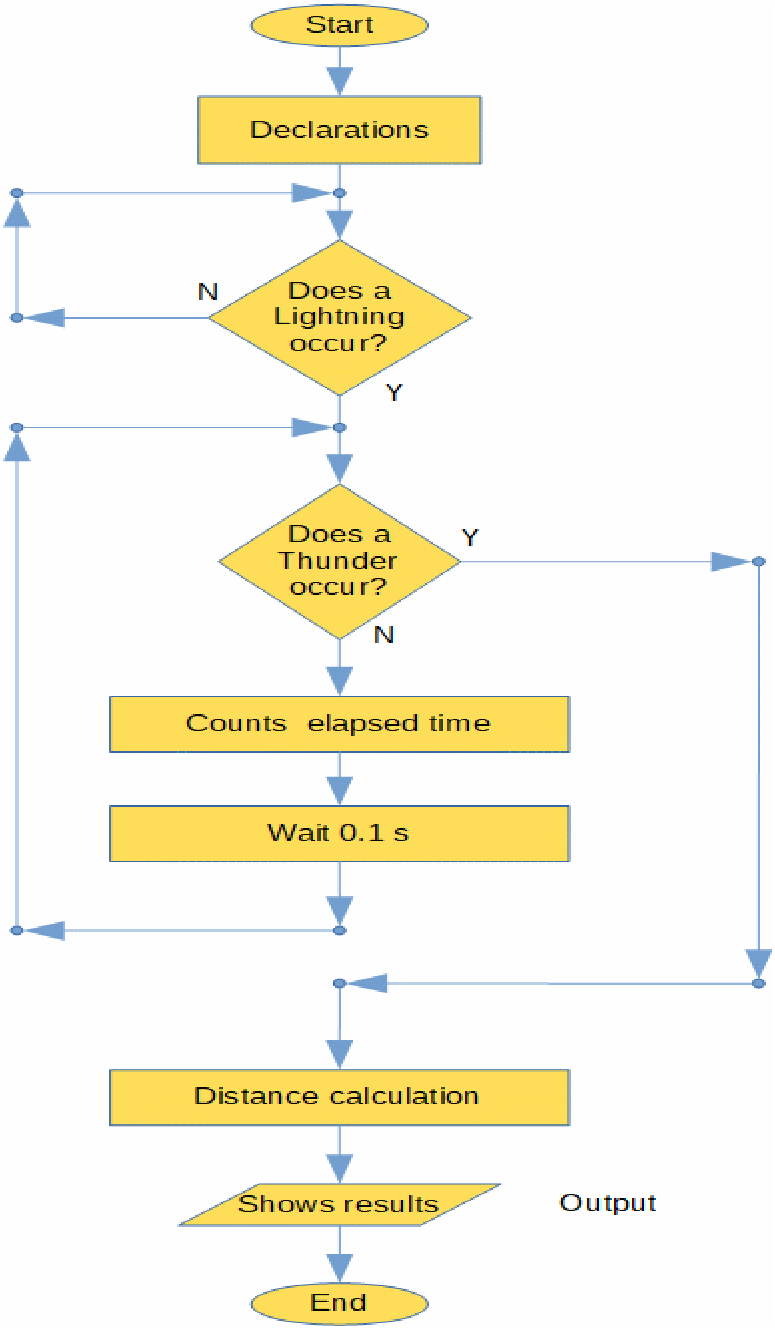


Figure 5: The flowchart of the firmware

Application:

Using the device is very simple. When it rains, switch on the circuit and wait for a lightning. The message "Wait ForLightn" appears on the screen of the display. When it occurs, immediately press the button labeled with "LIGHTNING" connected to PORTA.0. The counting of tenth of seconds starts until you press the second button labeled with "THUNDERS" and connected to PORTA.1, in correspondence with a thunder. The counting stops and the distance of thunderstorm, in meters, is shown on the display (see figure 6).

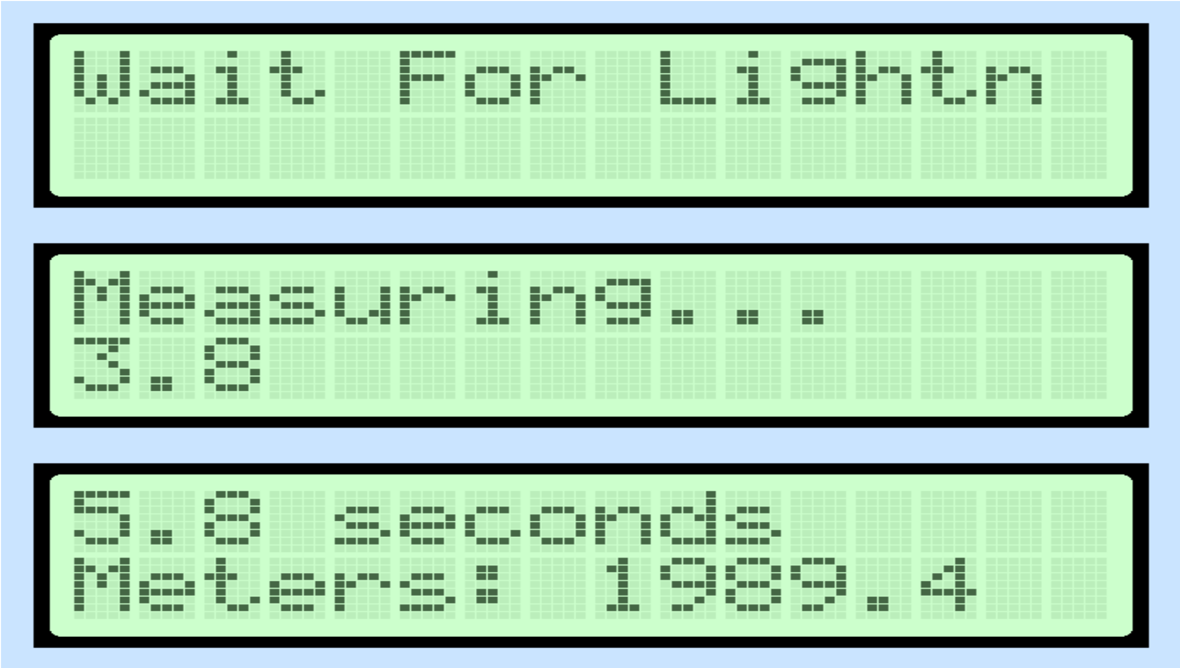


Figure 6: the operative sequences of the circuit

Electronic Components of Main System:

This is a list of the electronic components used to build the main system. The power dissipation of resistor can be 1/2W or 1/4W.

• R1-R2-R3: resistors 10k Ohm

• RV1: potentiometer 10k Ohm

• C1-C2: ceramic capacitors 22 pF

• C3-C4: electrolytic capacitors 22uF / 16 VL

• 3 buttons N/A

• LCD1: display LCD 16×2

• U1: microcontroller PIC16F1826

• X1: crystal 20 MHz

How to Automate the Detection Procedure?

The main system works very well but you must press the buttons when a lightning and a thunder occur. In any case, the manual procedure is the best because it avoids false detection by automatic sensors, and operators can choose how to perform it. However, to allow automatic detection you must build a lightning detector and a thunder detector. The former uses a light sensor; the latter uses an electrets microphone. Let's see the first general schematic. The solutions shown below are only generic examples. You can adopt any idea, according to your needs.

The Lightning Sensor:

This device must "capture" the light of a lightning, amplify it and translate the signal to a digital voltage between 0V and 5V (see figure 7). It must be read by the microcontroller. The sensor must be very fast, so the photo resistor is not good. You can use a photodiode. The gain of circuit is determined by the relation:

G=1+(R11/R10)

You can change the gain by choosing different values of resistors. The gain of opamp must be very high. The output signal must go to saturation because it has to be a digital signal.

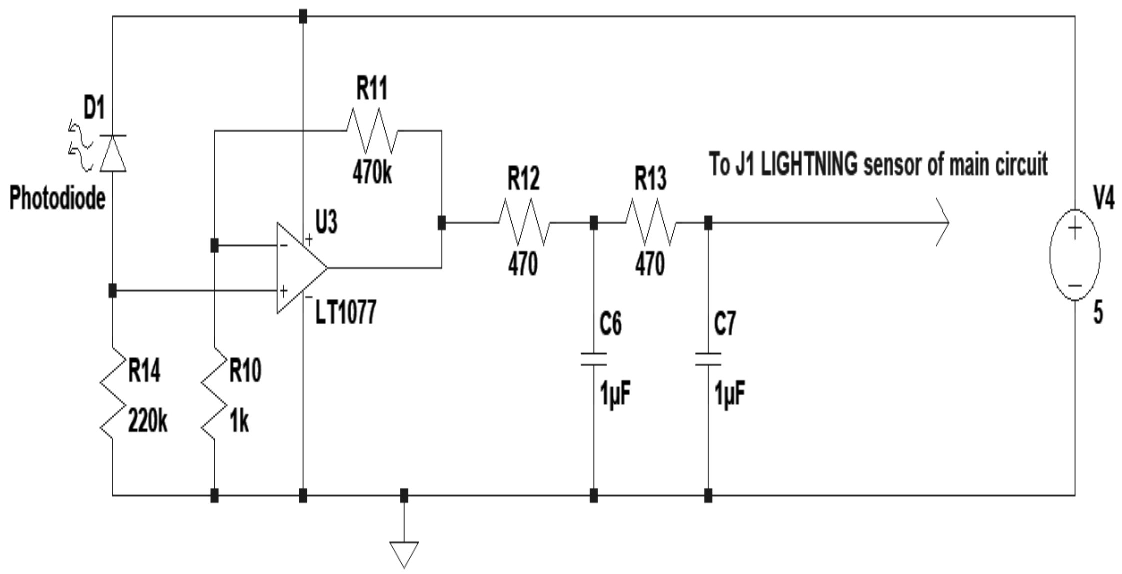


Figure 7: electrical schematic of the detector of lightning

This is a list of the electronic components used to build the Lightning sensor.

• R10: resistor 1k Ohm

• R11: resistor 470k Ohm

• R12-R13: resistor 470 Ohm

• R14: 220k Ohm

• C6-C7: electrolytic capacitors 1uF / 16VL

• D1: photodiode

• U3: opamp LT1077 or equivalent

The Thunder Sensor:

This device must “hear” the roar of a thunder, amplify it and translate the signal to a digital voltage between 0V and 5V. Also, it must be read by the microcontroller. The circuit, shown in figure 8, uses an electrets microphone and an opamp, to amplify the signal. This type of microphone must be powered through a resistor to work correctly. A low-pass filter ends the circuit and cuts the signals above 300 Hz. The low-pass filter can be modified or removed if you don’t like its response. The gain of circuit is determined by the relation:

G=1+(R6/R5)

You can change the gain by choosing different values of resistors. Also in this case, the gain of opamp must be very high. The output signal must go to saturation because it has to be a digital signal.

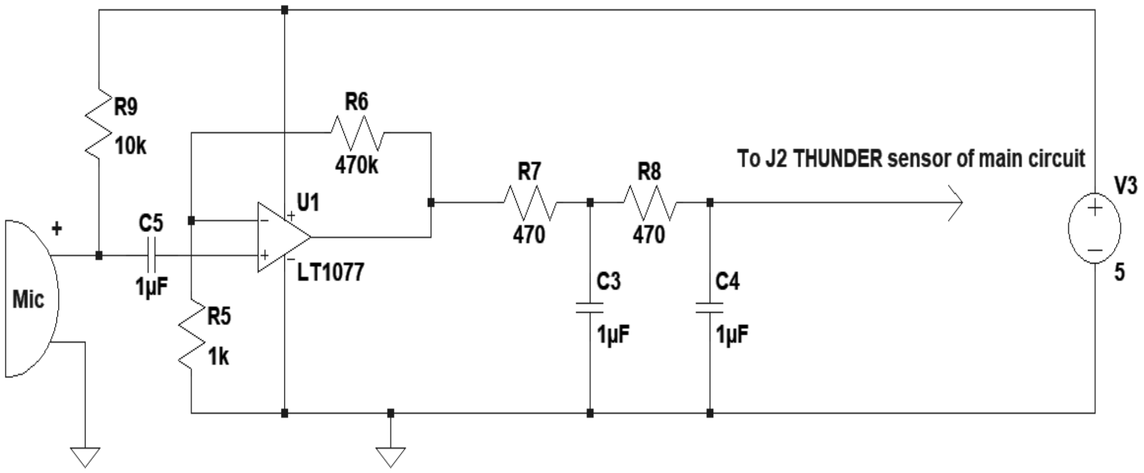


Figure 8: electrical schematic of the detector of thunder

This is a list of the electronic components used to build the Lightning sensor.

• R5: resistor 1k Ohm

• R6: resistor 470k Ohm

• R7-R8: resistor 470 Ohm

• R9: 10k Ohm

• C3-C4-C5: electrolytic capacitors 1uF / 16VL

• MIC: electrets microphone

• U31: opamp LT1077 or equivalent

Thunder is the noise caused by lightning. Its frequency is low but very powerful. As we can see in the graph of figure 9, a filter cuts high frequencies.

