

M AXWELL

Magazine of the Electrotechnische Vereeniging

Graduation report

Nanoparticle additions for thin film solar cells

Exploring the EE departments

Remote Sensing of the Environment

Circuit bodging

One controller to rule them all



Edition 14.4
Alumni edition

July 2011



Start a career where you develop more than just your professional skills

Philips is a diversified health and well-being company, focused on improving people's lives through timely innovations. As a world leader in healthcare, lifestyle and lighting, Philips integrates technologies and design into people-centric solutions, based on fundamental customer insights and the brand promise of "sense and simplicity".

Grow with Philips. Join an innovative company in health and well-being that makes a real difference to people's lives. We challenge and empower you to make the most of your talents while working in multidisciplinary and international teams. You will be surrounded by passionate, insightful colleagues who share your drive to create superior customer experiences. Our growth depends on yours, so we'll support you with career opportunities that will let you accelerate your growth in directions to which you aspire.

Visit www.philips.nl/carriere and grow your career in a company that values the interaction between technology and people.

PHILIPS
sense and simplicity



From the Board

Dear Members,

A lot has happened since the last Maxwell (14.3). Especially for us, the Board, it was a very busy time. On March 12th we organized the parents' day. At this day the parents of the freshmen saw what their children were doing in this faculty. A lot of parents experienced that the study of their child was a lot tougher than they expected.

We also organized ten days full of a wide range of 105th anniversary activities, from an educational symposium to the biggest party of the last five years, our anniversary dance. Our stunt committee made the biggest game controller in the world. Further on in this magazine you can read a detailed report on our anniversary activities.

Professor Van der Sluis and Professor Ligthart did a lot for our association in the past few years and that is the reasons they became honorary members of the association (Ereleden van Vereeniging) on March 26th.

On the 31st of March and the 1st of April the faculty had open days. There were a lot of pupils who were interested in Electrical Engineering, so we hope that the next years there will be some more registrations for the study.

As you know the Electrotechnische Vereeniging is also a part of EESTEC (Electrical Engineering Students European assoCiation). Every year there is a congress in a foreign country and this year the Secretary and the President of the ETV went to this event in Romania. They met a lot of people from all over

Europe. It was very interesting to see and hear about the differences in the electrical engineering education.

This year we had a lot of committees which did a great job for the ETV. On June 8th we thanked all the members of our committee with a free BBQ.

With all these activities behind us we are getting closer to the end of our year as a Board, and looking back I can say that it was a challenging, but very rewarding year. Especially the last few months have brought us a lot of organizing work, and also a lot of fun activities. We are now busy with the preparations of our Freshmen weekend. We think next year there will be 100 new Freshmen and at the freshmen weekend they get to know the faculty, the ETV and each other much better. In the new year there will also be a new Board. The potential board (pb) already presented his self on June 8th. The members of the pb are: Adriaan Taal, Paul Marcelis, Remco van der Plaats, Bas van Wee and Lennart Boeke.

In the year 2011/2012 there will be a new Master called Signals & Systems. This Master covers the broad field of signal processing and system design and offers the possibility for graduation in a signal processing area, like multimedia signal processing, signal processing for communication, and biomedical signal processing.

For now, enjoy your vacation and see you next year!

Editorial

Ah, the alumni edition of Maxwell. Each year the greatness of our magazine is celebrated by producing an extended version, for it counts 48 pages full of interesting articles. No effort was spared to create the last Maxwell of 2010-2011, with a printing run of no less than 5500.

So, what can the reader expect to find this time? Have the editors finally overcome the struggles of finding at least one appealing article to publish? Or have we degraded to publishing white space in order to show people the advertisements? Nothing is further from the truth, as the ETV has organized loads of cool events in her Lustrum weeks. The activities of the last two Lustrum weeks have produced many interesting stories, which you can read in our 'ETV activities' section.

As always these particular busy weeks have produced some nasty side effects. Apart from a daily morning headache, there was no time to be bothered with thinking about redesign of the Maxwell. To make matters worse, when the Lustrum ended, many of our highly skilled editors were occupied with their Bachelor Project. So the organizing of articles came down more to the younger, clumsy and inept editors. Even the editorial will be written this way.

And that's why, as always, we are with six people stressing last minute to finish our most anticipated edition yet. For us a moment to find peace at mind in these times of important exams. For the reader one less distraction during studying. And fantastic reading material when at the beach on our holidays for us all.

Adriaan Taal
Editor

Contents



Welcome in Japan!:
Experiences from an internship 

Exploring the EE groups 



ETV MAGAZINE "MAXWELL" Year 14 – edition 4 – July 2011 PRINTING DeltaHage B.V., Den Haag NUMBER OF COPIES 5500 EDITORS Ben Allen, Joost van Driel, Benjamin Gardiner, Maarten Kastelein, Jeroen Ouweneel, Richard Spijkers, Ester Stienstra, Adriaan Taal, Imke Zimmerling CONTACT Maxwell, p/a Electrotechnische Vereniging, Mekelweg 4, 2628 CD Delft, phone: 015-2786189 or 015-2781989, e-mail: maxwell@etv.tudelft.nl, website: www.etv.tudelft.nl CHANGE OF ADDRESS Please send your changes to the address above, or use the website. Alumni can change their address via the Alumni Office website: www.alumni.tudelft.nl ADVERTISEMENTS Philips(p.2), ASML(p.14), Technolution(p.17), National Instruments(p.23), Smit(p.27), Supair(p.30), Atos Origin(p.31), V-PS(p.37), Deerns(p.41), TNO(p.47), TenneT (back) SUBSCRIPTIONS Non-members can receive the Maxwell four times a year, against a contribution of €10,- per year. For more information, please contact the Maxwell Committee.







- Graduation report Silvian Bensdorp:
Nanoparticle additions for thin solar cells 







- Tweede lustrum week 

- Cooking with: Ryoichi Ishihara 



- ✦ From the board  3
- ✦ Newflash  6
- ✦ Activities of the ETV  8
- ✦ In the right direction with GPS  15
- ✦ Joost may know it  22
- ✦ The right person for the job  24

- ✦ An advanced beard trimmer  28
- ✦ Circuit bodging: One controller  32
- ✦ A quick guide into electric vehicle
recharging infrastructure  38
- ✦ Column  45

Newsflash

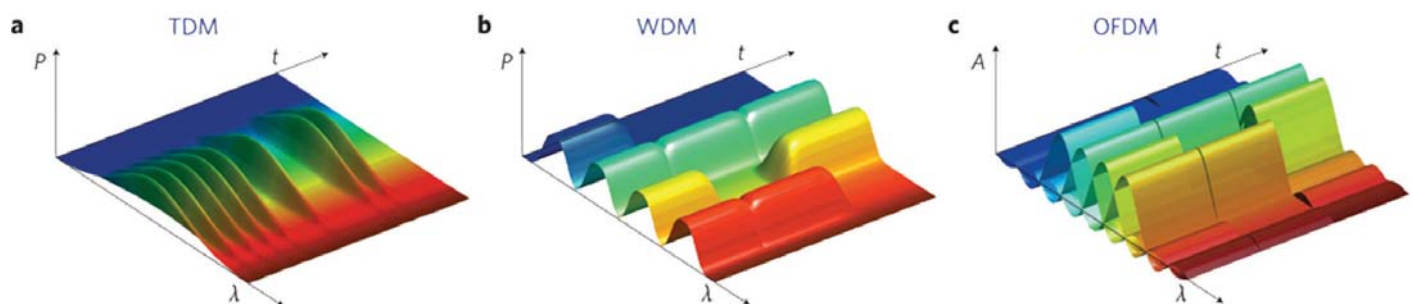
26 Terabit per second optical transmission

German researchers from the Karlsruhe Institute of Technology succeeded in sending record amounts of data through an optical wire using a single laser. It is not so much a speed record, as it is an efficiency record – speeds of 26 Tb/s are not unheard of, but the implementation in this research is quite innovative.

Traditionally, Time-Division Multiplexing (TDM) is used to send multiple signals over an optical cable. This means that each signal is assigned a certain timeslot that recurs after all of the other signals sent data in their timeslot. This, however, is

ters and receivers with stabilized lasers for every signal (i.e. transmission wavelength) and that some space is needed between the different wavelength bands, in order to separate the signals. This is depicted in figure 1.b.

To cope with these disadvantages, the German researchers made use of Orthogonal Frequency-Division Multiplexing. This is implemented by positioning several data symbols in one timeslot; each symbol is interpreted as a complex Fourier coefficient in the frequency domain. To transmit these sym-



Figures 1 a, b and c: Graphical representation of different optical transmission techniques.

not very efficient, since every bit uses the entire light-spectrum emitted by the transmission laser. A schematic time-wavelength plot is depicted in figure 1.a.

More efficient use of the available light spectrum can be made by using Wavelength Division Multiplexing (WDM). With WDM, each signal is assigned a certain part of the light spectrum, rather than a time slot. This means that different signals can be sent in parallel (instead of serial when using TDM), which can vastly improve the total data rate. The main disadvantages of this implementation are that it requires transmit-

ters and receivers with stabilized lasers for every signal (i.e. transmission wavelength) and that some space is needed between the different wavelength bands, in order to separate the signals. This is depicted in figure 1.b.

To cope with these disadvantages, the German researchers made use of Orthogonal Frequency-Division Multiplexing. This is implemented by positioning several data symbols in one timeslot; each symbol is interpreted as a complex Fourier coefficient in the frequency domain. To transmit these sym-

Source: *Nature.com*, <http://www.nature.com/>



Mobile phones could be charged by the power of speech

For mobile phone users, a flat battery or a lost charger are among the frustrations of modern life. Now new research promises a way to recharge phones using nothing but the power of the human voice.

Electrical engineers have developed a new technique for turning sound into electricity, allowing a mobile to be powered up while its user holds a conversation. The technology would also be able to harness background noise and even music to charge a phone while it is not in use. However, there could be a downside to the innovation, if it gives people a new reason to shout into their phones as they attempt to squeeze in every extra bit of power they can.

Dr Sang-Woo Kim, who has been developing the design at the institute of nanotechnology at Sungkyunkwan University in Seoul, South Korea, said: "A number of approaches for scavenging energy from environments have been intensively explored."

"The sound that always exists in our everyday life and environments has been overlooked as a source. This motivated us to realise power generation by turning sound energy from speech, music or noise into electrical power. Sound power can be used for various novel applications including cellular phones that can be charged during conversations and sound-insulating walls near highways that generate electricity from the sound of passing vehicles. The latter development would have the additional benefit of reducing noise levels near highways by absorbing the sound energy of vehicles."

The technology uses tiny strands of zinc oxide sandwiched bet-

ween two electrodes. A sound absorbing pad on top vibrates when sound waves hit it, causing the tiny zinc oxide wires to compress and release. This movement generates an electrical current that can then be used to charge a battery. A prototype of the technology was able to convert sound of around 100 decibels - the equivalent of noisy traffic - to generate 50 millivolts of electricity.

"This is not enough to charge a phone properly, but Dr Kim and his colleagues hope that by altering the material the wires are made from they will be able to produce more energy at lower sounds levels. "Our current output performance can be applied to various electronic devices with low-power consumption such as self-powered sensors and body-implantable tiny devices. We believe that we can realise more efficient sound-driven nano-generators."

Researchers and some manufacturers have already started looking at using 'energy scavenging' as a way of powering portable electronic devices. Scientists have developed devices that can use the heartbeat to power MP3 players, while Nokia has filed a patent for a device which harvests energy from movement, much like a kinetic energy powered watch. 📶

Source: Richard Gray, <http://www.telegraph.co.uk>



Activiteiten van de Electrotechnische Vereeniging

ASML Excursion

Auteur: Sander Geursden

As known, one off the steps to produce an IC is lighting the photoresist on the wafer. In this step, the lithography step, machines from ASML can be used. To produce smaller IC's, the image lighted on the wafer have to shrink to almost unthinkable small sizes. This is what ASML has been doing for the last 27 years.

On the 9th of June ASML organized an excursion for students of Electrical Engineering of the three technical universities in The Netherlands. As expected the ETV was there with a large delegation. After a bus trip to the Dutch version of silicon valley it was time to hear about the ins and outs of the world leader in lithography machines.

In case there was somebody that did not know ASML, the first talk was about what they do and what kind of challenges they are facing. Impressive numbers where given about what modern lithography machines are capable off. The second talk was about HSI, an internal system they are using to model, document and describe each part of the system. When a new part is done, its description, model and firmware is entered. The configuration for the whole machine is then automatically generated.

After the morning talks it was time to meet some employees with an Electrical Engineering background. They showed us around the campus, from clean-rooms where some parts are assembled to a few labs where new high voltage electronics designs are developed and tested.

With a nice lunch as a little energy boost, it was our time to do some thinking. The case they had for us looked a bit of a non-electronical one about optics. During the brainstorming however, it appeared that even a problem with an optical basis can be solved by electrical engineers. The proposed solutions from most groups where quite similar, a solution that is actually used by ASML nowadays.

The last talk was more about the internal, project based, way of working at ASML and how a day could look like for an Electronic Development employee. The day was concluded by a drink with all participants and employees. This concluding drink with bitterballen brought an end to the day in the world that keeps on shrinking and shrinking. 🇳🇱



A tour of the facility is of course part of the excursion.



You have toys for boys and toys for Electrical Engineers.

Lunch lecture Riscure

Auteur: Auke Booij

In ye good old days, any message could be authenticated using a wax seal. The familiar red ornaments on letters from countries far away would tell you it really was the King of Spain asking you for your army. Those times are long gone, and nowadays it is more convenient to electronically sign or encrypt your message, according to the type of security needed, and smart cards found in many everyday devices such as SIM cards, debit cards and especially satellite TV cards, supply a secured environment in a mobile form factor. However, while the encryption itself may be hard to break, the implementation can sometimes be broken.

