Electrotechnische Vereeniging

MAXWELL LIMITS

Issue 21.4

WIRELESS GOING DIGITAL
Digital intensive wireless transmitters

BIOCMOS
Efficient bioanalytical systems at the nanoscale

THE DEVELOPMENT OF ELECTRIC LIGHT
Aspects of efficiency in the production of electric light

From the Board

Commissioner of Education

Thomas Roos

Dear reader,

Our bachelor has been working on a conversion from Dutch to English for some years now, but the plans for that switch are currently postponed. As the computer science bachelor demonstrated, the amount of students can easily double by removing the Dutch language requirement. To avoid this hurting the quality of the Education a numerus fixus would be necessary. But since the current political situation is not favorable for a numerus fixus, the language switch will be postponed until that situation changes.

The EEMCS Teacher of the Year-elections have been held. We made a new online platform for students to vote and the amount of responses has been fantastic. The results have been announced at the drinks on June the 11th. Rob Remis and Joost de Groot have been elected to #3 and #2 of Electrical Engineering respectively. Chris Verhoeven has not only been elected to the number one of EE, but also became the EEMCS wide winner! This means he has the honor of representing our faculty in the University wide rounds. Congratulations to Rob, Joost & Chris and thanks for your awesome teaching!

The book sales service of the ETV has not always been up to the standards we would have liked it be. This is mainly due to the fact that our book supplier has not been very consistent, but that might change soon. We found another party for delivering our book needs, the VSSD. The VSSD is the Students' union from Delft and we setting up a collaboration to provide our students a better book-buying experience starting that would start in 2019, the second semester of next year.

Zesje, the open source exam grading software I wrote about in previous Maxwell's, has made a lot of progress thanks the hard work of an CS bachelor graduation project group. The new version that will be deployed when this Maxwell hits your doormat is a lot easier to use for lecturers, even if they are not tech savvy.

This concludes my Educational updates section. Not just for this Maxwell, since this is the last edition of this Educational year and next version will written by a new board. Writing is definitively not my strongest skill, but I sincerely hope that you enjoyed these articles!

Commissioner of External Affairs

Karen van der Werff

Dear reader,

Here before you lies the fourth and final Maxwell-edition of this academic year. While the Maxwell Committee has been working hard to deliver a gorgeous magazine packed with interesting articles time and again, the year has flown by in an instant. And what a year it has been!

The biggest edition of the EEMCS Recruitment Days until now, the special Arnbak ElecTrip in Denmark and the wide array of challenging, technical workshops are just a handful of examples, compared to everything that has happened in the past year.

For my fellow Board members and me, our mandate is drawing to a close. Going back to full-time studying will take some getting used to, but with all the great memories, unique experiences and wise lessons, we will have enough to keep us going. And of course, you, as a member of the ETV, have contributed to this, so: thank you! I hope you enjoy reading this Maxwell as much as I do. Have a great summer and see you again in September!

Colophon

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Editorial

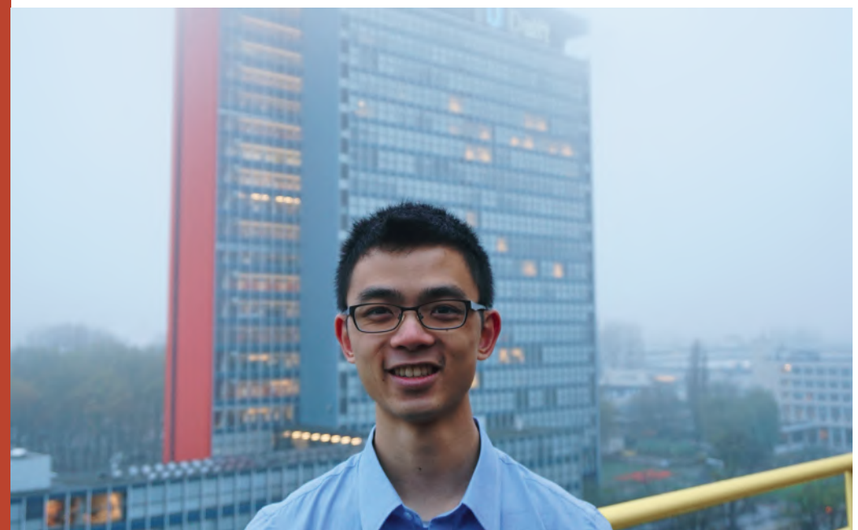
Dear reader,

The academic year is coming to an end and likewise, this is already the last Maxwell edition of the 21st Maxwell. Coming up with a theme has always been challenging but fun quest the past year: the scope of the theme should still allow for articles from various research areas.

With this issue we want to highlight a very important aspect in engineering: limits. If you want to design, realize and reach the next level of technology it's really essential to know what the current limitations are, and of course where they come from. Without this knowledge, you might even miss out on new theories or other research that might be the key to your problem.

On behalf of the whole Maxwell committee, I hope that you'll enjoy reading this issue and have a great Summer!

Jun Feng



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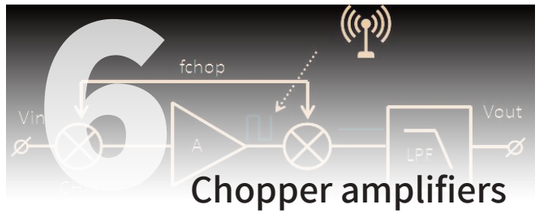

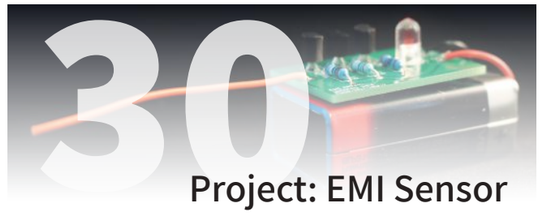

Chopper Amplifiers:
Blessing or Curse?

Dr. Qinwen Fan and prof.dr. Kofi Makinwa

Sensors such as strain gauges, Hall sensors and thermocouples are widely used to measure pressure, magnetic field and temperatures. Such sensors output signals with frequencies ranging from DC to a few kHz and amplitudes ranging from microvolts to millivolts. Processing such tiny signals can be a real challenge! Firstly, a precision amplifier is needed to amplify them; and then a high-resolution analog-to-digital converter (ADC) has to be used to digitize the amplified signal for further signal processing. In most cases, the amplifier determines the performance of the whole readout chain since any errors from succeeding circuits will be suppressed by its (high) gain. For slow sensor signals, the major sources of error will then be the offset and flicker noise of the amplifier.

In modern CMOS technology, the offset voltage of an amplifier can easily be in the order of a few millivolts to tens of millivolts; while its flicker noise will typically dominate the noise below a few kilohertz. Offset can be regarded as a static error and so can be minimized by trimming. However, this is an imperfect solution since offset will drift slowly with temperature and packaging stress. Flicker noise is more problematic because it is definitely not static, and so cannot be trimmed at all. To continuously tackle both of these major error sources, dynamic offset cancellation techniques, such as chopping, would seem like a perfect solution [1].

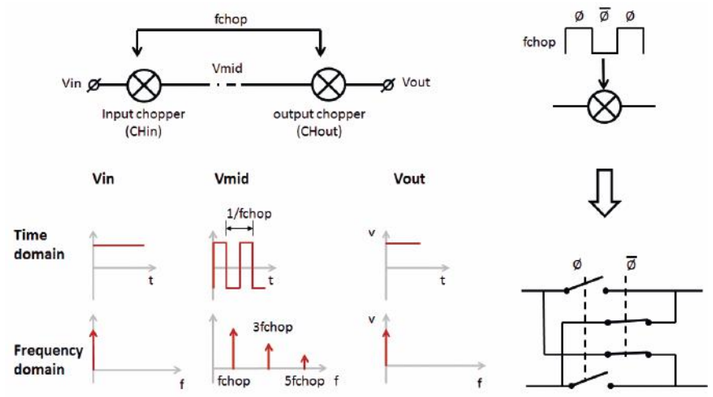

Figure 1: Basic operating principle of chopping

The basic working principle of chopping is illustrated in Figure 1. It requires two polarity-reversing switches, or "choppers" as they are usually called. Each chopper simply consists of four switches. In CMOS technology, switches can be implemented with either an NMOS or a PMOS transistor, or both. The input chopper CH_{in} modulates the signal V_{in} to the chopping frequency (f_{chop}) and its harmonics. And the output chopper CH_{out} demodulates the signal back to the base band. When chopping is applied to an amplifier (Figure 2), the modulated signal V_{in} is first amplified by a factor A and then demodulated by CH_{out}. The offset V_{os} and flicker noise of the amplifier, however, are up-modulated to f_{chop} and its harmonics

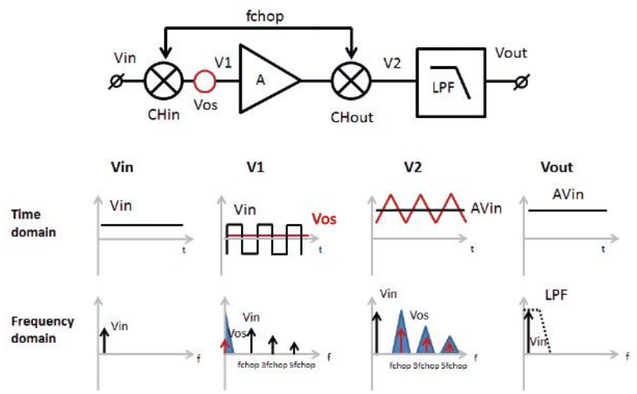

Figure 2: A basic chopper amplifier with a low-pass filter

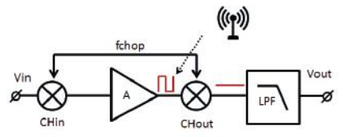

Figure 3: A chopper amplifier with interferences from the environment.

by CH_{out}, and thus appear as AC ripple at the output, which can be suppressed by a low-pass filter. At low frequencies, both offset and flicker noise are absent, and so the measurement accuracy is significantly improved! In literature, many designs can be found in which chopping has been used to achieve nanovolt-offset and sub-hertz flicker noise corners [2-3]. Chopper amplifiers would thus seem to be ideal for precision sensor readout, and the price to pay for their excellent performance seems to be rather low (consisting of just some switches and a low-pass filter).

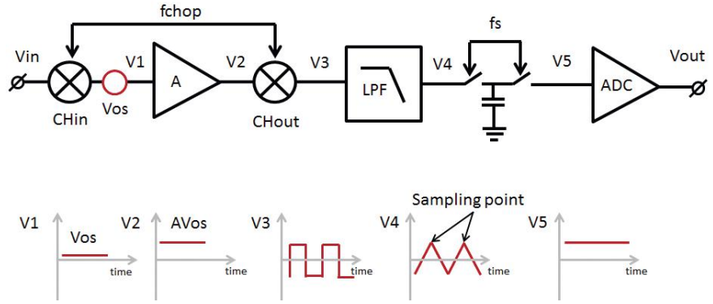

Figure 4: A chopper amplifier followed by a switched-capacitor sampling ADC.