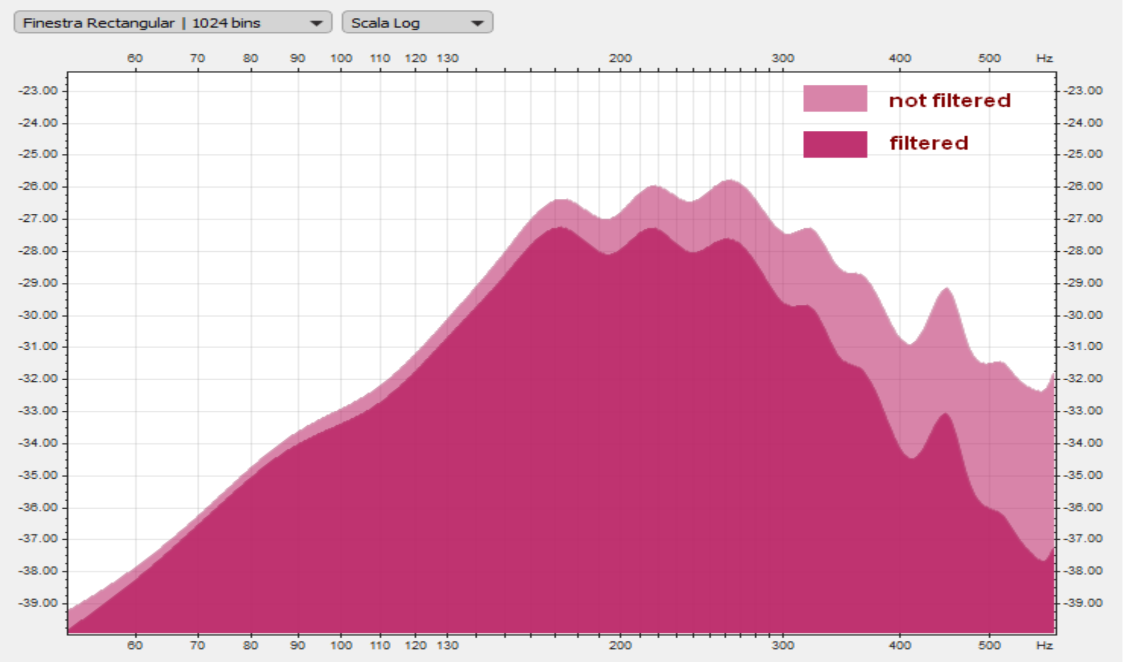


Figure 9: audio spectrum analysis of a thunder

Conclusion:

Using this device is very simple. We prefer manual use for its reliability. To get best results, point the microphone and the photodiode to the sky. It is very useful to know the distance of a thunderstorm. If it is arriving, you can reach a sheltered place to minimize the risk of accidents. Very often thunderstorms can be very dangerous. You can store your device in a plastic box to protect electronic components and give a beautiful design to the system. If you use the automatic sensors, the opamps can only be substituted with correspondent models.

How Hattie B's Continues to Bring Hot Chicken to the Masses with Technology

By Mr. Kadam Kishore Dhanaji (TE); Mr. Mithari Shrishail Satish (TE)

One of the coolest cuisines on the scene these days is hot chicken, the signature dish of Nashville and the comfort food of the South. Not only has hot chicken established itself as a cultural phenomenon, it has taken flight as it rapidly works its way up the East Coast and across the United States.

At Hattie B's, we love hot chicken and are determined to bring the heat to the masses. Our executive chef, John Lasater, has worked hard to put a unique spin on this tasty dish, ensuring that every bite delivers just the right flash of juicy, spicy flavor. His formula has seemed to be working since August 2012, when we opened the original Hattie B's in central Nashville. We've additionally opened seven more successful locations across the city and in Birmingham, Memphis, Atlanta, and Las Vegas.

But growth this heated comes with unique challenges. The main concern for us was how we could ensure that our food safety and quality programs were enforced consistently and rigorously at all our locations. Because we were expanding outside of Nashville and into other states, this was especially critical. "As we've started to expand our business, thanks to the success we've seen, I want a good QA and food safety program in place to cover all our bases," said John. "That way, we can protect our customers and our brand and continue to take advantage of new opportunities."

In order to do this, we implemented Compliance Mate, an automated temperature-monitoring and food safety checklist system. Compliance Mate proactively tracks temperatures in refrigerators and freezers, eliminates human error in manually checking temps and other food safety procedures, and takes 50% less computer time than manual procedures. That returns time back to our staff to focus on other areas of the restaurant. It also ensures consistency across locations. So when the temperatures in our refrigerators go out of range into unsafe territory, the system notifies us in real time, letting us make corrections immediately to ensure that our food remains fresh, flavorful, and safe — everywhere.

In order to successfully implement more effective food safety systems and drive greater efficiencies, Laird Connectivity, a supplier of wireless connectivity solutions, integrated Semtech'sLoRa devices and the LoRaWAN protocol into temperature-monitoring sensors developed for the Compliance Mate solution. LoRa is the most advanced wireless communication technology available today. The LoRa-enabled sensor can penetrate stainless steel doors and concrete walls, and it can even reach across significant distances, like buildings with multiple stories. Even better, the LoRa tech boosts battery efficiency; LoRa-enabled sensors have a much longer lifespan when compared to traditional batteries.

Together, LoRa and Compliance Mate can be a lifesaver. In late March, a massive power outage struck downtown Nashville *after* we had closed for the night and our team had gone home. The entire city went dark, but Compliance Mate and its LoRa-based alert system notified our management team immediately when temps started rising. As a result, we were able to successfully move perishable food to a safe location until power was restored. If we hadn’t received that alert, we could have lost up to $50,000 worth of inventory in a single night.

Our business is pleasing customers with the best hot chicken around, and the thought of anything less than the best food safety system leaves us cold. The reliability of our food quality and safety protocol has not only strengthened our food safety and quality assurance, it has helped to ease the growing pains that come with business expansion and deliver an outstanding customer experience. That way, we can focus fully on delivering the most palate-pleasing hot chicken in Nashville — or anywhere.

How the IoT is making Heavy Equipment Safer and More Efficient

By Ms. Kamat Neha (BE); Ms. Desai Kshitija Sunil (BE)

Heavy equipment represents a large list of heavy vehicles, engineering equipment, and bulky industrial machinery. Things or characteristics that one would expect from heavy equipment are oversized dimensions, long life expectancy, and improved equipment performance, as these machines are a fundamental part of the workflow process in many industries. Safety and efficiency are the key concerns for companies that extensively use such equipment.

Heavy equipment is mainly used extensively in industries such as construction, oil and gas, mining, forestry, energy, civil engineering, military engineering, transportation, and many others. Industrial heavy machines include construction equipment, wheel loaders, oilfield pieces, manufacturing equipment, earthmovers, hydraulic cranes, bulldozers, oversized trucks, forklifts, and more. Organizations rely on heavy machinery to speed up production and to avoid human errors or health risks.

With developments in IoT, it is possible to decrease equipment downtime while improving the efficiency of the output. Companies that supply industrial machinery and components are seeing strong interest in connected machinery and components with IoT integration. IoT-powered asset management solutions offer a host of benefits, including predictive maintenance to prevent equipment failure, increased asset reliability, improved asset health, accident avoidance in the workplace, and downtime reduction.

Smart Asset Monitoring with IoT:

Safety of personnel and assets, theft or pilferage of assets, accidents and resulting injuries, and bottlenecks in the supply chain are some of the common challenges that are prevalent in asset-intensive industries like manufacturing, utilities, construction. By improving visibility into day-to-day operations, replacing legacy systems with an integrated solution and automating manual processes, many of these challenges can be overcome.

Digitalization, combining connected devices with IoT solutions, can help to overcome these issues. End-to-end clarity on the status of the equipment enables improved decision-making, increases asset reliability, and also improves the people and process efficiency. With the advances in technology, mature organizations have heavy machinery that is computerized, automated and enabled with connectivity and big data analytics, which increases the efficiency of the overall product development process.

Use cases: IoT in Heavy Machinery Management:

Let's take a look at some of the use cases where IoT is transforming the way heavy equipment and related assets are managed.

Smart Heavy Equipment in Warehouse Management:

Material handling equipment like trucks, forklifts, pallet trucks, and pump trucks are very important for any warehouse to perform daily activities such as loading, unloading, transporting goods to different areas, and picking goods from risky areas. Needless to say, these machines and their operators need to be managed properly to minimize the chances of accidents. Warehouse operators need to take preventive measures for vehicle accidents and injuries that occur while from shifting material, and take proper care while handling hazardous materials.

Today, futuristic warehouses are using driverless robotic equipment to assist in picking and moving operations. Guidance systems like global positioning system (GPS), lasers, and radio-frequency identification (RFID) are used in such warehouses and equipment.

For example, advanced driverless pallet trucks and forklifts are equipped with audible warnings and lights and have built-in sensors to detect obstructions. These sensors come with lasers or camera systems, which are positioned to detect objects and activity from the floor and are able to determine the height and distance around all sides of vehicles and warehouse corners. This makes the equipment intelligent – it knows when to slow down and stop to avoid a collision.

With the recent advances in IoT for warehouse equipment, the market has a new breed of smart forklifts that come equipped with 360-degree detection forklift antenna, which is able to detect when the workers come into forklift zone. When a worker is detected within the predefined danger zone, audio and visual alarms are set off inside the forklift cab to alert the driver. This helps to reduce the risk of injuries and property damage.

Smart Heavy Equipment in the Construction Sector:

According to a Market and Markets report, the heavy construction equipment market size is estimated to grow from USD 121.46 Billion in 2015 to USD 180.66 Billion by 2020, at a CAGR of 7.0%. Depending on the construction application, heavy machines are mainly categorized into four types:

Earthmoving equipment construction vehicles material handling equipment construction equipment

Wireless technology has a huge impact on the construction industry to provide connectivity for heavy equipment. These machines use technology-enabled devices combined with cloud computing solutions, allowing storage and sharing of data.

IoT is playing a key role in boosting productivity, improving preventive maintenance, minimizing downtime, and reducing repair costs. Sensors integrated with the equipment are able to detect and send automated alerts related to the status of the equipment systems and parts. They can also compile and analyze usage and maintenance data, helping with preventive and predictive maintenance.

One of the major problems in the construction industry is injuries caused due to accidents involving people and heavy equipment. As the number of heavy equipment continues to rise, the risk also increases. IoT can help to make the equipment smarter and safer.

Additionally, IoT can help to track assets as they move around the site, or to a different site, ensuring that the assets are never stolen or lost – an ongoing issue on large construction sites that causes delays and decreases productivity.

Smart Heavy Equipment in Transport and Logistics:

Transportation and logistics businesses want to optimize the supply chain. Many transportation companies are already using mobile devices, such as barcode scanners, mobile computing devices, and radio frequency identification (RFID) to solve challenges related to the supply chain. With RFID, many companies are achieving a high level of shipping and receiving accuracy, inventory accuracy, and faster order processing, along with a reduction in labor costs.

However, due to drivers' careless behavior, while driving heavy trucks or conveyors, company owners have to shell out a big amount for accident-related injuries, material loss or shipping delays. By using advanced technology that is capable of monitoring driver's behavior and delivering alerts in case of possible collisions, the risk of these issues can be minimized.

Computer vision-based techniques and ADAS solutions, with a number of onboard sensors, can help with lane detection, traffic signal detection, driver behavior detection, GPS tracking, fuel management, report generation, notification alert, and predictive maintenance.

Using such solutions, the driver receives support to detect and avoid accidents. It is also possible to monitor a driver operating a heavy machine and automatic alerts can be generated if the driver is sleepy or inactive for a long duration.

Another effective solution for tracking of heavy machines/vehicles is based on installing GPS fleet tracking devices on the vehicles to gain real-time data updates. This is an efficient and secure solution that helps to resolve issues related to operational inefficiencies, theft, and fleet maintenance, increasing the overall productivity of the machines and vehicles.

How to Design a Tesla Coil?

By Mr. Bodde Sammed (BE) and Mr. Goud Avinash (BE)

Electric current is often magic and mysterious. Before people knew about electricity, many natural phenomena appeared as supernatural events caused by angry gods. Fortunately, people today know physics laws, and they can operate with them according to their needs without problems.

A Tesla coil is a resonant circuit composed by two LC circuits, inductively coupled. In other words, it's a transformer with a primary circuit and secondary circuits that can raise the electrical voltage to produce sparks. Under normal conditions, the air can be considered an insulator. A voltage applied between two isolated points does not cause the passage of any electrical current. If the voltage is increased, the electric field can become intense enough to receive the energy for ionizing other particles. The phenomenon is amplified with a progressive increase in moving ions. An electric current is established with heating of the area that causes further ionization of the air. A highly ionized gaseous channel is created, which acts as an electrical conductor, capable of sustaining an electric arc. The spark has an intense glow in a very short duration on a zigzag path, with a detonating sound. Lightning is a spark of great intensity. To trigger the spark, the electric field must exceed the rigidity threshold of the dielectric. For standard air, it's about 3 kV/mm, but it decreases easily with humidity. To produce a spark of 10 cm, you must supply a voltage of about 300,000 V (300 kV).

Length of spark:

With this very general formula, you can measure the voltage between two conductors by measuring the length of the sparks. When a potential difference is applied between two electrodes, an electric field is formed:

$$E = V * d$$

where "V" is the voltage and "d" is the distance between the electrodes. For each material, there is a value, known as the breaking point, which represents the minimum electric field necessary to trigger a spark. To generate a spark of 1 cm, it is necessary to apply 30 kV. To know the voltage between two electrodes, simply multiply the length of the spark (in centimeters) by 30 kV, at a temperature of 25°C with dry air. This method works with two spherical electrodes. The value may vary based on pressure and humidity. As shown in Figure 1, it is really hard to generate big sparks. For a spark of 10 cm, it needs a voltage of 300,000 V, and for a spark of half a meter, you must supply about 1,500,000 V really very dangerous.

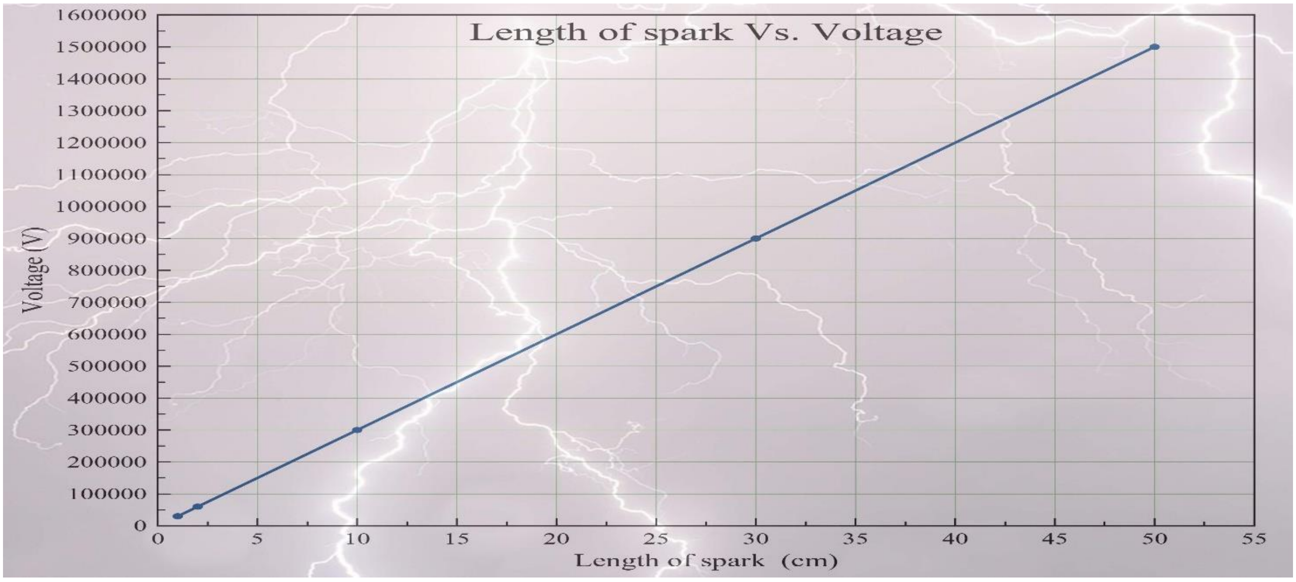


Figure 1: Graph of the length of spark vs. voltage

It’s very impressive how nature can produce very big lightning bolts of millions of volts!