On June the 6th, Jasper van Woudenberg of Riscure gave a lunch lecture in which he explained some of the basic techniques of hacking such cards using side-channel analysis and fault injection. In side-channel analysis, researchers attempt to retrieve information about the chips internal state using externally measurable properties of the chip, such as its power consumption and EM-field. Since smart cards usually have a lot of similarities with CPUs, this can sometimes give a lot of information, although manufacturers these days of course try to counteract such attacks, mainly by making the internal processes less deterministic. Fault injection concerns the art of fiddling with a chip until it surrenders. Back when fault injection was easy, simply spiking the power at the right time would skip a check in the decryption algorithm, circumventing the need to get the right key.

The fight to make security implementations perfect is an ongoing battle between manufacturers and security researchers, and I think I speak for many when I say this was an insightful talk. Now where did I store my lockpick? 🗝️



All students of the EEMCS faculty where invited to this lunch lecture.

Lunch lecture Technolution

Auteur: Ingmar Jager

On the 3rd of May, Sjors Hettinga from Technolution visited Delft to talk about his thesis project and current work at Technolution. During his master thesis project, he came up with a solution for Control Engineers, who do not have a lot of programming skills and computer hardware knowledge.

His solution consists of a processor written in VHDL on a FPGA which gets its instructions from a file generated by a self made compiler. The FPGA is part of a control platform for high speed motion control.

The compiler is very cool. It interprets Simulink block schemes and translates it into instructions for this VHDL processor. So now a Control Engineer only has to worry about the control stuff he knows best. Then he just loads his Simulink file into the compiler and into the FPGA and the servo system connected to the FPGA 'just works'.

He even put his creation into action in front of us. He showed how he could damp a tuning fork by changing some settings in Simulink.

After Hettinga completed his thesis, he continued working to improve the system at Technolution. So it is like he is still studying but now he gets paid while doing so. Sounds great!

While enjoying a nice lunch I learned a lot about his project and Technolution. I think Technolution is a great company, since they are open to projects from students, and are willing to offer extensive guidance in executing it. 🍴



Sjors Hettinga answering questions about his work.

De tweede lustrumweek

De ETV is dit jaar op 26 maart 105 jaar oud geworden en dat moest natuurlijk groots gevierd worden. Nu, aan het eind van dit academisch jaar, werpen we met trots een terugblik op de afgelopen tien maanden.

Auteur: Jasper Boot

Al sinds het jaar 1906 komt de Electro-technische Vereniging op voor de belangen van de elektrostudenten. Nu, 105 jaar later, is de vereniging alleen maar gegroeid en daarbij is ook het aantal eerstejaarsstudenten nog eens gegroeid ten opzichte van een aantal jaren geleden. Met een groot aantal actieve leden die zich inzetten voor de vereniging ter beschikking brak ook dit academisch jaar het moment

aan om de verjaardag van de vereniging te vieren. Het 21e lustrum werd uitgebreid gevierd met een aantal pre-lustrumactiviteiten en maar liefst drie lustrumweken! Na al deze activiteiten kunnen we een beetje moe, maar voldoen terugkijken op een geslaagd lustrumjaar.

In september werd het 139e Bestuur geïnstalleerd en konden de zes kersverse

bestuursleden samen met de commissieleden van de Lustrumcommissie, de Galacommissie en de Stuntcommissie aan de slag met de voorbereidingen van het lustrum.

De Lustrumcommissie had de taak om een groot deel van de lustrumweken te vullen met activiteiten, maar zij besloot het daar niet bij te laten. Al voor de eerste



lustrumweek plaats zou vinden kwamen zij met het Lustrum voorproefje, alwaar er onder het genot van een stevige rum het thema van de stunt bekend werd gemaakt; MaXXImal.

Kort daarna kwam de commissie met de 21-spellenborrel. Verschillende spellen die ook maar een beetje met het getal 21 te maken hadden werden hierbij uit de kast getrokken en voor het spel Blokus is de commissie zelf nog aan het klussen gegaan om het spel uit hout te vervaardigen.

Menig student beleefde zijn of haar jeugd opnieuw bij de "Ken je deze nog?"-borrel. Een nostalgische quiz en vele themaliedjes van verschillende programma's en tekenfilmpjes zorgde voor heel wat "Oh ja!"-momentjes.

Op maandag 21 maart was het zo ver; de eerste lustrumweek ging van start. Die maandagavond was cabaretier Theo van Duuren uit het welbekende plaatsje Reek van de partij. Hij liet op deze Cabaretavond op een humoristische wijze zien hoe we keer op keer gefleest worden door het leven en waarom de rokende mensen de drijfveer zijn van de maatschappij.

De dag erna was het tijd voor het Groot Dictee der ETV. Matthijs Weskin en Jeroen Ouweneel, de hosts van deze avond, wisten een goed samengestelde tekst met een elektrotechnisch tintje te toetsen. Dhr. Alderliesten was die avond de persoon die zich de gelukkige winnaar van dit festijn mocht noemen en daarbij de pen ontvangst nam.

Tijdens de kroegentocht op woensdag werden de interessantste kroegen van Delft bezocht. Geen kroeg was te ver, te klein, of in sommige gevallen te excentriek voor de groep ETV'ers die genoot van de grote diversiteit aan drankjes.

Op donderdag verzamelden veel mensen van faculteit EWI zich in de voorhal. Zoals de meesten al wisten zou er taart uitgedeeld worden. Een grote taart werd dit jaar gesponsord door Technolution en zelfs het logo van dit bedrijf was om van te smullen.

Kort daarop zou het ETVoetbaltoernooi plaatsvinden op het sportcentrum. Het Bestuur heeft zich hard ingespannen, maar waar de bestuursleden – en de tegenstanders – al snel achter kwamen was dat een jacquet geen geweldig sportkos-

tuum is. Al glijdend over het voetbalveld werd het Bestuur tegen alle verwachtingen in keer op keer ingemaakt. De winnaars van deze dag waren de mensen van team ELKA1.

De donderdag werd afgemaakt met de Zusjesborrel in de /Pub; de uitgelezen kans om je zus voor te stellen aan al je ETVrienden. Een aantal mensen maakte dankbaar gebruik van deze gelegenheid en daarnaast waren bij deze borrel wat nietjes van de ETV aanwezig.

De volgende dag stond iedereen vroeg op om zich klaar te maken voor de ETV-Lustrumrally. Met opdrachten van verschillende moeilijkheidsgraden werden de teams door Nederland en een stukje van België gestuurd. Onderweg werden er nog opdrachtjes gedaan om extra puntjes te verdienen, maar de echte winnaars waren de teams De Bak en de Kirchoff Crashers.

Zaterdag 26 maart was een erg bijzondere dag voor de Vereeniging. Niet alleen mocht zij officieel haar 105e verjaardag vieren, maar werden er tevens twee Ereliden van Vereeniging geïnstalleerd. »



De gelukkige nieuwe ereleden em.prof. dr.ir. L.P. Ligthart en prof.ir. L. van der Sluis werden deze dag ceremonieel geïnstalleerd in de studieverzameling van faculteit EWI. Achteraf was er de gelegenheid om de nieuwe ereleden in de /Pub onder het genot van hapjes en drankjes te feliciteren. De aanwezigheid van andere ereleden en familieleden, vrienden en collega's van de twee heren hebben enorm bijgedragen aan het succes van de dag.

De eerste lustrumweek was afgelopen en dat gaf de gelegenheid om weer even rustig aan te doen. Twee kleine maandjes verder brak echter de tweede lustrumweek aan, die in de loop der tijd zodanig was aangevuld dat er nog een derde week aan vast zat.

De ETVeiling luidde het startschot en waren hier mochten verschillende mensen zich de trotse, nieuwe eigenaar van o.a. een gebruikte monitor, een oude computer, een stereo-installatie of zelfs een draaitafel noemen.

Het Bestuur stond even later om 16:00 uur buiten klaar voor de lustrumreceptie, alwaar de bestuursleden al gauwnamens de Electrotechnische Vereeniging felicita-

ties in ontvangst mochten nemen. Vanwege de harde wind werden er extra maatregelen getroffen en werd de traditionele, jonge jenever Vlek met behulp van dubbelzijdige tape op dienbladen geserveerd. Vanaf half zeven vertrok het Bestuur met e.t.s.v. Thor uit Eindhoven, E.T.S.V. Scintilla uit Enschede, Alcmaeon uit Utrecht en ETV-commissieleden richting Breintje Beer om er vervolgens nog een mooie avond van te maken onder het genot van vele spare ribs.

Op dinsdag presenteerde de Stuntcommissie van de ETV op de Markt in Delft de stunt waar zij door het jaar heen zo hard aan hadden gewerkt. Met twee reusachtige gamecontrollers een groot scherm en een geluidsinstallatie was iedereen van harte welkom om zijn of haar NES-talent op de proef te stellen. In groepen van twee personen kon er tegen elkaar gespeeld worden met een ouderwets voetbalspel of het welbekende spelletje Tetris. Ook bij het spelletje Mario bleek het een hele opgave te zijn om voorbij level 1 te komen, daar twee personen altijd iets anders in gedachte hebben.

Speciaal voor alle faculteitsmedewerkers van faculteit EWI had de ETV op woens-

dag het faculteitsdiner georganiseerd. Het diner bestond uit een salade, verschillende pasta's en onbeperkte drankjes en daar werd dan ook optimaal van genoten.

De volgende dag kwamen erg veel mensen af op de bowlactiviteit. Om een beetje competitie in het spel te krijgen werd er besloten om een bowltoernooi van te maken. Niet iedereen bleek veel talent te hebben voor deze sport, maar winnaars waren er ook zeker aanwezig. Helaas is het i.v.m. de fluctuerende regels niet echt duidelijk wie die winnaars uiteindelijk waren.

De barbecue die daar kort op volgde was een goed voorbeeld van een geslaagde barbecue. Met een grote groep deelnemers, gratis drankjes en muziek op de achtergrond leek al dat overheerlijke vlees nog lekkerder te smaken.

Toch moest er een eind komen aan de barbecue, want de daaropvolgende karaokeavond was ook een evenement dat je niet mocht missen. Hoewel niet bij iedereen de kwaliteiten in het muzikale vlak liggen klonken sommige liedjes nog best goed... aan het begin van de avond. Uiteindelijk



was het een onvergetelijke dag – ook voor de mensen die niet van zingen houden.

Om het een beetje rustig aan te doen was de enige activiteit van de vrijdag de uit-braklunch. Eenieder die al dan niet brak was kon hier een lekker bodempje leggen voor de rest van de dag.

De Galacommissie heeft zich het hele jaar ingezet om een geweldig Lustrumgala te organiseren en op zaterdag 21 mei brak daar dan het moment aan. De avond begon met een heerlijk Galadiner en een paar uurtjes later ging het Lustrumgala van start. In de loop van dit academisch jaar was de Als je maar kaal-band in het leven geroepen, die voor het overgrote deel bestaat uit ETV-leden. Tijdens het gala traden ze op en zetten daar een geweldige show neer. De avond werd daarna voorzien van muziek door Juicy Rocks en in de laatste uurtjes werden heerlijke hitjes gedraaid door de DJ. De combinatie van de leuke muziek, mooie locatie en feestelijke stemming was een formule die garant stond voor de buitengewoon fantastische avond die de gelukkige aanwezigen mee hebben mogen maken.

Studenten van verschillende faculteiten kwamen op maandag 23 mei op faculteit EWI af. In de fietsenkelder waren er obstakels neergezet en na het aanzwengelen van de rookmachine mochten de eerste twee groepen de ruimte binnen om te larsergamen. Vele strategieën werden uitgeprobeerd, zoals het zogenaamde ‘campen’ en het in de rug belagen van de tegenstanders. Een methode die nog aardig bleek te werken was de ‘Rambomethode’, waarbij iemand als een gek naar de tegenpartij rende om anderen van hun virtuele levens te beroven.

Voor nog een andere commissie brak op dinsdag het moment aan om iets moois neer te zetten. Het betreft hier natuurlijk het Symposium, georganiseerd door de Symposiumcommissie. Het Symposium stond dit jaar helemaal in het thema van veiligheid in het verkeer, of beter “Safety in Transport”. De commissie heeft het gepresteerd om, met dank aan de sprekers en de dagvoorzitter, een zeer interessante dag samen te stellen.

Voor de ETV’ers die de traditionele, Delftsche Vlek zo enorm waarderen is er speciaal een excursie georganiseerd. De excursie ging naar de distilleerderij Boomsma,

waar Vlek tegenwoordig vandaan komt. De excursie droeg daarom ook de naam “Vlekscursie”. Met de Kwibus werd er naar Leeuwarden gereden en aldaar kregen de deelnemers een rondleiding door de distilleerderij. Vervolgens begaf de groep zich naar het centrum van Leeuwarden. Daar kreeg eenieder verschillende jeneverstijlen te proeven en wat glaasjes later vertrok de groep met de Kwibus weer richting Delft.

De laatste lustrumactiviteit van het jaar was de jaarboekuitreiking van de Vereniging. Dit jaar heeft de jaarboekcommissie zich hard ingezet om niet alleen een mooi boek te maken, maar ook om dit in een korter tijdsbestek te bereiken. Zo is de “vertraging” die er door de jaren heen is opgelopen drastisch ingekort, zonder dat het ten koste ging van de kwaliteit van het boek. Al met al was het een mooie afsluiter van het 21e lustrum der Electro-technische Vereniging. 📖

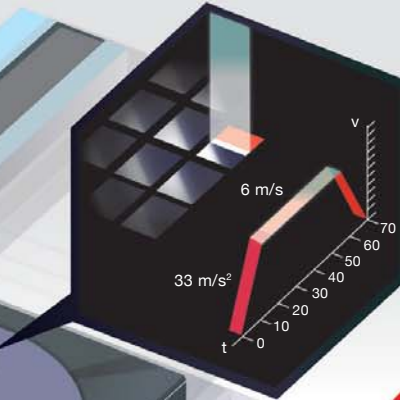


Tomorrow, we will be able to make chips faster. Today, you can tell us how.

