Maxwell

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Sensing with THz radiation
Research activities of the THz Sensing Group

From papyri to smartphones
EM appetizer for starting EE students

At the THz Sensing Group
A promising start of your career

Food for Thought
Project STAR GATE

Theme content

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... and more

FRAMES

Editorial

Dear readers,

Since summer break just started, most of you will probably be reading this whilst sunbathing on the beach. For those of you who still have some studying to do, I would like to wish you all the best of luck with your exams on behalf of the Maxwell committee. Either way, whether you're studying or putting your feet up, whether your short of time or having plenty of time, anytime is the best time to read the Maxwell.

The theme of the last –and yes we did save the best for last- Maxwell edition of this year is 'remote sensing'. The theme section includes articles varying from on-topic jokes to thesis abstracts and more. Also, you do not have to be afraid to get bored this vacation as this edition offers an intellectual challenge for Bachelor, Master and PhD students in the shape of lectures on the subject of telecommunication engineering. Are you really not into reading more mind-boggling stuff and just looking for an academic break? No need to worry: this edition also includes, inter alia, the usual ETVIP section and reports on the DIES and the ETV sailing trip.

The articles mentioned above only cover a small part of the contents; to experience the greatness of this Maxwell in its entirety I am afraid you are going to have to browse through the whole thing. This might be scary but I promise it will be worth every second of your time.

We, the Maxwell committee, wish you an awesome summer break, hope you enjoy reading this Maxwell, and are looking forward to see you all back next academic year.

With the kindest regards among all regards,

Richelle van Capelleveen
Editor

From the board

An innovative green story

Author: Ludo van den Buijs

Sweat can be seen on the brows of many of our students. This is not just the result of the rising temperature due to the start of the first months of summer, but mostly due to their hard work during these last months of the fourth quarter. Not only have many of our members been working on the projects I mentioned last edition, everyone is studying hard to make sure they will pass their upcoming exams. On behalf of the board I would like to wish them all the best of luck.

Luckily for them a long summer break is waiting for them and with it comes a time of change. There is a significant group of Dutch teenagers celebrating their summer break as we speak. They are the freshmen of tomorrow and will bring many new faces to our study association. It will be these new students who will become new active members and who will be a central part of the ETV as a whole.

In order to welcome these new students the ETV organizes our freshmen weekend (EOW) just prior to the new academic year. During this weekend they won't just be introduced to the faculty or the ETV, but will mainly be introduced to each other. The number one goal of the weekend is for the new students to get to know each other to ensure they will feel right at home the minute their classes start. The past EOW's have proven their effectiveness and this has helped the EOW to reach the status of one of our most important events as a study association.

In order to accomplish these goals and hold an EOW worthy of the name, we need a lot of help. A committee has been installed and is currently hard at work to make the most out this weekend. They will continue their work throughout the summer break to ensure the success of the next EOW. To help them guide and energize the EOW-participants, a group of mentors have been selected to play an active role during the weekend. All of these mentors have just finished their first year of Electrical Engineering and know exactly what is like to start studying for the first time. Moreover, there luckily are always other active members willing to help out wherever the can. It is this mentality that has made the ETV what it is today and is hopefully something we can bring across to our new members.

The potential board will also be present and become well known to our new members, as they are hoping to take our place soon after the EOW. They are tasked to get to know as many freshmen as they can. As a study association we need all of our members to feel comfortable around the board and feel free to mention anything that might bother them, ranging from educational complaints to personal issues. The traditions we have been upholding throughout the years regarding the potential board are aimed at smashing down any barrier a freshman might feel to do exactly that.

As a board we are very much looking forward to the EOW and to welcoming our new members, even if it means that our time as board members is coming to a close. The editions following will include the traditional From the Board- article, it will however be written by my successor.

The 142nd Board of the ETV

I'm looking forward to reading all of them and I would like to wish him and his fellow potential board members the best of luck and an amazing year.

With innovative regards,

Ludo van den Buijs

Electrip

A Electrical Engineering trip in Europe

Author: Laurens van Dam

From the 14th until the 17th of May, a delegation of ETV members travelled to several countries in Europe to visit interesting and innovative companies competing in our field of engineering.

We started in our home country, visiting a factory of the company Omron in `s-Hertogenbosch. The manager of the manufacturing department gave us an interesting presentation about how they are able to compete with factories in China. It can be said that this involves a great challenge: the wages in Chinese factories are way lower and thus the operating costs are significantly smaller. Still, it is a problem for a company like Omron to quickly supply their customers with equipment when their factory is located on the other side of the world. Hence it is a good solution to build a factory in Europe so that you are able to supply your customer within a day.

The next visit was at the Heidelberg cement factory. Although the office building looked colossal and heavily used, we were surprised by the fact that at least a half of it was not used. It looked like it was not going well with this factory and that its future does not look too bright. However, the staff of the factory was very enthusiastic and they gave a passionate presentation about how cement is actually made and the structure of the power systems in the cement factory. At the tour we were surprised with a humongous "washing machine", actually being the big rotating cylindrical oven. It makes you wonder how such big machines are even able to rotate, but that's not our point of consideration.

In Germany, a research and distribution center of Thales received a visit from us. The person responsible for the presentation our trip through the center was sick that day, so after 45 minutes of waiting, the Managing Director of the location was able to pick us up and give us a tour. This specific location was focused on military radar equipment, which makes it extra cool to see the inside of this factory because of all the classified information. There even was a military radar weighing a couple of tons.

Proceeding to the following country, Switzerland, we visited the Paul Scherrer Institute. PSI is a research center for natural and engineering sciences, doing groundbreaking research on proton therapy. We had a look at an impressive "synchrotron light source", a particle accelerator that excites light beams of 2.5 GeV. They are also able to produce their own protons to be used for proton therapy. PSI was the first center for proton therapy.

Another subject related to this radioactive story is the following. Close to Zürich was the humble town Leibstadt. At Leibstadt, a huge nuclear reactor is situated. We, being very important people, had the privilege to receive a tour through the reactor. Not only did we have a look behind the heavily secured gates, but we were also privileged to take a look at the actual reactor pool itself. A huge pool with a big metal cylinder inside, containing the radioactive fuel bars. It was an impressive sight: the water with blue light inside was so clear that you could see the bottom of the 50m deep pool. In order to be able to see the inside of this high-tech power plant, we had to take some security precautions. One of them was to exchange our suits for an outfit that made you look like a monkey. Including the fashionable white underpants, uncomfortable blue overall and white clown shoes. Everyone wore his very own dosimeter, displaying the amount of received radiation compared with the regular dose. Among everyone we were closely watching each other's dose to check who had the current high score. The speed of the ticking counter went up considerably at the colossal steam engine (being surrounded by concrete walls of a few meters thick) and at the storage pool for nuclear waste.

The journey back to our motherland was kind of the same as all of the other journeys. At least for half of us. For the other half, their arrival in Delft was scheduled to be 3 hours later than ours. They have been waiting next to the Swiss highway for a replacement van since theirs had a problem with the oil level. Meanwhile, the passengers of our van had the pleasure to stop by at Ludo's parents and had the opportunity to review our trip there.

It is clear that our trip was very informative and above all 'gezellig'. Definitely two reasons to be there next year for part two!

Mars one
The next Columbus?

Author: Ir. R. Noomen, Faculty of Aerospace Engineering

Spaceflight always has had to cope with one major enemy: Money. The *very* few exceptions were the Lunar programs of the United States and the former Sovjet Union in the 1960s and early 1970s, and their military programs - although the US Department of Defence has to do business in different, more cost-effective ways nowadays. The European Space Agency (ESA) also has limited financial resources and has to make a careful long-term planning, with many promising concepts and missions being the victim of budgetary restrictions. This holds in particular for really big projects, like missions to other celestial bodies – moons, planets.

Mars One - initiated by two Dutch engineers, Bas Lansdorp *(a former employee of TU Delft)* and Arno Wielders - tackles the problem in a very unusual way. First: get the finances in order, and second: Try not to reinvent the wheel but rather rely on the decades-long experience of highly-qualified space industries. Two absolutely good selling points for Mars One.

Project and status

For readers not familiar with the project: Mars One intends to take humans to Mars, have them construct and live in a permanent settlement, and not have them return to Earth. A crew of four would do the first trip, which would be followed by four new people every two years - which is when the constellation of Sun, Earth and Mars is most favourable for a transfer. The first human trip is currently scheduled for a landing on Mars in 2025 and it is foreseen that the human base will grow to beyond 40 people. All of this is to be preceded by the delivery of the first supplies in 2018 and 7 more cargo missions in the years in between.

At the time of writing, February 2014, Mars One has completed the first round of astronaut selection: More than 200,000 people responded to the invitation to participate and this number has been reduced to 1058 of which two have the Dutch nationality. Also, in December 2013, Mars One issued contracts to Lockheed Martin and Surrey Satellite Technology Ltd for concept studies and, of course, fund raising is an ongoing activity.

Feasibility

Obviously, one can ask critical questions: Is Mars One technically feasible? Financially sound? Ethically acceptable? Let's review some of these questions. First of all, the technical feasibility: a mission to Mars is a big thing, there is no doubt about that. Not only does one have to launch and transfer the crew, but one will also have to send a number of so-called precursor missions – missions in

An artist impression of the martian base

which the location for the Martian base is selected and prepared, and rovers, living modules, communication satellites and other cargo are delivered. According to a Boeing deputy program manager of the International Space Station *(ISS)*, the total mass to be put in initial Earth orbit for a human mission to Mars is 800-1000 tons *(this number may serve as an "order of magnitude" for Mars One)*; this is less than for instance the total 2800 tons assembly mass of the ISS. From a mass budget point of view, Mars One is certainly not unrealistic. The situation is made more favourable still by the recent development of new launch systems: the commercial Falcon Heavy *(payload capability: 53 tons)* and the US-government subsidized Space Launch System *(payload capability: 130 tons)*. The main working horse for constructing the ISS, the US Space Shuttle, had a payload capacity of a mere 24 tons so it took much longer to bring the total amount of mass into space. Technical developments will be needed on two aspects in particular: radiation shielding and life support *(consumables, a.o.)*, both during the transfer and on Mars. However, neither of them are expected to be real showstoppers.

Other critical issues are the social, psychological and ethical aspects: Can four people live and work in a very confined environment for years in a row, possibly decades, until their death? This obviously puts major demands on the social and mental capabilities of the crew. Experience on these aspects has been developed in the past decade. In particular, with 6-month stints on board of the ISS, and dedicated projects like Mars-500: An experiment in 2010-2011 by ESA, Russia and China, which isolated 6 people for a total period of 520 days. The suggestion is that the Mars mission can be done, although the outlook to be in such a situation and eventually die of course is quite different from the perspective of the participants in the mentioned experiments. To reduce potential problems, a careful screening of candidate astronauts will be done and the teams of four members each will have to consist of a balanced set of people. Speaking about balance: a mixture of two male and two female astronauts might lead to another kind of problem. As for ethical aspects: one can argue about this endlessly. No matter what: Since no law forbids participation in such an event and as long as the participants are 100% aware of what they are up to and the risks, there is no way that anyone can stop them.

Can four people live and work in a very confined environment for years in a row, possibly decades, until their deaths?

Finally, we are back at square one: money. It is currently estimated that the cost of putting the first four people on Mars will amount to about $6 billion *(any subsequent crew of four would require another $4 billion)*. This number is comparable to the revenues of the Olympic Games. The "easy" conclusion is that the required amount of money is within reach, as long as the media exposure is at a comparable level; pay-tv and commercials would have to provide sufficient funding. However, it is also quite clear that a significant part of the money has to be available upfront to design and construct hardware, train astronauts and such. Not undoable, but certainly not "easy money".

Outlook

No matter what, human exploration of Mars *(one-way or two-way)* is recognized as the next major step for mankind into the universe. Mars One is a serious candidate project to do so, and is claimed to become the largest media spectacle ever. From a technical point of view, the project appears realistic. The main question marks can be put on the financial aspect and on the time schedule, which both appear quite ambitious. This holds in particular for the moment when real construction and contracts are up and running, and hard dollars or euros will have to be provided. Whether media coverage delivers a powerful enough cashflow, remains to be seen.

Find more information on

- www.mars-one.com

Circuit Bodging

NERF Ammo Counter

Author: Ben Allen

Someone once told me that engineers are glorified toy makers. Most of engineering is not something people need, but stuff people want. This makes sense, nobody *needs* an HDTV, yet most people have one. Toys for adults, as it were. I find that toys for kids are quite often equally entertaining, and as a result I have a number of NERF guns, which fire little foam darts at whatever you happen to be pointing at when you pull the trigger. That's fun enough to start with, but the potential for modification is nearly limitless.

I'm not the only over-18 (I don't think I'll ever be an adult) who enjoys messing about with these things. People all over the world hold NERF battles in abandoned buildings and they're also used by cosplayers who want to recreate stylish weaponry for their costumes. As such, modifying NERF guns is a global phenomenon.

Most modifications focus on increasing the dart's muzzle velocity or improving accuracy - but for a generation that grew up with video games, there's one thing very obviously missing from a device that shoots things: a way to know how many darts you have left.

Because I intended to embed the circuit in to the gun's housing, the most important constraint was size. As a result I chose to use a microcontroller, as this allows for a single-chip solution. I had a look in my parts bin and found a PIC18F2455 microcontroller. This is not a good part selection for this project, as I'm not using any of the wide array of built-in peripherals, I'm not using half of the available IO pins and it's rather expensive. That said, it has multiple external interrupts, and I had it lying around which means it doesn't cost me anything at all.

What does our circuit need to do?

- When a new magazine is loaded, reset the counter to the number of darts in a full magazine.
- When the trigger is pulled, subtract 1 from the dart counter, unless the counter has already reached 0.
- Because NERF magazines are sold in 3 different size variants (6, 12, and 18 darts) the counter must accomodate for all three sizes.

From the above, we notice there are two distinct things the circuit must measure: a pull of the trigger, and the replacing of the magazine. While those things aren't happening, the counter needs to display the current count to the user. Remember those interrupts I mentioned? They map nicely to the two events the circuit has to capture, and those interrupts are represented in Figure 1 by red boxes. What I call the default counter value is actually the capacity of a full magazine and is the value the counter must be set to when a new magazine is inserted into the magazine well.

We also need a way of telling the counter which magazine size we're using, so I chose to have a trigger pull with no loaded magazine represent a size change. See the flowchart for details.