> *"Chopper amplifiers would thus seem to be ideal for precision sensor readout... In reality, however, nothing comes for free. "*

In reality, however, nothing comes for free. Chopper amplifiers also have their issues, and some of them are quite major. The first issue to watch out for is interference. Chopping is inherently a modulation process which is sensitive to electro-magnetic interference (EMI) and cross talk. For instance, if you place your cell phone close to a chopper amplifier, there is a good chance that you will observe an instantaneous change in its offset when the phone rings! This happens because large RF signals are emitted by the phone's antenna when it is active, and these may couple to internal nodes of the chopper amplifier. For instance, when interference is coupled to the input of CH_{out} and happens to be located near f_{chop} or its harmonics (Figure 3), they will be demodulated down to DC and will thus completely ruin the amplifier's low frequency performance! Such interference can also come from within, e.g. from circuits that generate switching transients on the same die. Conversely, a chopper amplifier can itself become a "hazard" to its neighboring circuits due to it switching artifacts [4]. One artifact is the AC ripple at their outputs (the up-modulated offset and flicker noise), which usually cannot be filtered out completely. When sampled by an ADC, as shown in Figure 4, the residual ripple can be aliased back to DC.

Another issue associated with chopper amplifiers is their input current [5]. The switches of the input chopper are typically driven by a square-wave clock V_{clk}, which is capacitively coupled to the amplifier's input as shown in Figure 5. As a result, the signal V_1 will contain AC spikes (picture). When referred back to the input V_{in}, these spikes will effectively be demodulated by CH_{in}, resulting in an input current that has both an AC and a DC component. Both these currents will then flow into the sensor, which will always have a finite source impedance. The DC component creates extra offset; while the AC component creates extra ripple. For instance, with a sensor source impedance of *10 MΩ*, a DC error current of *100 pA* and an AC error current of *100 pA* (peak-to-peak) will produce an offset of 1 mV and a ripple of 1 mV (peak-to-peak). In some cases,

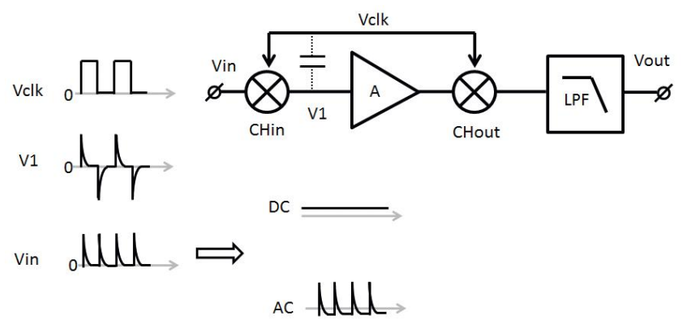

Figure 5: Chopper amplifier input current.

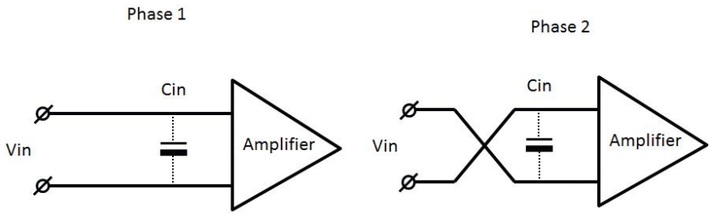

Figure 6: Reduced input impedance of a chopper amplifier due to input capacitance.

the ripple may be tolerable since it is usually out of the signal band, but the offset can be a big disappointment since microvolt offset is often expected from a chopper amplifier. To make matters even worse, when a capacitive sensor is present, the input DC current will continue to charge or discharge the sensor until it saturates, thus completely ruining the performance of the whole sensing system.

A third issue associated with chopping is that it can degrade the input impedance of the amplifier. This is because, as shown in Figure 6, the input stage of an amplifier inevitably exhibits some parasitic capacitances C_{in}. Chopping at the input means that C_{in} must be charged and discharged periodically, turning it into a kind of resistor with a resistance of about $1/(2C_{in}f_{chop})$. As a result, the input impedance of the amplifier decreases with increasing f_{chop} and C_{in}. This in turn can reduce the amplifier's effective gain. For instance, with a *10 kΩ* source impedance and *100 kΩ* input impedance of the chopper amplifier, the gain loss is *~10%*. To make things even worse, since the source impedance and the input impedance of the chopper amplifier will usually have different temperature coefficients, the result is a temperature dependent gain loss. In other cases, the sensor's impedance may not be purely resistive, but rather capacitive or inductive or combined. This will then lead to a frequency-dependent gain error. The way to solve this problem is to either calibrate the system at different temperatures and frequencies, or to make sure that the input impedance of the chopper amplifier is significantly larger than that of the sensor under all conditions. However, since the typical input impedance of a chopper amplifier is usually in the order of several *MΩ* to tens of *MΩ*, this may not be sufficient for some applications, e.g. microphone readout.

So, are chopper amplifiers a blessing or a curse in precision measurement systems? The answer is that - it depends. Although chopper amplifiers can achieve micro-volt offset and low flicker noise, they are not the remedy for all precision problems and must be used appropriately. Care must be taken to minimize the coupling effects from the environment and other "noisy" circuits to the chopper amplifier to ensure its optimal performance. It is equally crucial to avoid degrading system performance due to the switching artifacts produced by the chopper amplifier itself. Last but not least, even when the aforementioned issues are all taken care of, choosing chopper amplifiers for high-impedance sensors can still ruin system performance in a very disappointing manner.

[1] F. Witte, K. A. A. Makinwa and J. H. Huijsing, Dynamic Offset Compensated CMOS Amplifiers, Dordrecht: Springer, 2009.
[2] A. Bakker, K. Thiele, and J. H. Huijsing, "A CMOS Nested-Chopper Instrumentation Amplifier with 100-nV Offset," IEEE J. Solid-State Circuits, vol. 35, no. 12, pp. 1877-1883, Dec. 2000.
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[5] "Input bias current of a chopper amplifier - STMicroelectronics," http://www.st.com/content/ccc/resource/technical/document/application_note/be/20/25/b4/31/2c/42/44/DM00133793.pdf/files/DM00133793.pdf/jcr:content/translations/en.DM00133793.pdf

Factories of the future

On breaking the energy limits in industry 4.0 and saving the planet at the same time

Ir. Nikos Kouvelas, Dr. Vijay Rao, Sujay Narayana, MSc

The Internet of Things (IoT) paradigm is leveraging the tremendous growth of Cyber-Physical Systems in terms of building 'smart-x' applications. The IoT and the advent of the Tactile Internet bridge the gap between the physical world of sensors and actuators and the cyber world, which defines how the communication between them takes place. That is achieved by providing ubiquitous connectivity in the form of 'smart' things and minimal communication delay by decreasing round-trip time between sensors and actuators down to 1 ms.

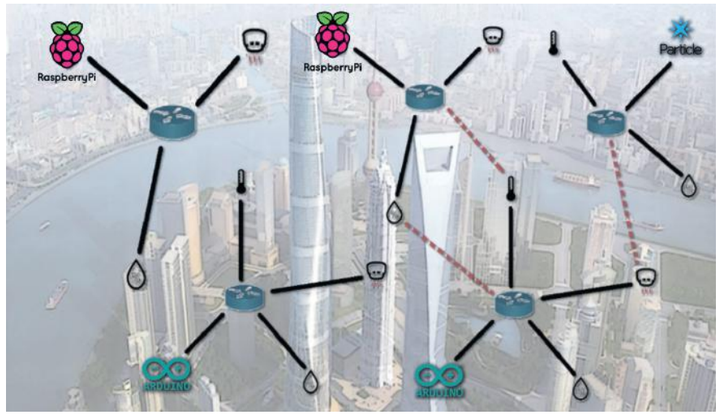


Figure 1. The Smart Interconnected Future [1].

Industry 4.0

These trends connote the commencement of the next Industrial Revolution, Industry 4.0, with massive numbers of sensors and actuators. The Factories of the Future will be operating being dependent on multitudes of IoT-devices. Currently, these devices base their operational longevity on batteries and they consume energy, especially to sense and to communicate wirelessly. Thus, eventually, they die out and need to be replaced.

Environmental limits

Powering all the IoT-devices through batteries is neither scalable nor environmentally sustainable. Creating batteries costs a lot to the environment, as minerals and metals are mined and produced, leaving behind them a considerable carbon footprint. Considering large-scale industries with hundreds of thousands of sensors, like automobile or logistics, 2777 batteries will need replacement monthly per 100,000 devices. With every Li-Ion battery generating 170 g CO2 for 1 Wh of storage capacity, you can already imagine the earth burning.

In addition, transportation, and even destroying of used batteries generates greenhouse gases. Furthermore, frequent battery replacement is labor intensive and, in many situations, even impractical due to physical or deployment conditions.

Operational limits

The longevity of a battery depends on the duty-cycle and the computational burden that its device has to take. Today, on average, 3 years of lifetime are assumed per IoT-device due to its battery. However, as the potential of IoT-devices grows, so does their computational burden. Thus, the expected lifetime of future batteries will be much less. But at the same time, as the Industry grows, more and more batteries will be needed.

It is obvious that relying on batteries is the critical limiting factor on the growth of the future IoT systems. So, let us turn IoT systems into ecosystems.

Energy harvesting: a batteryless future for the sensor systems

We envision a batteryless future, a future of 'green' ecosystems of IoT-devices, wherein batteries will not hinder the ecosystems' longevity. The innovation lies in the technological development that involves highly energy-efficient wireless sensor systems, able to guarantee the high quality industrial requirements regarding latency and reliability. Even in cases where it will not be possible to get rid of batteries completely, because of the volatility in the amounts of harvested energy by renewable sources, we will be able to extend the battery-life by several folds.

Currently, the systems of IoT-sensors communicate using Low Power Wide Area Networks (LPWANs), a group of standards and technologies intended for low bitrate, wireless communications among distant, resource-constrained devices.

Among LPWANs, Long Range (LoRa) WAN has been the most promising; an upcoming IoT protocol already adopted by big players and mobile operators like KPN and TTN. A vast number of the IoT-devices that operate on batteries will communicate using LoRa-Networks. With LoRaWAN, IoT-devices transmit data to their corresponding gateways over many kilometers in a single hop and with a 1% duty-cycle.

Narrow Band (NB)-IoT is another popular LPWAN; by operating on licensed bands of the radio spectrum and by preserving the low-power attribute needed by IoT ecosystems, NB-IoT is speculated to act as an enabler of many already-in-use low range sensor technologies for energy constrained systems, like ZigBee or Bluetooth. Like LoRa, NB-IoT guarantees 2 hops to the Internet and thus can act as a gateway to multitudes of the future sensors.

These energy efficient ways of communication can be combined with techniques of energy harvesting on the sensor level in order to guarantee a zero-energy ecosystem of sensors and actuators. Depending on the industrial domain, different harvester-types can be utilized.

What are the challenges and risks?