The race to increase the number of IC switches per square centimeter is not the only race that is underway in the chip world. Manufacturers are also aiming to accelerate chip production. But how do you boost a machine that needs to be accurate to the nanometer?

ASML is now working on chip lithography systems in which a disk of photo-sensitive silicium (the wafer) is illuminated at high speed.

Deep UV-light
(193 nm)



Chips with 45 nm details can only be made if, between acceleration and deceleration, you illuminate the wafer precisely to the nanometer. One thousand sensors and 800 actuators control and, consequently, illuminate 180 wafers an hour. How much software and how many processes are required to do this? And how do you manage the necessary IT architecture?

The wafer lies on the so-called wafer stage, which weighs more than 35 kilos. It is passed back and forth under the light, with an extreme acceleration and deceleration of 33 m/s².

33 m/s²

Accelerating by 33 m/s² poses a challenge in itself. Which motors do you choose? Where do you find amplifiers with 100kW capacity, 120 dB SNR and 10 kHz BW? And that is just the beginning – because the heat itself distorts the accuracy of your system as well...

For engineers who think ahead

Profile: Worldwide market leader in chip lithography systems | Market share: 65% | R&D-budget: EUR 500 million | Opportunities for: Physicists, Chemists, Software Engineers, Electrotechnicians, Mechatronics and mechanical engineers | Discover: ASML.com/careers



ASML

In the right direction with GPS

Virtually every smartphone has GPS these days and in-car navigation systems have become indispensable. In the space of ten years, satellite positioning has become a mass product and work is already well underway on a new generation of GPS.

Author: Technolution B.V.

Initial development

We all use the term GPS as a collective name for satellite navigation and positioning. However, GPS is actually a brand name for the American system. There are also systems from other continents such as GLONASS (Russia) and Galileo (Europe). The general term is Global Navigation Satellite System (GNSS). The development of the United States' GPS began in 1967 as a military application. Eleven years later, the first satellite was launched. The 1990 Gulf War was the first conflict in which GPS was used on a large scale. Only in 1995 did GPS become officially available for civilian navigation. However, the army did not release the highest degree of accuracy. They degraded the civilian signal, restricting its accuracy to a hundred metres. In order to avoid dependence on the American GPS, Europe decided to build its own system: Galileo. America watched these developments closely. The frequency bands chosen for Galileo were so close to those of GPS that the US would not be able to interfere with Galileo without paying a price: if they did, they would degrade their own GPS.

Eventually, Europe chose a different frequency band. And the US switched off the jamming signal in 2000 in order to ward off competition from Galileo. Accuracy went from a hundred metres to fifteen metres, making GPS attractive for civilian navigation. Moreover, at that point PDAs were just powerful enough to run navigation software and mapping material was becoming available for PDAs. This conjunction of factors made a personal navigation device feasible. And so TomTom was born.

As at 2010, the future of Galileo is still uncertain. Recent developments have been more political than technical. Even so, Galileo has already been very important in keeping the Americans on their toes. They keep on dreaming up new things to stay ahead of Galileo. If Galileo never becomes a reality, that need not be a problem, technically-speaking. Strategically it would be risky: Europe would then have no system of its own and would be permanently dependent on other powers such as Russia, China, India and, of course, the USA.

How does satellite navigation work?

A GNSS satellite is not a spy satellite that continuously follows you. It is exactly the other way around; the user tracks the satellites in order to calculate his position. Positioning using satellites works according to a geometric principle; if you know three fixed points in space and you know your distances to those three points, you can calculate where you are. A GNSS receiver can calculate the position of the satellite and its distance to the satellite from a satellite signal. If it knows the positions of three satellites, it can calculate its own position on earth.

A satellite is constantly sending out messages with information about its orbit. A satellite's orbit is roughly elliptical, with several parameters being of interest; the zero point of the orbit (position at time point zero), its velocity and the dimensions of its orbit (which is an ellipse, so the relevant parameters are the short axis and the long axis; a and b). Because the orbit information is not exact, it is corrected every few hours by »

a ground station. This involves the ground station sending the satellite a new set of parameters to transmit.

The receiver, for example the smartphone or an in-car application, does two things with the satellite signal. It processes the information about the orbit in order to calculate the satellite's position and it very accurately measures the arrival time of the signal. The report states the time that it was sent. The difference between the two times tells the receiver how long the signal has taken to travel; it can use this information to calculate its distance to the satellite.

In order to determine distance in this way, accurate time measurement is essential. Every satellite is therefore equipped with an atomic clock. The clock in a simple GNSS receiver is not accurate enough for this purpose. You therefore need a fourth satellite for accurate time measurement. The clock in the receiver is synchronised with the atomic clocks of the four satellites. That generates four mathematical equations with four unknowns: time + XYZ coordinates, which can be resolved mathematically by the GNSS receiver.

Satellites for navigation do not hang in geostationary orbit. They fly over the earth, each one in its own orbit. So the receiver sees different satellites coming by all the time. The receiver needs to be able to be receiving at least four satellites in order to calculate a position. So the system needs to plan the orbits of the satellites in such a way that there are always at least four of them well above the horizon everywhere in the world.

Ever-improving signal

Although, ten years on, GNSS systems are now completely established, development goes on. The accuracy of fifteen metres can already be increased by a factor of five with a differential GNSS. This makes use of a (purchased) signal from a ground station alongside satellite signals. However, such devices are more expensive and require a subscription to receive the extra signals. Civilian applications currently only use one frequency band, around 1500 MHz. In the future, a lower frequency band will be added (the L5 band), which will allow transmission at greater power. This will carry extra signals, for greater accuracy and other services (at a charge). The basic signal will remain free to use.

More data, more signals and more frequencies will make GNSS systems a lot more accurate. This will enable us to navigate better. And new applications are coming into view, such as indoor reception. However, we will have to wait until there are enough satellites which offer services on the L5 band. Changes to the GNSS system take time. You cannot simply bring down

the satellites for modifications. Improvements are always introduced in new satellites. Satellites have a lifespan of ten to fifteen years. They stay in use until they fail; only then is a new one launched and the replacement satellites are ready to go. Only when that stock is used up will a new generation of satellites be built. This means that rapid modification to the system is impossible. Around 2018, the current American GPS system will have been entirely replaced by modern satellites. The expectation is that the Galileo system will be fully operational by then.

Own R&D

Most companies that want to build GNSS functionality into their applications buy a standard GPS module for the purpose. There are only a few manufacturers in the world that make these positioning chips. These are chips with limited functionality which the user cannot modify. For example, most standard GPS modules transmit their position once every second. But if you are using position for regulation and control purposes, you may want to know your position ten or a hundred times per second. That capability is not sold as standard, except in very expensive systems.

Technolution wants to have this flexibility, which is why it has built its own GNSS receiver. Not with a view to marketing it as such but to acquire knowledge and experience and to be able to try out the extra possibilities of the new generation of satellites and combine the signals from the different GNSS systems. Our own design receives the basic signals on the L1, L2 and L5 bands used in GLONASS, GPS, EGNOS and Galileo. The receiver can accept several frequencies at once. The signals are digitised and then go to an FPGA with a built-in GNSS receiver.





As a developer, this means you can do what you want: calculate where you are, make measurements and experiment. At any point in the process, you can draw off signals and see what happens. The optimisations you want for a particular application, for example higher reliability, accuracy or speed, you can make yourself. You can combine GNSS with sensors. In this design, we can do that as soon as the signals come in and not, as with the ready-made modules, only when the receiver transmits its position. For example, we are going to use this receiver to investigate the availability of the Wide Area Augmentation System (WAAS) signal of the EGNOS satellite.

In other words, our GNSS receiver creates opportunities for realising new innovations with GNSS. For example, it is crucial to current applications such as intelligent speed modification, helping to minimise changes to the intended steady speed and avoid incorrect interventions. In addition, the improved reception in the L5 band makes possible navigation within buildings, more accurate positioning on the road for road pricing and better navigational support for the driver.

Projections: WGS84

In order to accurately determine your position with satellites, you also need a good mapping system. No problem, you might think – after all, maps have been made for centuries. But map-makers were using different systems side by side. This is also linked to how maps used to be made: by means of land surveying, with everyone using their own local mapping systems with their own points of beginning. Land maps used one system and nautical charts another. GPS requires a worldwide standard for map projections (A cartographic projection is a way of translating a physical location to a point on a map.). This was only established in 1984 with WGS84 (World Geodetic System 1984). Only by using WGS84 can you represent your position unambiguously anywhere in the world with a single mapping system. 📍

“Ik moet over de grenzen van mijn eigen vakgebied heen kunnen kijken.”

System Designer Electronics

**>Frank's
passie**

voor techniek

Lees meer over Frank's passie voor techniek op

www.technolution.eu/collega

Technolution



Technolution is een projectbureau, specialist in het gecombineerd ontwikkelen van elektronica, programmeerbare logica en software voor embedded en technische informatiesystemen.

>the right development



日本へようこそ! Welcome to Japan!

Experiences from my internship in Japan

Ever sat on a pre-heated toilet seat? Ever ate rice three times a day for three months in a row? Ever used a train that departs on time to the second? Ever seen a bunch of men in suits sleeping on the street drowning in their own vomit? Ever had to duck for every single door to prevent bumping your head? Welcome to some of the fascinating aspects of living in Japan!

Author: Stephan Groot, BSc

Last September I moved from the familiar surroundings of Delft and the Delft University of Technology (DUT) to Sendai and the Tohoku University in Japan. In this report I will give you an idea of the unique experience studying abroad in a totally different culture brings along. To do so I will guide you through all the stages of my internship: starting with the preparation, I will touch upon the project itself, illustrate some practical issues and address how it felt to live in Japan.

Fixing an internship abroad

Starting the second year of my master program Telecommunications I was up to something different. Experiences from other students combined with my own interests drove me to pursue an internship abroad. For myself I had determined two demands for the country I was going to visit. First, I wanted a country with a totally different culture than ours. This means that in an early stage the larger part of Europe and North-America was excluded. The second goal I set was to find out for myself whether radar research was really my thing.

With this in mind I consulted a couple of teachers from the faculty. Almost immediately professor Yarovoy from the radar group indicated that he had contacts in Japan. Prof. Yarovoy laid the first contact between me and Sato sensei, the Japanese professor which I ultimately visited for three months. From that moment on things went very rapidly. Sato sensei indicated that he would be very happy to work with me, and his secretary was kind enough to arrange a lot of practical issues, like housing and funding from the Japanese university. From the DUT I could also get some funding via Jan de Vries, the internship coordinator. The only thing left was to buy a plane ticket, and then a couple of months before September I only had to wait for the departure date!

Working from 9 to 9

My project focused on data processing for radar applications, in particular for ground penetrating radar. An on-going project at the Sato lab was the detection of tree roots and the estimation of the size of those roots. My task was to develop a chain



of data processing steps such that from radar measurements the size of tree roots could be estimated accurately. Over the past years a lot of effort has been put into lowering the amount of carbon dioxide (CO₂) in the atmosphere. Although many efforts are merely aiming to lower the amount of CO₂ that is put into the atmosphere, some methods actually lower the amount already in. One very promising technique is carbon sequestration by means of afforestation and reforestation, in plain English: by (re-)planting trees. In carbon sequestration the CO₂ of the atmosphere is stored elsewhere. By using afforestation and reforestation a very natural way of storing the CO₂ into the bodies of the trees is realized. Most of the carbon is actually stored in the roots of the trees. Therefore knowing the size of the tree roots give information about how well the sequestration process is executed.

Traditional methods for the estimation of tree root biomass almost all include actually harvesting (some part of the) tree roots. Although this method is obviously highly accurate, these traditional methods also have major disadvantages. Inherent to harvesting the tree roots are the destructive and labor-intensive nature of these methods. In this case Ground Penetrating Radar (GPR) comes into play. GPR provides a non-destructive and fairly easy to use method to detect the tree roots. How to estimate the sizes of the tree roots from the GPR data is on the other hand less trivial, and was the goal of my project.

Besides the actual contents of the project, studying abroad also brings you into contact with the work (or study) attitude of another culture. In my opinion the differences between the work attitude of Japanese cannot be more different than the Dutch. I'd like to mention two of the most visible differences. At the same time these were the ones that really tested my ability to adapt.

One of the difference that struck me almost immediately was the amount of time Japanese spent at their work. A typical Japanese work day starts between 8 AM and 9 AM. So far, so good! But when I after 9 hours of fanatically Matlabbing shut down my PC, I was one of the first people to leave. Some inquiries confirmed my suspicions that it was very common to stay in the lab until 9 PM or even much later. Working in the weekends was also rather a rule, than an exception for most of the students. One student even was known to be in the lab from 5 AM until 10 PM every single day of the week. For me as a Dutch guy, more specifically a Dutch student, this was insane. Luckily, I could comfort myself with the thought that the for Japanese standards little hours I spent at the lab were at least efficiently spent. This in contrast to the native students, who although being most of the time at the lab, did not spent



all this time working. Common ways of spending their time were of course normal things like using the Japanese variant of nu.nl and Facebook, but also playing computer games, watching movies or sleeping on their keyboards was quite normal.