To measure a trigger pull or if a magazine is loaded, I installed two micros-

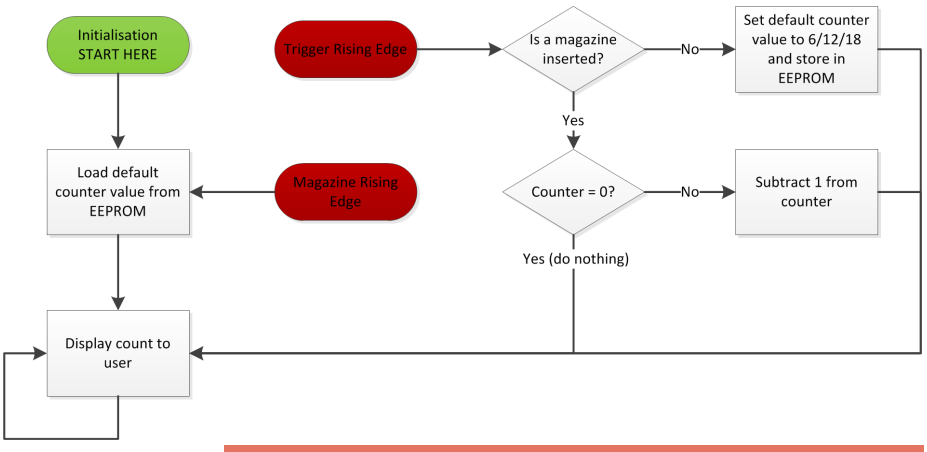


Figure 1: Firmware flowchart. Red boxes indicate triggered interrupts.

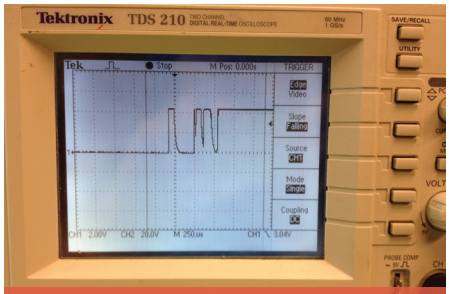


Figure 2: What switch bouncing looks like.

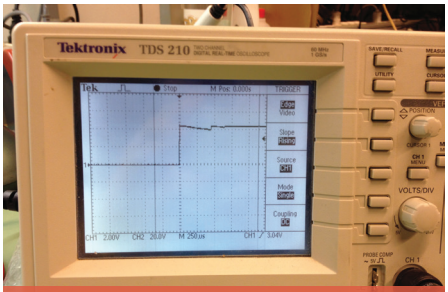


Figure 3: Switch signal with compensation.

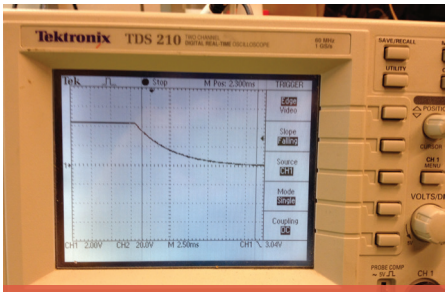


Figure 4: Trailing edge of debounced signal.

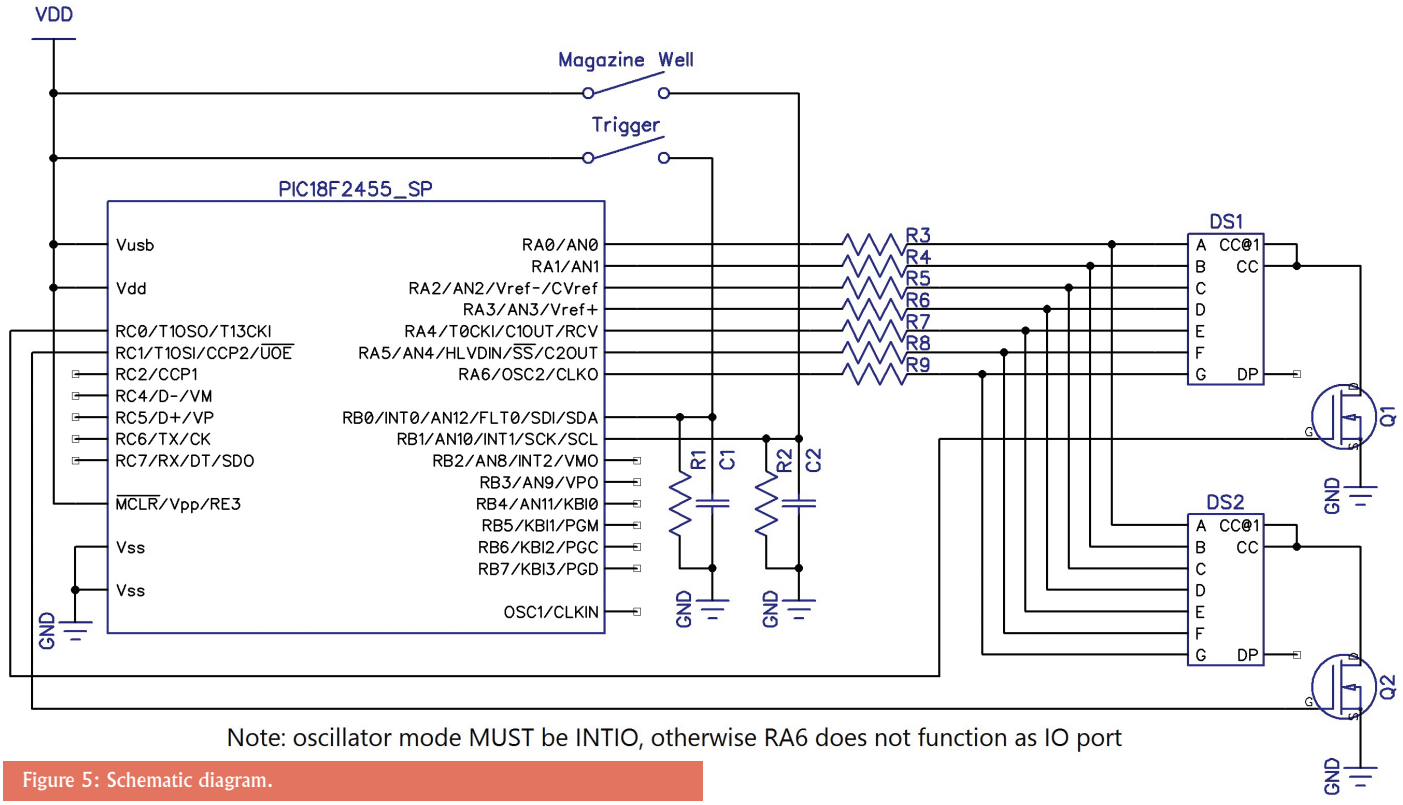
witches in the plastic body that interface with the mechanical components already there. These are the two switches on the schematic labeled 'Trigger' and 'Magazine Well'. You'll notice the the RC networks connected to them, these are there to counteract switch bouncing. Switch bouncing is caused by the fact that switches are mechanical and usually don't switch cleanly, see Figure 2. This is problematic because we only want to trigger the interrupt once. Adding a 4,7nF capacitor in parallel with a 1 MΩ pulldown resistor yields a much nicer result:

In the circuit shown below, the interrupts are configured to trigger on a rising edge. Nevertheless it's better to be safe than sorry, so let's take a look at the falling edge just in case something funny happens, see figure 4 which should look familiar.

For the display I'm using a multiplexed set of two 7-segment numerical displays, using n-channel MOSFETs to switch the displays on and off. Resistors R3-R9 limit the current drawn from the IO port on the micro, as the datasheet shows the pins cannot source more than 25mA, whilst total current draw from the microcontroller must not exceed 200mA. The value of these resistors will depend on your supply voltage and your display, as the forward voltage of the LEDs will vary with your colour choice and from manufacturer to manufacturer. Always read the datasheet for the parts you're using too, as a different microcontroller might not be able to source that amount of current.

$$R = \frac{V_{dd} - V_{led}}{I_{spec}}$$

To calculate your resistor values use the simple formula above. Please note that the MOSFETs will also be operating in their ohmic region but I have not included them in the resistance calculation for the sake of simplicity.



Note: oscillator mode MUST be INTIO, otherwise RA6 does not function as IO port

Figure 5: Schematic diagram.

TNO

Joint Angle-Frequency Estimation for Circular Arrays

Author: Joost Geelhoed

For my Master thesis I investigated some joint angle-frequency estimation techniques. These techniques estimate angle-frequency combinations of multiple signals at once. This project was carried out by the Electronic Defence department of TNO, a Dutch organization for applied scientific research. They offered me a very interesting project based on my wishes, a lot of freedom and a workplace at one of their premises in The Hague. In this article I'll give a short introduction about the context and some techniques for joint angle-frequency estimation.

Antenna arrays are very useful for beamforming and are widely used, for example in routers that use 802.11n for better down-link performance and in radio astronomy. Beamforming is a technique for steering radio waves in a certain direction, but instead of transmitting in a certain direction it is also interesting to receive signals from a certain direction. A receiver could measure the strength of the signals in certain directions with beamforming techniques to see from where the signals are coming. Smarter techniques exist to estimate direction from which signals are coming.

Array Steering Vector

When a signal impinges on an antenna array it arrives first at the antenna closest to the source, then the second and finally at the last. The time difference of arrival on the antennas is measured as a phase shift. When a signal impinges from a direction perpendicular to the array the phase is the same for each element, but in other cases there is a phase-shift between the elements. This phase-shift is different for each angle and when each possible phase-shift is less than half a wave the DoA can be computed from the phase shift without ambiguities. This is just Nyquist theorem translated to the spatial domain. A vector describing the phase differences between the antenna elements caused by the DoA, distance and spatial frequency is called the array steering vector.

High Resolution Techniques

To obtain a high resolution with a small antenna array of only a few antennas subspace techniques are very useful. These techniques use the singular value or eigenvalue decomposition in order to obtain a signal subspace that contains orthogonal vectors that represents a mix of the array steering vectors from the collected samples. For my project I used ESPRIT, which is such a high resolution technique. This technique is designed for linear arrays and exploits the array geometry. Techniques based on correlations or beamforming, as described before, can be used with all array geometries, but have

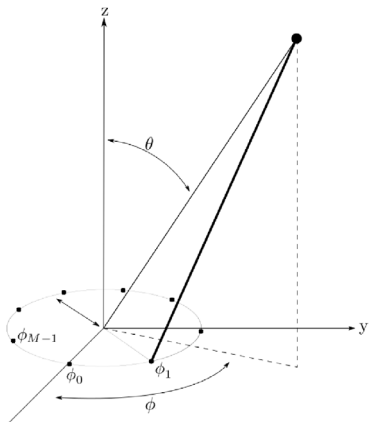


Figure 1

under similar conditions a worse resolution than ESPRIT. If M antenna elements are uniformly distributed over a line, the phase-shift between adjacent elements is the same. In ESPRIT a vector with the upper M-1 elements and a vector with the lower M-1 elements is extracted from the estimated mix of array steering vectors. Then the pseudo-inverse of one of the vectors is multiplied with the other to obtain the phase-shift of each signal from which the DoA can be calculated.

Circular Array

Since this technique requires a uniform linear array a transformation of the data from circular array is required. I used a concept phase-mode excitation for this. If enough antenna elements are distributed over a circle the array approaches a perfect circle, which is periodic by 2ϖ. The Fourier transform of a signal that is periodic by 2ϖ results in a delta pulse on a certain frequency. The phases terms in the array steering vector are also periodic by 2ϖ so the Fourier transform leads to a delta pulse with a certain phase. When a finite number of elements is used, for example 5, the antenna array is not a circle but a pentagram, which causes systematic errors for DoA estimation. Figure 3 shows the (maximum) bias in the azi-

muth estimation when a finite number of antenna elements is used.

The Fourier transform of the data from a circular antenna array leads to small number of pulses in the frequency domain. These pulses can be represented by a vector and when the array parameters are chosen carefully ESPRIT can be used to calculate the DoAs from this vector. The magnitudes in this vector depend on the elevation. Because of this unknown differences in magnitudes ESPRIT is not applicable directly. When the array is used to estimate sources that lie in the plane of the array it is ESPRIT is possible. Then the elevation is then fixed at 90 degrees and the magnitudes can be equal-

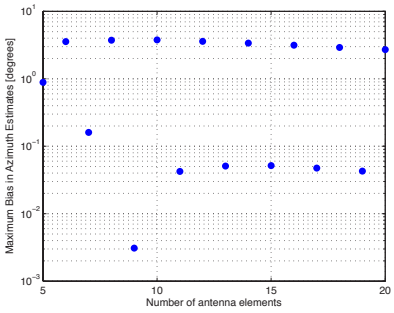


Figure 2

ized, so ESPRIT can be used to estimate the azimuth angle of 360 degrees. It is also possible to apply a technique called spatial smoothing to elevate the problems that occur as multiple users use the same frequency, as in UMTS, where CDMA is used.

Frequency Estimation

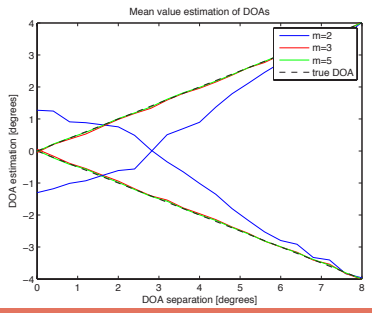
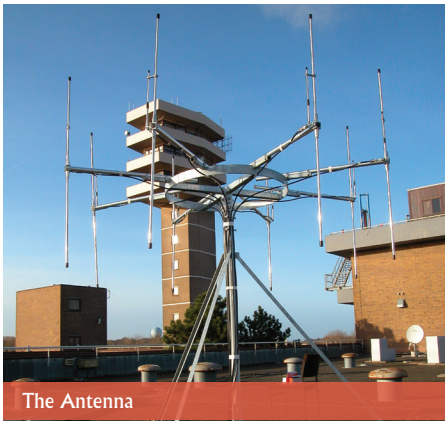


Figure 3

To estimate the frequency of a signal one has to look at the phase differences between the temporal samples instead of the spatial samples for DoA estimation. To estimate the combination of the direction and the frequency of signals some smart trick is necessary. One way is to first rearrange the sampled data. Usually a data matrix with spatial samples in the columns and temporal samples in rows is used. Then the columns contain only appropriate information for DoA estimation. When time-shifted versions of the data matrix are stacked upon each other a new matrix is formed. The new matrix has taller columns with time shifted samples in it from which the frequency can be calculated using ESPRIT. After the signal subspace is estimated orthogonal vectors are obtained from which the DoAs and frequencies can be computed. Since these orthogonal vectors contain a mix of the signals the estimated angles and frequencies will appear in a different order, but the trick is that after estimating DoA (or frequency) with ESPRIT a matrix that describes how the signals are mixed in the signal subspace is obtained This matrix can be used to extract all the individual signal vectors from the signal subspace.

Temporal Smoothing

When multiple signals have the same DoA the singular value decomposition cannot separate them. The reason for this is that the columns with spatial samples have a linear dependency. To cope with this problem temporal smoothing is frequently used. This processing technique stacks multiple time-shifted versions of the data matrix. The effect of a time-shift is that every element in the array steering vector is phase-shifted. For a certain time-shift signals with different frequencies undergo a different phase-shift. When multiple time-shifted versions of the array manifold are stacked the columns of the new, taller matrix won't be linear dependent on each other anymore as long as the frequencies of the signals are different.