The Factories of the Future will rely on innovative ambient-harvesting solutions (including multi-source harvesting) which can be used in industry environments. To this end, the whole sensor ecosystem

Figure 2. Used batteries (cmaecocycle.net).

will need to be as autonomous as possible with respect to energy. Therefore, the main challenge is that despite having low amounts of energy harvested, the system should guarantee the requirements set by the industry. Since energy harvesting is based on intermittent sources of energy (e.g., sunlight, wind), energy-aware forecasting methods based on neural networks need to be used to predict the

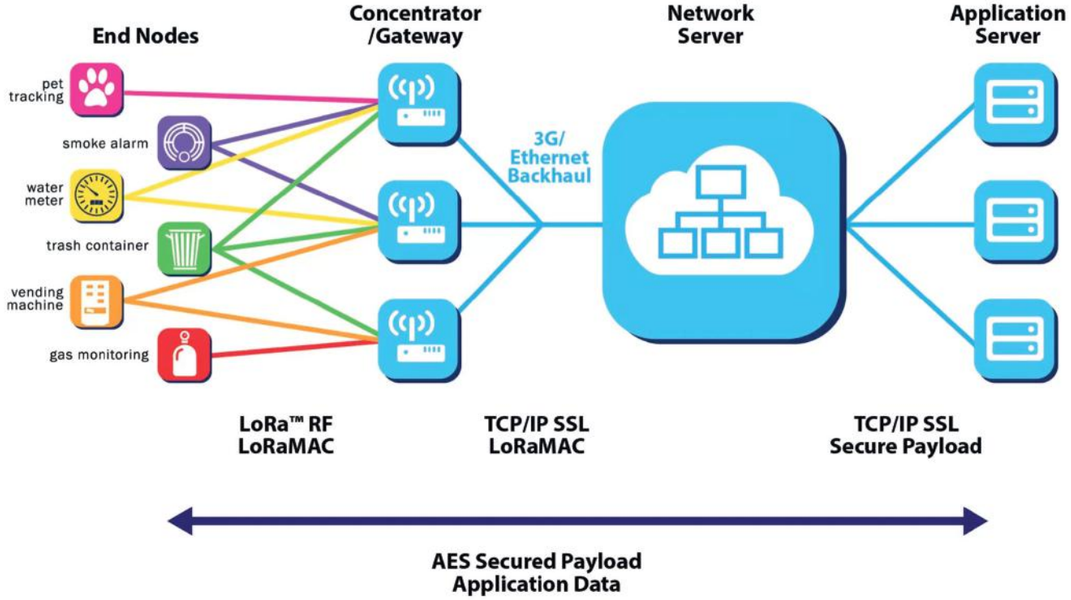


Figure 3. LoRaWAN (forum.loraserver.io).

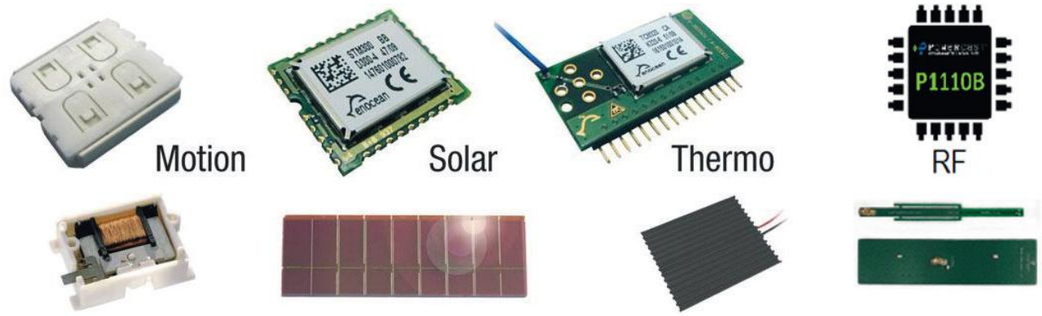


Figure 4. Types of Harvesters [2].

"The readiness of the market to accept and adopt harvesting as the main technique of acquiring energy and supporting the systems of Industry 4.0 is still questionable."

amounts of energy that are to be supplied. It is in the hands of the researchers to eliminate any unreliability provoked by the volatility of scavenging from ambient renewable energy sources.

Further, the heterogeneity of the industrial sectors poses another critical challenge. This implies the following:

- the need for different harvesters,
- the need for different sensors, and
- different deployment conditions.

For example, in railway logistics monitoring, vibration harvesters should be preferred, while in agriculture, the first choice is solar panels. On evaluating the structural stability of an airplane (heavy manufacturing), the sensors should be tested on totally different conditions than the sensors used for monitoring crops (agriculture).

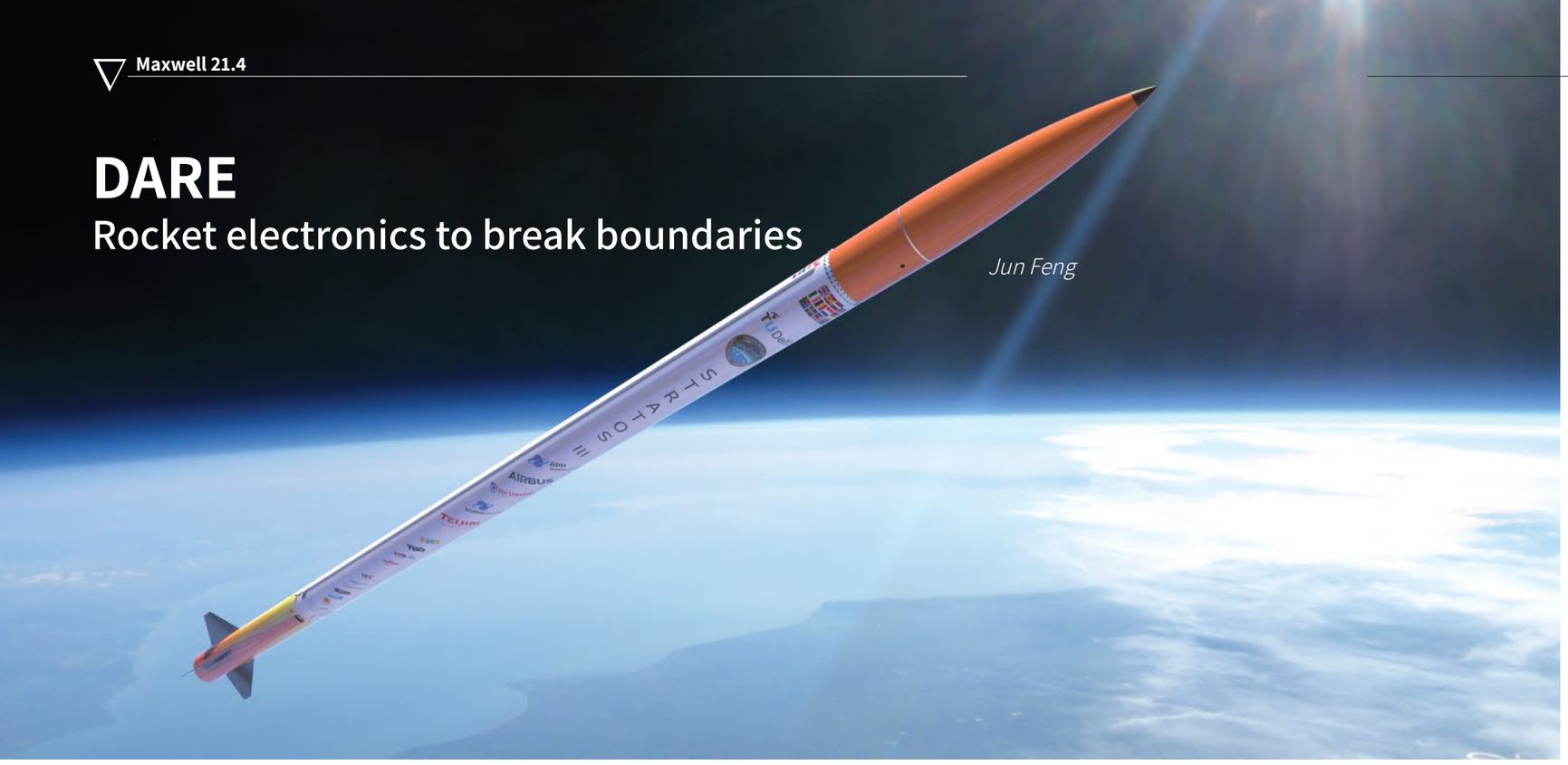
The main risk lies in the market reaction! Although harvesting technologies have made a long way since their initial conception and great leaps are done in forecasting the amounts of energy that can be harvested by renewable sources, the readiness of the market to accept and adopt harvesting as the main technique of acquiring energy and supporting the systems of Industry 4.0 is still questionable. And this is reasonable up to a certain point. Are we ready to eliminate once and for all one of the main means of powering our world? The change will not come overnight; coexistence of energy harvesting systems with traditional battery powered ones is foreseen at least at the beginning.

How does the future look like?

For the big factories of tomorrow, the future is 'green' and sustainable. Ecosystems of sensors and actuators will work seamlessly under a zero-energy framework. Additionally, the whole 'deadly'-spiral of creating batteries, using them for short-term, and finally dumping them will be in the past, along with its consequences on our planet.

[1] Nikos Kouvelas, R.R. Venkatesha Prasad, 'Can We Handle So Many IoT-devices? Scalable Distributed Ecosystems of Sensors', poster for SATIS '18 The 1st ACM SIGOPS Summer School on Advanced Topics in Systems, August 14-17, 2018, Tromsø, Norway, http://site.uit.no/satis2018/

[2] N. Kouvelas, V.Rao, S.Narayana, 'Making LPWANs Batteryless', poster for Transiently Powered Computing – IDEA League Doctoral School, November 8-10, 2017, Delft, the Netherlands, http://tpc2017.neslab.it/



DARE

Rocket electronics to break boundaries

Jun Feng

Everything is possible or rather: the sky is the limit, right? We disagree, here at DARE (Delft Aerospace Rocket Engineering). As TU Delft dreamteam, we aim to be the first student rocketry team to reach space: that is over 100 kilometer. Step by step, while developing more powerful systems, we come closer to that goal. This July, the next step will be taken as we launch the newest rocket Stratos III, aiming to bring the record back to Delft. Rocket science is not an easy thing, but the rockets' electronic systems are really the part distinguishing our rockets from flying tubes.

If you have been around some while on the university already, you probably biked by our lab plenty of times. This lab is in the low-rise of EEMCS, next to DEMO: it's the "Korolev" lab, named after the owner of the first dog in space! From this lab we do all rocket design, simulation, and of course rocket electronics development.

In the early beginnings (with the workshop still next to the Study Collection in the basement) we set the 12.5-kilometer EU student-built rocket altitude record using a two-stage rocket in 2009, launched from Sweden. Sadly, it crashed into the ground afterwards, so the recovery of the payload was not successful.

In 2015, Stratos II+ launched successfully from Spain, reaching 21.5 kilometers (twice the altitude planes fly at) and successfully breaking the record. The rocket flew a stack of PCBs forming its flight computer that has autonomous control over cameras, various sensors but also blackboxes and payloads (standalone systems from external parties that support the project in return for a piggyback testing environment). After lift-off was executed by the engine control unit, people at grounds stations were able to receive data telemetry and live video feed from during the actual flight.

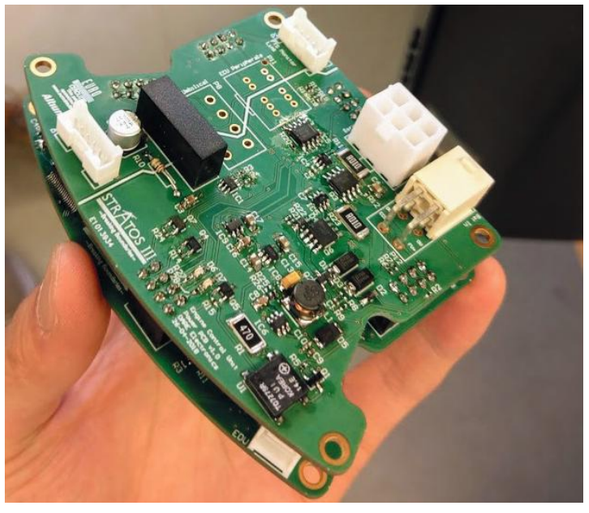


Figure 1. Stratos III engine control unit assembly, without encasing.

In the time that has passed since, the record was taken over by another team in Stuttgart. With Stratos III we have a more powerful rocket, increased its length to 8.2 meters and revised the electronic systems: all electronic upgrades stem from knowledge gained for previous launches.