A second difference between studying in Japan and in The Netherlands is the hierarchical structure. For the local students a suggestion (or command) of the sensei was to be taken without a doubt. The professor was also the single entity on all the decision making. For me, this was quite hard, since in The Netherlands we are basically used to the opposite situation, at least to make decision based on discussion. I also noticed within the group of students a lot of differences. An extreme example is that the suggestions of a Japanese 3rd year PhD student were taken much more seriously than for example the same comments from a first year international PhD student.

Practical stuff

Moving your life, although only temporarily, to another country of course introduces a lot of practical issues that have to be taken care of. One of the important things being your housing in the country of your visit. During my time in Japan I stayed in a so called Guest House. It basically meant that I had a room »



for myself, and that things like the bathroom and the kitchen were shared. The room was - to put it delicately - furnished Japanese-style. This sounds fancy, but in practice this meant that the only furniture I had was a futon, which I consider to be another word for thin mattress, which could be rolled out on the tatami mat floor for a good night rest. One of the main advantages of staying in the Guest House was that I immediately came into contact with other people than my lab mates. My flatmates were both from Japanese origin, as other foreign people like me, coming from countries as Australia, France, Sweden and even another Dutch guy.

The biggest obstacle for living in Japan for a longer time is the language. Before I left I quite underestimated this aspect, simply because we are used to the fact that we can manage almost everywhere with English. In Japan this was not the case, even the English skills of my lab mates were questionable, to put it mildly. Luckily, there were some other international students, with whom I could communicate normally, but it certainly improved my skills to communicate with as little words as possible.

Additional advantage was that I had to put some effort in learning Japanese. Learning to write and read Japanese is almost impossible; even the Japanese students take until the end of the secondary school to master a certain level of basic reading and writing. This mainly comes from learning the kanji, the symbolic characters that represents words. Being able to read the news paper requires knowledge of about 2000 kanji. However, Japanese also knows two other writings systems, more close to

our alphabet. Both of these alphabets represent the same finite number of vowel-consonant combinations, although - to make it easy - each alphabet uses other symbols to represent these sounds. The first, hiragana, is used for conjugating the verbs and for particles, which are little words that give structure to the Japanese language. The second, katakana, is used for words originated from other languages and is for example often used on menus. Hiragana and katakana were quite easy to learn and especially katakana was quite useful in daily life.

In contrast to writing and speaking Japanese, Japanese is supposed to one of the easiest Asian languages to master speaking and listening. Although for me the sounds of Japanese language were quite hard to distinguish from each other, after three months, I had reached a basic level of Japanese speaking, in which I could manage myself at the supermarket, in restaurants, taxi's et cetera.

Understanding the Japanese

At some point, after spending three months almost entirely surrounded with Japanese people, all the differences that seemed immense at the start of my internship, seemed to have vanished. However, there are some very typical aspects of Japanese everyday life, that I consider to be deeply rooted in their culture. Let's mention some of these interesting aspects.

One of the things I noticed after a few weeks in Japan is that belonging to some kind of a group is rather important in Japan. Every single individual belongs to at least one group, in which a lot of time is spent. Most of the time this group consists of your

co-workers, of in the case of my internship, of your fellow students. Coming from The Netherlands, where of course we also do things with friends, but where it's also considered to be very important to being able to do things on your own, this seemed a little bit forced at first. Japanese eat, work, sport and do fun things within the same group. As a matter of fact the group of co-workers is often considered being more important than their own family. It is quite common for Japanese men to close the week of hard work with going to some kind of eating and drinking event with their co-workers. Besides that it is totally socially accepted to get yourself completely wasted, misbehave on the streets and even to sleep it off in public places.

Where in The Netherlands you can count on being topic of some good and correcting jokes the day after, in Japan this kind of behavior is to be discussed never again.

Second, maybe more well known aspect, is the discipline of the Japanese. Every single queue you encounter is perfectly straight, the delay of metros and trains is indicated in seconds, and what still strikes me as impossible, all the streets are perfectly tidy without the presence of a single bin on the streets. In making appointments with Japanese people I figured out quite fast, that when they agree on a time, they mean come fifteen minutes

earlier. Quite confusing at first, but yet again, when you are used to these things, after some time you stop noticing it.

Not typical for Japanese culture, but still something that I encountered everyday was the very little amount of minorities in Japan, resulting in a lot of attention for the few foreigners on the street. Of course you strike out, coming from Europe. Not looking Asian and hovering with your head over the crowd draws a certain attention to you. Children turning their head in impossible angles to cast a glimpse of you, or groups of teenage girls passing you with highly pitched giggling were quite common. Fun at first, annoying for a while, but when becoming part of your everyday life, also these kind of things go by unnoticed.

Final remarks

I've asked myself many times after my return: was it all worth it? Would I do it again? And every single time I answer this question with a convinced yes. Spending three months in a country and a culture so different than ours, was an experience that taught me many valuable things. To people who are thinking themselves of pursuing an internship or doing some part of their study abroad I can only say: get out there, you won't regret it! 🍷



Joost may know it

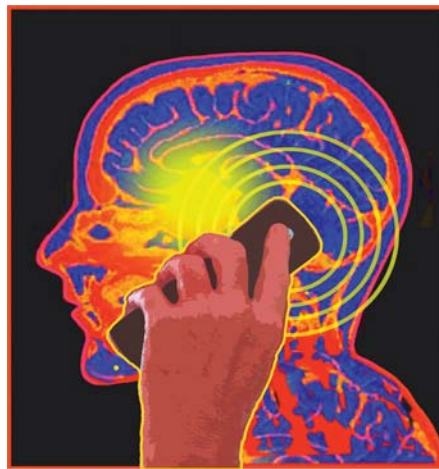
Dude! Where's my car? We often ask this sort of question (especially after a party) and answer it by pressing a button on a small device that is hanging on our key chains. How does this device work? And how secure is it? Can I open other cars with it or can other people open my car with their key?

Author: Dr. Ir. Rob Remis

Nowadays you usually cannot, of course, but the situation was quite different around the 1950s. Remote entry keys for cars did not exist back then, but wireless garage door openers were already around. These openers were actually very simple transmitters that transmitted a single signal. A garage door opened or closed after receiving the signal. That's it. Pretty simple. Problems appeared, however, when wireless garage door openers became more popular. You could drive down the street and open all the garage doors in your neighborhood simply by pushing the transmit button all the time. Great when you are a teenager, but not very secure as you can imagine.

The remote entry keys of today operate in a much safer way. A key typically consists of a transmitter and a controller chip. The controller chip holds a so-called hopping or rolling code that is used for security. By pushing the button on your key, the code gets transmitted along with a code that tells your car what to do (lock the doors, for example). The receiver in your car also has a controller chip. It holds the current hopping code and the car performs the requested task if this code agrees with the code it received from the transmitter.

The hopping codes on the transmitting and receiving side are both generated by pseudo-random number generators. When the transmitter sends out the code



it uses the generator to select a new hopping code and after receiving the code, the controller chip on the receiver side generates a new hopping code as well. The transmitter and receiver remain synchronized, since both chips use the same pseudo-random number generator.

Now what if you are way out of reach and you keep pushing the transmitter button? The transmitter and receiver are then clearly no longer synchronized. To handle this problem, the receiver is programmed to accept the next 256 codes in the pseudo-random number sequence as well. Your transmitter-receiver system now gets desynchronized after (accidentally?) pushing the button 257 times or more. If this happens, then you better first ask yourself: How? What? When? Then re-synchronize your car.

Finally, there are some claims (mainly on the internet) that reception is improved by holding your key close to your head, while pressing the button. Since I am unaware of any controlled experiments verifying or disproving these claims, my suggestion is that you try it yourself. Put your key close to your head, your neck, your arms, your knees, your feet, and do all this in the open air, your garage, or at the parking lot. See what comes out, but be careful. If you experiment and do not receive anything more than 256 times in a row, you have some resynchronization to do. 📶

Build Your Engineering Career @ NI



Join the National Instruments Engineering Leadership Program (ELP) and engineer the tools of scientific discovery!

Wij zijn op zoek naar talentvolle engineers die klaar zijn voor een uitdaging; jong talent dat klant- en oplossingsgericht werkt en gaat voor resultaat. Het Engineering Leadership Program (ELP) van National Instruments biedt een 18 maanden durende opleidingsprogramma. Naast deze hoogwaardige opleiding bieden wij een aantrekkelijk salaris en een uitdagende baan bij één van de beste werkgevers wereldwijd.

Ben jij die talentvolle engineer die de uitdaging aan wil gaan? Neem dan contact met ons op via **jobs.netherlands@ni.com** of bel **0348-433466**

Worldclass Training Program

Attractive Compensation

Great Company Culture

Career Opportunities

>> Voor informatie over het ELP programma, bezoek **netherlands.ni.com/elp**

0348 - 433 466

The right person for the job, not just the engineer.

“SUPAIR did an excellent job for me, so it is my pleasure to help you build a case”, Jasmina replied when we asked her for input on this article. She now works at the cutting edge of innovation at Riscure, as a security analyst. During her first talk at our office, Jasmina told us she was bored with her post-doc and wasn’t too excited about finishing it. She told us she wanted to get hands on with state of the art technology. So we got to work.

Author: Supair

Jasmina’s case is an excellent example of what we come across at SUPAIR on a daily basis. To us, clearly, Jasmina’s other skills (besides being incredibly smart and a wizard with theory) would be of great value to a niche, hands-on, state of the art company. Oddly, Jasmina had applied for a job as researcher at TNO when she came in. We talked, listened to her, and figured that Riscure would be an excellent place for her. It proved to be bulls-eye for Jasmina:

“I know all the people and this is where the real engineering work is done. I especially like the diversity of the work that

I have to do for Riscure. It is a small company with excellent engineers from different fields and I enjoy the atmosphere, the people, the work and the topic itself. My background is in electrical engineering, but I worked a lot in mathematics during my PhD. But sometimes background knowledge is simply not enough. At Riscure, we are very dependent on each other, since it is quite impossible to have all the knowledge and skills needed for the projects. We have to be smarter than engineers that made the product we are evaluating. So, I would say that for instance social skills are always important.”

At SUPAIR we aim to find jobs for any young engineer that truly combines the skills, ambitions and wishes that he or she might have. We commit to our personal approach: we have learned over the past 14 years that a personal touch enables us to find jobs that are much more suited to an individual profile. To us, education, extra-curricular activities and jobs should always be seen in relation to personal characteristics and skills. What matters is who you are, where you stand in life. Eventually, this will lead to the most interesting and most valuable results, both for you and your employer.

Ali, mediated by SUPAIR for a job as a patent engineer at Epyon, explains:

“My education is useful at Epyon in the sense that I have good analytic skills and I know how to distinguish main from side issues. These are typical things you learn very well at Electrical Engineering. But more importantly, as a patent engineer you need to be very interested in other fields of work. You need to master other fields very fast and you need to understand a new invention throughout in no time. Being a patent engineer is similar to the work of a journalist: you need to be able to ask



the right questions - a skill you won't learn at Electrical Engineering!"

Obviously, Ali's educational background is important for a company such as Epyon, but his side-jobs and electives in patenting, and his natural interest to dig deep clearly got him the job. This statement doesn't just hold for Ali. Equally, we found a job as patent engineer for an industrial designer a while ago at one of our clients. Similarly, he has a (natural) interest in getting to the bottom of things and is highly skilled in making new information his own. However, he works at Vriesendorp & Gaade, since they are involved with patents where his expertise in design is particularly useful. Ali would not have fitted there, even though these are similar jobs.

As you probably understand by now, SUPAIR gets to the bottom of you. And we're much appreciated for that. You receive honest and constructive feedback from us, and clients keep

SUPAIR

banen voor jonge academici

coming back to us because we are able to deliver the right man or women for the job, not just the engineer. Are you about to look for a job, or have you started doing so already? Do you have questions for us after reading this article, or are you interested about the options we have for you? Please register at supair.tudelft.nl and we will contact you for an intake at our office at the TU Delft! ➡



Cooking with...

Ryoichi Ishihara

Mixed Sushi with Smoked Mackerel

I assume all of you know sushi, but the most of you has probably never heard of chirashi-sushi (mixed sushi or scattered sushi, I call it mixed sushi hereafter). In fact, making sushi doesn't get any easier than the mixed-sushi. There is nothing to roll or shape with your hands. So this is a great recipe for beginners. There are many recipes of the mixed sushi, but we found a recipe with a Dutch local ingredient: the smoked mackerel (Gerookte Makreel). So it is a great collaboration between Japan and the Netherlands. Let's try it!

Ingredients for 4 Serves

- Sushi rice: 2 cups (1 cup = 0.18l)
- A piece of Smoked Mackerel (about 250g)
- Cucumber: 1/2 piece
- Sweet pickled ginger: 30g (*You could buy it at a big supermarket. If not, slices of ginger will be fine as well.*)
- Toasted white sesame seeds

6. Arrange the toasted white sesame on top.

Recipe

1. Boil the sushi rice
 - Put the rice in a large bowl and wash it with cold water
 - Repeat washing until the water becomes almost clear
 - Put the rice with water in a rice cooker
 - Let the rice soak in the water at least 30 minutes
 - Start the cooker. When rice is cooked, let it steam for about 15 minutes.
2. Break up the fish meat into pieces
3. Prepare salted and squeezed cucumber
 - Slice the cucumber
 - Remove seeds of the cucumber
 - Salt the slices of cucumber
 - Soften them by squeezing
 - Remove the water squeezed from the cucumber very well
4. Mix the sushi rice with 2 and 3
5. Divide the rice between 4 wooden or ceramic bowls/dishes.