The Antenna

In figure 2 the effect of this technique is demonstrated for two signals, some noise and temporal smoothing factors of 2,3 and 5. It shows the effect of the temporal smoothing for different angle separations.

The reader who payed close attention already noticed that this stacking technique is the same technique that is used for the extension for frequency estimation as well. This temporal smoothing technique not only elevates the linear dependency, but also reduces the dependency of array steering vectors. Therefore this technique is very useful if multiple signals and noise are present in the data. One requirement for this technique is that the baseband signal does not change over the time-shift, so oversampling can be helpful, although oversampling has its limits. First of all the hardware, especially the ADCs, must be able to operate properly on the chosen sample rate and the sample period must be high enough in order for the consecutive noise sample to be uncorrelated. Since antennas have capacitive properties this can be tricky.

More information

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From papyri to smartphones

EM appetizer for starting EE students

Author: I.E. Lager

Information is an asset of inestimable value. In ancient Alexandria the law had it that any ship laying anchor in the harbour was to be searched for papyri and those found were shamelessly confiscated. In the Middle Ages, unique parchments containing, possibly, the last surviving evidence of some antique piece of wisdom were seen as worth killing for (occasionally, literally).

The present day technological environment is dominated by Information and Communication Technology (ICT). Information is produced at a hallucinating rate, with the equivalent of the entire knowledge generated from the dawn of civilization up to 2003 being generated in at most 7 days. Nevertheless, information, as such, has little value when not accessible. The role of "Communication" in "ICT" is to bring information at hand whenever needed, wherever needed and however needed (or, at least, this is what it is aimed at). Communication has a technological support and, as long as quantum entanglement based transfer will not turn up in our daily life (and this may still take a while), the only way in which information is (trans)ported is by waves. In the overwhelming majority of cases, electromagnetic (EM) waves. It is then imperative to understand the potentialities and limitations of EM wave propagation for being able to build the info-sphere of the present and, above all, of the future.

Understanding EM waves started with Maxwell's equations that unified for the first time electric and magnetic fields as manifestations of the same interwoven physical entity. The existence of these waves was soon afterwards demonstrated by Heinrich Hertz's famous experiment of 1887. A replica of the original experimental setup realised by one of our faculty's staff members, Dr. Martin Verweij, is shown in Fig. 1. Starting with Guglielmo Marconi's radio broadcasts, EM waves have pervasively entered in our daily routine and are now one of the society's indispensable ingredients. Their immense range of applications is constantly expanding and it is conceivable that this trend will continue for many years to come.

A test case: stereo sound is so common that we, practically, take its availability for granted (the 2 channels concept often looks outdated, with 7.1 audio systems seeming more in trend, although audiophiles still maintain that stereo sound is unbeatable when it comes to quality). Everyone has a smartphone, with tons of stereo music on it. But that is only played in mono! Switching to stereo seems al-

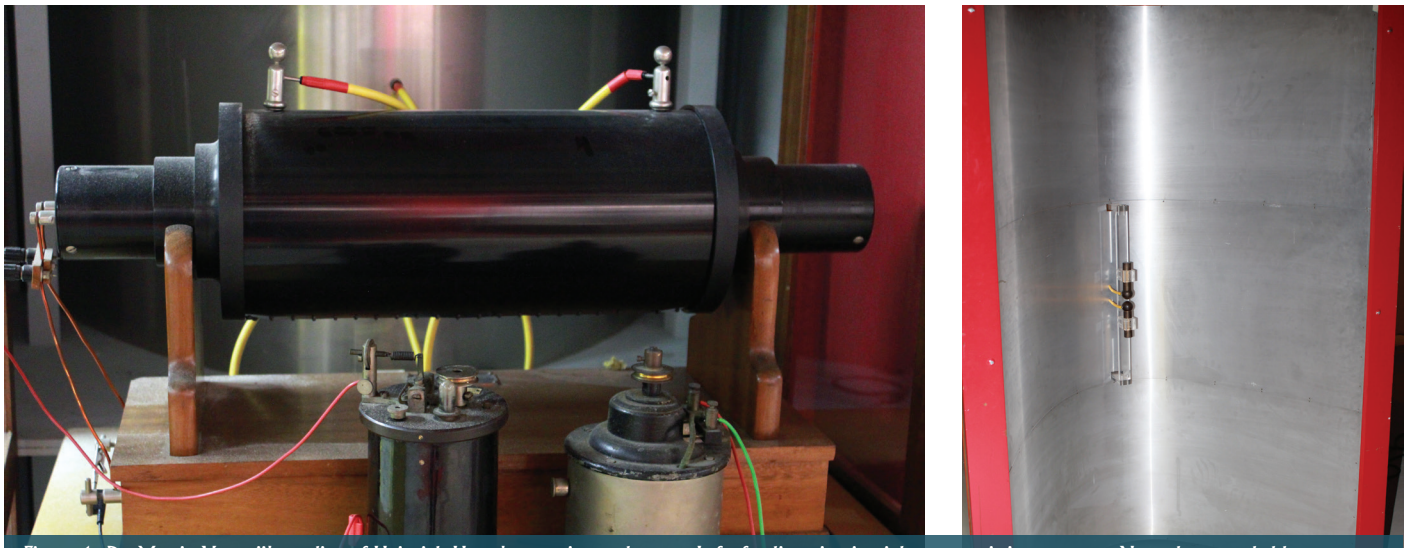

Figure 1. Dr. Martin Verweij's replica of Heinrich Hertz's experimental setup. Left: feeding circuit; right: transmitting antenna. Note the remarkable resemblance with present-date telecommunication systems. The experimental setup is located in the "Studieverzameling" in the basement of the EWI building.

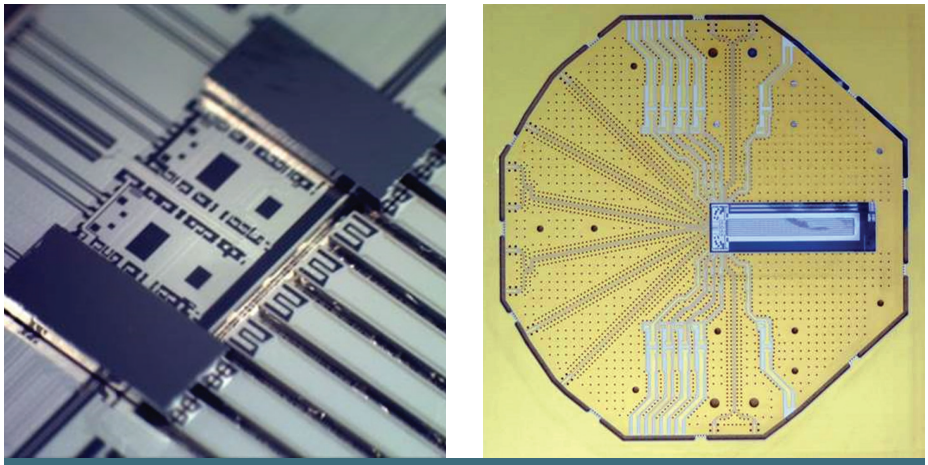

Figure 2. Mm-wave Integrated Imaging Radar. Right: final demonstrator; left: antennas and T/R modules. Pictures published with permission from the Microelectronics section.

most childish – just pick up another smartphone, link the two in a local network, invoke the needed app and stereo sound will flow out of the system. And if there's no app, here's your opportunity! But why wasn't it there, in the first place? Well, the reason is because… it is not trivial! And it is ultimately related to the way in which waves are generated, propagate and are received that, in turn, determine the kind of protocols a network can support. And present wireless protocols support very poorly (if at all) distributed applications requiring coherent processing, as simultaneously playing a tune on two mobile devices is. And that is for an audio signal! Think broader, to a number of smartphones cooperatively determining the direction to a target that can be a lost toddler or an elderly sending a distress signal! As said: the challenges are manifold and readily present themselves to you, as EE students.

The path to accomplishing those objectives will inevitably lead you through Electromagnetic Land. There you will have a tangible evidence of the need for thorough training in math, physical insight and acquaintance with exotic manufacturing technologies. Proper training will quickly lead you to the point where fantastic achievements are within reach. Look at the device in Fig. 2: it is a mm-wave integrated imaging radar operating at 96GHz that was designed and realised in the Microelectronics Department. From an electromagnetic perspective, minute as it is, it contains a number of antennas that are controlled to produce beams that can be pointed as needed. But there is much more! At that scale, the habitual circuit models break down and new models, adjusted to the components' sizes coming ever closer to the operational wavelengths, need being devised – another very hard EM problem. With the digital throughput being permanently pushed up by increasingly more complex applications, wireless networks are steadily moved towards higher frequencies (with Terahertz communications being an important competitor) or towards single-pulse/bit transfer, the physical implementation of which is again a (pretty much, terra incognita) EM problem. And the list goes on.

The conclusion is obvious: working in EM theory and applications is an investment in your future. Do not hesitate to drop by the Terahertz Sensing section, our colleagues will be happy to tell you more about the hot topics that are investigated there and will definitely present you with challenging projects that can be solved via an Honours Programme assignment, or via highly rewarding BSc and/or MSc graduation works.

- [1] See Peter Lyman and Hal R. Varian, "How Much Information", 2003. Retrieved from http://www.sims.berkeley.edu/how-much-info-2003 on [22/05/2014] and the comments at http://readwrite.com/2011/02/07/are-we-really-creating-as-much.
- [2] James Clerk Maxwell firstly devised a system of equations uniting the electric and magnetic fields in 1855. The equations were formulated in the structure that we currently use in his "A Treatise on Electricity and Magnetism" of 1874 and were cast ten years later by Oliver Heaviside in the widely used vector terminology that you are familiar with.

SSD trip

All the way to Berlin

Vinay Bharadwaj

We called it the Berlin fever, it spread in the air fast and it all started when the SSD announced that they were planning a trip to Siemens Berlin. Reinout Getreuer told us that there were limited places and that we had to be quick to enrol. He also gave us a date and time when the list will be released for enrolment and we were quick to add it to our schedules. Time flew and the enrolment day had come, I found myself sitting on the seats near the ETV desk one hour before time hoping to be one of the 16 lucky people getting to go on the trip and within minutes familiar faces began to crowd the area and we were all getting a little impatient and shaky looking at our numbers.

Two vans were waiting for us at the Aula and the third had already left an hour earlier to Eindhoven to pick up three students and continue to Berlin. All those who assembled to enrol successfully found a place in one of the vans and the journey had begun. We were doing 140 kmph on the highway admiring the beautiful scenery that went by every minute and were chatting amongst ourselves in the van. Our van driver Mart Huijbregts was an experienced one and we had nothing to fear, except maybe a flat tire. It was time for lunch and we soon stopped somewhere near Hanover where we were joined by the other two vans, we brought out the picnic bags and began to feast on bread. Isabelle Vlasman made sure we vegetarians had our fair share of food before we left.

The SSD at Siemens

The hotel room was amazing; each room was to be occupied by two people, my room-mate was Rei and our room was on the 3rd floor. When our bags were dropped I lay flat on my bouncy bed and smiled staring at the ceiling hoping that things should be as good as this for the next few days to come. The Greek restaurant we had entered had arranged a few tables to host some twenty plus of us; the food had arrived and was accompanied by a shot of Ouzo for each of us, on the house. The night was far from over as we decided to explore the city looking for a nice club. Berlin was friendly and was made even more so by the free unlimited travel tickets that the SSD had arranged for us, the weather was great, we could go anywhere we wanted for free, just perfect!

Saturday morning was a bit lazy for we had arrived rather late the previous night. A quick shower and soon we all gathered at the dining hall where a beautiful

The SSD at the Brandburger Tor

breakfast buffet waited for us. With a full tummy we set out to further discover the historic places that were famous in Berlin. I can't name all of them, but I can sure describe their beauty well, for they have been inscribed deep into my mind and manage to instil awe even now as I type this article.

The same breakfast hall had a different atmosphere that morning, handsome suited men and dignified women now occupied the chairs. In a group we all carefully entered the Metro making sure we all made it inside the train within the short time frame before the doors closed. Rohrdamm was the name of the station at which we had arrived at. Twenty something men and women with business attire and Siemens visitor badges were seated inside an auditorium in the Siemens' main building. Mr. Jan Langedijk gave us an introduction and there was a presentation describing the history of Siemens and also safety tips to ensure that we all return home with the same number of limbs that we arrived with. We were split into two groups and simultaneously began to tour the Switch-gear factory. Textbooks came alive and many doubts that had lingered in our minds had been cleared when we saw the massive Circuit Breakers and Gas-Insulated Sub systems all being carefully assembled by a team of experienced personnel. We toured around the new workshop, warehouse, and the high voltage testing laboratory. We were given a special tour of the assembly of high voltage switch gear dressed up like clients in green lab coats and I must admit we felt rather special at that point. After the tour we were taken to a restaurant meant for clients and were treated to a feast, I don't even want to get started on what we all we ate!

All content we left the restaurant to begin our next tour, the one of the relay factory. Here we were given another presentation, treated to more refreshments and were shown around the manufacturing unit dressed up in lab coats and ESD protection. The massive machines could assemble 16 components on the PCB within seconds and looked extremely sophisticated. The next step involved using really powerful cameras to make sure the components were in place, if not were physically assembled by an engineer. This was the playground of the Electrical Engineer full of expensive devices and machines. The tour ended and we took a group picture to relive the moments when required.

We reached Tucher am Tor, a continental restaurant where Siemens had arranged a dinner for us. Two tours, a business class lunch and an exotic dinner, could things get any better? Apparently it can, a third tour was in store for us at the Dynamowerk factory of Siemens the next morning. A similar breakfast and travel scene and we reached the factory, where we met Mr Rink Groenveld, a senior manager who had flown in from the Netherlands for us. The tour was preceded by a presentation and of course refreshments and never had we been given the opportunity to break a sweat or feel the lightest bit of hunger. Large rotors, accurately wounded copper windings and smooth stators surrounded us making us feel miniscule in their presence. It was as if we were at the temple of our core engineering and we could hear the chants of the rotating metal echoing through the large factory, we were electrical engineers!

At the THz Sensing Group

A promising start of your career

Author: Sven van Berkel

One of the possibilities in composing your individual study program (ISP) is doing an internship at the university or a company. This article describes my experience working at the THz Sensing Group.

Electromagnetic (EM) Sensing in Electrical Engineering is a broad term describing the methodology of extracting information from objects by means of electromagnetic waves propagation and scattering. One of the key features of sensing is that no physical contact is made with the object from which information needs to be acquired, this allowing for non-destructive sensing. The number of applications is enormous. One well known type of sensing is radar (RAdio Detection And Ranging) that became a well-developed technology since World War II for both civil as military applications. Google is vastly progressing in the development of self-driving cars making use of radar sensors, while Thales Netherlands is one of the key suppliers for radar systems on naval vessels.