How does it work?

We know that a Tesla coil, created by Nikola Tesla, is a special resonant transformer with two coupled coils. A Tesla coil transformer operates differently than a traditional transformer with an iron core. In a conventional transformer, the two coils generate a voltage gain, which depends on the ratio of the number of turns. In a Tesla coil, on the other hand, the gain can be much larger because it is proportional to: $\sqrt{L2/L1}$.

The right balance between the individual parts allows a coupling capable of generating an electromagnetic wave suitable of lighting a luminescence lamp. It has an air core. Its operating frequency is between 50 KHz and 30 MHz The coil transfers energy from the primary to the secondary. The voltage produced on the secondary increases until all the energy of the primary circuit has been transferred to the secondary one. The system is based on an RLC group and on a sinusoidal generator, as shown in Figure 2. An RLC circuit is an electrical circuit consisting of a resistor (R), an inductor (L), and a capacitor (C), connected in series. The transformer on air steps the input voltage up 100× to create a high voltage. After a few seconds, the voltage is high enough to fire the spark gap. The capacitor and the primary coil of the second transformer then form a resonant circuit. The secondary transformer coil is attached to a toroid, representing capacitor connected to ground. It also forms a resonant circuit with the same resonant frequency. The energy is gradually transferred from the first circuit to the second, then the spark gap stops conducting, leaving all the energy in the toroid circuit. Once the spark gap stops conducting, it takes a while for the voltage to build up enough for it to fire again.

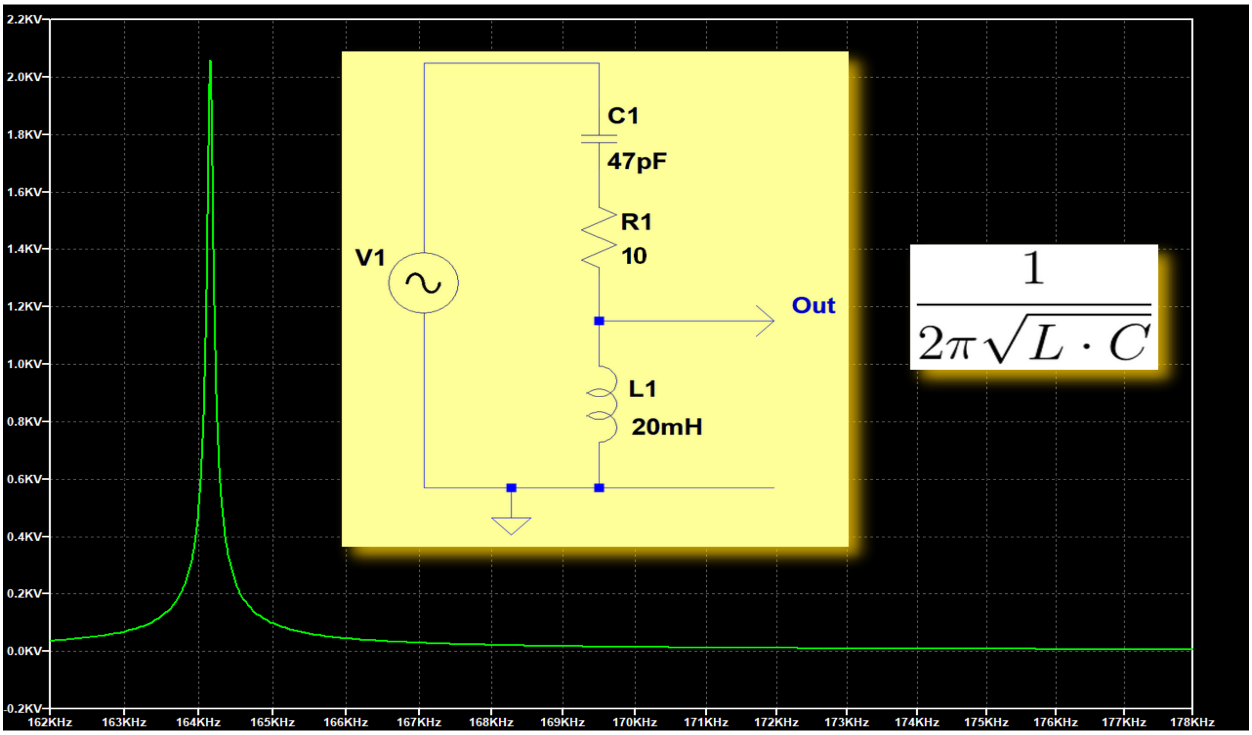


Figure 2: An RLC circuit and the graph of its output, in the domain of frequency

The example of the figure consists of a resistor of 10 Ω (it determines the Q factor of circuit), a capacitor of 47 pF, and an inductor of 20 mH. To calculate the frequency of resonance of the circuit (in the example, it's 164,155.78 Hz) you can use the formula shown in the box. If the RLC circuit is supplied exactly at its resonance frequency, on the inductor, we obtain a much higher voltage than that which is applied to the input. In these conditions, the circuit is, for the voltage generator, a perfectly resistive load. For these characteristics, we understand that the construction of the coils cannot be random but must be the result of precise and accurate calculus and formulas.

General schematic:

Figure 3 shows a general but fully working schematic of a Tesla coil. The spinterometer and the capacitor (tank) can be mounted according to two different configurations. Let's illustrate its components. The construction is not hard, but it requires care.

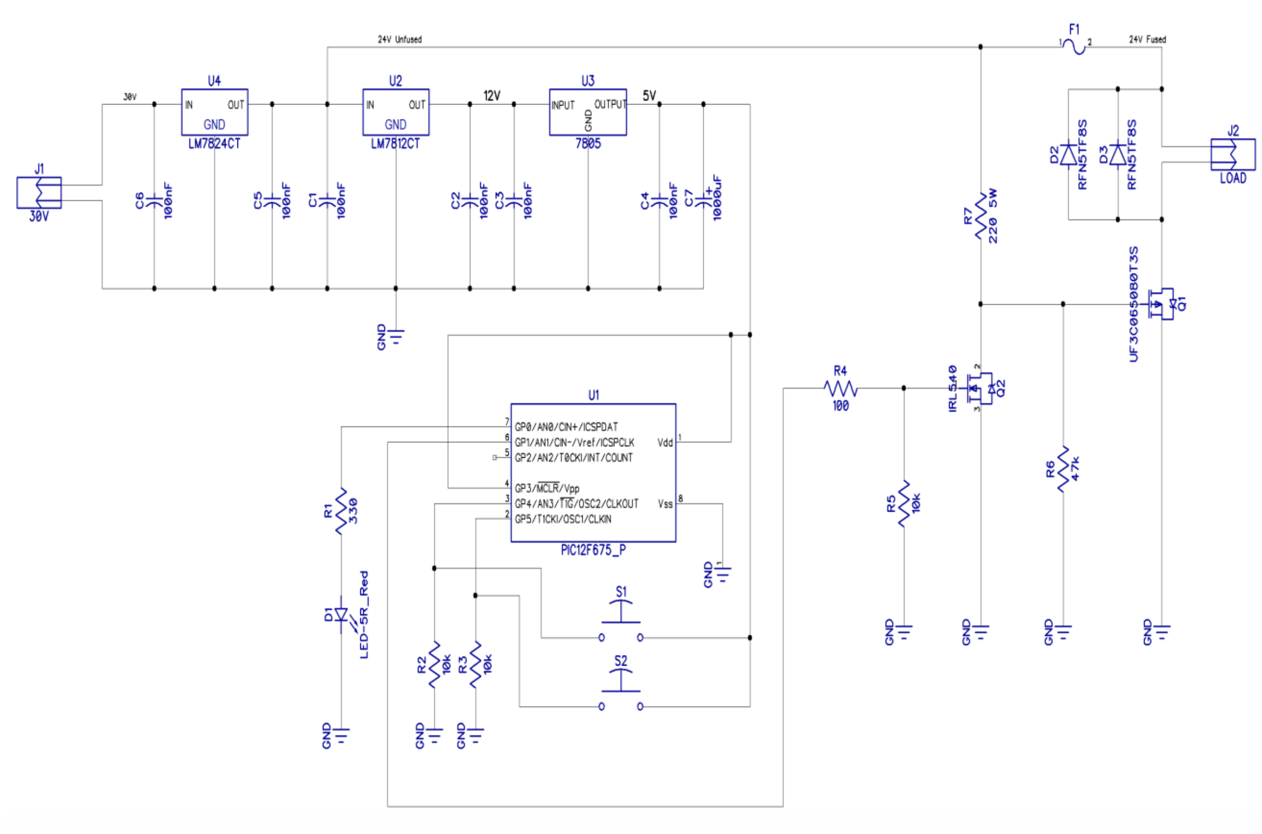


Figure 3: General schematic of the Tesla coil

The transformer T1 increases and elevates the input voltage to about 10 kV. This component is usually used to illuminate advertising signs with neon. You cannot use a traditional transformer. The capacitor C1, a Leyda's bottle or a high-voltage capacitor, is connected in parallel to the secondary of the transformer. C1 charges and discharges its voltage at the frequency of the input voltage. It's interesting to note that the input voltage can be also a DC voltage (but without the first transformer). When the difference of the potential on C1 exceeds the limits imposed by the spinterometer, a spark occurs between its terminals and a strong current flows through L1, discharging the capacitor. The spark closes the circuit. L1 and L2 are two components of a transformer -L1 is the primary and L2 is the secondary. On the terminals of L2, a very high voltage will be present. The power of the current on the coils depends on the capacity of C1. You can connect several capacitors in parallel. It's very important that this component be suitable for the used voltages. On the other hand, you can connect in series and in parallel many capacitors to obtain the requested operative voltage.

Construction:

As said before, the transformer T1 works as elevator of the input voltage. Be careful when handling it. As shown in Figure 4, the primary coil L1 is made with a thick wire wrapped around to plastic support with a diameter of 25 cm. The construction of L2 is very tedious. You can use a long plastic tube with a diameter of 12 cm. For optimal performance, it’s a good idea to treat the support with a plastic paint. The coil is composed by 2,000 turns of enameled wire of 0.4 mm (26 AWG).

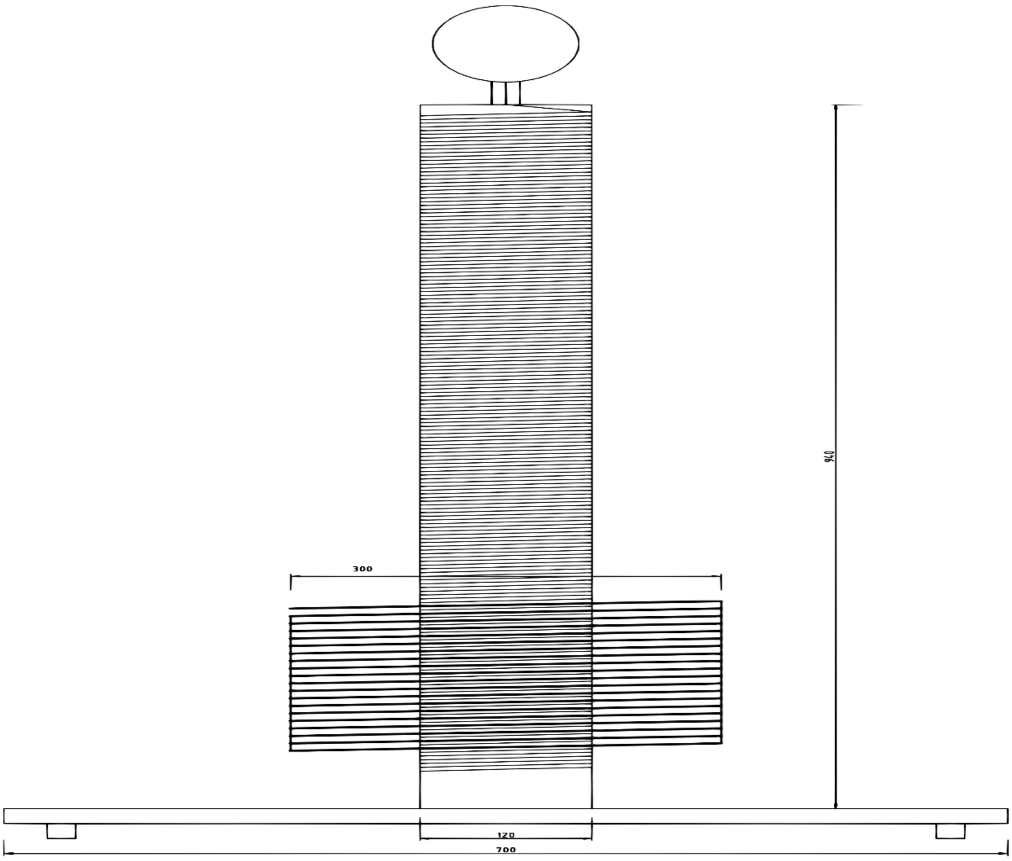


Figure 4: Design and measurements of the coils

The capacitors must be chosen and built with care. You cannot use normal capacitors. The difference of potential is very high and the components could be destroyed. It can follow the project of a Leyden jar or you can connect together many polyester capacitors in series/parallel to obtain the maximum amount of capacity and voltage of at least 15,000 V. The capacitors must not be polarized. You can build a very efficient capacitor using two aluminum foil glued to a glass plate, in the opposite faces. With the dimensions of 50 × 50 cm, and a thickness of glass of 3 mm, you can get a capacitor of 7,378 pF. Glass has a very high dielectric constant. Anyway, this capacitor can be smaller. Figure 5 shows different examples of high-voltage capacitors.