Rocket engine control

Just like at SpaceX, getting big rockets in the air is difficult and takes quite some time to get right. Stratos III's thrust comes from feeding liquid nitrous to the solid part of the engine and releasing energy from a combustion. The sequence making the ignition successful and maintaining the combustion is managed by the engine control unit.

The engine control unit is a stacked PCB assembly stored in a 3D-printed encasing. On top, cable harnesses from pressure sensors come in but also signals to e.g. a servo, solenoid-based valve and a DC motor emerge. The (brushless) DC motor is actuates a main valve to control the liquid flow in the engine. The DC motor can quickly fully open the valve so that the rocket accelerates to 136 km/h in just 0.35 seconds, reaching up to Mach 4 in flight. In addition, all power conversion and regulation are managed on the top PCB for the whole engine control unit too.

The bottom half of the engine control unit does the data readout and logic part of its functionality. One microcontroller implements the lift-off sequence by actuator control, while another microcontroller helps to manage communication to other electronics systems on board like the flight computer (5 meters away from the engine control unit) on multiple UART lines.

As the countdown decrements, the rocket is armed from a long distance and starts running on internal power, becoming autonomous. At t = -6 seconds, the engine control unit's ignition sequence starts while mission control personnel anxiously monitor the rocket's data until t = 0 seconds: the rocket lifts-off with full thrust and data is only received by telemetry and video downlink.

Flight data

The most valuable thing for the mission, apart from the altitude record, is retrieving data. The data will be priceless in case the mission fails for post-mission

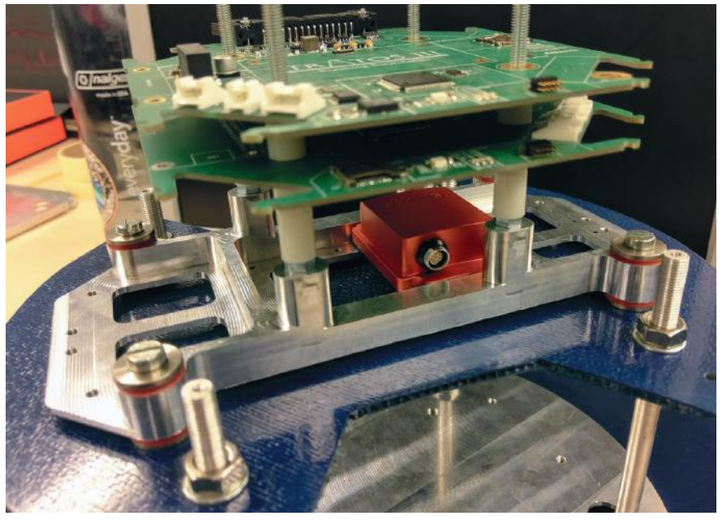


Figure 2. Stratos III engine control unit assembly, without encasing.

"The DC motor can quickly fully open the valve so that the rocket goes to 136 km/h in just 0.4 seconds, reaching up to Mach 4"

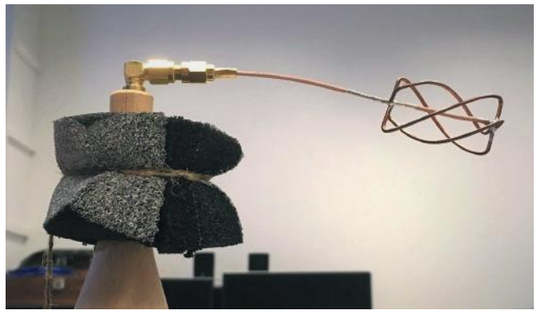


Figure 3. QFH antenna testing. The test was so see the effect of the outside paint of the rocket on the transmittivity of the antenna.

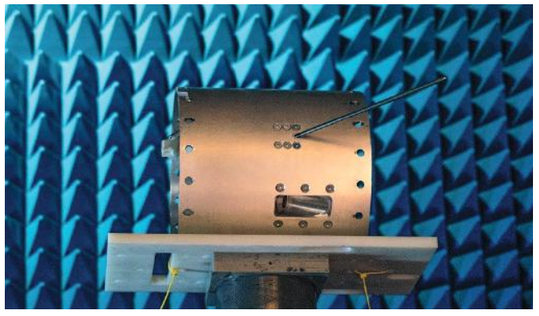


Figure 4. Stratos II+ (2015) flight safety receiver antenna testing in an anechoic chamber. Stratos III will fly the same antenna configuration as it proved to work well.

forensic analysis, or for developing the next generation of Stratos. Think of engine performance, the measured rotation for fin stabilization performance or useful data for real-time simulations.

If the flight is successful, a total of 10 micro SD cards spread over the electronics systems will be recovered with precious data. For example, the GPS coordinates at full data rate. The wireless downlink to the Earth during flight from two antennas is not sufficient to stream all data in a short amount of time.

During flight, we have multiple ground stations with self-made antenna systems and inside the rocket we likewise fly own-built and tested antennas, but also off-the-shelve solutions for GPS reception. Two of the own-built antennas are quadrifilar helix (QFH) antennas, pointing towards the Earth during ascent; one is for telemetry transmission while the other is for live video transmission.

A fun but important feature of the telemetry and video transmission is the redundancy of the telemetry link. The audio channel of the video link is used to modulate the telemetry data as a redundant way of acquiring data, but also on the video stream, some pixels are used for an on-screen overlay to display the most critical data.

Mission reliability

How do we make sure that the rocket doesn't fail due to the intense circumstances like huge vibrations, extreme temperatures or defect critical electronics? We have just one shot: the flight must be safe, and we want to succeed in the mission.

As for safety, the rocket can receive a termination signal from the ground during flight if it's deemed that the flight is unsafe. The antenna reception system was tested thoroughly in the past and this flight termination system also has a back-up function to terminate in case that the carrier signal is lost for too long, or when the power supply is failing. All these features are there to maximize safety during the mission.

At the point of separation of the top section of the rocket (all data is stored in the top section), the recovery system must be certain of that it wants to actuate the staged parachute systems. For this reason, we have two boards that do independent pressure and acceleration measurements and together decide on the right moments of deployment.

We are also testing the feasibility of using real-time simulations to predict the exact state of the flight to see if we will still land safely for possible decision making in future rockets. This kind of experiments are ideal to push the boundaries for the next-generation Stratos rockets.

Figure 5. Separation is one the most crucial phases during the mission and relies on firing bolt cutters in a spring-loaded mechanism. Altitude detection must be on point as well as the timing of the parachute deployments that follow on the way down.

Bachelor graduation project

The last stage of the Electrical Engineering Bachelor program is the bachelor graduation project, usually called BAP from the Dutch name. With this project you get to prove your electrical engineering skills and convince the university that you are worthy of a Bachelor of Science degree.

Ampelmann

Matti Dreef

Supervisor: Dr.ir. Rob Remis, Circuits and Systems
External Collaborator: Frank Nieuwenhuizen, Sr. Motion Control Engineer, Ampelmann

Figure 1. An Ampelmann system in 'engaged' mode, allowing safe transfer from ship to offshore structure.

A system to test motion sensors

I did my BAP at Ampelmann, a company developing self-stabilizing gangways for safer and cheaper offshore access. With a group of six we developed a system to test motion sensors used for these gangways, allowing Ampelmann to check whether a sensor is up to the task. This project was not chosen from the list provided by the university. Rather, we set out on our own to find an interesting project at a company.

A large range of electrical engineering

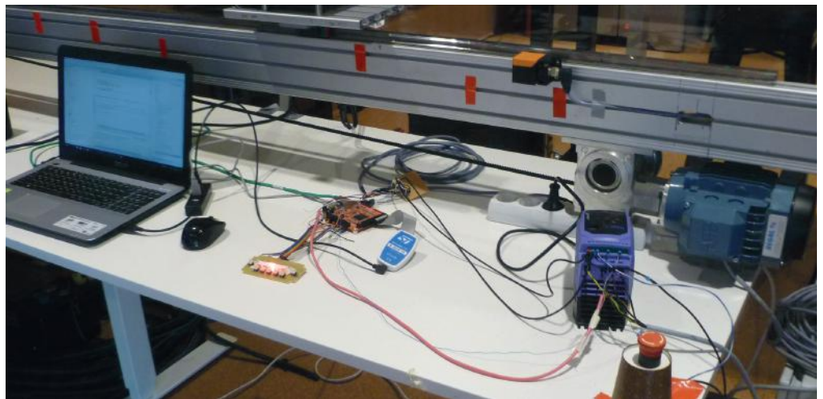
The group of six was split into three groups of two, each responsible for a separate part of the system and producing their own thesis. My part concerned the hardware, which includes both the mechanical 'Linear Motion System' (a straight rail) and the electrical control system. The electrical system covers a large range of electrical engineering, from a 3.3 V microcontroller to a three-phase 230 V motor. Between searching for that one wire in the schematics and making sure no fingers were crushed by moving parts, the occasional soldering provided some relaxing moments to appreciate.

"The occasional soldering provided some relaxing moments to appreciate."

The BAP is set apart from the EPO projects by not being largely prescribed. There is no manual to follow, and even the goal of the project can change over time. Working for a real company was also very different from the university; from Ampelmann there was no need to write a thesis which describes the design process, what really mattered was the final completed system and some documentation.

In the end, we successfully delivered a working prototype of the test system to Ampelmann, and a bachelor thesis to the university. While the thesis will be under embargo for five years due to a non-disclosure agreement, I can assure you it's a good read! I definitely enjoyed my time working at Ampelmann with five friends, and am eager to see how our system will be used by Ampelmann in the future.

More information: *www.ampelmann.nl*



◀ *Figure 2.* The final prototype of our test system.

Neural stimulator

Simon Verkleij

Figure 3. The team of our bachelor graduation project.

Supervisor: Prof.dr.ir Wouter Serdijn, Bioelectronics
External Collaborator: Dr. Bertil Blok, urologist and medical coordinator, Dept. of Urology, Erasmus Medical Center

Emptying the bladder

I did my bachelor graduation project at the Bioelectronics group of the TU Delft, together with an urologist from the Erasmus Medical Center. The goal was to develop a neural stimulator for people who cannot empty their bladder, to let them empty it again.

Millions of people have difficulty in emptying their urinary bladder. Well-known causes are spinal-cord injury (SCI) and multiple sclerosis (MS), but many more non-neurological patients suffer from similar problems without an obvious cause. These patients cannot void because they do not feel when their bladder is ready to empty and unable to activate the brainstem switch to start voiding.

New stimulation method

The most common treatment is to use a catheter, but this results in pain and high healthcare costs. Current electrical stimulation methods are ineffective.

Our solution makes use of a new kind of electrical stimulation. This should enable patients to void more easily. The advantage of this solution is that the operation is minimally invasive and that stimulation does not damage existing nerves.

Creating the prototype

With the six of us, we divided the project into three parts: the *Control and Interface* that made an easy to understand interface in collaboration with the Medical Center. The *Arbitrary Waveform Generator* that creates the stimulation waveform from the parameters set and the *Safety Module* that checks if the stimulation is safe at all times and shuts it down if it is not.

After a lot of research into these fields, we simulated and tested our circuits which still showed many minor issues. After a lot of testing and improving, we finally made a prototype that fulfilled the requirements.

Fish lunch

As a group, we had our own room to work in on the 18th floor. This meant that, unlike in the Tellegenhal, we had a lot of contact with the people from the Bioelectronics department where we worked at.