The pervasiveness of radio- and microwave applications makes the strict regulation of the spectrum allocation mandatory. However, from 100 GHz to 30 THz a rather unutilized frequency band is still available. This band, the THz domain, has got increasing attention since a couple of years and is mostly promising in terms of applications. Most sensing applications in this domain concern imaging and radiometry problems. Detecting concealed weapons or explosives beneath clothing on airports is one example. The short wavelength of these frequencies allows for high-resolution imaging while it can still penetrate clothing. Also a very wide range of less down to earth applications can be found; deep-space observation (>90% of radiation from deepspace is in the THz range) or earth observation in terms of climate mapping. The reason why this frequency band is still underutilized is therefore not the lack of applications but the scarcity of sources and detectors of THz radiation. This is the point where the THz Sensing group of TU Delft comes in. This group is specialized in the development of advanced antenna technology for both passive (radiometry) and active (radar) applications in the THz domain.

Presently I am a second year Telecommunications student specializing in radar and electromagnetic wave theory. The first semester of this year I did an internship within the THz Sensing group. In this article I should like to describe my personal experience within the group, to give you an idea of what the THz Sensing group can offer in terms of an internship or master thesis projects. It will give you the right toolbox for a glorious career in applied electromagnetics.

Motivation

In the first months of my master it became clear to me that I prefer to specialize in radar systems and electromagnetic wave theory. By opportunely planning my studies, I managed to make room for a half-year internship at the THz Sensing group. The goal of my work during this internship became clear very soon. A good transmission line design is of great importance for integrated antennas. An antenna designer at lower frequencies would like to know the ohmic losses in the transmission lines. However, at higher frequencies, not only the ohmic losses, but also the radiation losses or surface-wave losses will become significant or even dominant. Many readily available tools can calculate ohmic losses, but there seem to be no analytical tools, nor equivalent textbook formulas for the radiation losses. My task was then to characterize integrated transmission lines in terms of radiation and surface wave losses and to make an adequate Matlab graphical user interface (GUI) for supplying the computed data. Such designed tool was supposed to be freely accessible.

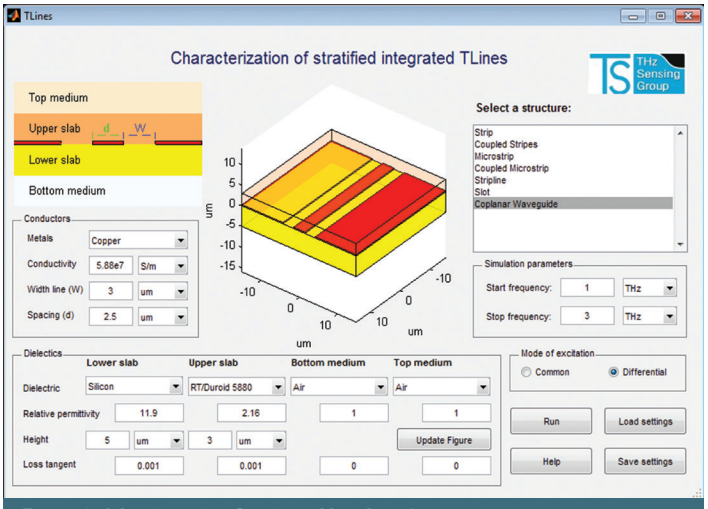

Figure 1: Matlab made, Graphical User Interface

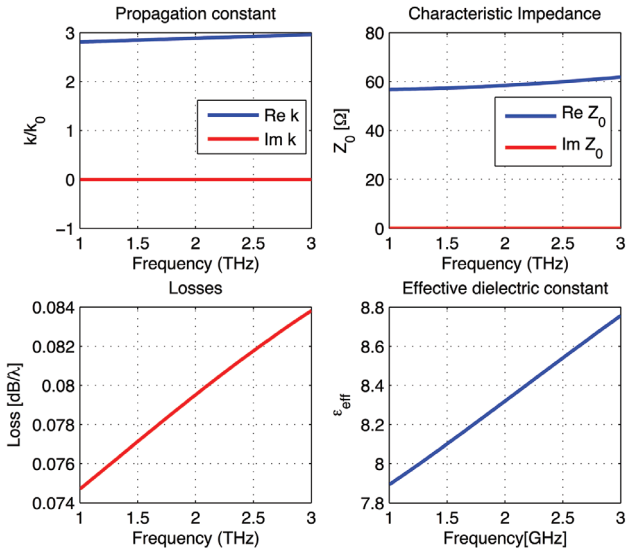

Figure 2: Example of results

Approach and Results

To accomplish my goal, I decided to structure my internship optimally. First, a month of preparation was needed. The most important preparation before the internship was the course of Electromagnetism by Prof. Neto, Prof. Llombart and Prof. Lager. In this course I became familiar with Green's functions – solutions of differential equations for delta-sources. Only the Green's functions of sources in free-space are analytical. Despite following this course, more extensive study of the Green's functions was required in the first month.

Secondly, I started to implement with Matlab the Green's functions of all integrated transmission lines of interest. A long lasting research of the microstrip transmission line was started. The radiation conditions and efficiency of a microstrip were analysed: How much power is lost into surface- or space-waves? The tool should not only account for radiation losses but also for the ohmic and dielectric losses. Ohmic losses occur due to the finite conductivity of the metals used in the strip and the ground plane. Dielectric losses are the dissipation of electromagnetic energy in the dielectric slab of a microstrip, expressed in terms of the loss tangent.

The last task of my internship was to build a graphical user interface in Matlab. This user interface is shown in Figure 1. The user can select the materials and loss tangents of each stratification and also the type of metal and its conductivity used in the design. After choosing the dimensions and frequency range of operation, the user obtains the results as presented in Figure 2. In the top left figure, the wavenumber is shown, from which the effective dielectric constant in the bottom right figure can be extracted. The characteristic impedance in the top right figure is very important for matching the transmission line to the antenna in order to minimize reflection losses. The bottom left figure gives you the radiation, ohmic and dielectric losses depending on your structure.

Future work

The result of this internship proved to be very fruitful for me. After summer I shall continue to work on the code for my master thesis, since Netherlands Institute for Space Research (SRON) is interested to

Thirdly, I extended my research on the microstrip to other integrated transmission lines of interest, such as the coplanar waveguide (CPW), the stripline and the slotline. This task was relatively easy as the theory used for the microstrip can also be used for other transmission lines.

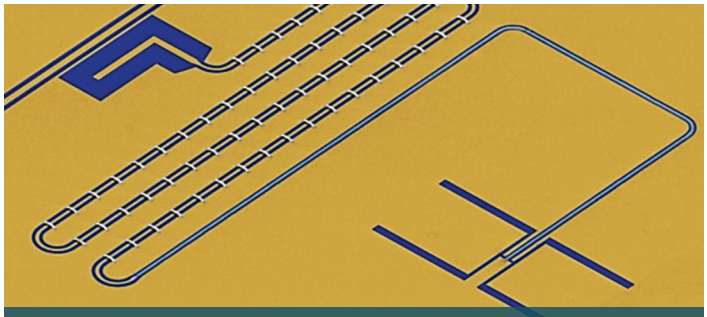

Figure 3: Kinetic Inductance Detector

make this code suitable for superconductive materials. Superconductive materials are used in Kinetic Inductance Detectors (KIDs), which are also extensively researched in the THz Sensing group. A KID, shown in Figure 3, makes use of resonant structures where THz signals received by an antenna change the resonance frequency of the transmission line, this shift being proportional to the power intercepted by the antenna. In this manner, KIDs are instrumental for measuring THz radiation. The analysis of KIDs requires a further extension of the code. First of all, superconductive materials have to be implemented in the code. Secondly, inhomogeneities in the transversal planes of the stratified media needs to be implemented since the Green's functions used thus far, assume infinite transversal stratification which is not sufficient for KIDs.

To conclude I can say that taking the internship in the THz Sensing group was proven to be a very good decision, as it did not only give me an enrichment of my study but also gave me a good preparation for doing a master thesis. Besides this preparation, it also provided me with a master thesis opportunity. The THz Sensing group gives you enough potential for developing yourself in a truly import electrical engineering facet. An internship or a master thesis is an ideal start to continue your career in research or industry.

Food for Thought
Project STAR GATE

Author: Ben Allen

It's 1970, and we're in the thick of Cold War. The Americans and Soviets are collectively soiling their underpants and during this ironically prosperous and technologically advanced period, the Soviets managed to convince the Americans they were spending millions of rubles on "psychotronic" research. Not known for taking potential security threats lightly, the United States responded by launching their own government-funded research project.

Personally, I hold no love for the paranormal. Proponents argue that my mind is closed and that just because I can't see or measure something doesn't mean it isn't there. They're not entirely incorrect, but saying "You can't prove I'm wrong" is not the same as "I am unequivocally right". But that's where the whole thing becomes a bit unscientific. In fact, unscientific thinking runs rampant throughout the subject of the paranormal, with even the aforementioned American studies falling prey to bias and ambiguity.

Let's define the subject matter a little more closely, seeing as I'm complaining about a lack of science. I'm considering paranormal effects including telekinesis (influencing a physical system without interaction), precognition (witnessing an event before it happens), and clairvoyance (being able to see something from afar). If Uri Geller claims to be able to do it, that's the stuff I'm talking about.

I wish I could send sparks into other people's heads like this. It would be awesome.

When I googled for "telekinesis", just looking for a simple definition, I found a guide on WikiHow on how to perform telekinesis yourself, and I'm just astounded. In the intro, it reads:

> ***"Telekinesis has been ambushed with scepticism and mockery for years. Often people do not let the ideas of such things enter their minds simply because they have not seen such things. Despite there being no science to back it up, many still believe that telekinesis is possible. If you have an open mind, this is for you."***

"Ambushed with scepticism". "Open mind". These phrases caught my eye instantly, because even the authors telling you how to *perform* telekinesis are fluffing their intro with escape routes and betray their own lack of confidence in the language they choose.

The article later goes on to tell you that it might take *years* before any paranormal ability manifests itself, but that it *will* suddenly come together. I don't know about you, but I'm not about to spend years of my life training for something that might just suddenly happen after a few years of pouring effort in to it without any result whatsoever.

My favourite part is this: "Despite there being no science to back it up, many still believe..." That's genius, because it sounds like a well considered argument. Let me illustrate how it isn't:

> ***"Despite there being no science to back it up, many still believe in pink unicorns that fart rainbows."***

Same sentence, but looks at least eight times more preposterous. Arguing from authority is fun, but not exactly a strong point.

Ok, so it's obvious I'm not convinced; but this doesn't really mean much. Let's add some objectivity to this noxious mix. Remember the cold war research project? You have to hand it to the Americans: they're absolutely fantastic at making stuff sound really, *really* good. Over time as the project was handed from organisation to organisation, it was named GONDOLA WISH, GRILL FLAME, SUN STREAK, and finally STAR GATE.

Sweet mercy, if more people used names like that for what they're doing the world would be a sexier place. The aim of the project was to determine the validity and military usefulness of paranormal abilities, with a focus on remote viewing. After a lot of experimentation, the Americans

reportedly spent over $20 million over two decades, which doesn't sound like much until you read conclusions drawn by a member of the evaluating committee working for the CIA, which by then had been given oversight of the project, in 1995:

"Psychologists, such as myself, who study subjective validation find nothing striking or surprising in the reported matching of reports against targets in the Stargate data. The overwhelming amount of data generated by the viewers is vague, general, and way off target. The few apparent hits are just what we would expect if nothing other than reasonable guessing and subjective validation are operating"

- Ray Hyman

Oh dear. On a government scale, $20 million might not be a lot. However, paying $20 million for a delivery of *absolutely nothing* is considered somewhat expensive, and the CIA promptly cancelled and declassified the project. So what did these studies with cool names find out? What, if anything, *did* we learn from the Americans?

First off, don't give parapsychologists twenty million dollars. It's a bad investment.

Secondly, putting a man in a dark room with ping pong balls on his eyes might make him see pretty colours, but it sure as hell isn't a missile silo in Kazachstan. Thirdly, for the price of one paranormal research project, you could launch a spy satellite which is pretty much guaranteed to get better results.

With all this complaining done, there's one more thing I need to get off my chest, and that is that I admire and respect the men and women who did this research. The people who came up with the idea of ESP obviously didn't spend much time thinking so much as doing a lot of LSD, but real researchers did real work trying to establish the science of parapsychology. And they did the best they could, but measuring something that doesn't exist turns out to be pretty difficult.

Nevertheless, once upon a time, mankind believed that the sun revolved around the Earth, that the stars were but punctures in a thick sheet that covered the sky and that humans would never set foot on extraterrestrial worlds. All those things turned out to be false. And similarly the ruling majority has always felt a bit intimidated by new ideas. So here's to the brave souls who dare to challenge conventional wisdom, go out on a limb, and research something crazy.

A more conventional method of remote viewing.

Picture Page

Masters of precision

Author: Derk-Jan Hulsinga

As one may find, the background of this picture page is probably a common sight for many of our readers. If not common, at least known. It is a top-down picture of a VLSI-PCB. The formost precise thing we use in electronic device production are ASML lithography machines. Though ASML is not the only company that has extreme resolution written all over it - The Satelitte Imaging Corporation owns the worlds most precise satellite for rent, called the Geo-Eye 1 that takes pictures with a precision of 46 cm or about 18 inches. All of this in mind, I started wondering...

The facts:

The Geo-Eye 1 revolves around the world at a distance of 681 kilometers above mean sea leivel, which is 260 km - 50% - further away from earth then the ISS is. Yet this beauty takes pictures with the precision of 46cm.

The best ASML lithography machine currently available is the Twinscan NXE:3300B which hands a resolution at the microscopic size of 22nm with a technique known as EUV - Extreme Ultra Violet. Explanitory images estimate that the light used travels somewhere between 0.5 and 1 meter through the machines mirrors and lenses before hitting the wafer.

Although, regardless of the outcome, the SIG states very clearly that these are the most presice 'commercial' satellites, so don't give up your career just yet minster Trueman.

The back of the envelope:

Geo-Eye 1: With a precsion of 46 cm at a light distance of 681 km our imaging satelite scores an astounding distance of

$0.46 / 681{,}000 = 4.55 * 10^{-7}$

meter precision per meter distance.

That equals 455 nm, which happens to be the wavelength of a colour known as Royal Blue.

Twinscan NXE: With a precision of 22 nm at a light distance of about half a meter, the dutch lithograpy machine scores

$22*10^{-9} / 0.5 = 44*10^{-9}$

meter precision per meter distance

44 nm - That about the size of a Rhinovirus, better known as the common cold.

Sensing with terahertz radiation

Research activities of the THz Sensing Group

Authors: Andrea Neto and Daniele Cavallo

Terahertz (THz) is a technology with an abundance of promising applications in various fields: security, space science, wireless communication, chemistry and biomedicine. It exploits THz radiation, i.e. the electromagnetic waves with frequency between microwave and infrared (from 10^{11} to 10^{13} hertz). About two and a half years ago, the "THz Sensing Group" was born in TU Delft to conduct groundbreaking research in this field.