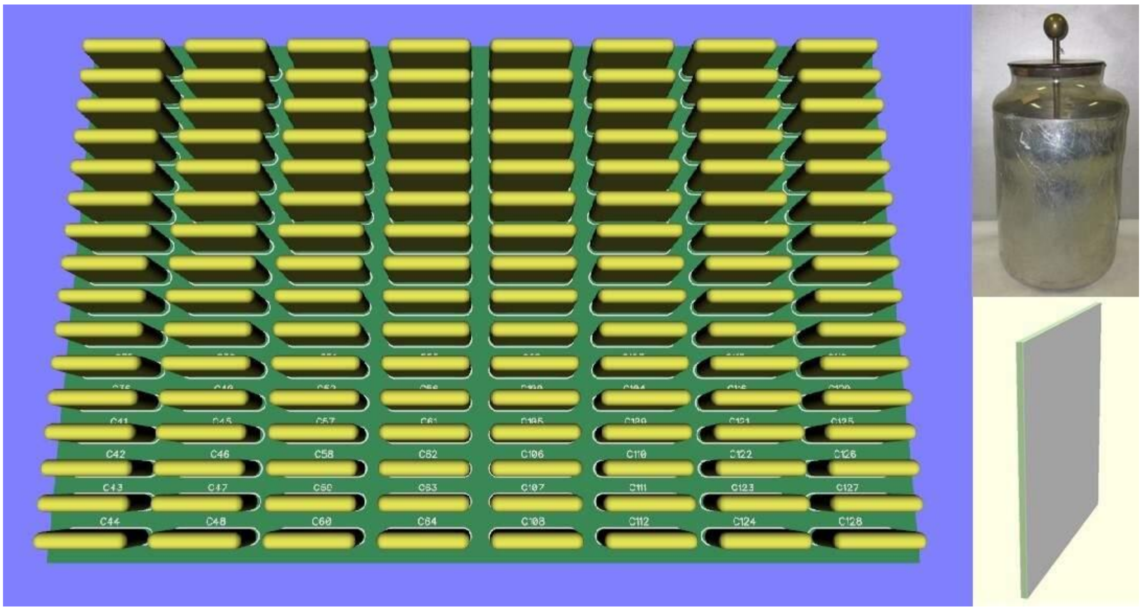


Figure 5: Different examples of high-voltage capacitors

The spinterometer is a very easy component and is very important. It is a device used to generate electrical discharges in the air through two electrodes. It consists of two spheres. The distance between the terminals can be progressively reduced until the intensity of the electric field exceeds the dielectric rigidity value of the air and a spark occurs. You can see an example of a spinterometer in Figure 6.

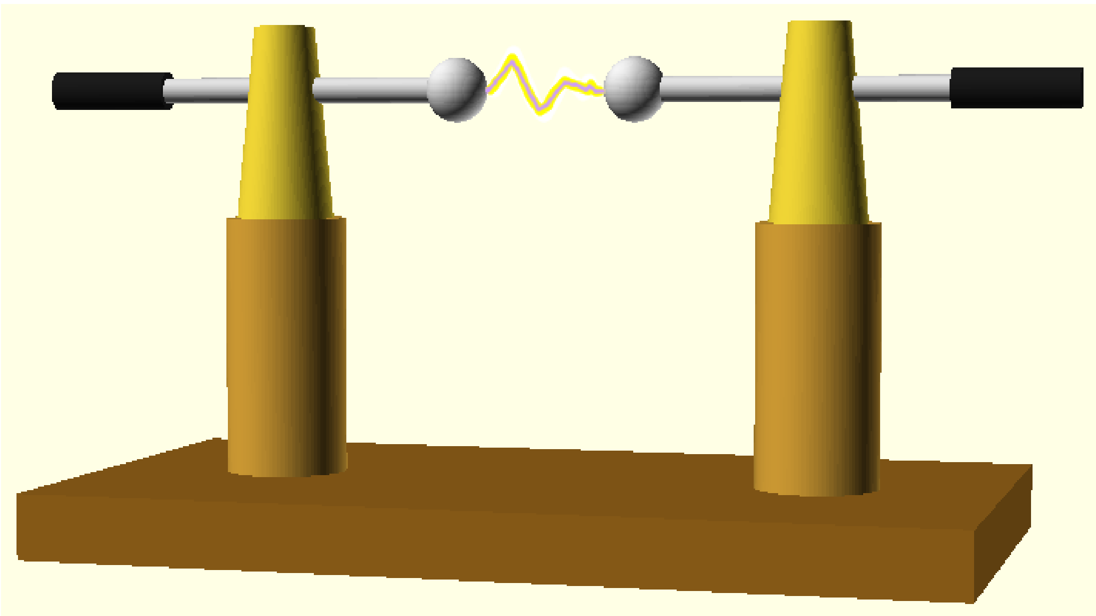


Figure: Example of a spinterometer

During the construction, pay attention to insulate the critical parts of the circuit.

Use:

When the construction is done, you can soon test the device. Be careful with any operations. The setup must be executed without electric connection. The sparks could be very painful. When the device is turned off, you can adjust the distance between the two spheres of the spinterometer to get a spark. To adjust the spark, move the two spheres away about 5 cm apart. Then approach the electrodes in small steps, turning off the device each time. The power of the sparks is proportional to the capacity of the capacitor. Once you get the sparks in the spinterometer, the secondary coil is ready to produce a special effect. From its top, you can produce large sparks, approaching metal objects to the sphere on the coil. You must keep them with a long insulated handle (wood or plastic). The length of the sparks (electric arcs) is proportional to voltage across the secondary coil. Don't touch any part of the circuit with your hands. A spark of 20 cm is a very good result.

Tuning

The Tesla coil is similar to a radio receiver. It has to tune to the resonance frequency to get the best performance from it. To improve the efficiency of the device, we suggest the following solutions:

• Increase or decrease the number of turns of the primary coil.

• Increase or decrease the number of turns of the secondary coil.

• Move closer or further away the two spheres of the spinterometer among them by some millimeters (remember to switch off the power).

• Increase as much as possible the capacity of the tank of capacitors.

• Change the connection on different circles on the primary coil, as shown in Figure 7.

• Use good quality materials and good components.

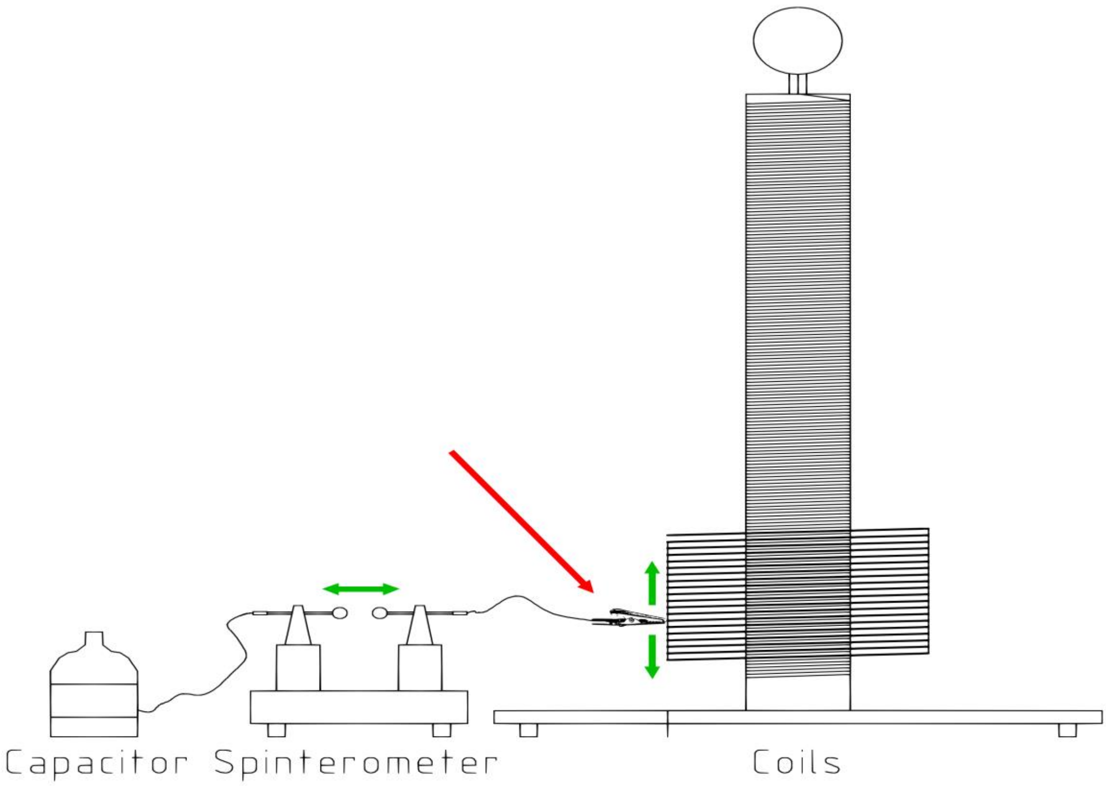


Figure 7: You can improve the coupling of the LC circuit by changing the value of inductance of the primary coil with a different position of the connection.

Conclusion

There are many solutions to build a Tesla coil. This is probably the easiest one. Be careful while you work with these circuits, as the voltage is very high. During the operation of the Tesla coil, a strong ozone smell is left in the air. Eventually, you can build a smaller version of the device and then you can increase the power of the Tesla coil. In Figure 8, you can see a complete Tesla coil. In it, we can distinguish (from left to right):

- the transformer (230 V to 10,000 V)
- the HV capacitor
- the spinterometer
- the two coils (primary and secondary)

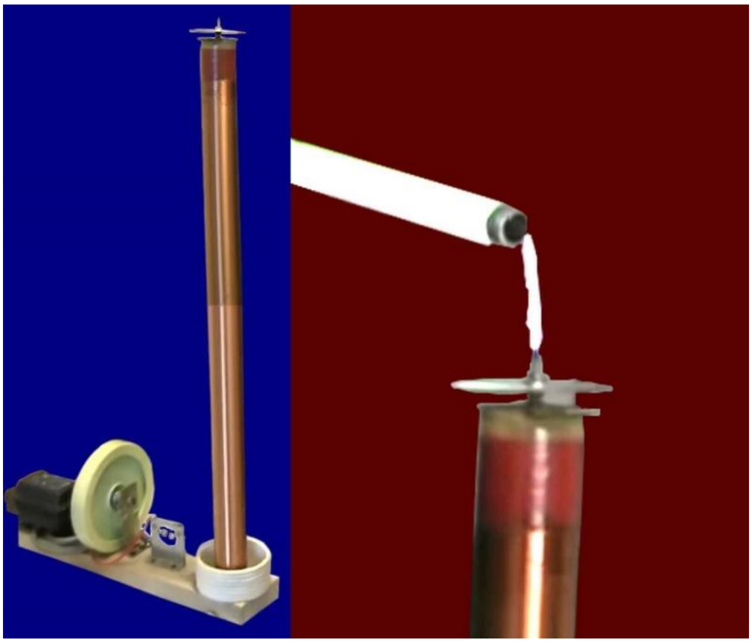


Figure: A complete Tesla coil

Reactive Power Compensation in Electrical Plants with Generators

By Ms. Mulla Saba (BE) and Ms. Patil Manali Sunil (BE)

Compensation of Reactive Power:

Compensation of reactive power applied in buildings or small facilities operates in the first and second quadrants of the coordinate system. Increasingly, complex industrial plants, for example plants burning wood dust, are using generators driven by steam engines running parallel to the main supply.

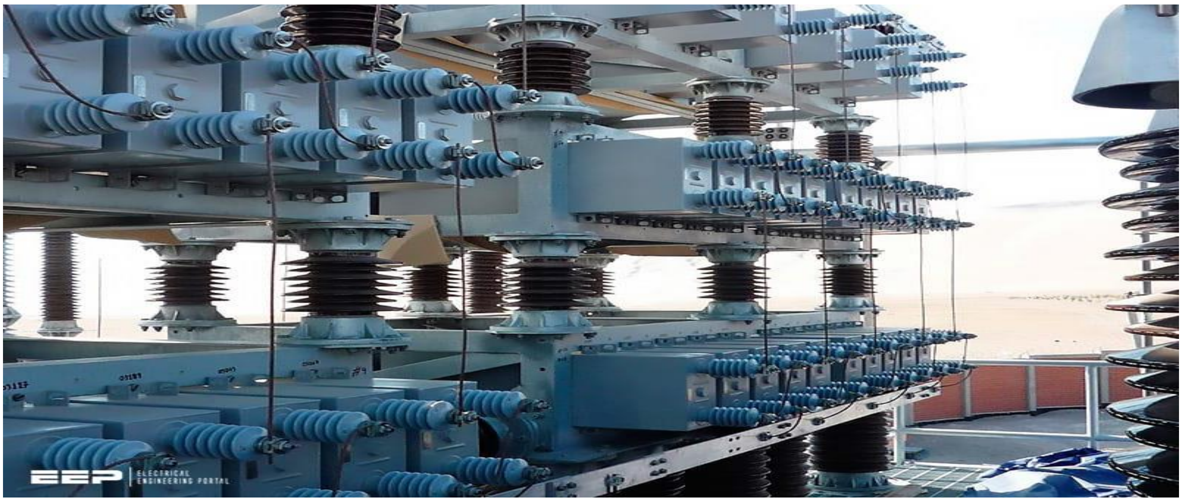


Fig: Reactive power compensation in electrical plants with generators
(photo credit: ingelmec.com.pe)

This technical article explains the technical and economic aspects regarding the desired power factor or reactive energy to be charged. If generators are feeding back active energy to the distribution company, one speaks of four-quadrant operation.