Notes

If you want, you could also prepare "vinegared rice" instead as follows: Mix 3 tablespoon white wine vinegar, 1 tablespoon sugar, and 1/2 teaspoon salt in a sauce pan. Put the pan on low heat and heat until the sugar dissolves. Cool the vinegar mixture. Spread the hot steamed rice into a large plate or a large bowl. Please use a non-metallic bowl to prevent any interaction with rice vinegar. It's best to use a wooden bowl called sushi-oke. Sprinkle the vinegar mixture over the rice and fold the rice by shamoji (rice spatula) quickly. Be careful not to smash the rice. To cool and remove the moisture of the rice well, use a fan as you mix sushi rice. It's best to use sushi rice right away.

You could arrange also nori stripes, a small amount of wasabi, scrambled egg, etc.



About Ryoichi Ishihara, PhD.

Ryoichi Ishihara was born in 1967 in Yamanashi in Japan. He studied Physical Electronics and received the Bachelor, MSc, and PhD. degrees from Tokyo Institute of Technology, Japan in 1991, 1993, and 1996, respectively. Since 1996, he has moved to TU Delft (Laboratory of Electronic Components, Technology and Material/Department of Microelectronics), where he is currently an Associate Professor. His research has been focusing on thin-film transistors (TFTs), more specifically on single-grain Si TFTs with a novel laser crystallization process on a plastic substrate, and carbon nano-tubes (CNTs) for interconnection and carbon electronics. He is a co-author of more than 60 journal papers and 90 international conference papers and a co-inventor of ten granted patent families. He is in charge of a number of projects related to the thin film transistor technologies for 3D-ICs and flexible electronics. One of the projects is the super e-paper project which is financially supported by STW with industries.

Itadaki-masu
Enjoy your meal!



Partners in Power



Transformatoren



www.sgb-smit.com



SMIT TRANSFORMATOREN B.V.

Groenestraat 336
6531 JC Nijmegen

P.O. Box 9107
6500 HJ Nijmegen

T. 024 / 356 8911

F. 024 / 354 1598

E. info@smit-trafo.nl

An advanced beard trimmer

User-centric product design by Philips Consumer Lifestyle

Author: Pieter-Jelle Buijs

The first thing to ascertain before you design anything is exactly why you are designing it. When it comes to producing new consumer products, that means identifying real user needs. It may not sound like an engineering problem, but it's fundamental to the design process, because it is only when you understand exactly why someone will buy a product and how they will use it, that you begin to understand both the form and function you need to achieve when you design it. If it's going to give you an edge over the competition rather than being a 'me-too' product, it needs to incorporate functionality that shows a unique understanding of end users. In the case of a new beard trimmer, recently designed at Philips Consumer Lifestyle's Innovation Site in Drachten (The Netherlands) to extend Philips' personal grooming product range, that consumer need can be summed up in two words - 'perfect stubble'.

Our consumer research indicated that an increasing number of men want to have well-designed stubble for the weekend, particularly when they go out on a Saturday night. Depending on how fast their facial hair grows, they will typically stop shaving on a Thursday or Friday morning in order to grow a stubble for the weekend.

The problem with most beard trimmers on the market is that they use a set of interchangeable combs that only allow users to adjust the trim length in steps of around 1 mm. The unique consumer need that we identified was therefore a trimmer that provided greater control of the trim length. Consumer testing in our user-experience laboratory at Philips Consumer Lifestyle in Drachten, suggested that 0.5 mm trim length adjustment was required. Another driver that will promote sales of a stubble trimmer is that the trimmer should be washable 'under the tap'.

From interchangeable to adjustable

Because 0.5 mm trim length adjustment precluded the use of interchangeable combs (too many would have been needed to cover the total trim length range in 0.5 mm steps), it was decided to investigate the feasibility of an adjustable comb that could be operated by a control on the body of the trimmer. Direct linear actuation of this comb via a click-stop slide control was quickly discounted because of the need to provide click-stops 0.5 mm apart that could be easily set by the user. Pro-

viding an 'at a glance' indication of the set trim length would also have been impossible using this technique. An adjustment mechanism with a long scale length that could be geared down to sub-millimetre linear movement of the comb was therefore required. Electrical actuation of the comb was deemed too complicated and too expensive a solution.

The mechanism chosen to solve the problem was based on a leadscrew design that converts the movement of a rotating 'zoom wheel' into linear movement of the comb. However, in order to accommodate this zoom wheel where it could be easily operated by the user, it was necessary to wrap it around the trimmer's battery/motor drive train assembly. In other words, this assembly would need to become the hub on which the zoom wheel rotates. Unfortunately, none of the drive train assemblies for our existing trimmers had been designed with this zoom wheel functionality in mind, so one of the first tasks was to design a new assembly. Because our drive train manu-



facturing is outsourced, detailed design of this new assembly was performed in conjunction with the manufacturer, based on a specification that indicated parameters such as battery capacity, motor torque, diameter and hermetic sealing (required to achieve washability 'under the tap'). Hermetic sealing was achieved using a special seal design, patented by Philips, that provides clip-together simplicity for the battery pack while also coping with the thermal and pressure stresses associated with battery charging and discharging. With the battery/motor drive train assembly inserted through the middle of the zoom wheel, it was then possible to transfer rotary movement of the zoom wheel to the comb via a sliding bar that runs in a groove in the trimmer's internal housing. Click-stop positioning of the comb is provided by a conventional spring and ballbearing detent mechanism that mates with indentations in the rim of the zoom wheel. The large diameter of the zoom wheel provides a scale length on which the set trim length is easily visible.

Maintaining brand image

With the mechanical and electro-mechanical design of the trimmer complete, the final step was to design a body shell that would provide the trimmer with the right look, feel and brand image. The objective was to give the new trimmer a similar aesthetic appearance to Philips' high-end SensoTouch shaver, which has metallic foils inlaid into its plastic body shell molding to give it distinctive flashes. However, on a lower cost product such as the trimmer, these foil techniques were too expensive. A technique therefore needed to be found that gave a similar appearance at significantly lower production cost. We therefore worked with our plastic injection molding supplier to come up with a double-shot injection molding technique that would provide contour lines with a depth effect similar to that on the SensoTouch shaver. This involved producing a test mold to test whether we could produce consistent results within the constraints of the injection molding process window. Ultimately the technique proved very effective and has now become a formula that we can apply to future products. »

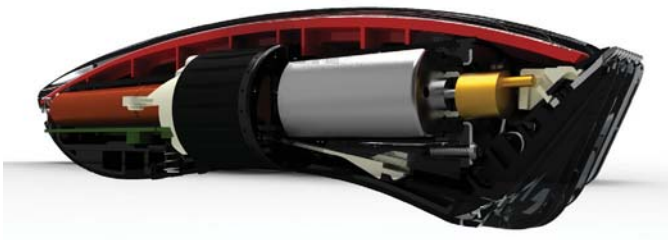


Rapid design innovation

It is worth pointing out that the entire design cycle, from initial idea to production ramp up of the finished product, was completed in little more than a year and a half by a closely knit multidisciplinary team of around five design engineers working at our Drachten Innovation Site. This is in stark contrast to the large in-house design teams that develop Philips' high-end products such as its SensoTouch and Arcitec shavers, and was achieved by leveraging the specific expertise of different component and assembly suppliers. By allowing the team to focus their creativity on making sure that the product concept meets a real user need and on architectural-level and system-level design aspects, this way of working keeps the team close to the targeted end-user experience. Design decisions that impair functionality or impact cost are therefore less likely to occur.

After producing a comprehensive set of design requirements, much of the detailed design is then performed by the component or assembly supplier. This has the added benefit that the design is automatically optimized for their production methods and also for minimum cost. In fast-moving consumer product markets, where changing fashions can limit product lifetimes to little more than a year, the flexibility and agility of these small design teams really pays dividends. 📌

Pieter-Jelle Buijs is a Project Manager and Design for Six Sigma Black Belt at Philips Consumer Lifestyle's Innovation Site in Drachten, just outside Groningen in the north of The Netherlands.



Échte banen
voor jonge
academici

SUPAIR
www.supair.tudelft.nl

Jumpstart your career



Traineeships voor ambitieuze starters.

Ben je klaar met je studie en wil je de beste start voor je carrière? Mogelijk heb je al een aantal maanden werkervaring opgedaan en ben je toe aan een nieuwe uitdaging? Dan biedt Atos Origin je volop interessante mogelijkheden. Voor je het weet ben je een echte IT-professional. Atos Origin geeft je alle ondersteuning om je inhoudelijk en persoonlijk te blijven ontwikkelen. Ga je voor de techniek in IT of heeft de bedrijfskundige kant je voorkeur? Wat je ook kiest de toekomst is van jou!

Aangenaam kennismaken

Atos Origin is een internationale aanbieder van full life cycle IT-diensten zoals hi-tech transactiediensten, advies, systeemintegratie en beheer van de uitvoering.

Atos Origin is de wereldwijde IT-partner voor de Olympische Spelen en heeft een klantenkring bestaande uit internationale, gerenommeerde bedrijven uit alle sectoren.

Kijk voor meer informatie op www.atosorigin.nl/carriere. Voor meer informatie over jouw mogelijkheden kun je ook contact opnemen met Campus Recruitment Atos Origin via campusrecruitment@atosorigin.com.

Circuit Bodging

One controller to rule them all

As a stunt to celebrate the 105th birthday of the ETV, the ETV lustrum stunt committee, of which the author was a member, built a giant Nintendo controller. It is a tribute to classic gaming, and the electronics that goes into these seemingly whimsical devices, but also because – let's face it – most of us have fond memories of the computer games console that put video games back into the living room.

Author: Ben Allen

Of course, this project is a slightly larger undertaking than your average breadboard project. While the circuitry isn't very complicated, the construction of any object on such a scale is a different matter altogether. This took careful planning, and also takes a fair amount of time. In the end our design wasn't as fool-proof as we intended, but for a one-off project this doesn't present much of a problem.

Design

When building a super-sized version of something that was designed to be held in people's hands, it simply isn't sufficient to simply upscale everything and have it built. For one thing, the plastic the original controller was made of simply isn't strong enough to support people standing on it, and we had to consider a stronger and easier to manufacture design. Furthermore,

the electronics have to be approached differently. This leads to the conclusion we had to construct a NES controller from the ground up, whilst preserving the aesthetics and functionality.

Mechanics

In the end we went with a steel frame supporting MDF covering. The diagonals in the frame support the buttons and detection mechanisms, and blocks of wood mounted in between the top plates top support the areas where people would stand. This ensures structural integrity as we expected children to jump on the controllers and as such we made sure it could handle being handled roughly. A week's cutting, welding and grinding left us with 6 frames that would later be covered with the MDF plating and bolted together to form the largest gamepad ever conceived.

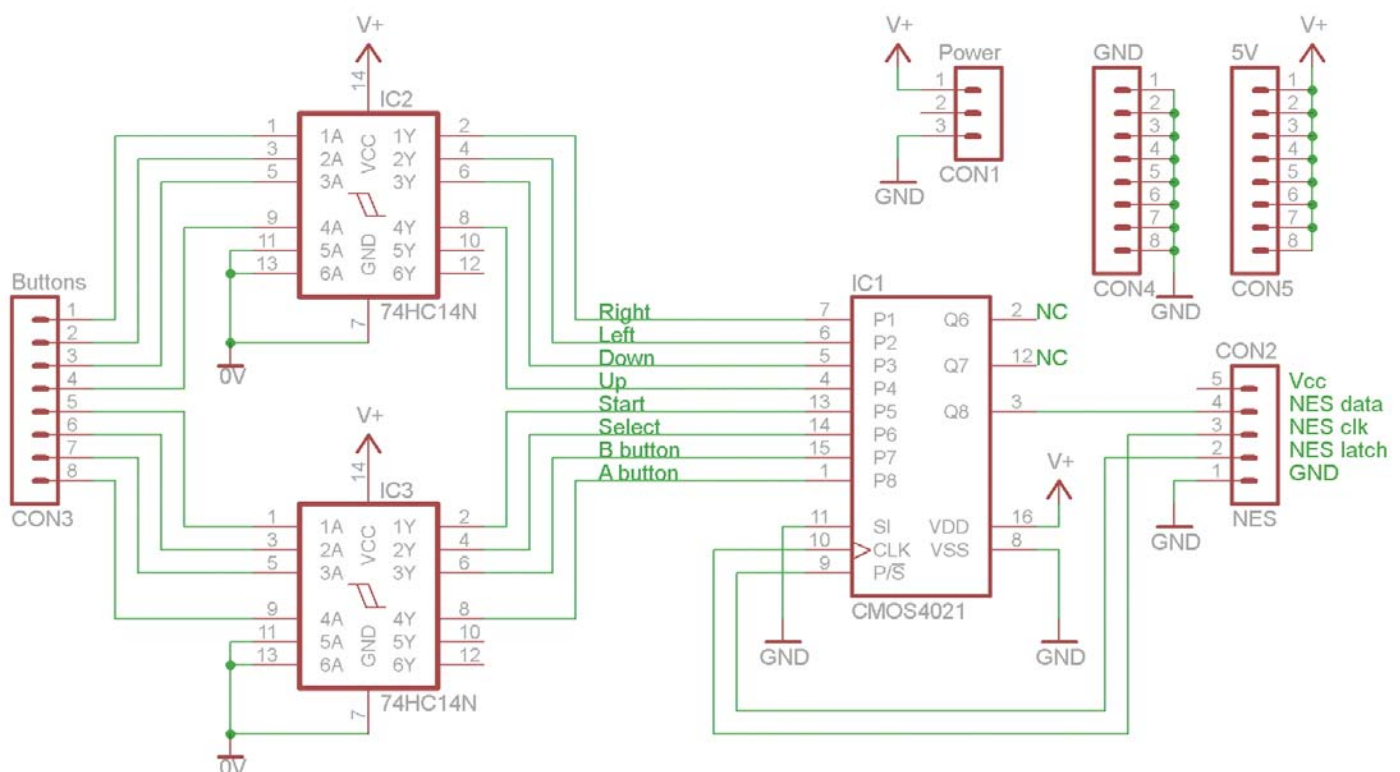


Figure 1: The NES controller circuit, including sensor signal conditioning.