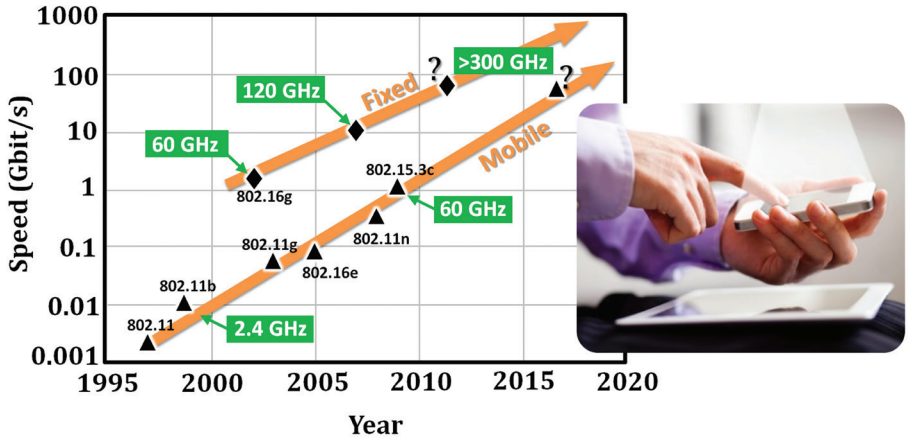

Figure 1: The need for increasing transfer speed in wireless communications.

Terahertz (THz) waves are those electromagnetic waves whose frequencies lie between the microwave and infrared regions. This frequency range has unique properties: THz waves can carry much more information than microwaves when used for wireless communication, due to their huge bandwidth *(with more and more people using wireless networks, moving to higher frequency carriers and broader bandwidth to achieve much faster data transfers is inevitable, see Fig. 1)*; THz radiation can penetrate through clothes and plastics, so it can be used for security screening, to detect concealed weapons on a person, at a distance; THz waves are non-ionizing and thus can be used for medical imaging with much reduced health risks, as opposed to X-rays; spectroscopy at THz frequencies could provide novel information in chemistry and biochemistry, in virtue of the particular spectral 'fingerprint' that most materials have in this frequency range.

Despite the excellent properties and the great variety of potential applications, THz waves are not even close to be exploited to their full potential. Their use is still limited to a few niche *(expensive)* scientific applications, due to the limits of current technologies employed for generating and detecting them.

In the summer of 2011, one of the present authors *(A. Neto)*, professor of Applied Electromagnetics at TU Delft, was awarded a grant of 1.5 million by the European Research Council *(ERC)* to develop breakthrough antenna architectures to revolutionize THz sensing and imaging applications. Right after the grant was awarded, the THz Sensing Group was created *(Fig. 2)*, as part of the department of Micro-electronics, within the Faculty of Electrical Engineering, Mathematics and Computer Science at TU Delft. The group comprises 19 scientific members *(including 5 visitors)*, among which 5 master students, 5 PhDs, 5 Post Docs and 4 Professors.

The activities of the group cover different fields. However, they can be broadly divided, looking at the application, into two main areas: broadband incoherent receivers and coherent systems.

We will now describe the activities in the framework of the ERC Project "Advanced Antenna Architecture for THz Sensing Systems" *(AAATSI)*. In this large project we develop theoretical analysis of focusing systems, to solve the fundamental problems that are encountered in THz radiometric scenarios for deep space investigation, integrated front ends above 0.1 THz and THz time-domain sensing systems.

The telecom scenario

One of the key properties of the THz regime that makes its exploitation potentially disruptive in comparison with other frequency ranges, is the availability of a large unused frequency range. It is well known that all communication and sensing schemes benefit enormously from using wide frequency bandwidths. The Holy Grail of THz applications is clearly wireless networks a million times faster than the present ones.

In today's wireless communication schemes, the wide bandwidth strategy is not largely adopted for the simple reason that the low frequency spectrum is completely used and strictly regulated. Frequency reuse schemes based on modulations *(digital signal processing)* have already reached the maximum capacity induced by the Shannon theorem. Frequency reuse architectures based on reduced cell dimensions, have been proposed. Now the cells are becoming so small *(a single room for instance)* that, despite the known problems of THz technology *(maximum transmission distance in the order of a few meters)*, front ends are almost capable of providing effective links at low costs. For these reason there is an exceptional drive to investigate the potentials of the THz spectrum for wireless communication.

Figure 3: THz Leaky lens antenna.

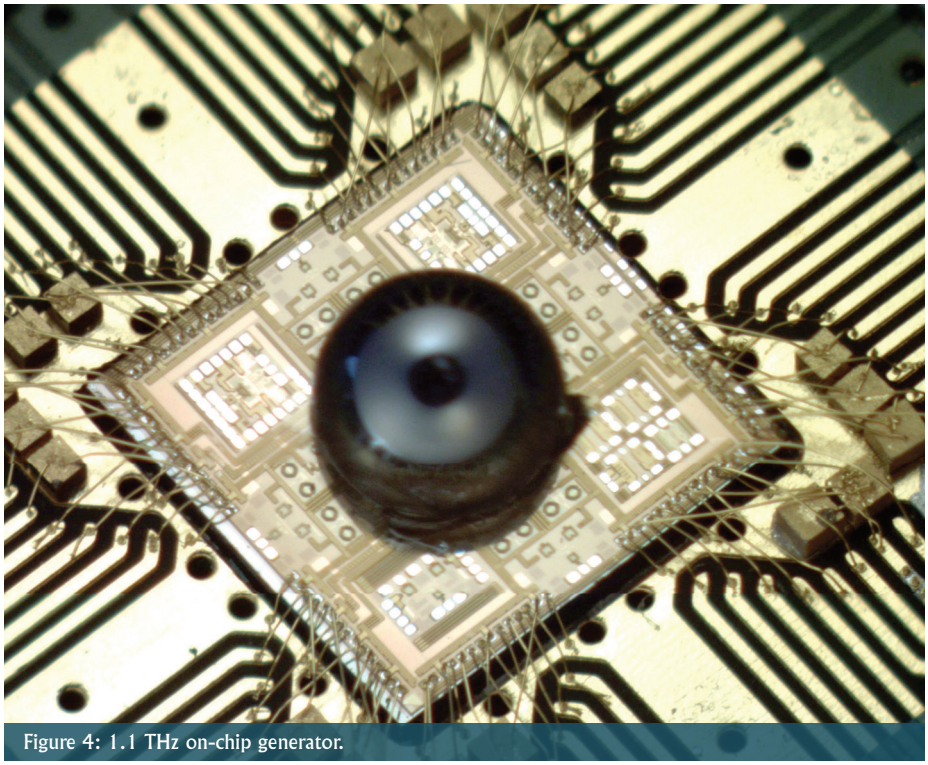

Figure 4: 1.1 THz on-chip generator.

Wideband, Non-Dispersive Sensing

Despite the potential associated with the availability of an enormous frequency spectrum, the THz domain is characterized by very high ohmic losses in metals. For this reason, and because of the limited information capacity of the present *(and future)* analogue to digital converters, the wave manipulation that at low frequency is performed in the electronic circuitry, in the THz domain can only be realized analogically by means of quasi optical components. Overall the efficient conversion of the very wide-band THz signals from guided to radiated and vice-versa is the enabler of any truly breakthrough sensing or communication schemes. However, all known antennas either introduce dramatic losses in the THz budget links or introduce unacceptable distortion of the signals that cannot be recovered in the electronic front ends. In one word, the main issue is dispersion, i.e. the mechanism by which an electromagnetic signal, short in time, thus broad in frequency domain, is damaged as it propagates through a high frequency electronic front end. This is the present day antenna bottleneck in the THz domain.

The group mission in the framework of the ERC Project AAATSI is to introduce advanced antenna technology that would solve the dispersion bottle neck. To achieve this goal, we use three theoretical breakthrough: leaky lens antennas, connected arrays and artificial dielectric layers.

Half way through the grant period a lot has been achieved. Given the mentioned target systems and the concepts that needed to be developed, the first phase of the project has seen two virtually parallel tasks. On the one hand, we have almost finished developing a theoretical framework to represent efficiently the electromagnetic field within focusing systems composed of thousands of elements that

need to be operated over extremely large bandwidths. On the other hand, we have realized some first prototypes of single element radiators to demonstrate that the promised concepts were actually feasible at THz frequencies.

Being able to actually manufacture the building blocks of the antenna architectures was anticipated to be the most risky part of the entire project. In fact, as applied as we try to be, the THz Sensing group is a group of electromagnetic theorists. We had to build solid alliances with other groups *(some in our department, some in the Netherlands and some in the United States)* in order to develop the desired micro-fabrication capabilities.

Figure 3 shows the first demonstration of the leaky lens antenna concept at THz frequencies *(specifically, from 0.15 THz to 1.5 THz)*. The leaky lens is a recent breakthrough introduced by our group, consisting of a dielectric lens antennas with very low-dispersive radiation over a wide frequency bandwidth. The antenna is integrated with a Kinetic Inductance Detector, a highly sensitive detector developed by SRON *(Space Research Organization Netherlands)*, that functions at extremely low temperatures *(0.1 degrees above absolute zero)*. This device, combining antenna and detector, is the cornerstone for achieving ultra-sensitive THz receivers to be used in far-infrared space telescopes that can measure radiation from the darkest corners of the universe.

A room-temperature, low-cost, on-chip THz generator has also been fabricated, see Fig. 4, in cooperation with the electronics group at TU Delft. The device has been manufactured with a BiCMOS process, and it employs novel concepts to improve directivity and bandwidth of the integrated antennas. Silicon technology, especially CMOS and BiCMOS, is the only candidate for drastically reducing the costs of THz systems and therefore greatly expand the use of this spectrum range for commercial applications.

Figure 5: THz image of a hidden bomb.

Coherent Systems: The security scenario

Besides space science and telecommunications, THz technology has also received increasing interest for security-related applications, because of its advantageous properties. THz radiation can detect concealed weapons since clothes and plastics are transparent to it; explosives and illicit drugs have characteristic THz spectral responses that can be used to identify them; unlike X-rays, THz radiation poses no health risk for scanning of people.

The THz sensing group is part of several European consortia active in the development of state-of-the-art THZ security scanners for standoff screening. Using these systems, a person can be scanned from tens of meters away at video-rate imaging speed, and very high resolution images can be generated *(Fig. 5)*. Such characteristics will fulfill the need for security scanners with new capabilities in airports and other public areas.

We have given an overview of the research activities carried out in our group. We conduct cutting-edge research in the field of THz science, by focusing on fundamental research and developing critical enabling technologies. Without a doubt, THz technology will play a major role in many disciplines in the future. However, as the THz field is relatively new, there is still a great deal of advancement required to fully exploit this technology. To be able to perform this challenging research, we look for motivated students to join our team for master or PhD projects and work together on this fascinating field.t

It's not even remotely funny

Humor in the world of telecom

Author: Ludo van den Buijs

It probably has not gone unnoticed that several articles within this issue of the Maxwell have a telecommunications theme to them. Al these articles are quite serious and we thought it would be a nice change of pace to add a page filled with telecom related jokes for you to enjoy on your summer holiday. Moreover, all of the jokes have been supplied by your telecom-teachers!

Q: When's the cheapest time to phone your friends?
A: When they're out

Q: Why was the VoIP phone late to the meeting...?
A: It got hung up in traffic.

Q: Why is a high speed Internet connection healthier than a regular one...?
A: It's high in fiber.

Frank wants to get his beautiful wife, Betty, something nice for their first wedding anniversary. So he decides to buy her a mobile telephone. Betty is excited, she loves her phone. Frank shows her and explains to her all the different and varied features on the phone.

On Monday Betty goes shopping in the local supermarket. Her phone rings and it's her husband, 'Hi ya, Betty,' he says, 'how do you like your new phone?' Betty replies, 'I just love it, it's so small and light and your voice is clear as a bell, but there's one feature that I really don't understand though.'

'What's that, Betty?' asks the husband.

'How did you know that I was at Tesco?'

I'd tell you a UDP joke, but you might not get it.

After digging to a depth of 100 meters last year, Japanese scientists found traces of copper wire dating back 1000 years and came to the conclusion that their ancestors already had a telephone network one thousand years ago.

Not to be outdone in the weeks that followed, Chinese scientists dug 200 meters and headlines in the Chinese papers read: "Chinese scientists have found traces of 2000 year old optical fibers and have concluded that their ancestors already had advanced high-tech digital telephone 1000 years earlier than the Japanese."

One week later, the Greek newspapers reported thefollowing: "After digging as deep as 800 meters, Greek scientists have found absolutely nothing."

They have concluded that 3000 years ago, their ancestors were already using wireless technology.

Customer:My phone bell is not ringing
PO:Oh,how do you know?
C:Every time someone rings me the dog barks.
PO:Ok we will send an engineer (thinks: another abortive visit)
Engineer at customer premises:I will test you phone(he he) and sure enough on ring back no bell but the dog barks its head off. On further investigation it turns out that the customer was on shared service,the bell coils had gone open circuit and the dog? well that was chained to the earth spike in the garden with a very new looking metal chain collar and and chain!

Q: What did the OSPF router say to the other OSPF router ?
A: Hello. Hello. Hello. Hello. Hello. Hello. Hello. Hello.

Q: What was a more important invention than the first telephone?
A: The second one.

Master thesis project

Bacteria sensor for medical purposes

Author: Ir. Stephen van 't Hof

Not all hospital equipment is yet as high-tech as an MRI scanner. Bacteria measurements in the hospital are currently performed by growing a bacteria culture on a Petri dish. This costs a lot of time, effort and therefore money. In my master thesis project for Biomedical Instrumentation I have worked towards a high-tech solution to measure bacteria concentrations for medical purposes.

Presented is an Escherichia coli detection system which is used to diagnose anastomotic leakage after colorectal surgery. If colorectal cancer or inflammatory bowel disease is diagnosed in a patient, the affected part of the colon needs to be removed (see Figure 1). Afterwards the colon needs to be reconnected. This reconnection is called the anastomosis. Finally, a drain is applied to release pus from the wound. If the anastomosis is sutured too tightly or loosely, it will leak, which is called anastomotic leakage. The intestinal content, containing the bacteria, will leak into the abdominal cavity and cause infections. Escherichia coli, in short E. coli, is a bacterium which lives peacefully in your colon. The colonic bacteria help to digest plant fibres. If E. coli escapes to the abdominal cavity, it will find abundant nutrients and start to multiply rapidly. Ultimately, the bacteria infection might kill the patient. Current anastomotic leakage diagnosis procedures take six to eleven days. To prevent morbidity, hospital stay and mortality, anastomotic leakage should be diagnosed early after colorectal surgery [1].