We could get detailed help from the technician, order components (and get the coffee card) at the secretary and maybe most importantly, join the fish lunch every Thursday. This is a tradition where half a baguette, fried fish, avocado and lemon are bought for everyone who is interested. This resulted in meeting a lot of people and having very nice lunch conversations.

Figure 4. Our prototype with buttons to set the stimulation parameters which can be viewed on the LED screen.

Momo Medical

Duco Veldhuijzen

Supervisor: Prof.dr. Paddy French, Electronic Instrumentation and dr. Massimo Mastrangeli, Electronic Components, Technology and Materials
External Collaborator: Danny Eldering and Thomas Bakker, Momo Medical

Smart pressure ulcer prevention

Momo Medical is a start-up at YES!Delft that develops a pressure ulcer prevention system. Pressure ulcers can develop when there is a high pressure on a piece of skin for a longer time. This is a common problem in hospitals. The best cure for pressure ulcers is prevention. Momo Medical's system can prevent these pressure ulcers by keeping track at the patients movement and position in the bed. When a patient is hasn't moved for a long time and thus pressure ulcers begin to develop, a nurse is alarmed that the patient should be repositioned in the bed. With this system, a lot of suffering can be prevented, but also al lot of money in healthcare can be saved.

"The best cure for pressure ulcers is prevention."

Our assignment

The system consists of a sensor plate underneath the mattress and an interaction unit for the nurses. Our job, as BAP group, is to improve the sensors and their readout in the sensors plate. We made an automatic calibration setup for the sensors and several PCBs were designed and produced. At the end, a whole redesign of the sensor plate was made, including a new encasement. It was great we got the help and resourced to accomplish this. We cannot tell a lot about the technical details since we signed a non-disclosure agreement, but we can tell our other experiences.

BAP at a start-up

It was great to do our project at a start-up. We have a place in Momo Medical's office to work alongside the other employees. This way you get really involved in the company. Activities like Friday evening drinks and a team building event also help with that. It was an interesting experience to participate in a start-up team and were leant a lot this last quarter of our bachelors.

Figure 5. Momo Medical's sensor plate placed under a mattress

James Clerk Maxwell

$$\nabla \cdot \mathbf{B} = 0 \qquad \nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0}$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial \mathbf{t}}$$

$$\nabla \times \mathbf{B} = \mu_0 \left(\mathbf{J} + \varepsilon_0 \frac{\partial \mathbf{E}}{\partial \mathbf{t}} \right)$$

Sustainability at 30k feet

A look at the technologies & challenges in the area of E-Aircraft

Shubham Harne

We all have heard of electric cars, but flying with e-propulsion aircrafts never acquired our imagination. Limits are being pushed to introduce sustainability in this sector. The experience from automotive department and the recent technological leap in battery department will provide some basis but the journey here has a completely different trail of challenges. The result being more efficient, sustainable and less noisy is what drives the research in this area.

Efforts in this direction seem to be good enough to fulfil the objective of European commission's 'Flightpath 2050- Europe's vision for Aviation' wherein 3 quarters of CO2 emission, 90 percent nitrogen oxides and 65 percent noise level reduction is benchmarked.E-fall stands a microcosm to this approach. The length being less than 7m and a wingspan of 9.5m is the first prototype of its kind. It comprises of the latest Lithium Ion Polymer batteries powering its 30kW engines.

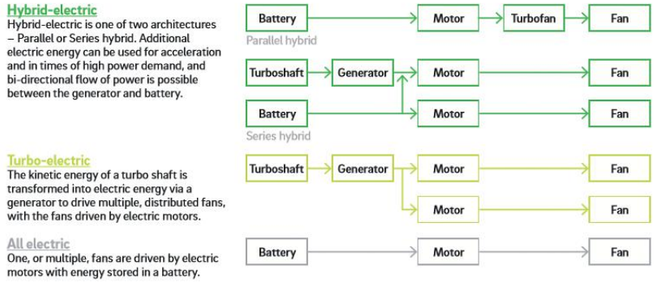


Figure 1. Source: NASA, Roland Berger

The increasing popularity of Internal Combustion engines during the last two centuries led to promotion of Gas turbine in aviation. Oil and its derivatives served as mostly used fuel. At the same time, electrification in the aircraft industry was also moving on with a comparatively slower pace. Electrical propulsion has gained significant popularity in this revolution [4].

More Electric Aircraft

More Electric Aircraft is a concept deploying more electric equipment in place of mechanical and hydraulic. For a long time, mechanisms such as air conditioning, de-icing and actuation were powered by mechanical, hydraulic and pneumatic sources which are relatively less reliable and demanded more maintenance when compared to the electric systems. Errors in hydraulic and pneumatic operations are difficult to spot given heavy pipes and ducts running through the complex system. In 1967, Boeing 737 flight introduced electrical cabin equipment and avionics. This led to the rise of More Electric Aircraft concept. Well on the flip side, reliance on power electronics for the proper functioning of electrical system is equally crucial.

Electrical propulsion

Another more revolutionary concept

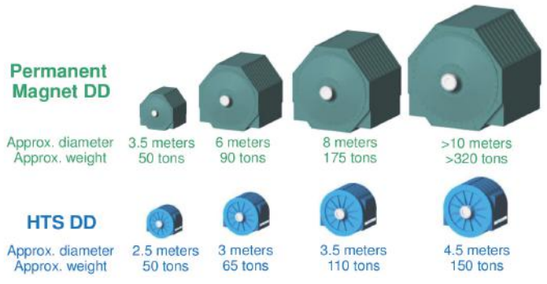


Figure 2. Source: The E&T Energy and Power Hub

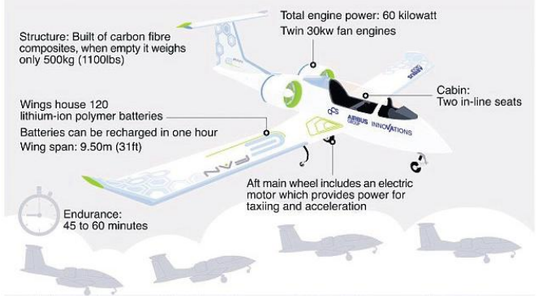


Figure 3. Source: Linus tech tips

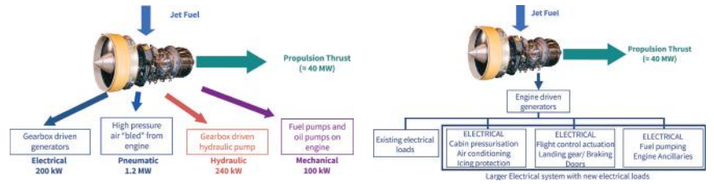


Figure 4. Source: Wheeler P, "Technology for the More and All Electric Aircraft of the Future"

"Electrical Propulsion" started its evolution journey with La France flying first time in 1884. The three design variants are as displayed in the image figure 1.

Battery - a crucial element

Batteries being the most important component of all electric aircraft can be seen undergoing several engineering efforts to fit this application. One of the technologies keeping the hope up for this sector is Lithium air batteries. These have very high energy density- 1000Wh/kg in contrast to the Lithium ion batteries having 250Wh/kg. Also, Lithium air batteries have less weight given that one of the electrodes being atmospheric oxygen is not considered.

But sustainability is not always welcome until it is economic. With the technological advancement mentioned above, the wait is still to make it pocket friendly for the customers. Maximum energy density with the available batteries in the market is 200-250 Wh/kg (li-ion battery) and the desired is naturally superseding to a value of at least 500Wh/kg. This requires advancements in electrochemistry to achieve such a feat. It will still be lower than the energy density of Jet fuel but on the positive side, more efficient and much cleaner. Secondly, the charging infrastructure and the batteries must be able to support high-speed recharging. Balancing battery charge in case of li-ion still needs attention. We really don't have any answer when it comes to anticipating life time of li-ion batteries, thus aggravating the scenario. After being eligible technologically, the deciding factor is safety and reliability. Still a huge mass of population is traumatized when a battery-operated vehicle is the topic. What will happen if the battery drains completely in the mid of the journey, what if it sets on fire and many more haunting the mindset. Reassuring the safety of this technology in the minds of public is not to be ignored.

Hybrid battery-solar architecture

Further support to this form can be obtained by including solar energy harvesting. Pathfinder, Helios by NASA and Swiss Solar Impulse find their place in this arena. With a wingspan of 70m and loaded with 17000 solar cells, this can charge the battery or supply load in peak conditions. Material science has progressed exponentially in bringing down the prices of PV cells so far. Though not the most optimized for aviation economically at this moment, the thought of same cannot be blatantly ignored.

Role of superconductors

In this arena of aviation, we talk in terms of MWs. Certainly, at this level we want losses to be minimized. At the same time, we want higher power to mass ratio for Motors and Generators. This is where superconductors come to our rescue. Superconductors found their mention first by Oberly in 1976. But since then very little research has been done in the field of superconducting motors. Superconductors exhibit zero resistance property and hence can carry high current density. NASA N3-X is testimony to this technology and its effectiveness. Powered by turboelectric and superconducting full distributed propulsion system, fuel and weight estimates went down significantly [3].

The cooling system-cryocoolers become a crucial part of the superconducting machine. The system is still not weight optimized for the aircraft system. An alternative would be cryogen storage- enough cryogen is mounted in the aircraft storage system at the airport to last its trip. And just like fuel refilling, this system might work as well [2].

A revolutionizing opportunity

Given the technology available till date and the challenges foreseen so far, there is still a lot new to be discovered traversing this path. While a shift to More Electric Aircraft seemed to be beneficial for many market players, further leap to All electric will revolutionize the aviation industry just like automobile sector. The question is whether this has the potential to become the next "Disruptive Innovation". If yes, then more importantly who will be the TESLA in this case.

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[4] Mark Williamson, "Air power the rise of Electric Aircraft"
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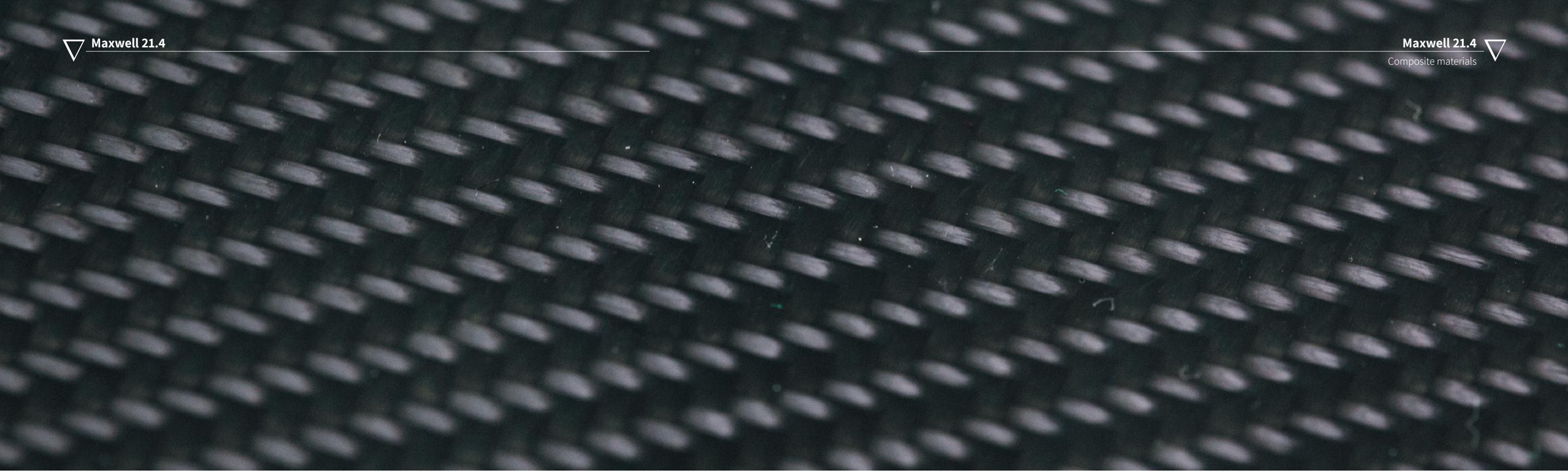
[6] Martin Hepperle , "Electric Flight – Potential and Limitations"



Composite materials

Cutting-edge manufacturing with carbon

Deba Jyoti Khawas, Purdue University

Historically, humankind has used a variety of materials to make everyday things: stones, metals or clay. One thing which has been common in the use of all these materials is the inherent simplicity of application: one does not need to worry about the orientation, application or usage of these.
However, with the modern demands from engineering materials, the old way of doing things is simply not enough. The use of materials in cutting-edge applications like making airplanes and high-performance cars require a new way of approaching the problem.