The tariff situation then has new aspects with regard to the reactive energy consumption to be charged. The tariff requiring an average power factor of cos φ = 0.9 lagging becomes invalid as explained in the following paragraphs.

Furthermore, it renders prominent the meanings of power factor cos φ and reactive power Q as totally different electro-physical quantities. One could describe them in an inequality like:

$\cos\varphi \neq Q \neq \cos\varphi$

Thus power factor is not identical to reactive power and vice versa.

Table of contents:

1. The complexity of putting generator(s) into action

Any plan for putting generator(s) into action **must be declared to the electricity supplier and registered in a specially negotiated contract**. It determines to which incoming supply (if more than one) the generator should be connected. Specifications issued by national or international institutions should be strictly followed.

First of all, power generator units running steadily in parallel to the main supply must be distinguished from emergency power generator units at hospitals that are activated in case of any fault or collapse in the main supply. Emergency power generator units are in use for a short time, mainly until the grid is active again. This situation may be excluded by referring to four-quadrant operation.

Power generator units may be driven by primary energy sources like water or wind power, solar cell plants, cogeneration district heating plants or fuel cells. The electrical energy may be generated by synchronous or asynchronous generators as well as by DC generators with DC/AC converters.

The following criteria on driving generators in parallel to the grid are to be noted: voltage stability, quality of the voltage and synchronized frequency. It must further be taken into consideration whether an autarchic operation will be intended.

However, this is possible **mainly with synchronous generators**.

2. Automatic Control of Reactive Power within Four Quadrants

2.1 Technical Considerations

Figure 1 illustrates the four quadrants of a coordinate system. If generators are in operation four different load situations may occur:

- **Quadrant I:** Consumers import (+) active and reactive energy.
- **Quadrant II:** Consumers import (+) active energy and export (−) reactive energy.
- **Quadrant III:** Consumers export (−) active and reactive energy.
- **Quadrant IV:** Consumers export (−) active energy but import (+) reactive energy.

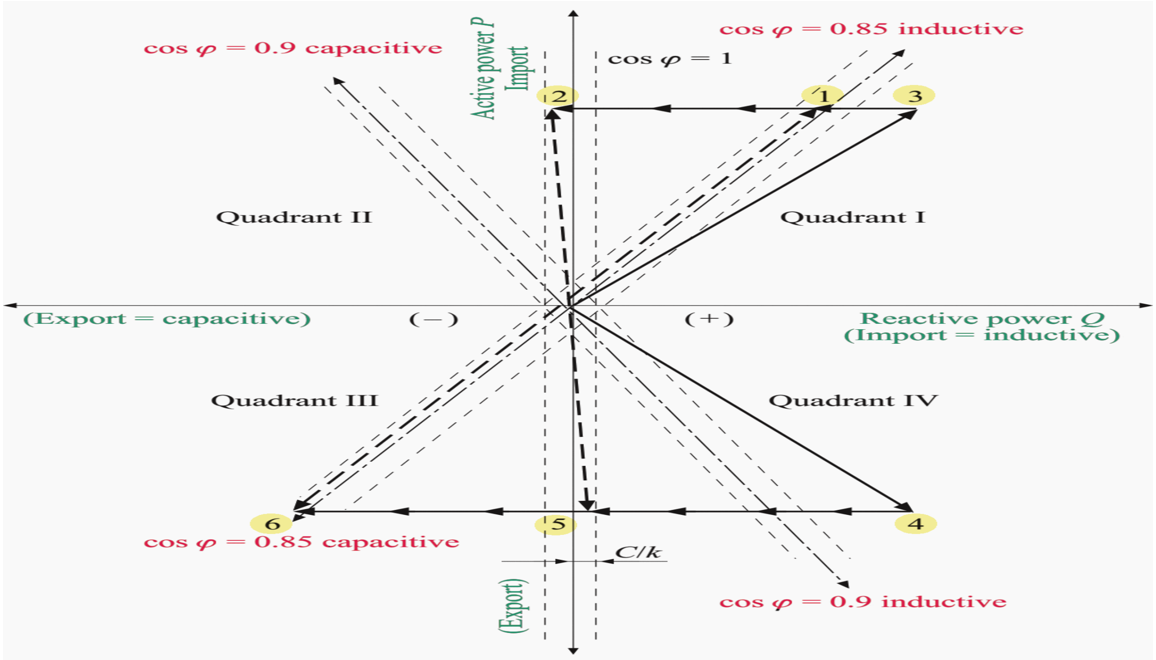


Figure 1 – Reactive power control within all four quadrants

In quadrants III and IV the generators are feeding back active energy to the electricity supplier to be measured by a separate kWh-meter.

Most attention is paid to the situation within quadrant IV! Asynchronous generators especially are able to feedback active energy to the grid, but they import reactive energy for magnetizing!

The situation in quadrants I and II is well known and can be referred as a standard. There the control of reactive power is explained by means of an automatic controller. One can recognize the insensitive bandwidth limited by the so-called C/k threshold lines and the turning around of the zero point of the coordinate system depending on the selected power factor target.

Figure 1 indicates two selected power factor targets: **0.85 lagging and preset to unity**.

Regarding load vector 3, one capacitor step is sufficient to achieve the power factor of approximately 0.85 lagging and the controller ‘stands by’. In order to achieve the desired power factor of **cos φ = 1**, the reactive power controller switches in three further capacitors.

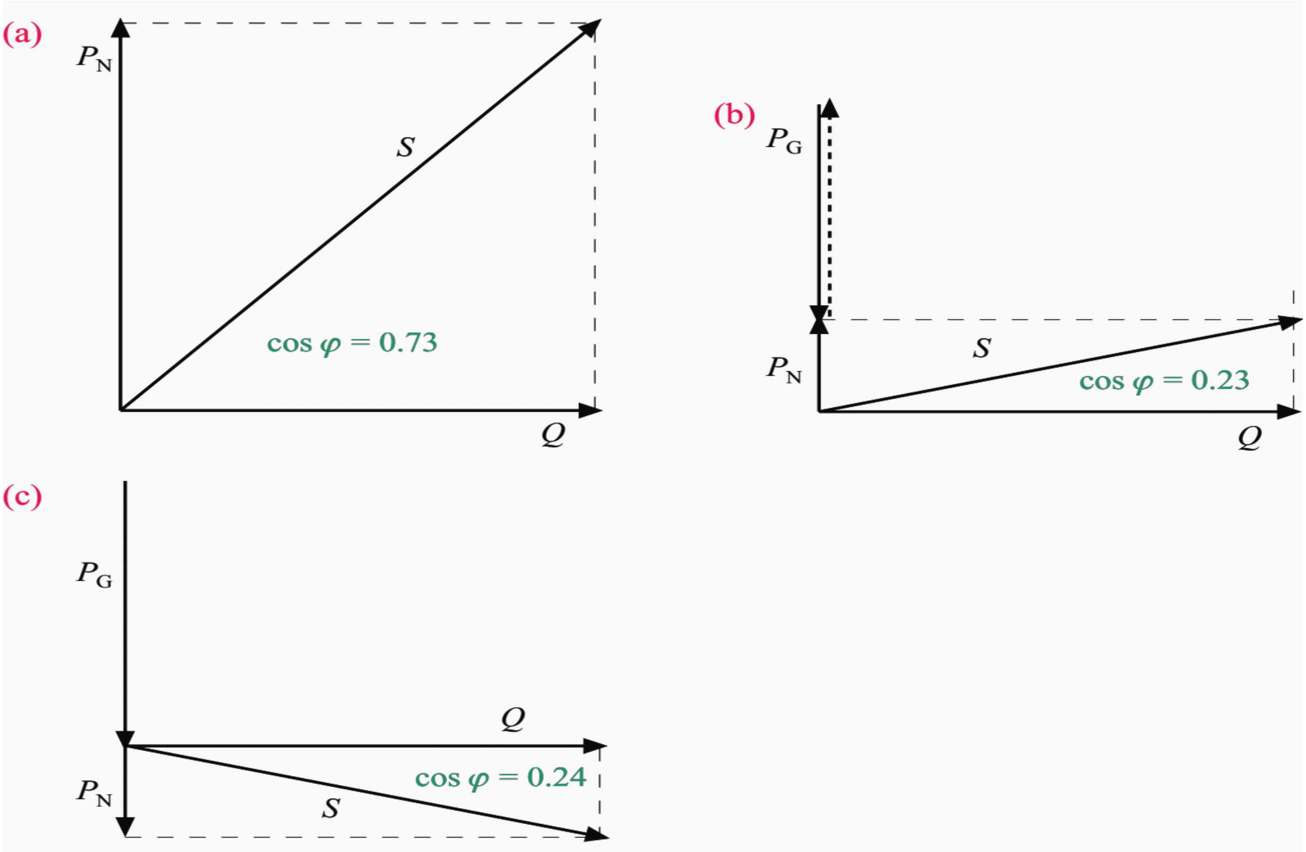


Figure 2 – 'Confusing power factors' in four-quadrant operation (current transformer fitted at incoming supply point)

Even though a generator is running in parallel just to reduce the consumption of the active energy from the main supply, the vectors are still moving within the first or second quadrant only (see Figure 2b).

However, if the generator takes over the complete active power consumption and even feeds back active energy into the electricity supplier's grid, then the vectors change into the third or fourth quadrant (see Figure 2c).

Most electronic reactive power controllers have a digital display indicating the actual power factor. For control of reactive power operating within all four quadrants, confusing power factors may be indicated, as shown in Figure 2c, if the generator is feeding back. Controlling within all four quadrants, any value of the power factor may be indicated from 0 to 1 in either the first or third quadrant and from 1 to 0 in the second and fourth quadrants.

Thus the controller indicates any possible value within 360° of the coordinate system, provided that it is suitable for four-quadrant operation. This is the pre-supposition that the reactive power controller is applicable for operation within all four quadrants.

It must be underlined again **that the actual power factor cos φ_a does not say anything about the actual amount of reactive power Q**.

Vector 4 in quadrant IV in Figure 1 symbolizes the load situation where the generator is covering the consumption of active power totally and is feeding back an identical amount to the grid in addition. If the target power factor had been preset to 0.85 lagging, **the controller would suddenly intend to compensate to the 0.85 leading side**!

The C/k bandwidth is extended from the first quadrant via zero into the third quadrant. This is called the **mirror-imaging behavior of the controller**.

It does not ensure that the compensation bank will be sufficient to compensate according to the 0.85 leading side (see vector 6). Seven capacitor steps would become necessary in order to achieve this power factor target.

As is well known, there is the disadvantage of a voltage increase when compensating into the capacitive area. If the compensation bank was not able to achieve this high power factor due to insufficient steps, many modern reactive power controllers would trigger an alarm.

To get proper control of reactive power does not mean presetting the power factor target into the second quadrant, for example the 0.9 leading side in order to achieve the 0.9 lagging side when controlling in the fourth quadrant (see Figure 1).

The simplest way to solve this problem is to preset **the power factor target to unity, cos φ_d = 1**. With this power factor target, symmetrical control of reactive power is ensured within all four quadrants (see vectors 5 and 2). Thus if the reactive power compensation is working within all four quadrants the capacitors' capacitance is determined sufficiently in order to achieve an average power factor of unity, cos $\varphi = 1$.

Remember that the total compensation of reactive power saves active energy (kWh) due to power losses along the leads.

2.2 Bargaining Considerations

As mentioned above, customers with their own generator(s) are obliged to compensate reactive power to a desired power factor much closer to unity, cos $\varphi_d = 1$.

Any standard tariff agreement on achieving an average power factor of 0.9 for instance becomes invalid. This standardized contract agrees that 48.5% of the consumption of active energy is free of charge with respect to the amount of reactive energy. In simple terms, if the consumption of active energy amounts to, for example, 1000 kWh per billing period, then 485 kvarh of reactive energy is free of charge.

The very human behavior of customers with generators ensures **that they will pay attention to bringing down the consumption of active energy to zero**. Then, at the end of a billing period, the electricity invoice may indicate 0 kWh of active energy but, for example, 17000 kvarh consumption of reactive energy!

As a matter of course the electricity company will not grant any kvarh without charging. Many electrical plants with generators are using an asynchronous generator that is asynchronous motors running with so-called **negative 'slip'**. Independent of whether the engine is running in motor or generator mode, it consumes reactive energy for magnetizing the iron core steadily.

Thus each customer intending to reduce the consumption of active energy particularly or even totally by the generator(s) is obliged to compensate any reactive energy totally as well, except if the customer has negotiated a special contract with the electricity utility company.

The following example underlines the facts described above.

2.3 Example

An asynchronous motor of 100 kVA rated power is to be driven in generator mode. Its nominal power factor is 0.82 inductive. Although it is feeding back active energy into the grid, the consumption of reactive power amounts to:

$\cos \varphi = 0.82 \Rightarrow \varphi = 34.9° \Rightarrow \sin \varphi = 0.572$

The reactive power of the generator is to be calculated by:

Q = S × sin φ = 100 kVA × 0.572 = **57.2 kvar**

Within one day, or 24 hours, the varmeter will count **up to 1373 kvarh** or **41200 kvarh approximately per month** if the generator is running steadily, for example at water power stations.

In operating with synchronous generators the consumption of reactive energy depends on the preset exciting rate. They are preset to a power factor referring regularly to the lagging side. Then the reactive power of the generator is calculated in the same way as for the asynchronous one.

3. Conclusion

Compensating reactive power within all four quadrants of the coordinate system due to generators running in parallel requires consideration of technical and economic facts in totally another way to that known from classical two-quadrant operation.

In general, the aim is **to compensate in achieving unity, cos φ = 1, as close as possible**. The compensation bank has to be determined accordingly and the reactive power controller must be suitable for control within all four quadrants.

It is a matter of course that the controller's current transformer must 'seize' the reactive current of the generator(s) as well. Thus the feed-in point of the generator(s) always has to 'look' to the L side of the current transformer's casing.