The Electronic Instrumentation Laboratory (EI) on the 15th floor of EEMCS researches the measurement of anastomotic leakage by various modalities. In my master thesis research anastomotic leakage is diagnosed by optical measurements on E. coli bacteria in drain fluid (pus). This is the continuation of previous research in EI, in which an optical waveguide chip was designed to measure these bacteria. The working principle of this chip is described in Figure 2. An infrared light source couples light into the TiO2 waveguide (green). The waveguide is so small, that light partly travels outside the waveguide (blue waves), this is evanescent light. The chip features a free-standing bridge, on which bacteria are captured. Bacteria present on the waveguide will absorb the evanescent light waves and therefore reduce the transmitted light power. By monitoring the light power at the output of the chip, the concentration of bacteria can be precisely calculated.

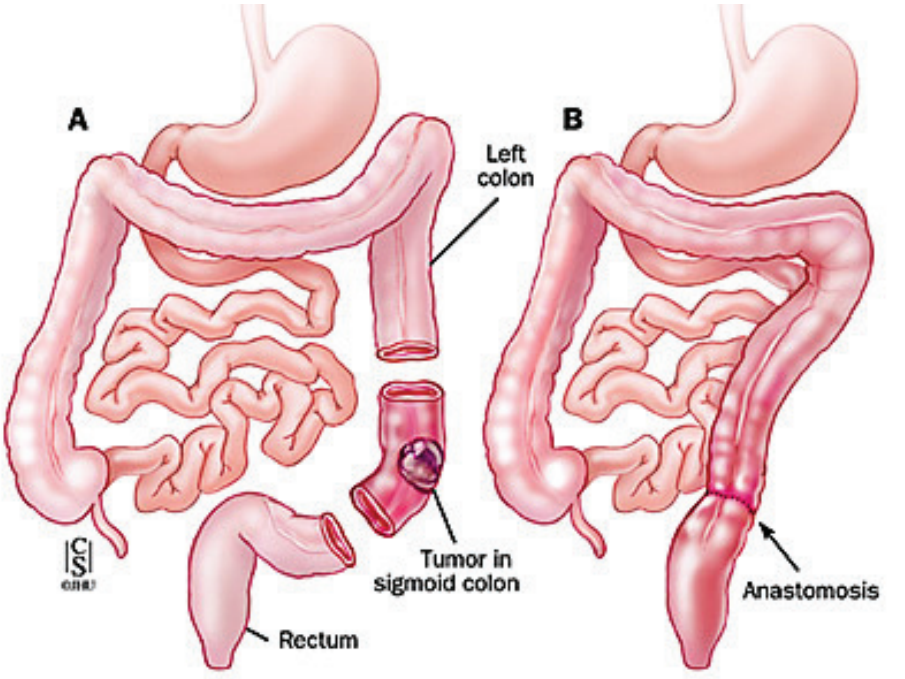

Figure 1: Colorectal anastomosis [2]

The aim of my research was to make a portable and user-friendly E. coli detection system and to test the functionality in clinically relevant simulations. In previous research the waveguide chip was designed and found to be functional, however the large optical setup could not be moved to a hospital. Therefore I decided to integrate the infrared light source and optical detector in a single portable smart system. This means the readout system of the waveguide chip was improved, the waveguide chip itself was not altered. The

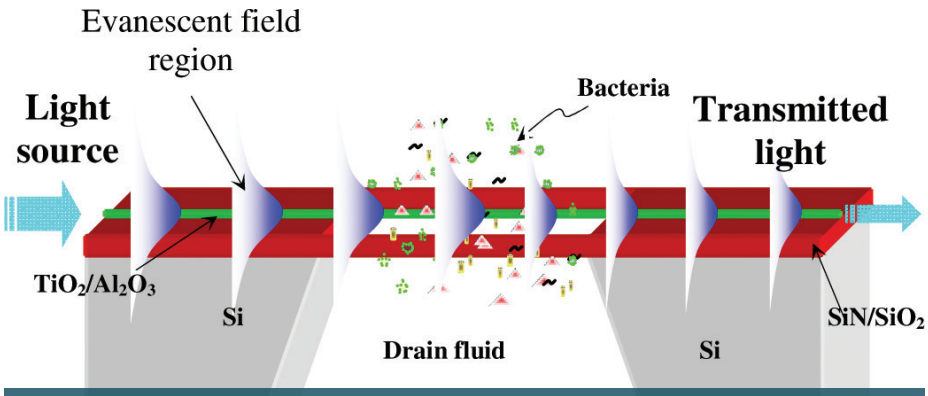

Figure 2: Optical waveguide chip working principle [3]

system performs the measurement and calculates the concentration of E. coli. Figure 3 describes the top-level system design. An Arduino microcontroller board forms the basis of the system. It drives an infrared LED through a constant current source. Light from the LED is coupled into the waveguide chip. Light from the waveguide chip outputs is channelled towards photodiodes. The signals are amplified by a transimpedance differential amplifier. The Arduino reads out this circuit, calculates the concentration of bacteria and prints this on a display.

From my background survey I found that the E. coli absorb between 0 and 0.1 dB of light power. If no bacteria are present, the absorption is 0 dB. If anastomotic leakage has occurred, on day five after colorectal surgery the E. coli concentration is 1,000,000 CFU/ml (colony forming units per millilitre) and the light absorption is 0.1 dB. That is very small, especially when it is compared to the total light power losses of 40 dB. Therefore the circuits need to be very stable. Since the system is powered by a computer over USB, the stability of the circuits became one of the major challenges in my project. The

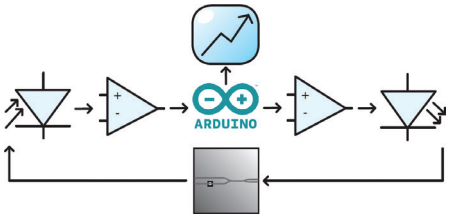

Figure 3: Top-level system design

waveguide chip was designed to allow for differential measurements, so the E. coli concentration can be precisely measured.

In the design phase most time was used to design the circuits, i.e. the constant current source to drive the LED and the transimpedance differential amplifier to read the photodiodes. The constant current source utilizes negative feedback to provide a constant current to the infrared LED. A shunt diode is used as a reference voltage; it behaves like a Zener diode, but even better. The circuit successfully suppresses ripples from the supply voltage and microcontroller. A constant current through the LED should render constant light output. The transimpedance amplifier translates the small photocurrents from the photodiodes to voltages. Next, a differential amplifier is applied to precisely find the light absorption by the bacteria. The output of the differential amplifier can be tuned with offset control to compensate for errors in the setup. The operational amplifiers suppress ripples introduced by the supply voltage.

The results show my measurement system can detect absorption levels as low as 0.0013 dB, corresponding to 9,700 CFU/ml E. coli. This means anastomotic leakage can be diagnosed on day four after colorectal surgery; an average profit of four days. Light from the infrared LED driven by the constant current source was found to be very stable, even more than the $2000 light source in our lab. The detection time of the system is 6.08 seconds, which allows for quick and online measurements. The transimpedance differential amplifier circuit shows a drift of 6.92•10-5 dB per minute, however this only becomes significant after 18 minutes of measuring. The system calculates the concentration of bacteria and displays this to the user, adding user-friendliness. This project brings us one step closer to a high-tech hospital. Unfortunately the system could not be tested on real patients. That will be the task for the next master student!

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Zeilweekend

#SAIL(Φ)

Author: Erné Bronkhorst

During the weekend of Pentecost a group of 24 ETV members went out the waters of Zeeland for a sail trip

The weekend started on Friday evening. While the group gently arrived at the accommodation in the middle of nowhere, everybody was already in the 'relax-mode'. We stayed at a camp full of chalets, with a nice place to make a camp fire, and so we did. After our first meal we have had a great night, and everybody was exited to go sailing the next day. In the early morning a selected group of people were heading out to the place where we should pick up our rented sailboats. When we arrived back at the accommodation with our boats, the sailing could begin!

The theme of this year's sail-weekend was #SAIL(Φ, and we as a committee we introduced some quests to make selfies at some special locations, for instance while passing a bow. Some people were really enthusiastic about the theme, and the first selfies were shot even before the boats arrived. The first day the weather was beautiful. My boat decided to go the end of the "Veerse Meer", to get something to drink at the supermarket in Wolphaartsdijk. The wind on the way to the supermarket was perfect, but on the way back the wind was gone. This was no problem because we had bought some chilled Corona's, and luxury snacks. Our average speed was so low, that we had to cheat by using our motor to get back in tame. At the end of the evening everybody shared their stories about what happened that day, and we had a BBQ on the camp fire. There even was a small party inside the main building! The plan was to go night sailing, but unfortunately after we had rigged the boats with some beautiful multi-colour LED lights, lightning appeared in the sky. This meant we were not able to sail, one ETV member was so disappointed, he decided to go for a night swim. The only thing we could do was sit near the campfire and drink a beer, but that was also a good activity to compensate the deception of not being able to go night sailing.

The next day was also perfect, in the morning there was not much wind, but that made a good opportunity to go swimming and enjoy the sun. Some people decided to get a drink at a bar in Veere. I'm still in love with the waitress of our bar. Luckily the wind decided to blow later that day, so everybody could enjoy one more moment of good sailing. After bringing back our boats to the rental service, most of the people were already packing their bags to leave. There was also the ability to go for the XL version of the weekend. So a group of five people stayed one night longer at the accommodation. As president of the organising committee, I am very happy to conclude that everything went great this weekend. Everybody had a great time and we are already looking forward to next year's sail-weekend!

One of the boats of the weekend

Career column

A story from a former board member

author: Joost van Driel

My graduation took place one year ago at the department of microelectronics, specifically at electronic instrumentation. Due to the fact that I have already given a report about this graduation project in the Maxwell last year, I will not write about that now. This story is about my experiences as a working man in the world of real working men and women. Well, mostly men.

Joost van Driel

First let me tell about the easy way that I have got my job. It all started with a career event in the Amsterdam RAI, which was not very interesting, because there were a lot of non-technical companies there. There was one company that did get my attention: TC Solutions, a 'detacheringsbureau'. *Editors note: A consultant employment agency.*

During the first interview with TC I have told the man at the other end of the table that I was interested in the railway industry. Yes, that is quite different from the microelectronics. I have chosen for something completely different because I felt that it was the correct thing to do. So when you are up for choosing some kind of job, or industry in this case, follow your heart.

Some while after the first interview at TC Solutions I visited Movares, an engineering and consulting company based in Utrecht. It was one of the companies that TC proposed and they arranged the interview for me. The interview, or actually conversation, was pretty nice and who soon was to be my boss invited me to do a personality test. I turned out to be a typical Electrical Engineer, great… They were however looking for such an employee, so they offered me a job.

So that is how I got my job, now let me tell you about some working experiences. To understand some of the things that I had to do, I first need you to explain the Dutch railway system a bit. The trains are run by companies like the NS and in other parts of the country by companies like Connexxion and Veolia. The railway infrastructure is owned by ProRail. Engineering and consulting about this infrastructure is one of the jobs that Movares does. The part where I am mostly working on is the train protection. As a consultant on these systems I am working on the special projects.

The first couple of weeks, or actually months, consisted of learning about these train protection systems. Most of these systems in the Netherlands still consist of pretty old-fashioned relay based circuits. Some of the older systems have been built just after the Second World War and are still there. And you can make jokes about trains having a lot disturbances, but these relays (almost) never fail. This results in few other of these train protection systems called interlockings.

Movares did engineer a new kind of interlocking based on standard PLC's. This was done before I joined Movares, but it proves that there is some development in the conservative world of trains. At the moment I am working on developing a new kind of railroad crossing for Belgium, based on PLC's. This project is in its final stage and the first crossing will be delivered in October.

Working at Movares is quite fun, because the subject is nice, but there are also a lot of activities organized by the personnel association, the Young Movares association and the young railway employees. I have drinks at least twice a month, went on a study tour to London, went sailing in Zealand *(not New Zealand)* and had some excursions. These activities are a nice addition to the working experience at Movares.

Dies

The 108th birthday of the ETV

The second week of the fourth quarter was a big one. Weeks of preparation were needed for these events. A lot of ETV'ers participated, from freshman to ETVeteran, almost everyone was there. This week gives a boost to people lacking motivation at the end of the academic year. A few ETV members have written some words on this week, and their experiences are shared here.

Elke Salzman

108 years ago no one could imagine how big the 108th birthday of the ETV would be celebrated. After we literally had a little peek on March 26 with the Dies-cake, the anniversary of the ETV was really celebrated in the last week of April. The pancakes on Monday were a warm welcome. And what would a dies week be without dies reception, where students from all over the Netherlands travelled all the way to Delft to congratulate the board with the anniversary of the association.

In the following days you could come across ETV'ers in various strange places, in a better or worse state. For example, on paintball fields, voluntarily in the lecture halls to learn a lesson about love, some even ended up laughing in the theatre. After an exciting game of karting and laser gaming, a true ETV member loves a good piece of meat, therefore the grill was well attended. And the good singers (and slightly less good singers) among us could show their singing skills during the karaoke. So there was something for everyone and after such a long week, we could talk on about the past week during lunch in the /Pub. After this amazing week the ETV can start to prepare for its 109th anniversary.

Waiting for food at the barbecue

Mitchel Gandhi

Every year, the ETV celebrates its anniversary during the so called 'Dies Natalis'. The Dies Natalis consists of a week filled with various activities for members of the ETV. These activities are organised by the committee, the Dies-committee.

I really enjoyed the ice-kart racing and laser gaming activities, which took place in an event centre in The Hague. We went with a group of 30 persons, so we couldn't all race at the same time on the track. That's why we split up in 2 shifts, each of 15 persons, and I was placed in the second shift. During the first shift I watched the others race and saw everyone drifting in the corner which looked really awesome. I couldn't wait to get in a kart and do the same. After 10 minutes, it was finally my turn to race! During the first round, I didn't go really fast because I had to get used to controlling the car. When I eventually figured it out, I was able to race fast and drift in all the corners! After the race, the results were announced and I turned out to be fastest of my shift!

With not very much grip the karts were driving on thin ice, so to speak

The second activity was laser gaming and took place in the same event centre. The laser gaming was held in a dark room with a nuclear setting; the walls were painted with radiation symbols. We were given a suit and gun and were divided in two groups for a team battle. The rules were pretty basic: points can be obtained by shooting someone and lost if you are shot. Someone who is shot, will be invulnerable for a short period of time (5 sec-

onds) so that he can't get shot multiple times and continue to lose points. I enjoyed the setting and idea of hide and seek to win points, but unfortunately I didn't finish very good in the ranking, so I better stick with shooting in video games!

Enthousiasm before the first paintball match

Daniël Kappelle

When I noticed the forms to sign up for the Dies activities, I was honestly impressed by the vast number of activities and how cool they were. I immediately signed up for a couple of the activities (BBQ, (ice) go-karting, laser gaming and paintballing) without even checking my calendar.

The BBQ was up first, a great way to start an awesome week full of joy. Everybody was clearly having an excellent time and enjoying the tasty food and obviously not to be forgotten: the drinks.