Properties of materials

Traditionally, manufacturing has used materials which are characterized by two important properties: homogeneity and isotropy.

A material is homogeneous if the material properties remain the same for all the points throughout the domain of the material which we considered as a material. Otherwise, the material is heterogenous. However, the categorization of materials based on homogeneity only makes sense at the macroscopic scale as all materials are heterogenous in nature at the atomic scale [1].

A material is isotropic if the material properties remain the same along all the directions at the same point. Otherwise, it is anisotropic which implies that the material properties are different along different directions at the same point.

It is important to note that these two properties are independent of each other. There are examples of materials which are neither isotropic, nor homogenous or have one or both of these properties.

Conventional materials

Conventional materials like metals, concrete or plastics are generally homogenous and isotropic in nature. These essentially implies the same value for properties like strength, coefficient of thermal expansion or the electrical conductivity in all the directions and at every point of the material.

"This means, theoretically, at high speeds these cars can drive upside down."

However, this implies a wastage of material as the same value of strength is not needed in all directions where there is a principal load in only one direction. For example, the spoilers of a Formula-1 car, has to withstand the tremendous down force when the car is going at high speeds. A modern F1 car can generate up to 3.5G (three and a half times its own weight) of lateral cornering force; thanks to aerodynamic downforce. This means, theoretically, at high speeds these cars can drive upside down. [2] However, there is not much need of strength going across the width of the spoiler as the only load there is the marginal drag from the air while turning which is orders of magnitude lower than the principal load. Hence, in these applications, a lot of advantage can be gained by designing materials which can provide strength only in specific directions and saving every gram of weight which can give the racers tremendous advantage. These requirements can be filled by the use of composite materials.

Composite materials

Composite materials consist of two or more different materials that form regions large enough to be regarded as continua and which are usually firmly bonded together at the interface. Many natural and artificial materials are of this nature, such as: reinforced rubber, filled polymers, mortar and concrete, alloys, porous and cracked media, aligned and chopped fiber composites, polycrystalline aggregates (metals) etc [3]. They are generally anisotropic and heterogenous in nature.

There are many examples of anisotropic materials in nature. For example, it is much easier to cut wood along the grain

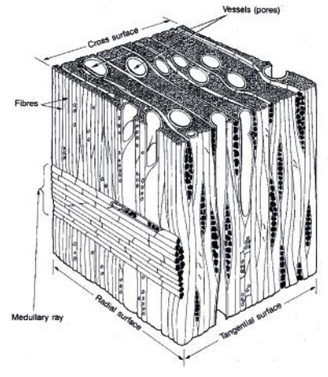


Figure 1. Wood microstructure.

direction than the growth ring direction. This is due to the microstructure of wood which has long thin-walled tubular cells called tracheids pointing in the grain direction [4].

Similarly, around 1500 BCE in the Fertile Crescent, humans began adding straw to strengthen clay bricks. The ceramic part of the brick (clay, loam, mud, sand) was suitable for compressive loads

while straws or rice husks provided tensile strength to the brick [5].

Modern composite material technology began to emerge about 1960 with the advent of modern fiber composites consisting of very stiff and strong aligned fibers made of glass, boron, carbon or graphite in a polymeric matrix and later also in a light weight metal matrix [3].

Advantages of composite materials

Compared to conventional materials, using composite materials can result in very lightweight structures due to their high specific stiffness and strength. The microstructure of the composite can be tailored to meet the specific demands and design requirements of a particular application by varying properties like volume fraction of each constituent, fabrication methods, layer orientations, layer thicknesses, processing parameters, number of layers etc. Composites are also known to have better fatigue life than metals, which has been exemplified in its extended use for designing rotor blades in the helicopter industry [6]. For structures operating in regions with fluctuating temperatures, composite materials can be designed to have very small or zero thermal expansion for dimensional stability, something which is not possible with conventional materials. Composite materials are also resistant to corrosion from moisture and chemicals which generally plague common materials.

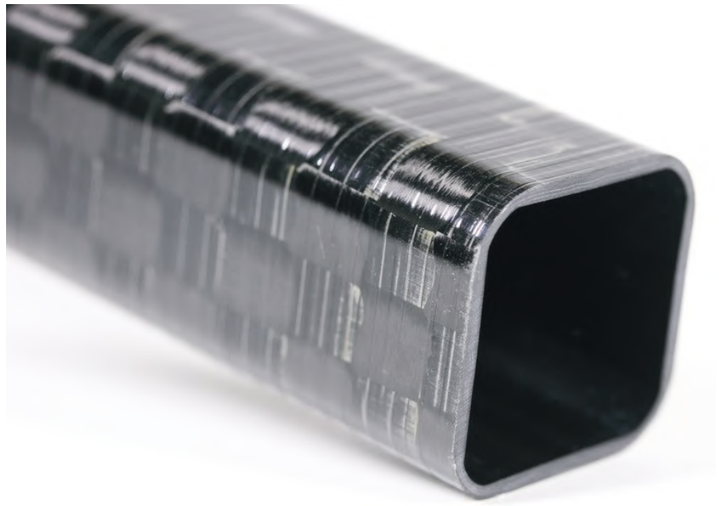


Figure 2. Fiber orientation makes the difference in properties.

Challenges for modeling composites

The same properties which makes the use of composite materials special, also hampers the design process using composites:

- Anisotropy: Composite materials being inherently anisotropic demands the use of much more variables to describe its materials properties than conventional materials which causes a less intuitive understanding of the materials.
- Heterogeneity: The heterogeneity of composite materials causes for much more complicated and resource intensive mathematical modelling of composite materials.
- Multiscale Modelling: The properties of composite materials vary depending on the scale at which they are analyzed. Carbon fibers typically have a diameter of a few microm-eters , but they are used to make wind turbine blades or helicopter rotors which are meters in length. Thus, analysis have to be done at every length scale from micrometers to meters to understand and design these structures well. This approach is computationally very expensive and time consuming

With all these considerations, the manufacturing of composite materials requires some special techniques which are quite different from conventional materials. These methods come with their own set of advantages and disadvantages.

Figure 3 . Resin being transferred to a sailboat hull [9].

Resin transfer molding

This method of making composites is divided primarily into two parts: spreading the fibers onto the part in the desired orientation and holding it in place; and forcing the resin into the same through some method where it is allowed to cure and form the final part. Forcing the resin is most commonly done by applying vacuum on the part while allowing atmospheric pressure to push the resin into the mold, in which case the process is known as Vacuum assisted Resin Transfer Molding (VARTM). VARTM is used primarily to make sailboats of fiber glass or bodies of airplanes like Airbus A350s.

Figure 4. Parts being cured in an autoclave [10].

"The microstructure of the composite can be tailored to meet the specific demands and design requirements of a particular application by varying properties like volume fraction of each constituent, fabrication methods, layer orientations, layer thicknesses, processing parameters, number of layers etc."

Autoclave curing

Autoclaves are pressure vessels used to process parts and materials which require exposure to elevated pressure and temperature. The manufacturing of high-performance components from advanced composites often requires autoclave processing traditionally [7].

In this manufacturing, generally, pre-impregnated fibers with resins are placed and cured in an autoclave where there is a constant application of both heat as well as pressure during the entire process to the part. This method gives the best possible parts, both in terms of mechanical properties and build quality. However, the size of the autoclave required to cure big parts and the increasing complexity in maintaining uniformity in heat and pressure throughout the part poses a big problem in the use of this method to cure parts like an airplane fuselage [8].

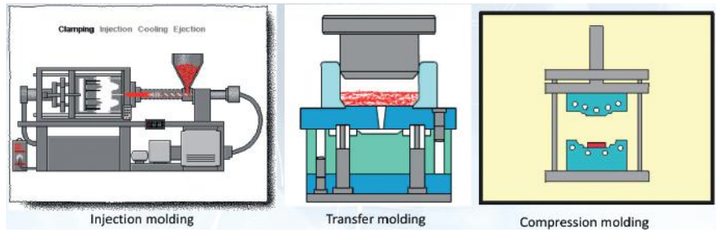


Figure 5. Composite manufacturing processes.

Molding

Molding is the most commonly used method to make mass manufactured parts made up of composites mostly for automobile parts. In this, a die is made for molding the final part required and the composite is fed into the system either by pre-placing them in form of pre-impregnated laminates (compression molding) or injecting them into the die (injection molding), or some combination of both the methods (transfer molding). This method is fast and highly repetitive but does not have the same quality of parts as those cured from the autoclave and also is only viable for mass manufacturing application only due to high maintenance required for the die and cast.

3D printing

3D printing composites is the newest and most interesting method to make parts from composite materials. With the advent of modern printing controls and technology and the use of fast setting thermoplastic polymers as the matrix material, 3D printing can manufacture parts far faster than other methods listed above

Figure 6. Compression molded Nissan GT-R decklid [12].

"...there are a number of aspects of making composites which we still don't understand or can't put into usable form."

as well as can be used for applications like making tools which can be used in one-off compression molding applications or making parts which are needed to have strength only in one direction.

However, this method suffers from the disadvantage of very weak adhesion and strength between different layers of the part being printed as well as limited choice of materials as the more common thermoset materials are not very successfully implemented in this application.

Conclusion

Manufacturing parts with composites poses a variety of challenges, both in the design as well as in the manufacturing phases. Even after centuries of development in the manufacturing technology and design and simulation methods, there are a number of aspects of making composites which we still don't understand or can't put into usable form. Empirical relations and approximations allow us to make composite parts a reality, but the real potential of this material and the limitless design flexibility and choices it offers still remain to be explored. Needless to say, composites test the limits of manufacturing today.

Figure 7. 3D-printed carbon composite parts [11].

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Exchange outside the EU
(But not really)

Marc Zwalua

My story begins in the famous land of cheese fondue, secret bank accounts and expensive watches. The country I'm talking about is, of course, Switzerland, or as some Swiss people call like to call it "Confédération suisse". Or as some other Swiss people would call it, Schweizerische Eidgenossenschaft (German), Confederazione Svizzera (Italian) or even Confederaziun svizra (Romansch). This brings me immediately to one of the major differences between studying in Delft and studying at the Switzerland, you never know when you are going to need your French, or your German, or your Italian.

Although there are three major languages in Switzerland, most of the Swiss people only manage to speak one of them properly. I experienced this very early in my exchange program. Already, in my first week, my neighbor came to me and started speaking in very fast and angry French. After experiencing a lot of French words and Mediterranean gestures, I understood that I was not allowed to say goodbye to my housemate at 23:00 on the staircase. Since my German is pretty acceptable (compared to my French), I tried to apologize. However, since my neighbor did not understand "Entschuldigung" and "Es tut mir leid", my apologies were not received. Luckily, the week after I was able to use "Je suis désole" instead and my apologies for closing the door too hard were received that time.