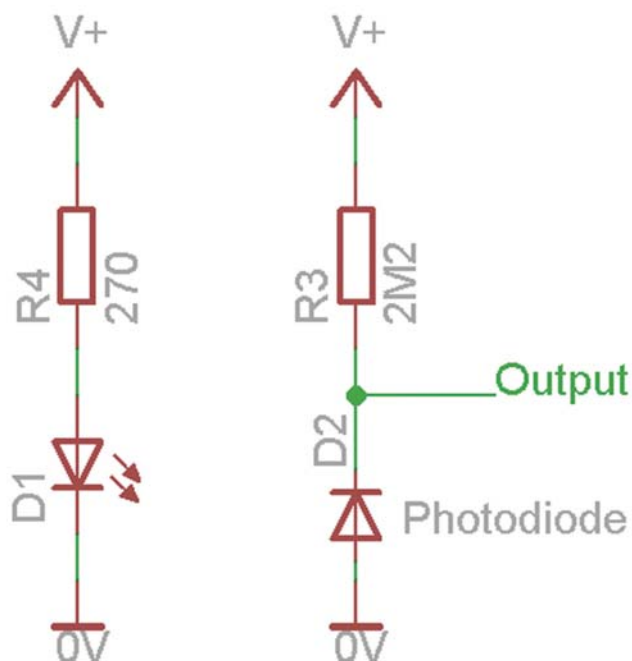


Figure 2: The sensor setup for the buttons.

Electronics

With the mechanical device in place, we need to consider circuitry. In figure 1 you see the circuit that accepts binary, active low input for the state of the buttons, and the observant reader will see that this is fed to a 4021 shift register. The NES simply clocks this shift register and reads the button states serially, as shown in figure 3. A very simple and effective method of reading button states, and also inexpensive to implement.

The next challenge is detecting whether the buttons are pressed or not. In early tests we experimented with using microswitches, but these proved to be too fragile. It was apparent that the button sensor design should not involve any moving parts, and as such we opted for an infra-red light-based sensor design as seen in figure 2. When IR light hits the reverse-biased diode, it conducts, and pulls the output low. When the light is blocked, it stops conducting and the output goes high.

At this point, we have two problems. Firstly, the output is inverted with respect to what the NES 'expects', as the NES is active low. Secondly, the signals are still technically analogue.



While it would work in principle to use the sensors in this configuration, it's better to be safe than sorry, and condition the signals before presenting them to the shift register.

This leads to a solution that kills two birds with one stone - use a schmitt trigger inverter to condition and invert the signals. The signals from the buttons can now be presented to the shift register and the circuit operates like the original NES controller from this point on.

After that, mount the sensors on the frame and add a piece of material that interrupts the light coming from the LED, and you're all set to play the original Super Mario Brothers in style. 🎮

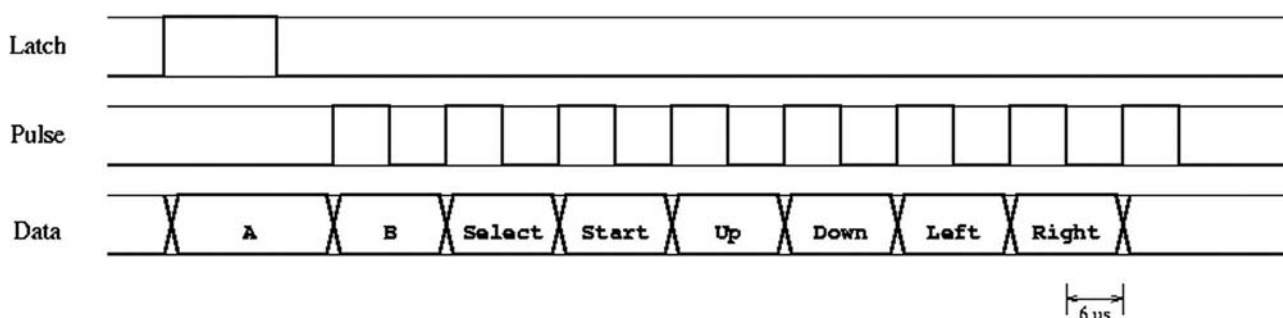


Figure 3: The NES shift register protocol. Source: <http://www.mit.edu/~tarvizo/nesc-controller.html>

Exploring the EE groups

Remote Sensing of the Environment

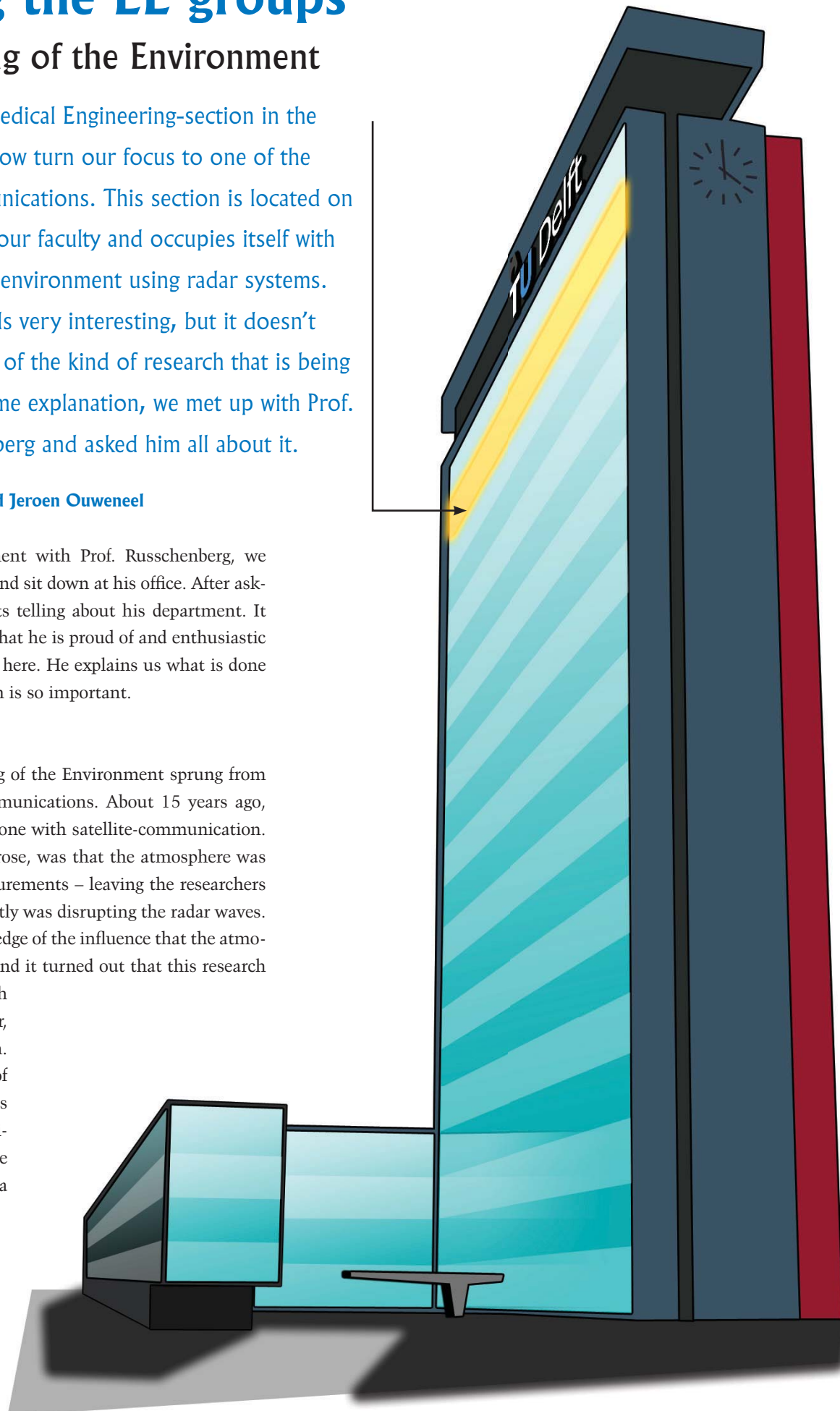
After visiting the Biomedical Engineering-section in the previous edition, we now turn our focus to one of the sections in Telecommunications. This section is located on the twentieth floor of our faculty and occupies itself with remote sensing of the environment using radar systems. This, of course, sounds very interesting, but it doesn't give much explanation of the kind of research that is being done. Eager to get some explanation, we met up with Prof. dr.ir. H.W.J. Russchenberg and asked him all about it.

Authors: Ester Stienstra and Jeroen Ouweneel

Having made an appointment with Prof. Russchenberg, we head to the twentieth floor and sit down at his office. After asking some questions he starts telling about his department. It very quickly becomes clear that he is proud of and enthusiastic about the work that is done here. He explains us what is done exactly and why the research is so important.

History

The section Remote Sensing of the Environment sprung from the department of Telecommunications. About 15 years ago, measurements were being done with satellite-communication. One of the problems that arose, was that the atmosphere was interfering with these measurements – leaving the researchers with the question what exactly was disrupting the radar waves. This led to a need for knowledge of the influence that the atmosphere has on radar waves and it turned out that this research could potentially give much information on the weather, climate changes and so on. Because the interpretation of atmosphere measurements turned out to be very difficult, Remote Sensing of the Environment came to be a separate section.



Research topics

As previously mentioned, the Remote Sensing of the Environment section busies itself with atmosphere (and surface) measurements using RADAR systems. With this, different studies are being done.

First off, technologies are being developed that can keep track of climate changes. Changes of interest of the researchers are, for example, the melting of the north pole, the drying out of rivers or land, but also changes in the radiation in the atmosphere, and the effect of clouds and carbon dioxide. To illustrate the difficulties with these measurements: clouds block direct sun light on one hand, but also isolate the earth and atmosphere, thus keeping built-up heat inside – making it near impossible to tell the overall effect. It is speculated that the uncertainty in these measurements is about as big as the effect of all human carbon dioxide emissions.

Currently, measurements are being done with the use of satellites, RADAR systems, radiometry as well as LIDAR systems (Light Detection and Ranging). These measurements are applied to get information on the composition and behavior of clouds, which can be used in improving climate models.

Another important field of research is the measuring of amounts of rain – but unlike the ‘KNMI’ (the official Dutch meteorological institute) with the use of radars ranging from 3 to 10 GHz. With this technique, the amount of water coming from the sky can be measured very accurately.

Measurements are also made with the use of other frequencies; these – naturally – give different information. What has to be taken into account, is that high-energy radio waves can have an effect on the atmosphere – in other words: by taking measurements, the atmosphere is physically changed. Also, the way data should be interpreted is completely different for low frequencies as for high ones.

Finally, one of the topics being researched is Earth Observation, using radar systems attached to airplanes. These measurements can give quite some information, ranging from data on vegetation, agriculture, the spreading of diseases, landslides and – very relevant for the Dutch – dike degradation.

CESAR

The department is involved in the CESAR project. CESAR stands for Cabauw Experimental Site for Atmospheric Research. Cabauw is a small village about 40 kilometers from Delft. Here a measurement site is placed in the country site. This project is a collaboration of different institutes in the Netherlands, such as the KNMI and TU Delft along with other universities and research institutes. The purpose of this site is to investigate the effect of different types of weather on the climate. CESAR is the biggest site in Europe in terms of the number of research sensors placed in the same project.

The RSE department owns two radars on this site the IDRA (IRCTR Drizzle Radar) and the TARA (Transportable Atmospheric Radar). The IDRA is placed on the 213 meters high tower situated at the site and covers a range of 15 kilometer around the site scanning for precipitation and especially drizzle. This radar has a much lower range than the average used radars in meteorology, but the accuracy is much higher. The TARA is a ground based transportable radar which scans a column in the sky to gain more knowledge of cloud system behavior. The resulting measurement is a graph in which in function of time every vertical line displays the particles in the column above the radar. »



Figure 1: The TARA

Fields of interest

So what interests should students have in order to fit in at the Remote Sensing of the Environment section? Basically, it doesn't really matter which Master you have chosen or are planning to choose – as long as you have a general interest in the topics mentioned above.

An important part of the research consists of basic Electromagnetics. The emphasis lies on correct interpretation of measurements (linking measurements to physical phenomena). Another important aspect in Remote Sensing is signal processing – forming a big challenge, since it is not uncommon for the measurements. Also physics is a big part of the research done, in order to understand what the measurements taken really tell about the way clouds are build up and behave. This results in a mixed group of people with a lot of different fields of knowledge.

Working atmosphere

The department is small, comparing to other departments. This means that the co-workers know each other well and the atmosphere is open and relaxed. Also, everyone can come up with new initiatives and if you have a problem there is always someone who can help you out. Because of the high amount of different fields, working together is essential.

Special activities for socialization are not done on this department. But frequently special measurement campaigns are done. During these campaigns a lot of activities are done. An example of such is a campaign is the one planned for the fall of 2012. The TARA will then be placed in the south of France for three months to do measurements. Around these campaigns measurement devices are brought back to the state of the art of technology. A lot of work is done to make the system better than ever in order to get good results from the campaign. During the campaign the co-workers stay at the place where the radar is.