Servo Voltage Stabilizers: The Best Defenders of Electrical Appliances

By Ms.Chougule Komal Maruti (BE) Ms.Gayakwad Sapana Shivaji (BE)

Today's market is dominated by servo voltage stabilizer manufacturers and suppliers. Stabilizers should be considered a necessity for the maintenance of any electrical and electronic appliances. Among the manifold options, servo voltage stabilizers are the best defenders of such equipment.

A servo voltage stabilizer, as the name suggests, is based on the servo mechanism. It enables voltage corrections in case of fluctuations and maintains the right output for any electric or electronic device. The servomotor is the main element of servo stabilizers: It manipulates the changes in voltage in a clockwise and anticlockwise direction and regulates its maintenance. The servo stabilizer can be used for industrial, residential, and commercial purposes.

The servo-controlled voltage stabilizers provide ±1% voltage output even if there is a voltage alteration up to ±50%. It enables higher load capacity, as it can support up to 3,000 kVA. They are more accurate and so popular when compared to traditional relay transformers.

Components of a Servo Voltage Stabilizer:

Here are the main components of a servo-controlled voltage stabilizer:

- **Dimmer:** Also called a variable transformer, its main function is to increase or decrease the input voltage to the next component. It is mainly responsible for 50% of the increase and decrease in the output voltage. It is round and built with a Silicon toroidal core for the base and copper wire.
- **Buck-Boost Transformer:** It acts as a connector between the input and output load terminals. It is a transformer that manages the voltage settings that are remained upon voltage increase or decrease by the dimmer. Unlike the variable transformer, it is rectangular in shape with EI CRGO core. In order to ensure its long life, the buck-boost transformer (the windings inside and the transformer as a whole) is varnished well to protect from the environment. Any coils of wires in this important component are truly insulated by the varnish.

- **Servomotor:** It is the most vital component of servo voltage stabilizers. Based on the input voltage, it enables the arm that is connected to the dimmer to move in a clockwise or anticlockwise direction. It is the leading part of the servo stabilizers and responsible for initiating voltage maintenance.
- **Carbon Brush:** It is a moving part attached to the dimmer and is intended to move along during voltage alterations. Like any other component, its quality should be maintained, as it erases more easily upon frequent voltage variations. The manufacturers and suppliers of servo voltage stabilizers like Servomax Limited use high-quality carbon brushes to maintain long-lasting performance.
- **Contactor:** This is an exceptional component that cuts the output of a servo stabilizer when there is an exceeding prescribed limit.
- **Miniature Circuit Breaker (MCB) and Molded Case Circuit Breaker (MCCB):** An MCB is engaged to enable switch-on or -off of the stabilizer and protects against short-circuits. An MCCB, on the other hand, ensures the protection of the device from overloads.
- **Electronic Circuit:** An electronic circuit provides signals to various parts of the servo stabilizer, and the device works as per the signals to correct the voltage.

While these are the important components of a servo voltage stabilizer, there are even certain accessory elements like ampere meter, voltmeter, connectors, and many others.

Single-Phase and Three-Phase Servo Voltage Stabilizers:

Servo voltage stabilizers can be single-phase or three-phase balanced types or three-phase unbalanced types.

In a single-phase servo voltage stabilizer, the voltage corrections are done by a servomotor, which is coupled to a single variable transformer. In the case of a three-phase balanced type of servo stabilizer, there will be three autotransformers that are coupled with the servomotor. So, upon fluctuations, the stabilized output is empowered with higher rates of accuracy and efficiency.

In a three-phase unbalanced type of servo voltage stabilizer, there will be a coupling of three independent servomotors with three autotransformers, so you can find three separate control circuits for such units.

How does the servo voltage stabilizer work?

Though it seems tricky, understanding how a servo voltage stabilizer works is simple. Here is an easy explanation.

By now, you might have noticed that the primary of the buck-boost transformer is connected to the autotransformer. The secondary end is coupled with the moving arm, which, in turn, is controlled by the servomotor. Furthermore, a series connection is found between the secondary buck-boost transformer and the incoming supply.

Now, let’s look at it in an easy, step-wise way:

1. The input voltage from the device is detected by the electronic control circuit. Powerful Servomax Limited servo voltage stabilizers use microcontrollers and microprocessors to embed in it. They show the input voltage, and they are provided with a standard reference voltage source. So they can easily find the dip or the rise in voltage.
2. With the simultaneous detection, the circuit identifies an error, so it signals the motor, which moves in a clockwise or anticlockwise direction to manage the voltage change.
3. As the motor is attached to the arm or shaft on the autotransformer, upon a continuous mechanism, there will be a final impact on the buck-boost transformer (primary).
4. By necessary changes made, the voltage from the secondary buck-boost transformer will be the desired output voltage.

In this way, servo-controlled stabilizers are more efficient — they manage and manipulate the changes in no time. The single-phase and three-phase servo voltage stabilizers are available in oil- and air-cooled units in different sizes and varieties.

Why servo voltage stabilizers?

Servo voltage stabilizers, by their intrinsic technical features, are eminently preferred when compared to any other models. This is because of the following advantages:

• Its output voltage correction is up to ±1%, enabling higher accuracy.

• It includes advanced technologies to incur better results of voltage stabilization.

• It supports a higher load capacity of up to 3,000 kVA.

• The step-less correction of voltage is the specific feature of a servomotor-based voltage stabilizer.

• Fluctuated voltages are adjusted by switchless systems at desired levels.

• With its best features, it is preferably used for hospitals and health-care units — machinery like X-ray machines, CAT scans, and radiation and diagnostic equipment are coupled with servo voltage stabilizers.

• It is a secured, stabilizing choice for schools and offices.

• It is available in different units — air-cooled and oil-cooled.

• It enables a minimal failure rate of various electrical and electronic equipment.

• It is the best support for safety and protection — it prevents fire and other accidents and avoids loss of production and human life.

• It helps in ensuring faster, instant, and immediate response for any input voltage transients.

• It is the best means for minimizing power consumption — it helps devices use adequate power required for their normal functioning. In this way, it serves as an outstanding energy-saver and reduces electricity bills.

• It is associated with lower maintenance costs; it is an affordable option for industrial and commercial firms.

• It increases the durability and life expectancy of various devices, machinery, and equipment. Therefore, the quality of the electric appliances is automatically improved.

• It is able to withstand inrush currents and is highly reliable.

• It secures industrial machinery and prevents susceptible damages.

While these are some of the benefits of servo voltage stabilizers, there are many others that help people, firms, and organizations to follow energy-saving strategies.

Want to choose a suitable servo voltage stabilizer?

Then you should consider some important things to make an apt selection.

• Input voltage range

• Output voltage range

• Type of load — balanced or unbalanced

• Type of voltage — balanced or unbalanced

• KVA rating

• Protection type

• Air- or oil-cooled units

Also, based on your purpose — whether residential or industrial — the range of input and output voltage varies. The type of machinery or electrical equipment present in your homes or firms varies the requirement of stabilization. In turn, this decides the capacity, load, or voltage types. You should also check for the mode of protection — whether you need protection against overvoltage or under voltage or short-circuit — then decide the model of servo controlled voltage stabilizer.

Special purpose of Transformers

By: Mr. Kulkarni Aniket Milind (BE) **Mr. Koli Harichandra B (BE)**

Transformers are the most efficient electrical devices used in different places. Unexpected voltage problems do arise frequently at houses, industries, hotels, and other places. Different types of transformers are used in specific areas to assure the best voltage regulation. However, there are certain special purposes of transformers that are used for customized applications.

Significance of transformers

Transformers increase or decrease the voltage levels based on the necessary applications. Based on the principle of Faraday's electromagnetic law of mutual induction, it creates a current of specific voltage. As per the voltage level required for the normal functioning of electric and electronic devices, the transformers enable the sufficient voltage levels based on the appliance.

Without appropriate voltage levels, it is impossible for any device to function efficiently. They play a significant role in several electric and electronic applications.

The Special purpose of transformers

Transformers are mainly intended for voltage regulation and safety.

Voltage Regulation

As you know, there are many power-based appliances that need different levels of sufficient voltage. For instance, the voltage required for household power appliances is different when compared to the voltage levels for industries. So, reliable transformers are required to consider voltage regulation and maintain their respective functionalities effectively.

They are used as power transformers at power generation stations to deal with the high current or low voltage levels. The capacities of power transformers depend on the model, capacity, and other considerations of the power plant.

The distribution transformers are engaged in transferring the adequate voltage levels to the end-use at houses, industries, hospitals, offices, and other significant places. Different types of industrial equipment work efficiently when the oil-cooled and dry-type transformers give sufficient voltage levels to them.

Safety:

Apart from voltage regulation, the transformers are used for safety purposes. They protect different kinds of electrical devices from unwanted power issues.

Isolation transformers are the best models of transformers that are meant for protection. They save the equipment in case of over-voltages, under-voltages, sudden shocks, power-cuts, and other such dangerous situations.

Through galvanic isolation means, they separate the loads from the power supply and stop the power passage so as to avoid the unexpected or unwanted electrical damage. In such isolation transformers, the number of primary and secondary coils remains the same. There won’t be any increase or decrease in the voltage levels.

Appropriate Power Consumption:

Transformers are meant for ideal power consumption and utilization. They increase or decrease the voltage levels to accommodate sufficient voltage levels only. This mere electrical energy transferred is used appropriately to do work. However, certain motors, generators, and other such equipment may degrade or waste a certain amount of power. To avoid this, capacitors and other latest technologies are used to enable the right power consumption and usage.

Customized Designs of Transformers:

Transformers intended for different purposes include power transformers, distribution transformers, isolation transformers, ultra-isolation transformers, and so on. Different applications need different types of transformers.

They have certain characteristics like – a specific number of coils for primary and secondary coils, the design of the iron core, the cooling or insulation means, etc. The capacity of the transformers will be designed in a different way based on the purpose of the transformer use and the load capacity. That means, the raw materials used the assembly of units, etc. will be fixed and offered for specific purposes.

However, there are certain special purpose transformers that are designed completely based on the customers’ demands. The capacity, the number of windings, iron core, insulation, etc. are defined by the customers. They are kept in mind and designed by the transformer manufacturers. Using state-of-the-art technologies, they are perfectly made to suit personalized power needs.

So, special purpose transformers can be made as power transformers, distribution transformers, isolation transformers, or others only upon the personalized characteristics and suitable applications. Servomax Limited is one of the best transformer manufacturers in India. It offers valuable customized transformer models to diversified client-base across India.

Using the Calorimetric Method to Measure EV Power Converter Losses

By Ms. Sangave Shradha Sunil (BE) Ms. Terwade Rasika Sanjay (BE)

Climate change, and the need to reduce carbon dioxide emissions, is revolutionizing the transport sector and driving it increasingly toward e-mobility. Electric vehicles (EVs) use high-efficiency power converters, with values close to 99%.

To design or evaluate a power converter, it is essential to measure its power loss with great accuracy. Normally measured by a wattmeter, the power loss is expressed as the difference between the value of the input power and that of the output power. Due to the high efficiency, this difference is very small, and therefore, only full-scale errors can be highlighted.

An alternative solution to the electrical measurement with the wattmeter is based on the calorimetric method, capable of achieving high precision without requiring any electrical connection to the converter.

The technique we will now describe uses a single thermostatic chamber, a Peltier cell, and a room temperature control system. The Peltier cell, operating in reverse mode, leading to the See beck effect, generates a current at its electrodes as an effect of the difference in heat between the cold and warm sides.

Conventional Calorimeters

Because power losses in an electronic circuit are mainly due to heat dissipation, they can be determined by measuring the heat generated by the system. Calorimetric methods, in particular, use a medium to remove the heat produced by the device under test (DUT). In an ideal calorimeter, the dissipated heat is absorbed entirely by the medium, which can be air, water, or another type of coolant.

There are three types of conventional calorimeters:

- Open-type calorimeter: The DUT is placed directly in the measuring chamber, while the coolant is represented by common air. The advantages of this solution are the simplicity of construction and the speed of execution of the measurement. The main disadvantage is the difficulty of measuring the heat capacitance of the air.
- Closed-type single-cased calorimeter: This comprises a separate cooling loop for heat exchange with ambient environment. By using water for coolant, it achieves greater

accuracy than the open-type calorimeter. However, because the heat capacitance of water is larger than that of air, the measurement time becomes longer.

- Closed-type double-cased calorimeter: This allows for active control of the air temperature in the gap between the two cases, thus leading to improved accuracy.

Regardless of type, the primary source of error is the loss of heat (*sub>wall) through the walls of the calorimeter. For the open-type and the closed-type single-cased calorimeter,*

sub>wall is denoted as: sub>wall=$(T_{test} - T_{amb}) \div R_{th,wall}$
Here, T_{test} *is the temperature in the test chamber,* T_{amb} *is the ambient temperature, and* $R_{th,wall}$ *is the thermal resistance of the calorimeter walls.*
For the closed-type double-cased calorimeter,

sub>wall can be estimated as: sub>wall=$(T_{test} - T_{gap}) \div R_{th,wall}$
Where T_{gap} *is the air temperature in the gap between cases.*

The proposed solution

The proposed solution uses a single chamber, a Peltier cell on the faces of which (inside and outside the chamber) there are two heat sinks, temperature sensors, and fan motors to cool the heat sinks (Figure 1).

The disadvantage of a single-room solution is represented by the error introduced by

sub>wall, or the heat leakage across the walls. In order to improve the accuracy of the measurement, the temperature in the chamber is kept equal to T_{amb} *thanks to the action carried out by the Peltier cell.*
The total amount of heat developed is shown in the following formula:
$u_c = S_p T_c I_p - (T_h - T_c) \div R_p - 0.5 R_p I_p^2$

Here, S_p is the See beck coefficient, T_c is the cold-side temperature, T_h is the hot-side temperature, R_p is the thermal resistance of the Peltier cell, and I_p is the input current to the Peltier cell.