The reason that there are four official languages has to do with the way Switzerland is organized. Switzerland is a federation of 26 cantons. These cantons are approximately half the size of the Dutch provinces. However, they do have a lot more power compared to the Dutch provinces. This results in a country where some laws (and also the language) can be different by only driving half an hour and where there is no official capital.

Another thing about Switzerland is the fact that they are not within the EU. As an exchange student, you notice this at several points. First of all, Switzerland is not part of the Erasmus Program. However, this does not mean there are no Erasmus Student Networks. In contrary, EPFL (but also UNIL) has a very active ESN association. Almost every week, there are activities for exchange students to join. Instead of the Erasmus Scholarship, the Swiss government has their own program. This is called SEMP (Swiss European Mobility Program) and is more in line with the Swiss prices.

The Swiss prices are another place where you can feel the difference between being inside and outside the EU. Almost everything in Switzerland (and especially those things that are imported) is more expensive. A small portion (300 gram) of minced meat or chicken filet priced at 7 or 8 CHF can easily set you back and bell peppers from the Westland can be about 3 (or more) CHF per piece. Luckily, the EU is not very far from Lausanne. Within half an hour, you can be at the nearest Intermaché. I used this geographic advantage about two times per month to buy meat, coffee and exotic products like bell peppers and curry paste.

"Passing the border on Thursday morning made my avocado/coconut milk/curry paste smuggling a lot easier"

This route, however, is very popular amongst Swiss people. Especially on Saturday morning, a lot of Swiss people cross the border to buy groceries. This is clearly visible at the parking lots of the nearby supermarkets. As a result of this, heavy traffic jams and elaborate border controls are there on the weekends. Luckily, my Dutch license plates and sudden very limited knowledge of the French language made sure I usually passed the border without a lot of trouble. Also, passing the border on Thursday morning made my avocado/coconut milk/curry paste smuggling a lot easier.

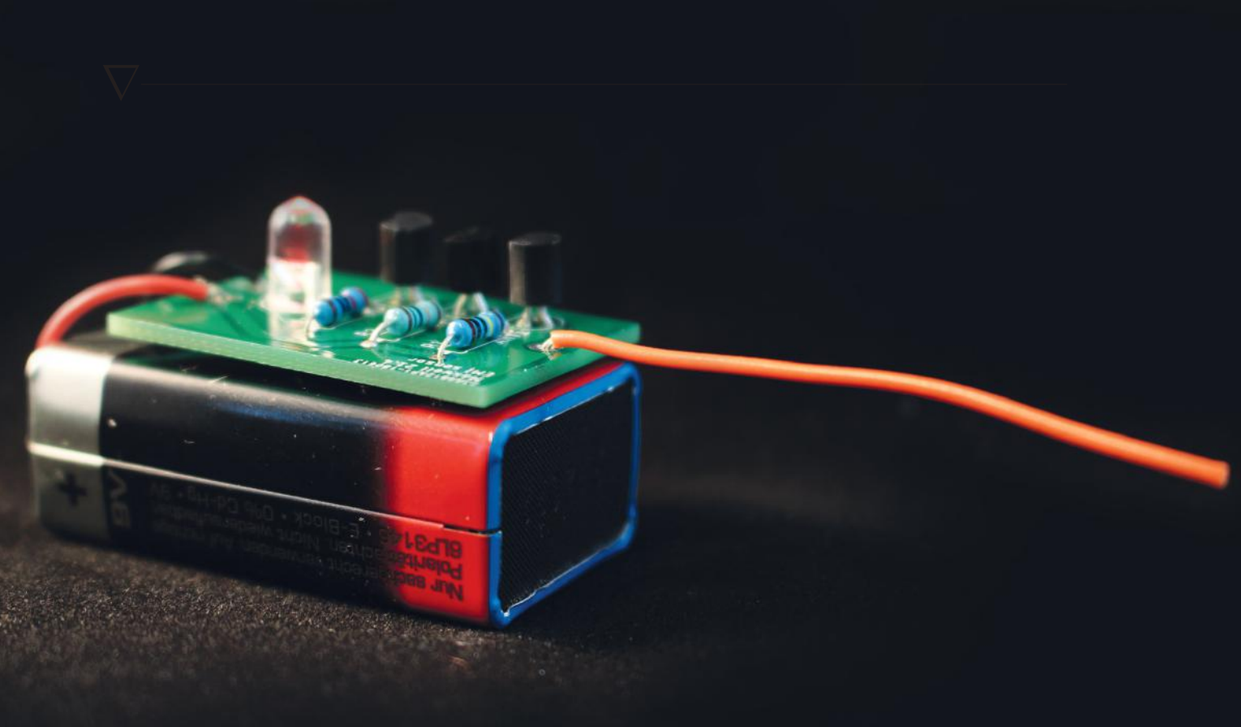
Although the Switzerland has two of the world's highest ranked technical universities (EPFL and ETHZ), the country itself is not very modern compared to the Netherlands. You'll notice this on the music on the radio, the way hipsters look (Bomfunk mc, Australians etc.) but mainly when you have to get something done. One example for this is the residence permit. Since Switzerland is not part of the EU, you'll have to get a Livret pour étrangers (Ausländerausweis, etc.). This requires getting to Contrôle des habitants. This office (that is only open on limited occasions) lets you write a small book about you, your family and your background. This has to be done on paper and you have to pay by cash. For someone who is used to mijnoverheid.nl and paying everything "sans contact", this was something I had to get used to. A lot of small shops, for example, don't even accept cards or only accept Maestro/Mastercard payments above 10 CHF.

All of this probably won't convince you to visit Switzerland. It is expensive, you need strange money and you probably won't understand the person complaining about you. However, there is one major thing I haven't mentioned yet and that is the stunning landscape. Some people say Switzerland is so expensive because of its beautiful nature. Although I'm not sure if this saying is true, it at least explains the price of living in the Netherlands.

The stunning view already starts at the EPFL. Although the architecture of the Ecole Polytechnique Fédérale de Lausanne is as stylish as the faculty of Civil Engineering, it is located at one of the most famous (and nicest) lakes of the world. Lake Geneva, or as the locals call it, Lac Léman (because the lake does not belong to Geneva) is a blue water lake surrounded by the Alps and some nice beaches. Next to the lake, starts the canton of Valais. This canton is known for its great mountains. Zermatt, Verbier and La port de Soleil are all located in this canton.

Since skiing is very popular and is one of the national hobbies of Switzerland, it's also integrated into student life. This clearly shows in the great amount of ski trips organized by the ESN. Also, as an EPFL student, you can get great discounts on ski passes in the area. I used this opportunity a lot during the winter. Almost every weekend I spend a day in the mountains, usually in France though, to save my wallet from burning up and to combine it with the traditional grocery shopping. When the ski domains close however, these mountains are still nice to go to. During the warmer months, hiking is another popular hobby amongst (exchange) students during the weekends. The nicest views, however, do require a lot of endurance. But since the elevation difference in the city of Lausanne is over 500 meter, you get used to these heights fast as an EPFL student.

After almost six months in the land of four languages, Swiss Francs and beautiful nature, my adventure has almost ended. I can only describe my time in Lausanne and Switzerland as amazing. I really enjoyed the grocery shopping in my civil looking smuggle car, the skiing, the ESN activities and even a lot of the lectures. Regarding my experience, I can only recommend other students to go here as well. Yes, it is expensive. Yes, they speak funny and yes you can feel that you're outside of the EU. But does that make it a less fun adventure?



Project: EMI Sensor

“Detect Electromagnetic fields wirelessly”

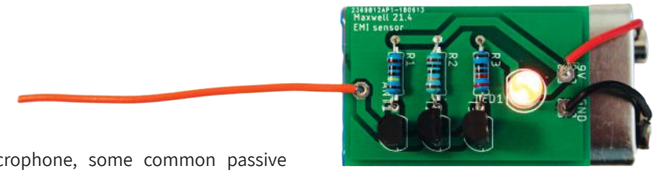
Tom Salden

We are living in a world full of electricity. Even though this electricity is generated, transported and used fairly efficiently, there are always losses in the form of heat, sound or other means. One particular type of loss is Electromagnetic fields. These fields are generated due to current flow. This means that every device or cable generates these kind of fields, which travel out in the open. For very sensitive equipment, this is a problem since the interference of these waves can cause issues, but it can also be useful to see where these fields are. The device in this project makes use of the electromagnetic interference and visually shows where fields are the strongest.

The DIY project has been a reoccurring item in the last editions of the Maxwell. And since this is our last edition, we liked to end this year by including the materials necessary to make the project. You probably already found the little bag with components that came with the magazine. Maybe you have already analyzed the (admittedly very simple) circuit or even assembled it.

During the 80’s, a sound activated power outlet was introduced in the United States. First appearing in an American television ads with the slogan "Clap On! Clap Off! The Clapper!" it was a product with a high popularity. The concept was a device which made it possible to power on or off appliances with the comfort of not having to leave your place. When introduced, it was a fun little gadget, but it had many troubles, for example, the device was meant to be activated just by clapping, but all loud sounds had an effect. How does the Clapper work? A microphone picks up an audio signal which is then filtered and processed by a power controller, which switches the connected power outlets on or off. For its time, it was a simple and cheap solution for remote controlling appliances. Luckily, technological improvements have brought us to easier and more reliable methods.

Not being a success, the Clapper still introduced an interesting concept, sound activated remote controlling. In this project we will build a similar circuit with



a microphone, some common passive components and the infamous 555 timer to switch on a led by just a simple clap.
Looking at the schematic, the circuit consist of 2 parts: the sound detection and the processing.

The sound is detected by a microphone which triggers transistor T1 to be turned on. Resistor R1 determines the sensitivity at which T1 switches, a variable resistor could be used to adjust this. If T1 is turned on, T2 is turned off. This will turn on T3, causing the trigger of the 555 to be activated. By just using the microphone and transistors, you could turn on a led for a short amount of time, but this is not our intention.

To be able to have the LED stay on, we need a flip-flop. Luckily it is possible to use the 555 timer in bistable mode, which gives it two possible outputs: High and Low. To get this mode, we need to use the configuration used in the schematic. Through a feedback from the output to T3 we are able to trigger the 555 when sound is detected and keep the state High or Low accordingly.

This project is cheap to build and can be completed in just an afternoon. It can also be adapted very easily to suit your needs and interests. For example, the LED can be exchanged for a buzzer to be used as an alarm. Or connect a relay to the output to get the intended function the original Clapper had, but be careful when working with mains electricity.

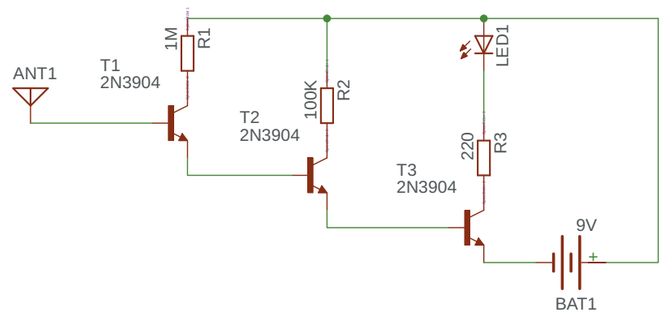
https://makezine.com/projects/non-contact-voltage-detector/

Components list:

- 3x 2N3904 NPN transistor
- 1x 1 MΩ resistor
- 1x 100 kΩ resistor
- 1x 220 Ω resistor
- 1x LED
- 1x 9 V battery connector

Not included in the Maxwell set

- 1x wire for antenna
- 1x 9 V battery



Activities

Heineken excursion

With a small group of the ETV members, we left for Zoeterwoude to visit the Heineken Brewery. At first, a very interesting presentation was given by a woman who had worked in several departments of Heineken. She told us about the origin of the company and how the Heineken brand expanded. After this presentation, we had the opportunity to order some beers and then the tour through the brewery started.