Figure 2: TARA and IDRA at Cabauw

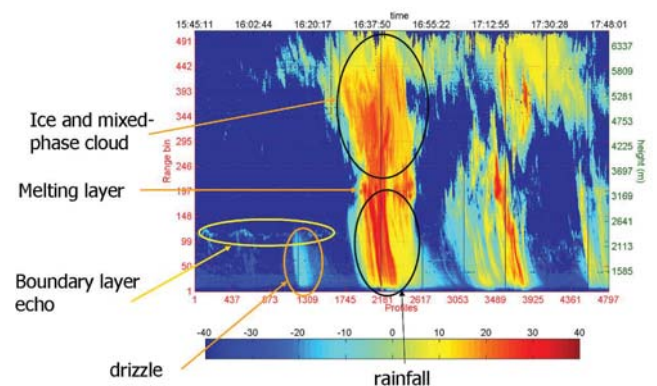


Figure 3: Measurement taken with TARA

Experiences of a BSc student

Every bachelor student of Electrotechnical Engineering does a project at the end of the bachelor program. This project is done in the fourth quarter in a group of four to six people. With a group of five students we were tasked to program the new computer for data processing and the controlling system for the TARA.

The goal of this project was to update the ten year old controlling and processing systems. As you can imagine after ten year the system has become faster and more efficient. One of the biggest improvements is that two PC's are replaced by one, which means a lot less communication problems. Also we made the user interface graphical instead of that the user should input everything with control statements.

This project was a challenging project, but luckily the people of the department were very helpful. It was very nice to work with all the people in the department, everyone was very enthusiastic. In the end the project was successful as almost everything



Figure 4: The students and supervisors of the project.

has been done that had to be done. Also, it is nice to know that the people at the department will finish the missing parts and when that is done, our system will actually be used to do measurements. 🙌

PCB EXPERTCENTRUM

V-PS

INNOVATIE IN PRINTPLATEN

PROTOTYPING

MULTILAYERS

FLEX-RIGIDS

SPECIALS

V-PS.COM

A quick guide into electric vehicle recharging infrastructure

An outlook for those (who will be) working in (or associated with) this industry.

Author Ir. Michiel Langezaal, Business Development @ Epyonpower

EVs expected to reach our markets and their recharging capabilities

As we speak, Nissan, Mitsubishi, Peugeot and Citroën are delivering their first batches of affordable mass-produced Electric Vehicles (EV's) to selected markets. These vehicles, such as the iMiev and the Leaf, are considered reasonable alternatives to typical fossil fuel powered passenger cars. This is a major step in the electric vehicle industry. Until now we have only seen vehicles produced in small batches, being retrofitted electric versions of their fossil fuel counterparts or more expensive products such as the Tesla, which are only affordable for the few and produced in limited numbers.

The sales figures of electric vehicles are expected to take a giant leap and predicted to approach a quarter of a million units sold by 2012. For our Dutch readers, we expect to have almost a thousand Nissan Leaf's on our roads by the end of this year. A sales figure, which in a single year has almost doubled the existing base of mass-produced electric vehicles.

Apart from the fact that these new vehicles are affordable and mass produced, there is one important new feature, which allows them to be called a reasonable alternative to a typical fossil fuel powered passenger car, Fast Recharging. This allows an EV driver to recharge their vehicle in a matter of minutes (20 min) using an off-board fast charging system at e.g. a service station. Until recently, electric vehicles only had a small on-board charger of roughly 3 kW's, which requires 8 hours to recharge a vehicle battery of 20 kWh. In combination with Fast Charging, an EV can just like a fossil fuel powered car be back on the road after just a short stop.

So what else can we expect from our OEMs? Well this is where the car industry complicates things. Most of the Japanese OEMs have adopted the CHAdeMO fast charging standard of the Nissan Leaf and Mitsubishi iMiEV. Alternatively, some of the German and US automakers are aiming for even higher powered off-board charging systems, while Renault announced

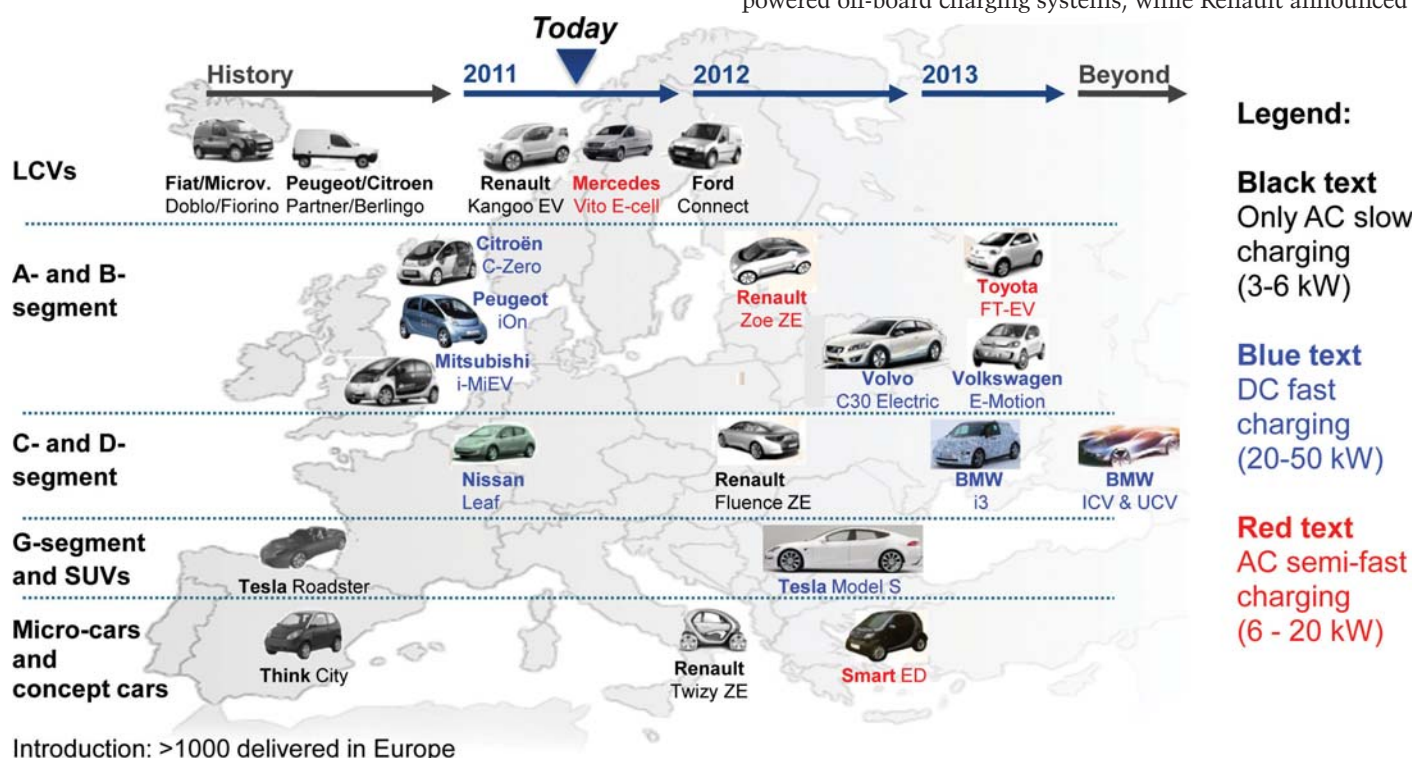


Figure 1: EVs with fast recharging capabilities have reached our markets

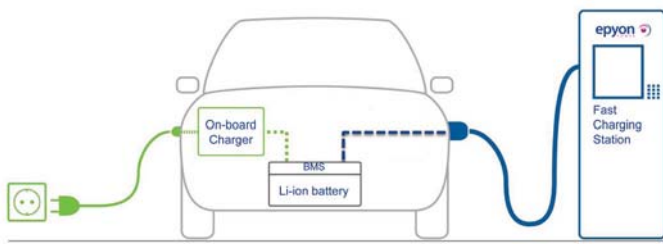


Figure 2: Two methods of charging, AC (on-board) and DC (off-board)

a semi-fast on-board charging system with recharging times twice that of the existing CHAdeMO systems.

A lot is happening in the industry and therefore we considered it worthwhile to dig into the recharging options offered by the OEMs and argue which technologies will sustain and why.

The recharging technologies used

Let's start with investigating AC or on-board charging. With this configuration the charger is built into the vehicle. The vehicle connects to the electricity grid using an AC connector. This method is regularly called slow charging because the on-board charger is often a relatively low power system. The reason behind this is that OEMs need the on-board charger to be small, cheap and light weighted in order to achieve an acceptable vehicle price and weight. Until now we have seen that each vehicle coming to the market has roughly 3 kW of on-board charging power.

So what is DC charging? Well, with this configuration the batteries of the vehicle are recharged using an off-board charging system. This system directly delivers DC current to the vehicle instead of AC and communicates to the battery or vehicle management system in order to supply the correct voltage and charging current.

This method is often called fast charging as the installed power of the off-board unit is in most cases much higher than that



	Slow Charging	Commercial or Fast Charging
Duration	Typically 8 hours	Typically 20 minutes
When to choose	<p>"Long stay":</p> <ul style="list-style-type: none"> Nighttime charging When parked for 8 hour or more at: work, during studies or at school Emergency charging in case of no other options 	<p>"Short stay":</p> <ul style="list-style-type: none"> For events like: client visits for work, shopping, going to the gym, football training, visiting a concert, etc. Emergency charging for range extension 
Connection standard	<p>AC:</p> <ul style="list-style-type: none"> Basic household plug CE (230V single phase or 400V three phase) Mennekes (400V three phase) SAE J1772 AC (120/240V single phase) 	<p>DC:</p> <ul style="list-style-type: none"> CHAdeMO (600V 125A) Combo coupler (600V 200A)
Charger	<ul style="list-style-type: none"> Small Placed on-board of the car Cheap (±€ 500-1500) Light (± 10 kg) 	<ul style="list-style-type: none"> Large Placed off-board Expensive but shared with others Heavy (>400 kg)
Price of Charging station	Low - Ranging from virtually zero for a household installation without security and payment terminal to € 5k for location with all that	High - Ranging from € 50k to € 100k (incl. typical installation costs)

Figure 3: AC and DC charging seem to be complementary

of an on-board unit (in case of CHAdeMO ± 20 times) and is therefore capable of recharging the car's batteries in minutes instead of hours. Because these off-board systems are shared with many other fellow EV drivers, more money can be invested in charging power while weight and volume are not that relevant anymore.

Nevertheless, AC and DC charging seem to be complementary (see figure 4). Where AC charging is more suited for use at home and remote locations where off-board charging equipment might not be available and where long charging times do not interfere with our driving needs. Fast charging or DC charging seems more suited at locations where a short recharging time is much more important and where equipment can be shared with many others. Locations such as regular service stations, short-term office parking, restaurants and such are well suited for this mode of recharging.

How can we expect EVs and their recharging capabilities to improve?

Let's start with improvements that have been announced in the press and will be reaching our markets within the coming years. We would like to discuss here improvements on both AC as well as DC charging technology and the battery capacities of the cars that are recharged.

Renault has announced to introduce a semi-fast onboard-charging system for its Zero Emission products, such as the Fluence and the ZOE. This system aims at charging powers of 10 to 20 kW's using a industry standard 400V three phase connection.

The standardization committee IEC TC69 has been working with the German and US car industry on reaching an agreement on a single connector and protocol, which would be able to connect to AC (slow) charging stations as well as to DC (fast) charging stations. This connection standard is known under the name DC-Combo coupler. The aims of this standard are to go to even higher DC charging powers of up to 80 kW (coupler certified for 600V @ 200A, with batteries at 400V this results in ± 80 kW) and to support the vehicle to charging station communication over powerline carrier.

Close to home, we have BMW retooling a production factory in Leipzig, Germany as well as building a completely new North American plant in Moses Lake, Washington, to produce their electric vehicles from 2013 onwards. The first vehicle to hit the market is the BMW i3, which is said to be equipped with a 35kWh battery capable of a range of up to 180 km. Rumors are that this vehicle might be the first on the market to be equipped with the Combo-coupler fast charging option.

Which technologies are expected to gain serious foothold?

This question is important for decision makers active in this or associated industries. Therefore we would like to share some of our views on the expected developments and the arguments behind them. For this we choose two subjects of discussion: (1) the expected growth in battery capacity and (2) the success of AC and DC charging technologies for fast recharging.

Expected growth in battery capacity

Current battery capacities of EVs are in the order of 20 kWh giving them a range of a little more than 100 km. Most agree that battery capacities will have to increase to make EVs a wide-spread success, so what is to be expected and how quickly?

In essence we see three ways to increase the vehicle's battery capacity:

- Allocate a larger part of the total cost price to batteries
- Improve battery and cell design
- Lower production cost through economies of scale

Although the first may seem an easy solution, it is important to recognize that today this is exactly what OEMs are doing. They are spending a very large part of the cost price of the vehicle on batteries (e.g. the battery of the Leaf represents $\pm 40\%$ of its cost price). Investments in battery research and production facilities are huge and most analysts conclude that battery prices will decrease towards €200 per kWh in the coming decade (Leaf is estimated at \pm €400 per kWh).

Will this then eventually lead towards vehicle ranges similar to what we are used to today? Well, we think probably not, because at some point in time, the OEMs will want to get a return on their investment, governments will reduce subsidy programs on EVs once they consider the industry mature enough and finally because the consumer might not often need that

range and is more likely to fast charge the vehicle a bit more often (e.g. see <http://youtu.be/R9NqSuk5gjQ>). »

This development of choosing a vehicle with a range that suits your daily needs is already happening today. Tesla Motors offers their Model S in varieties of 255, 370, or 480 km range. Because the price of the additional range is substantial consumers will think twice whether they really need this expensive option or would rather spend 30 minutes extra a few times a month at that fast charging station which costs them maybe ten euro's at a time.

The success of AC and DC charging technologies for fast recharging

So, now we have not only gained insight in the expected battery capacities of EVs to come on the market in the coming decade. We have also proven that batteries will not reach capacities large enough to live in a world without fast charging. So if fast recharging will remain important, which technology is expected to sustain and reach maturity?