Next up was probably the coolest day of the week. After some adventurous cross-country navigating we were able to find the spot where it was all about to take place. We drifted and powerslided over the ice track in go-karts first. After that we did some regular go-karting in electric go-karts (what a beautiful coincidence). And to top all of that off, we split up into teams and battled each other in a thrilling laser gaming match, surrounded by neon lights.

The next day was just about as stunning. We went indoor paintballing in Rotterdam. The map was rather sweet, it had army trucks, elevated watch towers and even the fuselage of an old airplane in the center of the map. We played a couple of rounds and had some extra fun when two guys forgot a safety procedure. They had to run across the map unarmed wearing bunny suits. The rest of us was by the airplane in the center of the map shooting them like crazy. That must have taught them.

The last activity I only vaguely remember, this was the karaoke evening at the /Pub. We were singing all kinds of songs - probably way out of tune - and had a marvelous time.

To conclude this here article, it was a brilliant week which I'm sure everyone truly enjoyed. Productivity might not have been on its best, but for one week that shouldn't be too much of a problem.


A lot of classic karaoke songs were sung on this evening

Stage lopen in Tokyo

Onderzoek doen in de wereld van supercomputers

Auteur: Michel Jansen

Minor buiten Delft? Leiden, Erasmus? Veel te gewoon! Ik besloot om voor mijn minor stage te gaan lopen bij de afdeling Mathematical and Computer Science van Tokyo Institute of Technology. Alle Westerse gewoontes konden voor een half jaar opzij gezet worden om mee te draaien in het land van animé, manga en sushi. Voorbereiding? Voor wat? Vooraf hoor je alleen maar gekke (stereotype) verhalen over de cultuur in Japan maar is daar wel iets van waar?

De universiteit

In het begin had ik geen enkel idee wat ik kon verwachten. Zonder een echt goede voorbereiding vloog ik dan ook naar Japan toe. Gelukkig kwam de universiteit mij een beetje tegemoet met zeer gedetailleerde routebeschrijving naar de internationale dormitory (ze zorgen erg goed voor je!). Na twee dagen uitrusten en de buurt verkennen, volgde mijn eerste ontmoeting met mijn professor en labgenoten tijdens de wekelijkse labmeeting. Bij deze meeting (waarvan ik 90 procent van de tijd niet kon bepalen of er nou Japans of Engels gesproken werd) werd al snel duidelijk dat er een hoog niveau verwacht werd. Ik zat namelijk in het lab van professor Satoshi Matsuoka, een grote naam in de wereld van High Performance Computing. Professor Matsuoka is één van de belangrijke schakels in de (door)ontwikkeling van supercomputer TSUBAME. De supercomputer staat al enkele jaren in de top 10 van de meeste krachtige supercomputers ter wereld en is daarmee één van de pronkstukken van Tokyo Institute of Technology. Daarnaast is het uniek dat TSUBAME erg energiezuinig is en ook in de top 10 stond van meest efficiënte supercomputers. Dit komt mede doordat vrijwel het gehele laboratorium(van Bachelor tot PhD studenten) onderzoek doet naar probleemstukken van TSUBAME. De structuur van de universiteit is namelijk aanzienlijk anders dan in Nederland. In Japan sluit je je aan bij een lab waar je naast de reguliere vakken die je volgt, ook alvast begint met je thesis vanaf het begin van de studie. Ik was het maken van tentamens even zat, en besloot daarom me volledig te focussen op onderzoek.

"Regelmatig zag ik mijn labgenoten dan ook even een dutje doen"

Onderzoek

Aangezien meeste onderzoeken wel iets langer duren dan de dikke 5 maanden die ik er was, werkte ik samen met een Thaise student die in Tokyo zijn master deed. Samen hebben wij onderzoek gedaan naar het verhogen van de totale bezettingsgraad van de TSUBAME cluster. De supercomputer wordt namelijk gebruikt door veel verschillende gebruikers (studenten, professors, bedrijven) tegelijkertijd. Een gebruiker krijgt vaak een aantal (virtuele) nodes toegewezen voor een bepaalde tijd en kan dan zijn programma uitvoeren. Het komt echter vaak voor dat een gebruiker niet alle beschikbare rekenkracht, met name grafische kaarten (GPUs), gebruikt. Aangezien alle TSUBAME nodes (dat zijn er 1408!) vaak toegewezen waren, zou een meer dynamische

Robot restaurant

manier van nodes toewijzen de efficiëntie kunnen verhogen. Om dit te kunnen realiseren, was het virtueel toewijzen van ongebruikte GPUs (via het netwerk) aan gebruikers een optie. Aangezien dit een behoorlijk groot project was, ben ik alleen betrokken geweest bij de beginfase van het onderzoek waarin we ons vooral bezig hielden met het wiskundig modeleren van de executietijd. Ondanks de beperkte tijd heb ik mijn periode toch af kunnen sluiten met een (geaccepteerde) poster voor het GPU Technology Conference (GTC) van NVIDIA.

Ontspanning en sightseeing

Zoals eerder gezegd, sluit je je in Japan aan bij een lab. Japanners staan er om bekend dat ze hard en lang werken. Regelmatig zag ik mijn labgenoten dan ook even een dutje doen op het bed dat zich in de werkruimte bevond. Waarschijnlijk hebben ze dit nodig om 's avonds weer los te gaan bij de karaokebar, want dat kun je wel aan ze toe vertrouwen! Met mijn lab heb ik een aantal diners gehad, waar we vervolgens met z'n allen in een karaokebar eindigden. Schitterende ervaring om je altijd-zo-serieuze labgenoten ineens los te zien gaan op catchy liedjes van schattig geklede meisjes waar je alleen van de deuntjes al vrolijk wordt.

Ondanks het harde werken in het lab, mocht de toerist spelen in een schitterend land natuurlijk niet vergeten worden! Ik kon mijn eigen uren in het lab bijna helemaal zelf indelen en daarom kon ik gemakkelijk af en toe een paar dagen vrij nemen. In deze vrije dagen ben ik onder andere meermaals naar bezienswaardigheden in en rondom Tokyo geweest. Zo ben ik meermaals naar de omgeving rondom Mount Fuji geweest en heb ik de berg van 3776 meter zelfs een keer beklommen (eerste en laatste keer berg beklimmen ooit). Ook was het erg goedkoop om korte ski trips van een paar dagen te boeken. Daarom ben ik dan ook een aantal keer naar verschillende gebieden geweest waaronder Japans grootste ski-resort Niseko op het eiland Hokkaido. In dit poedersneeuw paradijs valt elke jaar minimaal 20 meter verse sneeuw en was daarom ideaal om tijdens de kerst, die Japanners niet kennen, te vertoeven. Één van de meeste bizarre ervaringen die ik heb meegemaakt is een bezoekje aan het "Robot Restaurant" in Tokyo. In dit 'restaurant' beleef je echt een mind-blowing show met de perfecte elektro combinatie (vrouwen, bier en robots)! De meeste bizarre dieren pakken en robots worden hier uit de kast gehaald, waardoor je anderhalf uur lang gewoon dubbel ligt van het lachen.

Terugtocht van mount Fuiji

Terugkijkend op mijn periode in Japan heb ik een fantastische ervaring opgedaan. Japan is echt een schitterend land waar je je ogen continu uitkijkt. Een aanrader voor elke student om een beetje extra moeite te steken om een minor in het buitenland te volgen. Wel is aan te raden om wat sponsoren aan te trekken (of super-stufi natuurlijk!), want Japan is in ieder geval niet goedkoop.

Meer weten over een minor in Tokyo? Stuur gerust een mailtje naar : M.Jansen-2@student.tudelft.nl

Ecorunner

The most fuel efficient vehicle in the world

Author: Alexander Spoelstra, Team Manager Eco-Runner Team Delft

'Ecorunner, the most fuel efficient vehicle in the world', the slogan of the Eco-Runner Team Delft says it all: designing and building the most fuel efficient vehicle in the world. The Eco-Runner Team is a D:Dream Team where students from various faculties work together to design and build extremely efficient, hydrogen powered vehicles and do research in the fields of aerodynamics, structures, electronics, hydrogen fuel cells and driving strategies.

Delft University of Technology takes great pride in its so called D:DREAM (Delft: Dream Realisation of Extremely Advanced Machines) teams, and with cause. As one of these teams, the Eco-Runner Team offers students an opportunity to bring theoretical knowledge obtained during their studies into practice.

The Eco-Runner Team was founded in 2006 and since then have built three cars. The Ecorunner 1, the Ecorunner H2 and the Ecorunner 3. This year the team is building the Ecorunner 4, all knowledge from various fields such as dynamics, structural analysis and aerodynamics finally comes to life in the design and production of this new vehicle. 'Actually holding the parts you designed in CATIA for the first time is a great feeling,' says Pieter (Bachelor Aerospace Engineering), responsible for the suspension of the Ecorunner 4.

Cutting-edge

As in the aerospace industry, the Eco-Runner Team strives to build their vehicles as lightweight as possible, using high-end composite materials for the monocoque and wheels, and high quality aluminium alloys for the suspension.

For the Ecorunner 3 this resulted in an impressive total vehicle mass just shy of 40kg, still strong enough to transport a person of 50kg at an average speed of 25km/h. At the time of writing the, Ecorunner 4 is yet to be finished, but the mass is expected to be reduced by at least 7kg with respect to the Ecorunner 3. This significant weight reduction was achieved through extensive finite element modeling of the body structure.

The team competes in the hydrogen category. Fuel cells converting chemical energy from hydrogen into electrical energy have been around for several decades now, but have been gaining immense popularity over the past years. Several major car manufacturers (for example Hyundai, BMW) have already developed hydrogen powered road vehicles. The Eco-Runner Team sees the hydrogen category as the greatest challenge and wants to proof the potential and capabilities of hydrogen as energy source in future mobility.

The Electronics in the car are relative simple. The powertrain is (with the exception of the chemical energy conversion of hydrogen and oxygen to electricity) fully electrical and exists of a fuel cell with the related control systems (the Balance of Plant, BOP), a motor controller and a brushless in-wheel DC motor. To ensure that the losses in energy are minimal, also in the electrical department the losses have to be as low as possible. The biggest losses take place inside the fuel cell. The fuel cell for the Ecorunner 4 is developed in Germany, at the German Aerospace Laboratory (DLR), in close cooperation with the powertrain team. It is a state of the art fuel cell, able to convert more than 60 percent of the available energy in hydrogen into useable electrical energy. 'Being able to cooperate with such a high tech company on such a unique, custom product is a pretty cool experience,' says Enzo (Bachelor Electrical Engineering), Chief Electronics. The combined efficiency of motor controller and the electrical motor is in between 80% and 90%. Again this depends on the power that that they have to deliver. This means that the total efficiency of the Ecorunner 4 (from chemical to kinetic energy) to be over 50 percent.

Tests have shown that the maximum efficiency of the fuel cell is reached when it has to provide a power of 65W while during the race, the fuel cell only has to deliver an average power of 50W. This is a wattage that is not optimal, but driving faster and so need the 65W of power means more aerodynamic drag, what also is not preferred. To find the right optimum the team is working hard on a simulation program. This program can then be used to determine the driving strategy during the race. To make the program as reliable as possible, it is very important to validate the mathematical model of

the Ecorunner. If this model is not correct, the strategy will also be false and so the race will never be won. In the future the team sees a lot of potential in optimizing the model and making it possible that the Ecorunner can adjust its speed autonomous based and the correct driving strategy.

One of the biggest challenges in the field of electronics is to keep all the electronics as compact and clear as possible. The space in the car is really limited and withal everything also has to be as light as possible. The overview is important for soft- and hardware because if any problems arise during the race it has to be fixed really fast.

This year the team will for the first time use a wireless communication system using some powerful XBee's. These are necessary because the radio signal of these modules has to pass through the carbon fiber of the body and through Ahoy, the first tests using this system were very positive. With this wireless system, data from for example the fuel cell or the speed can be send from the car that is on the track, to the team that is at the side. Using this data the driving strategy can be recalculated and adjusted immediately.

Minimizing resistance

To achieve extreme mileages, keeping the total resistance to a minimum is crucial. The most contributing factors to the total resistance are rolling resistance and aerodynamic drag (approximately 50/50).

To reduce rolling resistance, special low-resistance tyres are used and the mass is kept to a minimum. The aerodynamic drag is reduced by keeping the frontal area small and by shaping the Ecorunner like an airfoil, increasing the amount of laminar flow over the body and reducing the drag. The frontal area of the Ecorunner 4 is only 0.25m2 (compare it to a Renault twingo series, with a frontal area of 2,315 m2). The aerodynamic design is tested and optimized using CFD software that was made available to the team. Besides that, the Eco-Runner Team is able to use the university's excellent facilities, such as the low speed, low turbulence wind tunnel and the open jet facility, to optimize the aerodynamic design even further. All this effort leads to an approximate total resistance of less than 3N at a velocity of 25km/h.

Competition

The Eco-Runner Team builds their vehicles to compete in the annual Shell Eco-Marathon. In the European edition of this global competition, almost 200 teams from over twenty countries compete for the prizes. In 2013, the team was runner-up in the hydrogen prototype category with a mileage of 287km/kWh (2914km/l of petrol).

The vehicles are split up into prototype (very futuristic) and urban concept ('conventional' car inspired) vehicles. Teams also have a choice in the energy source they use. A few examples are: petrol, solar power, battery electric and hydrogen.

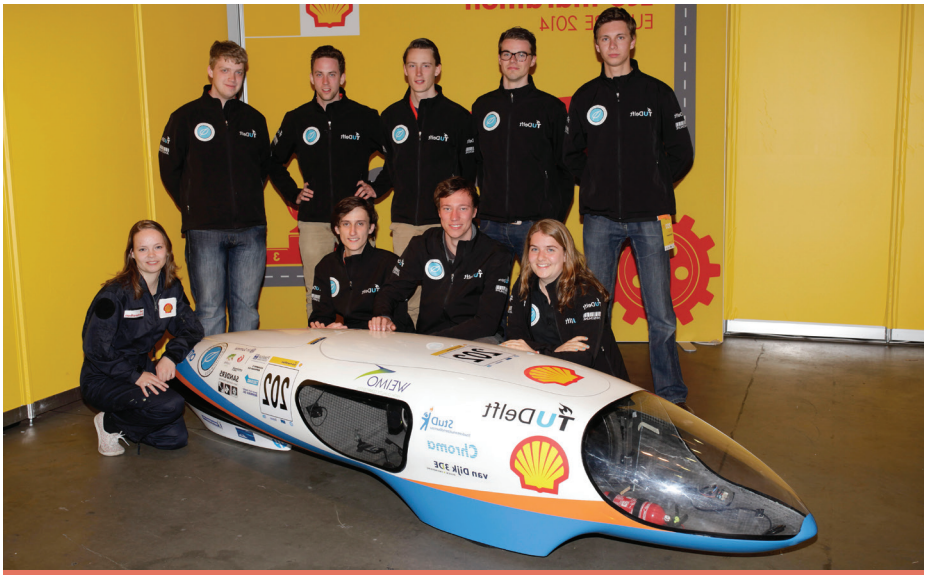
The Shell Eco-Marathon is a large event, challenging young engineers to think about solutions for future mobility. 'Even though it is a competition you can feel that teams are not only there to win, but also to share ideas and find solutions to common problems together,' team manager Alexander says.