We all got in a double-decker bus which took us around the terrain. Inside the brewery we saw all the different stages of making the beer that ultimately got packed in bottles and cans for the consumer. The bottling process was very satisfying to see.

After the tour, we got back to the reception hall and shared our experience with each other while enjoying a beer and of course, some 'bitterballen' to end the day.

Sanne Jongbloed

wAkCie lasergamen

The Winter has already ended. However, this did not stop the 8th wAkCie from organizing one last epic event!

On the 9th of May, all thrill-seeking members of the ETV gathered at the Koeienveldje behind EEMCS to participate in the outdoor TWTG Lasergame-event. There awaited them sixteen laser guns, ready to be used in battle. A total of eight teams

competed to find out who was the best and claim the victory title. This resulted in sneaking through the woods, hiding for opponents and steady aiming. The scores were kept track of, such that the winning team could be determined, which turned out to be "The A-Team".

Afterwards, a prize was awarded to them for their heroism. All this adventure combined with plenty of free drinks and pizzas resulted in an epic evening that will surely be remembered. Unfortunately, this event also indicated the end of this year's wAkCie, but do not be sad, next Winter new events will follow from the 9th wAkCie, see you then!

Michael Goddijn

Rally

The first year was more than halfway over when one of the most exciting yearly activities came by: the ETV rally. Not thinking about lectures or exams, we all gathered on an early Saturday morning: prepped and enthusiastic. About six teams would be battling for the win that day. The goal was simple: drive as few kilometers as possible, solving the puzzles and following the clues which would lead you to every checkpoint. The cars would be driven by the poor souls who had given up alcohol for one day to be the designated driver.

The first clues were quite clear, and you could find everyone easily at the first checkpoint. After that it started getting more difficult up until the point where most of the cars ended up in the middle of nowhere together, trying to get the other teams to sacrifice their safety balloon with the next destination, which would cost them extra kilometers.

The real challenge, however, was in trying to get kilometers deducted by doing all kinds of challenges. Ditches were jumped over, people were flexed on and ices were pulled all to get those sweet kilometers deducted.

After a long day of driving and doing challenges, we gathered again to look back on the day and eat a pizza together.

It was a great day full of laughter and beer, and a great example for all the rallies to come.

Geert Jan Meppelink

Digital Health Symposium

In the week after the first partial exams of the fourth quarter, the symposium - "Digital Health" was held. The symposium took place at the Science Center of the TU Delft. It was a practical and beautiful location near the campus. After everybody got something to drink, the symposium started with three presentations from different speakers who talked about their expertise of their respective engineering project.

It started with a presentation about autonomous robots, followed by a presentation about how you get from a concept to a product and the last presentation was about small-scale soft-bodied robots, that are very small robots that can be controlled by electromagnetic waves from outside the object, for example, your body.

ffAfter the interesting presentations, a discussion about different statements took place. Here, the speakers and the students or other attendees got the chance to discuss those different statements, which was quite nice and gave interesting insights. The day ended with a drink where everybody could talk some more about "Digital Health" and other subjects.

Rik van der Hoorn

HedoN workshop

On Wednesday, the 20th of June, we organized the System Design Workshop in collaboration with HedoN Electronic Developments B.V. During the afternoon, an Electronic Development Engineer, as well as a former Board-member of the ETV, came by to tell us more about the process of designing a product.

After a short introduction about the company itself, we were presented with a problem: how to unscrew bolts that are stuck on large shafts, for instance, in windmills? This problem might not sound that EE-related, but the solution to the problem can be found in our area of expertise. By heating the bolt, it expands and can be easily removed. And what easier way to achieve heating a metal than by induction heating?

We were guided through various steps of the design process. We started out with a brainstorm session, followed by a formulation of the requirements, a block diagram and finally arriving at a schematic of the various electrical components that should be included. A valuable lesson for all engineers!

Karen van der Werff

Teacher of the Year

Every year the ETV organizes the Teacher of the Tear awards. During these awards we celebrate some of the brilliant lecturers we have at the TU Delft. This year a new website was created to streamline the voting process. Due to the new website we also received way more votes than last year, which makes it even more special to win. Also, we were able to better collect the reasons for these votes, this then could be used to pinpoint the preferences of the students.

This years winner is Chris Verhoeven for his lectures in Oscillators which are part of the course on electronics. Many students really appreciated the connection he drew between theory and practice.

This all was celebrated with drinks in the foyer of the EEMCS building. There was a good turnout of various lecturers, however the student representation was a bit low.

Wouter Kayser

FeeCie Skihutexcursion

It all started with a great idea. We would invite big DJ's and hire a nice place. But when the party was just around the Hooke this all went overboard. It was back to the drawing board. This time the plan had to be perfect, without any Hookes or eyes. We figured we should take our beloved ETV members on an excursion to foreign territory far, far away. We decided to take them to the economic cursus center of our country. The place where you can throw your pan bami out the window. The place where the most beautiful McDonald's of the world and of course the beloved Skihut is located.

We went to the Skihut with around 20 members and all had an evening we will never forget. Thank you and till next year!

Tim van der Spijk

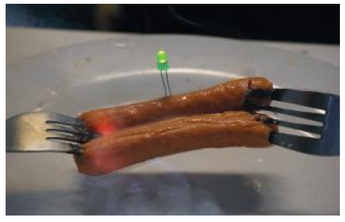
Safari drinks & Potential Board announcement

After weeks of teasing posters saying things like "Have you found us yet? We're hiding until the 19th of June" the moment was finally there. The zAkCie was hosting a Safari drink with lots of games to enjoy, like beer pong and roulette. The Safari wasn't going well, because the Potential board (PB) wasn't found. However, at some point the PB decided it would be nice to come out of hiding. To give a little teaser they had a video announcing the candidates. After the video, the PB stormed in whilst loudly singing the association song 'Voetstappen'. After the song they were properly announced by the board and everyone could mingle with them.

But it didn't end here. The drinks continued, and everyone could get their refreshments at the famed 'Pianotap'. All in all, the night continued to bring forth a great deal of epic stories that have the motto bijzijn = meemaken.

Lotte Zwart

Dies activities



Opening

On the 14th of May at 12:00, the Dies Week started with the official Dies opening in the hall of EWI/EEMCS. The Dies schedule showed that ‘’buns 230’’ were for free. Every electrical engineering student should be able to recognize the number 230, but nobody knew exactly what a ‘’bun 230’’ was. It turned out to be a bun with a Dutch hot dog, what some would translate to ‘’knaksausage”. The hot dogs were heated up by connecting them to a wall socket using the right equipment and that’s why they were called ‘’buns 230’’. Sparks came out of the hotdogs because the current through each hotdog was up to 2 Amps. When a LED was stuck into a hot dog, the LED also lit up.

At the end, the entire hall of EWI/EEMCS smelt like burnt meat, but it was a shockingly nice opening of the 112th Dies Week of the Electrotechnische Vereeniging.

Joris van Breukelen

BBQ

On one of the first beautiful summer evenings of 2018, the Dies week was opened with a delicious barbecue. The location was just outside of EWI. There were lots of tasteful kinds of meat from Leo and the piano tap made sure that there were plenty of beers. Lots of people attended the event and had a great time. To make sure that people could sit in the sun, bean bags were provided. Of course, there also were bar tables where lots of people had a drink. The barbecue ended around 10 o’clock when there was no more beer left, but by that time almost everybody had enough drinks for one evening. Overall the barbecue was a great success and a perfect start to the Dies week.

Joos Vrijdag

Reception

The Dies reception is an event held during the Dies week where you can celebrate the study association’s birthday and congratulate the current board. This year, as per the tradition, the boards of other associations coming from all over the Netherlands came to congratulate the board officially and to give gifts. Everyone that congratulates the board also writes a message in the guest book which serves as a memory for the event.

Regarding drinks, the awesome tap that looks like a piano was also on-site to serve free beer and soda. Since the weather was good and the event was well visited in general, there were plenty of students to get to know better or to catch up with. Personally, I had a great time with people from my project group from last year. We also congratulated the board with this group. To conclude, the event was a fun evening which I will definitely be attending again next year.

Tim Plantfeber

Uithofexcursion

The most intense activity in the Dieswek took place in the Hague. 32 people went to compete in 2 battles, airsoft and Go-Kart racing. At ‘de Uithof’, the most competitive spirit within each participant was brought to daylight. Intense battles were fought in order to capture the flag, heal the medic or make the other team surrender at airsoft. Many of our brave ETV warriors fell and some were wounded while competing against each other. Others were battling in Go-Karts for the quickest time on a track with multi-level features and banked turns, where a few of the participants even ended up in the daily top 10! At the end of the day, some surrendered themselves to tiredness at McDonald’s, but eventually, everyone got home just fine. It was a big hit and definitely an event to remember!

Jetse Spijkstra

Yearbook presentation and karaoke

Every year, the study association celebrates its birthday in the ‘Dies-week’, a week full of festivities and fun. A standard part of this week is the Dies-karaoke. It was my first time attending this evening/night, but I must say that I look forward to coming years, to re-experience this evening.

I was happily surprised by the vocal talents hidden in some of my fellow students, and also by their choice of music, ranging from classics such as “Even aan mijn moeder vragen” by Bloem to more modern masterpieces such as “Ow” by the Crane.

Although the karaoke was fun, the main event was even more fun because the students could not only sing their lungs out on stage, but they could also get a copy of the yearbook, signed by a very enthusiastic (and drunk) committee. All in all, it was a great night, which I always remember when I read through the hilarious anecdotes in my yearbook!

Niels van Tienen

Wine tasting

The big celebration week for the ETV, is the Dies week, a week filled to the nock with activities, friends and drinks. Although every student loves a nice cold beer, sometimes you just want something else. Something a bit more delicate.

Luckily, there was also a night of wine tasting. A wonderful night in the wine shop, Van Dorp B.V. followed. The cellars were filled with over 650 different bottles of wine from 15 different countries. To us, a selection of seven wines were served: white, red and rosé.

After a brief introduction, all wines were turned, smelled, tasted and judged by our group of ETV members. And with every bottle came a story: what the wine was made of, what ingredients could be tasted, where it came from and so forth. Besides the wine also came some appetizers of different kinds of cheese and of course, as the night advanced, lots of stories. A great night with great drinks and great company, what else could you wish for?

Marcel Brouwers

ELECTRONIC DEFENCE AT TNO

The Electronic Defence department at TNO researches and develops innovative countermeasures, using the electromagnetic spectrum, that can safely and securely counter or mislead the different sensor payloads and control devices of ubiquitous drones. When you think of jamming, spoofing and even hijacking a drone, that is what we do. We are the strategic research and technology partner of the Netherlands Ministry of Defence, the Intelligence Services and the Ministry of Justice and Safety when it comes to electromagnetic innovations.

Besides countering drones, we address a broad range of other challenges in the safety arena. Due to the nature of our work, our projects are classified in many cases. But if you would like to know more, come talk to us! We are looking for new enthusiastic employees and also offer unique internships.

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