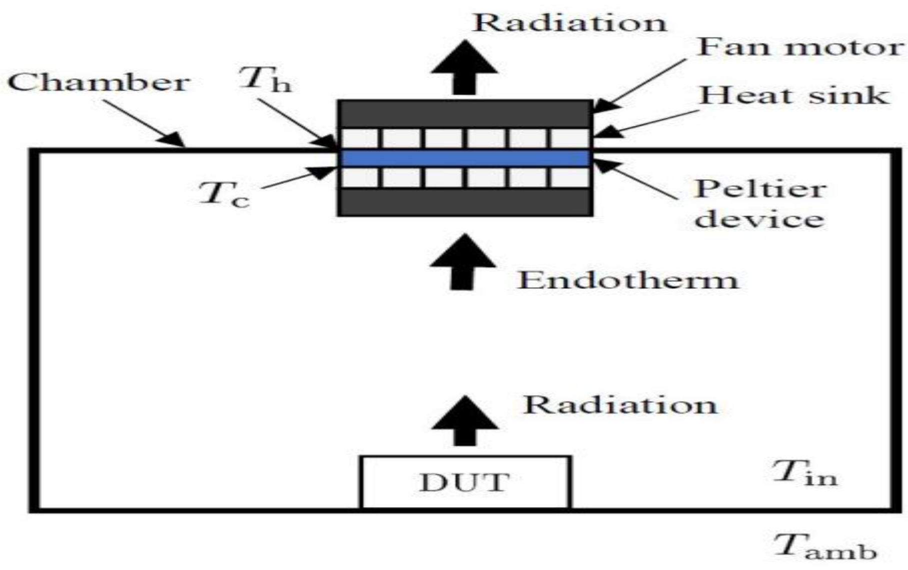


Figure 1: The calorimeter scheme uses a Peltier cell.

When the temperatures inside and outside the chamber are the same, the cooling capacity of the Peltier cell is equal to the power loss dissipated as heat. The power loss of the DUT (

sub>loss) can be calculated as follows: sub>loss = $S_pT_cI_p - (T_h - T_c) \div R_p - 0.5\ R_pI_p^2 - Q_{Fc}$ *Where* Q_{Fc} *is the power dissipation of the cold-side fan motor.*

Figure 2 shows the proposed calorimeter control system.

sub>1 is the plant of the calorimeter, sub>2 is the buck converter for current control, C_1 *is the PI controller for temperature tracking, and* C_2 *is the PI controller for current tracking.*

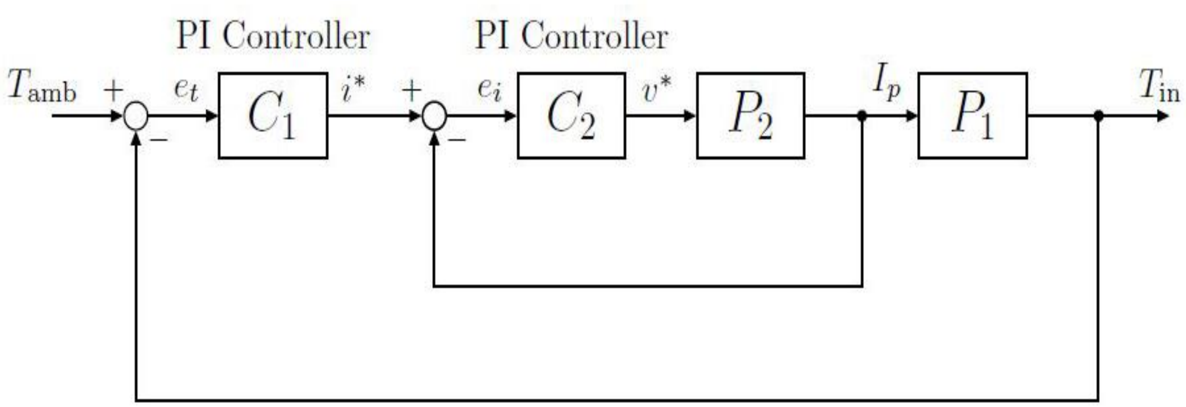


Figure 2: The calorimeter feedback control system

C_1 and C_2 are noted as follows:

$$C1: \quad Ip(t) = KP_i e_t(t) + KI_i \int_0^t e_t(t) d\tau$$

$$C2: \quad v^*(t) = KP_T e_i(t) + KI_T \int_0^t e_i(t) d\tau$$

Here, KP_i and KP_T are proportional gains, and KI_i and KI_T are integral gains.

Experimental Results

Initially, a simulation of the thermal equivalent circuit model was developed in the MATLAB and Simulink environments. Through this simulation, it was possible to derive the trend of T_{in} as a function of time, observing how, after a transient lasting about 600 seconds, the temperature in the chamber follows the trend of T_{amb}.

By operating in the same way, it was possible to derive the temperature trends on the hot and cold sides of the Peltier cell, the input current to the Peltier cell and the estimated power loss. The estimated power loss coincides with the power dissipation of the converter under test. The results obtained experimentally are aligned with the data produced by the simulation, confirming the validity of the proposed calorimetric method.

Vertical GaN Devices: The Next Level of Power Electronics

By: Mr. Shaikh Irfan Amir (TE) Mr. Jadhav Shivakumar Yuvraj (TE)

NexGen Power Systems Inc. is fabricating vertical power devices (vertical gallium nitride, or vertical GaN) using homoepitaxialGaN on GaN substrates. Vertical GaN devices are capable of switching at even higher frequencies and operating at higher voltages, which should lead to a new generation of more efficient power devices.

“Vertical GaN devices are 90% smaller than silicon; capacitance is directly related to the area of the device,” said Dinesh Ramanathan, CEO and co-founder of NexGen Power Systems. “The smaller the device, the lower the capacitance. The lower the capacitance, the greater the switching frequency. Vertical GaN delivers 67% lower switching losses than Si [silicon] MOSFETs in most typical applications, especially power supplies.”

GaN is a wide-band gap material that allows devices to operate at higher temperatures and withstand higher voltages compared to silicon. Moreover, GaN’s higher dielectric breakdown allows building thinner and, therefore, lower-resistance devices. Lower characteristic $R_{DS(on)}$ leads to smaller devices with lower capacitance.

The advantage of growing low defect-density epitaxial layers on low defect-density bulk GaN substrates is that it leads to vertical power devices with higher reliability under voltage and thermal stress, compared to lateral GaN devices manufactured on non-GaN substrates.

Vertical GaN is capable of operating at high breakdown voltage (*Figure 1*), which enables vertical GaN to power the most demanding applications, such as power supplies for data center servers, electric vehicles, solar inverters, motors, and high-speed trains.

Parameter	Si	SiC	GaN
Bandgap, eV	1.12	3.26	3.45
Critical Electric Field (E_c), MV/cm	0.3	2.2	3.3 – 3.7 (bulk GaN)
Baliga Figure of Merit (FOM) $= \varepsilon_s \times \mu \times E_c^3$	1	675	3,000

Figure 1: GaN material properties compared to Si and SiC (Image: NextGen Power Systems)

Traditional power devices and lateral GaN-on-Si

Power electronics use solid-state devices to process or convert electrical power. Power converters or adapters are ubiquitous and are available in all shapes and sizes. Most converters, called switch-mode power supplies (SMPS), use capacitors, inductors, transformers, and semiconductor switches to transfer power from an input with a given voltage and current to output at a different voltage/current configuration (*Figure 2*).

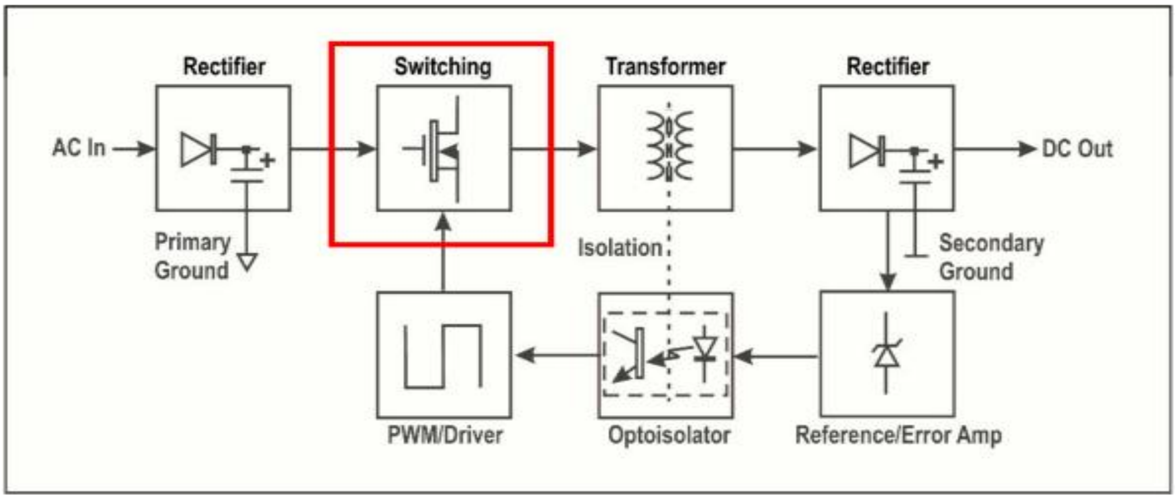


Figure 2: Block diagram of a switch-mode power supply (Image: NextGen Power Systems)

Capacitors, inductors, and transformers are passive and physically large components. To reduce the size of the SMPS, they must operate at high frequencies. To operate at high frequencies, they need a better semiconductor switch, which can overcome the limitations of incumbent silicon-based switches, which generally top out at a couple of hundred kilohertz.

Over the past three decades, silicon devices such as MOSFETs and IGBTs have dominated the power device market. Recently, silicon MOSFETs have seen only incremental performance gains. “Silicon has reached its limits; there’s nothing that you can fundamentally gain from silicon power devices right now, based on its material properties,” said Dinesh Ramanathan.

Silicon carbide (SiC) is another alternative to silicon, but GaN generally has more attractive fundamental material properties.

Current GaN devices are made on hybrid substrates: thin layers of GaN on silicon or silicon carbide, creating GaN-on-Si or GaN-on-SiC high-electron-mobility transistor (HEMT) structures (*Figure 3*).

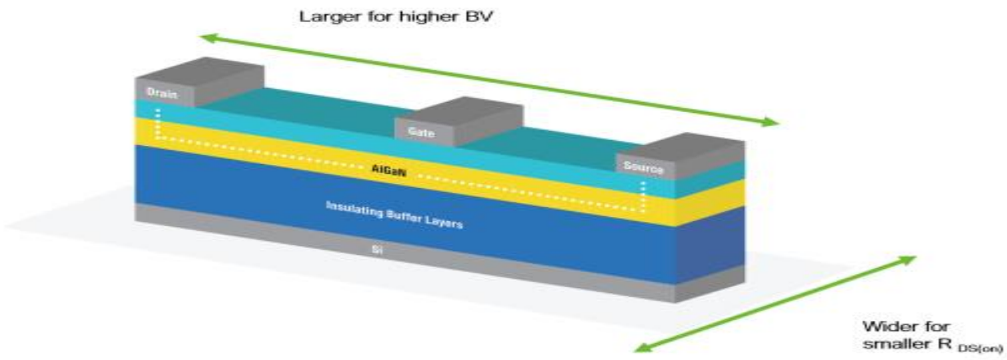


Figure 3: Representative schematic of a GaN-on-Si HEMT structure (Image: NexGen Power Systems)

Lateral GaN-on-Si (or GaN-on-SiC) devices combine materials with a mismatched coefficient of thermal expansion (CTE), which compromises both reliability and performance. Moreover, in a typical GaN HEMT device, the channel is very close to the surface (in the order of a few hundred nanometers), which creates passivation and cooling problems. In a lateral GaN-on-Si device, the drain-source separation determines the breakdown voltage of the device. A larger drain-source separation increases the channel resistance and limits the current capability. To compensate for this and increase current-carrying capability, the device must be made wider. The combination of higher voltage and higher current requirements results in devices with a large area and therefore higher capacitances. Hence, lateral devices are limited to a breakdown voltage of approximately

650 V.

Avalanche breakdown is a key property of Si and SiC devices to protect themselves under short-term overvoltage conditions. The absence of p-n junctions in lateral GaN-on-Si HEMTs prevents these devices from avalanche breakdown. Furthermore, GaN-on-Si HEMTs are difficult to cool from the top due to the sensitivity of current conduction close to the device surface. The buffer layers separating the Si substrate from the GaN layer limits the efficiency of bottom-side cooling. This means that, often, custom packages have to be created to cool GaN-on-Si HEMTs, further increasing their costs.

Vertical GaN Power Devices

Where the lattice mismatch between GaN and Si or SiC degrades GaN's electrical properties and affects reliability, when GaN devices are grown on GaN substrates, both the lattice and the CTE are, of course, perfectly matched — it is the same material. As a result, very thick layers of GaN can be epitaxial grown on bulk GaN substrate, which allows the creation of very high-voltage devices.

Vertical GaN technology unlocks the full potential of GaN's superior material properties, as it is based on GaN grown homoepitaxially on GaN substrates (*Figure 4*). Furthermore, vertical GaN devices use all three spatial dimensions: higher breakdown voltage by increasing the thickness of the drift layer and low $R_{DS(on)}$/current capability by increasing device area, effectively creating a 3D device that decouples breakdown voltage and current capability ($R_{DS(on)}$).

"AC systems require high-performance power factor correction circuits with a significant reduction of harmonic distortion," said Ramanathan. "Vertical GaN's high switching frequency enables new control algorithms and delivers all of this with smaller implementations and higher efficiency."