In the end, the greatest challenge might be for the drivers. Evelijn (Civil Engineering), who drove the Ecorunner 3 at the Shell Eco-Marathon 2013, explains: 'It can get pretty hectic. A lot of vehicles are on the track together at any given time, and the visibility from the cockpit is pretty limited. Good communication is really important.'

Future Prospects

The challenge of designing and building the most fuel efficient vehicle in the world is never ending. In the future new technologies may arise that can be used to improve designs and vehicles.

If the Eco-Runner Team sounds challenging and fun to you there is also a possibility to join the team. There are both part-time and fulltime members, and it is also possible to do your minor on the team.



The Ecorunner and the team

Onderwijs

Innovatie door het kwartaal heen

Auteur: Moritz Fieback

Er gebeurt veel in het Onderwijsland. Met deze twee pagina's probeer ik een update te geven over de huidige situatie.

Nieuwe roostering bachelor

Tentamens en herkansingen

Aankomend studiejaar zal er met de invoering van de nieuwe bachelor ook een nieuwe roostering voor tentamens en herkansingen gehanteerd worden. Alle tentamens zullen aan het eind van het kwartaal in week tien plaatsvinden. Week negen wordt een week waarin geen nieuwe stof gedoceerd mag worden. Hier zullen wel werkcolleges plaatsvinden waarin bijvoorbeeld oude tentamens behandeld worden.

De grote verandering ligt bij de roostering van de herkansingen voor het eerste en tweede jaar. De herkansingen van kwartaal één zullen plaatvinden in de zevende week van kwartaal twee, de week direct na de kerstvakantie. De herkansingen van alle andere kwartalen zullen aan het eind van de zomer plaatsvinden. Hiermee wordt getracht te voorkomen dat studenten aan het "doorschuifeffect" ten onder gaan. Lukt het een kwartaal wat minder goed, dan kun je het kwartaal daarop zonder de druk van de herkansingen doorstuderen. Probeer echter zoveel mogelijk vakken bij de eerste poging te halen. Met vakken van vijf studiepunten kan de belasting in de zomervakantie erg hoog worden.

Voor sommige vakken zal in week vijf van ieder kwartaal een deeltentamen plaatsvinden. Dit deeltentamen zal samen met het tentamen in week tien een cijfer opleveren. De verhouding waarin de twee verschillende tentamens gewogen worden staat in de studiegids.

Weekrooster

In het weekrooster veranderen ook een paar zaken. Zo zal voor de eerste twee jaren de woensdag vrij geroosterd worden. Deze dag is bedoeld voor zelfstudie. De eerstejaarsstudenten kunnen aan het einde van die dag hun huiswerkvoortgang van die week insturen. Het cijfer voor dit huiswerk telt voor ongeveer vijf procent mee met het eindcijfer. Voor tweedejaars geldt deze verplichting niet, zij worden geacht zelfstandig genoeg te zijn. Ouderejaars studenten kunnen ook hun huiswerk inleveren. De invloed op hun cijfer is echter nog onbepaald.

Ook zullen er in verhouding meer werkcolleges zijn dan nu. Dit om de student meer te motiveren zijn werk bij te houden.

Herinschrijving

Op 1 september begint het nieuwe collegejaar. Zorg dat je je voor die datum via Studielink opnieuw hebt aangemeld voor je studie!

Studentenraden

Op 21 en 22 mei kon er gestemd worden voor de studentenraad (SR) en de facultaire studentenraad (FSR). De FSR houdt zich bezig met onderwijs, faciliteiten en kwaliteitszorg. Belangrijke zaken voor de FSR zijn de OER en TER (zie verderop), het nieuwe curriculum en studieadviseurs. De SR is voor de hele TU. Belangrijke dingen voor de SR zijn het studentenstatuut, BSA en matching.

Moritz Fieback - Commissaris Onderwijs

De uitslag voor de FSR, kamer EE, is als volgt:

- Rob Bootsman
- Moritz Fieback
- Dorus Leliveld
- Ralph van Schelven

De zetelverdeling in de SR blijft hetzelfde als dit jaar; 7 zetels voor ORAS en 3 zetels voor Lijst Bèta.

Je kunt contact opnemen met de verschillende raden via: fsr@ch.tudelft.nl en studentenraad@tudelft.nl.

OER en TER

Ieder jaar worden de OER (Onderwijs- en ExamenRegeling) en de TER (Teaching and Examination Regulations) bijgewerkt. De OER heeft betrekking op de bacheloropleidingen van EWI, de TER op de masteropleidingen van EWI.

Studenten die een schakelprogramma vanaf het hbo volgen moeten dit programma binnen twee jaar af ronden om toegang tot een EWI-master te krijgen. Lukt dit niet, dan worden zij voor vijf jaar geweigerd.

Ook is de propedeuse uit de OER verwijderd. Dit komt doordat de propedeuse geen los diploma meer is. De P-in-1-uitreiking zal hierdoor waarschijnlijk komend collegejaar voor het laatst gevierd worden in zijn huidige vorm.

Daarnaast is aan zowel de TER als de OER een nakijktermijn voor practica toegevoegd. Deze termijn is dezelfde als voor tentamens; vijftien werkdagen voor de docent om het na te kijken met vijf werkdagen verwerking voor de administratie.

Logischerwijs wordt ook de overgangsregeling naar het nieuwe curriculum in de OER opgenomen.

Vernieuwing masterprogramma

In het collegejaar van 2015-2016 moet een vernieuwing van het masterprogramma doorgevoerd worden. De opzet wordt hieronder uitgelegd.

Naar aanleiding van commentaar uit het bedrijfsleven wordt er een nieuw vak geïntroduceerd om een betere aansluiting te geven tussen de studie en het bedrijfsleven. In dit vak worden zaken als optimalisering van ontwerpen op prijs/kwaliteit-gebied, projectmanagement en andere ingenieursvaardigheden gedoceerd. Ook wordt er een vak gegeven waar algemene academische vaardigheden aan de student bijgebracht worden. Hierin leert een student bijvoorbeeld over het schrijven van wetenschappelijke verslagen. Deze twee vakken worden verplicht voor alle masterstudenten die Electrical Engineering studeren.

Ook zal de huidige masteropleiding Computer Engineering toegevoegd worden aan de masteropleiding Electrical Engineering als een track. Dit gebeurt omdat Computer Engineering vrij klein is. Om de bijbehorende problemen hiermee te voorkomen wordt de master een track van Electrical Engineering.

De verdere opzet van het nieuwe programma is als volgt. Tien studiepunten zullen te verdienen zijn met de twee eerder genoemde vakken. Daarna moet een student drie uit zes vakken kiezen in een common core. Studenten van verschillende tracks kunnen dezelfde vakken kiezen uit deze core. Echter zijn bepaalde vakken natuurlijk meer in het straatje van verschillende tracks. De vakken zullen vijf studiepunten per stuk waard zijn.

Na de common core kunnen vakken uit de track core gekozen worden. Hier moeten weer drie vakken van vijf ECTS gekozen worden. De track core is, zoals al in de naam zit, specifiek voor iedere track. Het is echter wel mogelijk om vakken uit de common core te kiezen die nog niet gedaan zijn.

De overgebleven studieruimte wordt gevuld met het afstuderen, 45 ECTS, het vrije deel, 15 ECTS en de specialisatie van 20 ECTS. Studenten van de track micro-electronica kunnen nog steeds afstuderen voor zestig punten, dit gaat ten koste van het vrije en specialiserende deel.

Een belangrijke toevoeging aan deze nieuwe opzet is dat de discussies nog volop lopen en het dus zeer goed mogelijk is dat er bijvoorbeeld iets verschuift in de verhouding van het aantal studiepunten per deel. Ik en mijn opvolger zullen proberen de student zo goed mogelijk up-to-date te houden.

Aanmeldingen

Door een wetswijziging is het voor aankomende studenten verplicht om zich voor 1 mei voor één of meerdere (maximaal drie waarvan maximaal één lotingsstudie) studies aan te melden. Het gewogen aantal aanmeldingen komt hiermee rond 180 à 190 te liggen, een stijging ten opzichte van vorig jaar.

Studiekeuzecheck

Scholieren die zich voor 1 mei voor een opleiding aanmeldden kregen het recht om een studiekeuzeactiviteit bij te wonen. Hierin kunnen zij zien of de opleiding aan hun verwachtingen voldoet. Electrical Engineering. Dit wordt getoetst door middel van een vragenlijst. Hier kunnen drie verschillende adviezen uitkomen: positief, twijfel en negatief. Studenten die een twijfel of negatief advies hebben gekregen worden uitgenodigd om een dag langs te komen.

ETVIP

What's happening at the ETV?

IDEA League

Author: Ludo van den Buijs

In 1999 the IDEA League was founded as a network of four leading universities of technology and science. Via this collaboration the member universities cooperate on several areas including education, research and innovation. Throughout the years the members contained within the IDEA League has changed. At the moment the four member universities are the TU Delft, the ETH Zurich, the RWTH Aachen and recently Chalmers. Next to the collaboration at a University level, it has also led to cooperation between students via their student associations. The past academic year the different study associations of Electrical Engineering have decided on working together and meet twice a year. After having visited Aachen in November, we recently went to Zurich for our second meeting. First of all it is hauntingly apparent how alike electrical engineering students worldwide are. As a board it is quite interesting to see the differences and similarities between the different associations. It is quite interesting to discuss the way the ETV operates and how it can be improved with people having had a different experience.

Furthermore, we touched on several subjects involving the IDEA League. We set the goal for ourselves to make it as easy as possible for an electrical engineering student of any member university to do their thesis at a different member university. At the moment we're working on a website on which students can find all the information they need, from financial aid to contact information of Professors. A different interesting topic which we discussed was the progress each university had made on E-learning. After having heard from the TU Delft Student Council about the concept of "Flipped Classroom", in which the students watch their lectures online and only visit the University to ask related questions, it was interesting to see that the ETH Zurich had already started to implement the system. To make sure we can keep discussing the progress made by each university we added the current status to our database to use as a baseline in future discussions.

The groundwork for fruitful relations with the different Study Associations has been laid down and we are looking forward to seeing what the future will bring for the ETV via the Idea-League.

ETV members at the "Zwoele Zomerborrel"

ZakCie

Author: Sam de Jong

Sitting in the sun with a cold beer, we all know it, we all love it, summer is finally here. Ofcourse the best way to enjoy summer is by participating in some nice activities organised by the ETV.

That's why some enthusiastic first year students were asked to become members of the ZakCie. This commission has one purpose, making sure the aspiring electrical engineer has the chance to enjoy summer with his fellow students.

The ZakCie got together and decided that the first activity had to be a drink. The perfect location for this drink was, of course, the /pub. This pub situates itself underneath the EWI building and is well known by every student of the faculty. Cold beer for a nice price, that's all students need.

But the ZakCie decided they had to do something more to really bring the summer vibe to the bar. This was achieved by some nice background music, provided by our Aruban ZakCie member. In addition to that, we bought some Desperados, which got completely sold out that night. To top it all off, ZakCie provided some cool summer themed accessories and free ice cream.

To make this night a night to remember, we created a little photo booth. A beamer provided some cool backgrounds in front of which the students could pose for a picture. Soon enough the accessories got involved which resulted in some very funny pictures. The stars of the evening

definitely were the inflatable crocodile, toucan and turtle. All provided by ZakCie to ensure the best possible photo booth experience.

The ZakCie really enjoyed the evening and we hope the rest of the students that were there enjoyed it as well. If we consider the amount of beer drank as a measure for the success of the evening. I think it's safe to say that the evening was quite successful. If you enjoyed the evening, or you missed it but wished you were there after reading this article. ZakCie will be active until the end of the first quarter of next year. So make sure to keep an eye out for upcoming activities!

Tennet lunch lecture

Author: Reinier Prins

Sitting in the lecture halls with a bucket load of food means it was time to listen to a company willing to tell about their visions, missions and technology during a lunch reading.

This time we were given the opportunity to listen to Tennet, an electricity transmission system operator in the Netherlands and large parts of Germany. Tennet does not only provides electricity for 36-million users but also builds high-end systems to obtain and secure their high-voltage grid for a stable and secure power supply. Furthermore Tennet has been building cross-border interconnectors to provide cheaper electricity. Tennet's headquarter is located in Arnhem and most of the important location are within the Netherlands.

After an introduction about the company we were taught about the history, advantages and disadvantages of alternating and direct current. Later our presenter explained that different distances required different implementations of current. He explained that direct current is more efficient on long distance than high frequency alternating current. They are currently testing if efficiency improved by lowering the frequency. At the end a description were given on complex systems like the bipolar converter station that's been used in many of their cross-border interconnections. After many questions from the audience about the different electric systems the students and EESTEC-student left to continue with knowledge and a full stomach.

Batavierenrace

Autor: Joost Kerpels

Did you think students Electrical Engineering are not that sporty? Then think again! No less than 23 students took part in the biggest relay run of the world: the Batavierenrace. For those of you not familiar with the concept: the Batavierenrace is a relay race purely for students. Per team a distance of about 175 kilometers is covered running, with a teammate following closely by bike for safety and support. Each team is divided into three subteams (night, morning and afternoon) to create groups small enough for minivans. The number of students participating is overwhelming: this year 8614!

After training for weeks and weeks, the event finally commenced. For the first subteam the adventure started in Nijmegen, at the start of the event. After a long wait for the actual start (we started in the 5th starting group, at 1 AM), 8 of our night team runners gave everything to ensure a good result. The route led us through dark parts of both the Netherlands and Germany.

The rest of the team had spent the night in Enschede, at the finish location of the event. After a short night sleep, 8 team member took over the difficult task to maintain or improve our position by running as fast as they could. Well, they did! Each and every one ran faster than they were expecting. Finally, the task was up to our last 7 runners. Even though the rain was obstructing us more and more, the

Marc and Joey at the Batavierenrace

results kept on being great, all the way up to the final stage. With rain running over their faces, Isabella and Ralph concluded the great event – the running part, that is!

A little celebration for a great achievement was in place, so after some rest and some beers, we teamed up with our fellow Electrical Engineering associations Thor and Scintilla for a great barbecue. With new energy, most of us decided to go to the massive party which concludes the Batavierenrace. Amazingly, our legs were fresh enough to dance for hours and hours, after which everyone finally got some well-deserved sleep.

After waking up, having a banana-whisky breakfast, and pouring out rainwater from our tents, the weekend was really about to end. The only thing left to do was thank everyone for a great weekend, and drive a long way back to Delft. The event was a great success, so I'd like to thank all participants for their amazing performances. I really hope to see everyone again next year!

HET ECHTE NIEUWE WERKEN

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