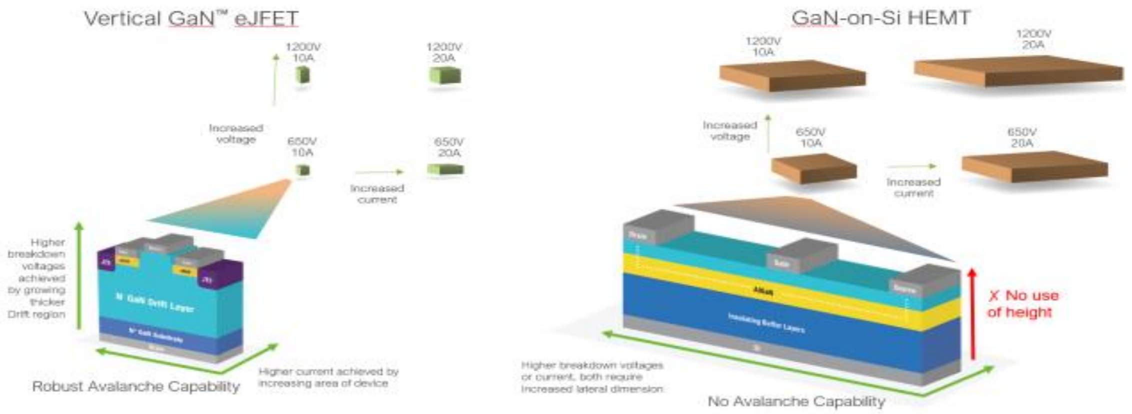


Figure 4: Vertical GaN vs. GaN-on-Si device construction (Image: NextGen Power Systems)

Figure 5 shows the diagram of the enhancement-mode vertical GaN junction field-effect transistor (eJFET) and GaN-on-Si HEMT. NexGen Power Systems said that it was able to demonstrate a drift thickness of >40 µm, producing diodes with a breakdown voltage of >4,000 V and transistors with specific resistance of 2.8 mΩ/cm^2. For the same current capability, the vertical GaN device size is approximately 6× smaller than a 650-V GaN-on-Si HEMT but delivers a much larger breakdown voltage of 1,200 V. The vertical GaNeJFET has avalanche capability that protects the device when the specified breakdown voltage is exceeded.

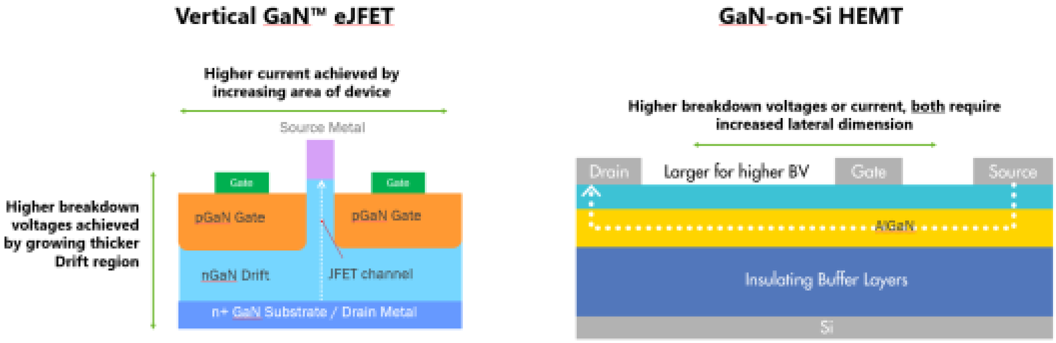


Figure 5: Schematic of vertical GaNeJFET and GaN-on-Si HEMT. Dotted white lines denote the electron conduction path. (Image: NextGen Power Systems)

Vertical GaN devices are built to conduct current through the drift layer, which is inside the bulk of the transistor. Therefore, there is no mechanism for dynamic R_{DS}(on) variation that is created by charges trapped due to surface interface impurities. The extension of the depletion region of the gate-source diode into the channel controls the current flow between drain and source. In situations when the breakdown voltage is exceeded, avalanche initially occurs through the reverse-polarized gate-source diode, subsequently causing the avalanche current to increase the gate-source voltage and the channel to open and conduct.

Due to the small output capacitance, switching losses in applications are very small. In contrast to lateral GaN devices, heat is optimally transferred through a homogeneous material — without additional layers — directly to the package lead frame (*Figure 6*) from the top and bottom of the device.

“The advantage of this device is the fact that it has just p-n junctions made from GaN,” said Ramanathan. “We don’t have 2D electron gases and complicated layers of materials. We have an enhancement-mode JFET, which is a well-understood device, and because it has p-n junctions, it avalanches, so you don’t have a destructive breakdown. Because it all happens in the bulk of the device, it can absorb a fair bit of energy during an avalanche, and after the event, the device recovers and operates like normal. So it has a built-in safety mechanism, and therefore, it’s a much more reliable and a much more robust device”.

Attributes	GaN-on-Si	Vertical GaN™
Defect Density, cm^{-2}	10^9	10^3 to 10^5
Lattice Mismatch, %	17	0
Layer Thickness, µm	1-2	> 40
CTE Mismatch, %	54	0
Breakdown Voltage, (V)	900	4000V
OFF State Leakage	High	1nA (Low)
Avalanche Capability	No	Yes
Reliability	Low	High

Figure 6: Advantages of homoepitaxially grown structure (Image: NextGen Power System)

Using vertical GaN in power circuits

The NexGen vertical GaN FET is a JFET with similarities to FinFETs used in silicon logic devices.

The voltage difference between gate and source (V_{GS}) controls the current between the drain and the source. When V_{GS} is below the threshold voltage (V_t), the JFET channel is closed. When V_{GS} is larger than V_t, the channel opens, and the current can flow between the source and the drain. This current flows within the bulk of the device. Electron mobility is high and, together with the smaller capacitance of the p-n junctions, creates a device with very small output (C_{oss}) capacitance. This allows the devices to operate efficiently at high frequencies and enables applications with switching frequencies above 1 MHz

The symmetric construction of the JFET allows the source and drain to exchange function if the drain terminal voltage drops below the source terminal voltage; channel current can then flow in a reverse direction. This resembles the function of a body diode in Si MOSFETS but without the losses and potential reliability issues caused by minority carrier/reverse recovery charge removal.

"NexGen's Vertical GaNeJFETs can be driven by well-established and cost-efficient standard low-cost Si MOSFET drivers [*Figure 7*] with only minor modifications to existing designs," said Ramanathan. "This enables quick adoption of the devices with superior properties."

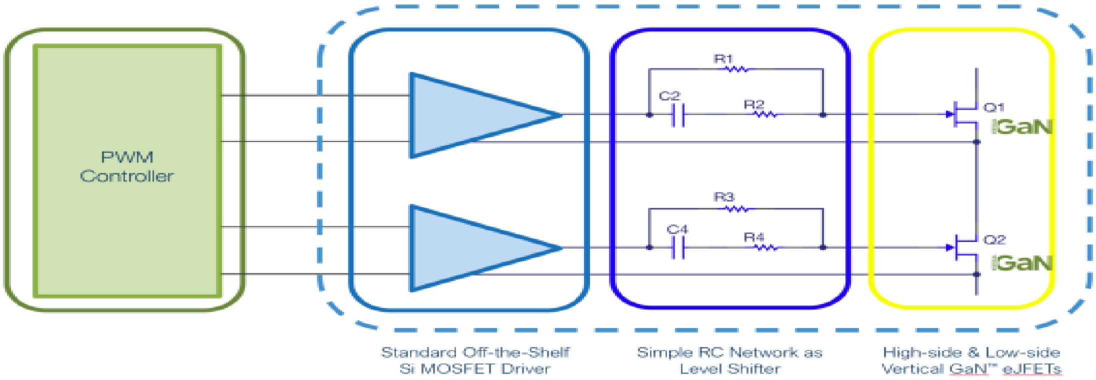


Figure 7: Driving NexGen's vertical GaNeJFETs (Image: NextGen Power System)

NexGen's Vertical GaN technology combines the properties of devices, which were previously considered incompatible and, therefore, impossible to achieve. Power conversion in automotive, consumer, solar, motors, and data centers are the main applications where one can experience the potential of this new technology. It offers lower losses at higher switching frequencies and better avalanche robustness than other switching devices and competes effectively on cost with silicon devices.

"From mobile phones to laptop computers, electronic devices are getting smaller and more portable," said Ramanathan. "With vertical GaN, the power supply system can be small, lightweight, lower-cost, and portable, too."

He continued with a particularly striking example: "In a data center rack, there is a certain number of racks units reserved for the power supply, which is converting AC power to DC power — we reduce the size of that power supply by 50%. Let's look at a 30-kW rack — 11 rack units are needed for power supply and 31 provide compute services. With our higher switching frequency, we can reduce the power supply size from 11 to five rack units, which means we free up six rack units to be added to the compute rack. Six additional compute racks mean an increase of computing density by 20%".

Vertical GaN allows you to address the full range of power conversion applications that can currently only be served by a multitude of technologies.

Why Do Engineers and Product Developers Get So Frustrated with Their Collaboration Software?

By.Ms Patil Pratiksha Maruti (TE) Ms. Landage Pooja Yashwant (TE)

Today, solutions come in different flavors of SaaS, on-premises, or hybrid, all promising you that with just a few mouse clicks, they will have you collaborating better. The one attribute most of them have in common is that they don't offer the product development capabilities and features that you really need.

Let's face it: The collaboration and project management space offers a wide range of options and choices.

Today, solutions come in different flavors of SaaS, on-premises, or hybrid, all promising you that with just a few mouse clicks, they will have you collaborating better. The one attribute that most of them have in common is that they don't offer the product development capabilities and features that you really need!

In fact, many of these solutions actually make collaboration worse. To help you navigate your options, let's lift up the hood and explore many of the common problems with today's collaboration solutions.

Too small or too big, won't scale.

Not all projects are created equal. Say that again: Not all projects are created equal.You know that prototype you were so proud of? Let's say that proof-of-concept you built, which only required a Git repo to store your work, now has your customer excited, and they want to turn that into a more polished product.

A more finished product requires a real team: project managers, engineers, and quality assurance. A more finished product also guarantees that you will need more than a Git repo like a wiki, back-office documents, and a ticketing system to plan, distribute, and track everyone's work. Scaling up a project's features should be just a few clicks of a mouse. Instead, many of today's collaboration and project management platforms leave you with the headache of negotiating with a vendor to buy more seats and additional features.

This is where the tools start to run the team. What started out as only a ticketing solution soon includes a wiki, chat, and help desk, and the next thing you know, you are looking at a bunch of tools held together with duct tape and web hooks, none being the authoritative source of your precious project data.

Who's working for whom?

That question may sound absurd, but yes, we are asking that question with a straight face. Are your tools working for you or are you having to bend to their will? To illustrate, let's start with something as basic as ticketing.

Tickets are the atomic unit of work by which things get done. All your planning, distribution, and tracking of work happen through tickets. In fact, most of your collaboration will be centered on the best ways to deliver the work outlined in a ticket. So why do so many systems get the most important, fundamental needs all wrong? Let's answer that by identifying common shortcomings of many collaboration tools:

- **Duplicate tickets** — When creating a ticket, should the system let you know that you may be submitting a duplicate? Furthermore, shouldn't the system give you hints that maybe the problem or goal in a ticket has been addressed already on sites like Stack Overflow?
- **Batch updates** — Updating multiple tickets in a batch should be easy to do. Yet many systems either don't allow for this or make this far more difficult than it should be.
- **Imposing workflo**w — Workflow can help teams stay on track and handle tasks in a consistent way. But your ticketing solution shouldn't force a specific workflow on your team.

- **Dependencies** — Dependencies between tickets is common. Solutions should make establishing blocking/non-blocking or parent-child dependencies easy and obvious.
- **Spam** — Getting notifications that a ticket, sprint, epic, or milestone has been changed is great, but do you really have to get a separate email for each update? Solutions should provide the option of receiving daily digests.

Collaboration's anti-pattern

Believe it or not, many collaboration solutions actually work against collaboration. To illustrate this point, let's discuss two problems:

- Traditional model of pull requests (PRs) is broken.
- There's more to collaboration than comments.

As for the subject of pull requests, what nobody seems to be discussing is the fact that most organizations have outgrown the traditional PR model. See, open-source projects are a unique animal and their needs can differ from the needs of businesses. How is that?

Today's PR models create tickets for tickets. Let's say you have a ticket instructing you to "Implement feature X." Once you are done, you create a PR, a completely separate ticket, that says, "Review my code and merge if it is ready." So now your team has to close out two tickets to complete "Feature X" and, worse yet, the code review comments live in the PR, not in the ticket. This proliferation of tickets for tickets creates unnecessary noise in your projects and flies in the face of traceability. So what's the fix? To put it simply, less is more.

You already have a ticket to "Implement Feature X." Your collaboration solution even allows you to associate your commits to the ticket. So why not rid yourself of the need to process a traditional PR and, instead, perform the code review and merge cycle *in the ticket*? If a ticket, the most atomic unit of work, is how work gets done, then doesn't it make sense to do *all* of the work in the ticket? Performing PRs this way ensures that everything is in the ticket: the audit trail of changes, comments on the ticket, relevant documents, and now even the code and associated code reviews. The value of streamlining PRs in this way would immediately improve efficiency and traceability.

Now repeat after me: "Comments aren't collaboration". Don't get me wrong, commenting on a ticket, wiki page, or document aids in collaboration, but it isn't true collaboration. That's why we’re seeing all sorts of chat solutions rushed to market. Chat conversations give concise context and often include references to key project artifacts (tasks, support tickets, documents). For those exact reasons, chat should be a foundational and well-connected component of any real collaboration solution, not an up sell.

They’re expensive

A common problem with many collaboration solutions is that their base functionality has a high price tag. And despite that high initial cost, they have a limited scope, implementing only a few well-thought-out features. Make no mistake, this is on purpose — vendors use this approach to get you to spend more money. They accomplish this in one of two ways:

- **The vendor up sell** — In this scenario, every time you want a new feature, you have to buy a new product that requires you to negotiate a new contract while leaving you responsible for keeping them integrated.
- **Marketplace ecosystem** — Some collaboration solutions get around their lack of features by offering a marketplace where you can purchase third-party solutions. This has the same problems as the vendor upsell, but now you also have to worry about fragile integrations between both vendors.

Finally, regardless of how you acquire the features that you need, the questions that you have to ask are: How do you move away from a collaboration system? Does your vendor(s) make project exports/imports easy? The short answer is no. Essentially; this is nothing short of good old vendor lock-in.

What’s irking you?

It isn’t all doom and gloom when it comes to collaboration software, but a solution that is right for you *now* may not be able to grow with you in the future.

To that end, it’s important to understand where many of today’s systems fall short and make choices that balance where you are today and where you want to go. Do you have a collaboration solution driving you crazy? We’d love to hear the reason why your collaboration solution sucks.

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MISSION

- To impart quality education by implementing state-of-the-art teaching-learning methods to enrich the academic competency, credibility and integrity of the students.
- To facilitate a conducive ambience and infrastructure to develop professional skills and nurture innovation in students.
- To inculcate sensitivity towards society, respect for environment and promote high standards of ethics.

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