Expectations in the market are that the winning technology for fast charging will be off-board DC charging. Arguments for this are based on; economic grounds, the timing of introduction, the number of followers and the technicalities.

We shortly discussed the economics of AC or on-board versus DC or off-board charging when we mentioned that in the case of off-board, the charging equipment could be shared with others. When compared to the existing gas station infrastructure with a sharing ratio of one gas station to 1000 vehicles or even more. The business case to favor DC technologies becomes more clear, as for every euro invested in charging equipment in the vehicle (AC) we could invest a thousand euro equivalent in infrastructure (DC).

When looking at the timing of introduction and the number of followers we can only say that at the moment there are multiple mass produced vehicles driving around with CHAdeMO DC technology. In Japan alone there are more than a few hundred of these charging stations, while the introduction of semi-fast AC technology is still to be awaited.

Last but not least we have seen earlier on in this article that the technicalities of the vehicle, such as volume and weight are in favor of DC technology and therefore it seems to become more and more clear that the future of fast EV recharging is in DC off-board technology. »

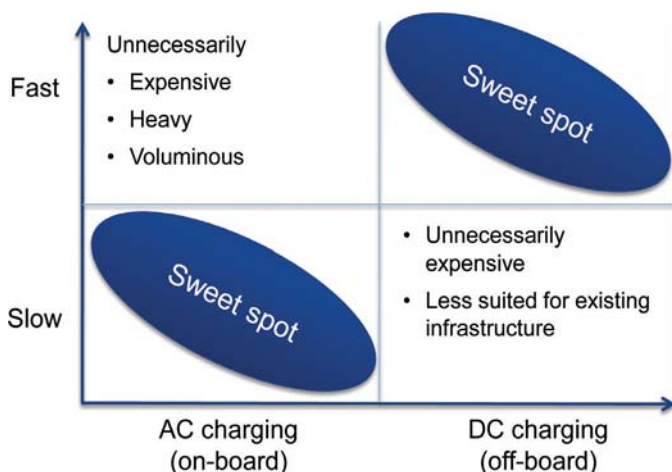


Figure 4: Recharging technologies versus charging speed

Bedrijfskritische
faciliteiten

Gezonde leef-
en werkomgeving

Veiligheid

Duurzaamheid
en energie

Nieuwe
technieken

*De Hermitage
technisch
mogelijk maken!*

Beeld: Hans van Heeswijk Architecten

*Kom werken bij het grootste onafhankelijke ingenieursbureau
op het gebied van Installatietechniek, Energie en Bouwfysica*

Bij Deerns werken we aan een groeiend aantal complexe projecten waarbij duurzaamheid meer en meer centraal staat. Daarbij kunnen we jouw kennis goed gebruiken!

Met innovatieve en duurzame installatieconcepten realiseren we comfortabele, veilige en energiezuinige gebouwen. Zo hebben onze technische oplossingen het mede mogelijk gemaakt dat de Hermitage in Amsterdam zich kon vestigen in een 17^e eeuwse pand dat voorheen als verpleegtehuis in gebruik was.

Wil je meer informatie over onze vacatures of stagemogelijkheden? Kijk dan op www.deerns.nl/vacatures
Deerns is het grootste onafhankelijke ingenieursbureau in Nederland op het gebied van installatietechniek, energie en bouwfysica. Met vestigingen in Nederland, Duitsland, Groot Brittanie, Dubai, Spanje, Frankrijk en de Verenigde Staten is Deerns een toonaangevende internationale speler.



Nanoparticle additions for thin film solar cells

Silvian Bensdorp, MSc.

The need for solar energy

For the last few decades, the use of all fossil fuels has risen constantly throughout the world, and there are no indications that this trend will reverse in the foreseeable future. It is a well known fact that supplies of fossil fuels are (economically) limited, and eventually we must replace their use by sustainable technologies completely. Advanced technologies take time to mature technologically, and they take even more time to be economically feasible. Considering the enormous amount of fossil fuels consumed every year this means the scale on which sustainable resources must be deployed eventually will be unprecedented by today's standards, and we must allocate significant scientific resources now to solve this problem before we are too late. Solar energy promises to be one of the main driving forces behind this sustainable revolution. Taken the expected mass deployment combined with the economies of scale, there can be a benefit in the increase of efficiency of solar cell of even a few percent. While the currently best performing solar cells have an efficiency of over 40%, these cells are very expensive to fabricate, and there is considerable research into thin film solar cells, which promise to be a large scale cheap solar technology.

Thin film solar cells

The last few years there has been a strong research focus on thin film cells, and with good reason. They use less material to produce, they are flexible and have a high collection efficiency. A solar cell can be seen as a light sensitive PIN-diode with terminals on both ends. In the PIN region of the solar cell, from here on called the photo-active layer, light is absorbed at a certain statistical rate. If a photon is absorbed its energy - determined by its frequency - is used to bring an electron from a lower energy band where it is attached to its atom to a free conduction band. These bands are separated by a certain energy level, and an electron is not allowed to be in between these two bands. If the photon is absorbed we have two oppositely charged particles, the electron and the charged atom, and we need to 'harvest' them to build up a voltage potential over the solar cell. In thin film solar cells movement of free charges in the photo-active layer is mainly determined by the drift, which depends on the applied electric field and mobility of the medium.

In thick solar cells, the primary force of movement is diffusion, where free charges follow a random Brownian motion path and

are collected 'by accident'. This would not be a problem if all free charges would surely be collected, but unfortunately the longer the path before a free charge is collected, the bigger the chance that it recombines with a particle of opposite charge, thereby emitting a photon.

Here we see an interesting trade-off appearing when we combine thin film cells with conventional solar cells. A thicker solar cell will make it more likely that a photon is absorbed, which is particularly true for lower frequencies, while at the same time the collection efficiency drops with increased thickness due to the prevalence of the diffusion over drift as the dominant separation process. Thus, we need a solution to optimize the absorption of light in a thin structure.

Optimizing photon collection

There are essentially two ways to optimize the absorption. The conventional method is minimizing the reflection by a coating, so that all incident light at the surface is transferred to the photo-active layer. Depending on the desired bandwidth of this coating, these coatings can be fairly complex. A second technique is the trapping of the light in the solar cell structure. By twiddling with the geometry of the cell at a nanoscale a broad range of interesting effects can be obtained that will *trap* the light in a structure. These techniques have become feasible only recently with the ongoing advancements in nano-technology and the corresponding benefits in production scale.

A technique that is gaining rapid popularity with the advancements in nano-technology is the use of surface plasmonic polaritons. These are electromagnetic waves that are trapped or guided along certain configurations. All materials have three properties on which the propagation of electromagnetic waves depend, permittivity, permeability and conductivity. While relative permeability is usually close to zero, relative permittivity can vary over a broader range. A particular interesting effect is that the

apparent permittivity of many materials varies with frequency. This effect is called dispersion. It turns out, that for some frequency band in and around the optical range the permittivity of a material is negative, and the interface between a positive and a negative permittivity a surface plasmonic polariton can exist. Note that this effect is not the same as meta-materials, which we are hearing quite a lot from lately, where we need *both* the permittivity and the permeability to be negative. A negative permeability is created typically by tuning some specific structure to obtain an effective negative permeability. Surface plasmonic polaritons are typically seen at the interface of a metal, such as silver or gold, and a dielectric such as a semiconductor. Electrons start oscillating at this interface, called surface plasmonic resonance, and as a result we have a sort of 'trap' around this interface. The optimum for this oscillation is when the two materials at the interface match each others permittivity in the opposite sign. This perfect match, unfortunately, usually only happens at a specific frequency, and around this frequency, »

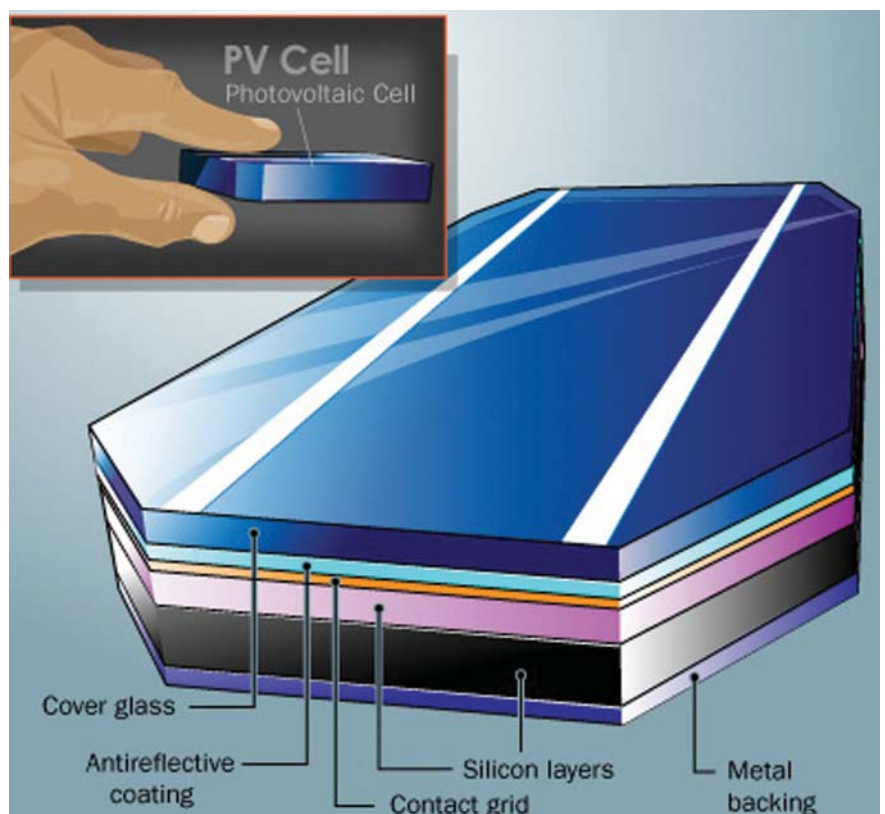


Figure 1: How thin-film solar cells work (source: www.howstuffworks.com)



where we still have opposing signs in the permittivity of both materials, we will see a less than optimal oscillation due to scattering of incident wave.

Why is all this important? We assume that all electron-hole pairs are actually absorbed by their corresponding collectors, which is a reasonable assumption since our structure is very thin. Unfortunately, most light is reflected at the various layers of the solar cell structure, and a typical 'plain' thin film solar cell will have an efficiency of only a few per cent. Most of the light will be scattered by the lowest layer, the reflector. This reflector is typically made of a highly conductive material, such as aluminium or silver. This high reflectance will guaranty us that the light will pass through the photo-active layer twice. What we want is to use the surface plasmonic resonance technique in such a way, that the electromagnetic wave adheres to it. While a back-reflector will take care of this for some part, its contact surface is relatively small. To increase the surface, we can corrugate it, either in a structured, thus tuned, or randomized way, or we embed extra metallic particles *inside* the photoactive layer to enhance the contact surface. This approach, however sounding promising initially, comes with a number of physical drawbacks. First, by adding particles to the photoactive layer, we decrease the volume, and to compensate we need to increase the layer thickness, thereby reducing internal quantum efficiency. Secondly, the surface plasmons exists on both sides of the medium interface, and while on the photo-active side the energy is dissipated into electron-hole pairs, on the metallic side this energy is converted into heat. Third, the inclusions will, when the permittivity is not perfectly matched, also act as scatters, blocking part of the incident light to reach the back reflector. However, light that does reach the reflector and scatters from this reflector will be partly trapped between the back reflector and the metallic inclusions.

Problem analysis

So, do the drawbacks weight in against the benefits? This question really hard to answer without experiments, and while you would certainly be able to create a whole lot of different samples in a laboratory, this is very costly. Thus we resort to numerical modelling of the problem. Using a computational approach, it

is easy to test dozen of different structures with relatively small effort. The method we use is the finite difference time domain method (FDTD). In this method we discretise time and space, and simulate the time behaviour of any given structure. The creation of an appropriate simulation scenario is something of an art, since a structure is typically much bigger than what fits in a computer memory of a powerful workstation PC, especially in 3D, and we have to come up with various tricks and approximations to make a useful simulation. Without going into details - you can find them in my M.Sc. thesis - we have run many different scenarios for a wide frequency band to see which additions performed best. All inclusions materials have been silver, since it has excellent electric properties for a reasonable material price. What we have seen from various simulations, is that the benefits that this technology promises, we have seen only moderate increases in efficiency, with the highest efficiency peaking at 5%. While the absolute increase against the plain flat cell at 3% is certainly impressive, it is far from efficiency of over 40% seen in the best multi-junction solar cells, and it is questionable if the increase in manufacturing price - after all, we are talking nano-technology here - can justify this increase.

What we did find, however, is that by aggressively corrugating the interfaces between the layers, efficiency ratios of nearly 30% were attained. This is a highly surprising results not the least to say, and these results are - as opposed to particle insertion in the photo-active layer - are not yet backed by lab experiments as far as I know. Possibly this is due to wrong approximations in our numerical model, or this could be a large breakthrough in the thin film solar research.

So is plasmonic resonance the next big thing in solar energy? I have my personal doubts, and what I heard from around the university, other scientists share these doubts. Numerous results are still being published from around the world - including from leading research institutes - and it would be too soon to dispose this technique. Much more additional research must be carried out before this topic is definately settled, and I think this is a great opportunity for students to explore as graduation project, as I have done. ➡

Column

Een keer per jaar is het gebruikelijk voor de Ereleden der ETV om met elkaar te dineren. Bij deze gelegenheid wordt het minst recent geïnstalleerde Erelid uitgenodigd om een toespraak te houden voor de aanwezigen. Dit jaar was alles natuurlijk in verband met het Lustrum net een beetje anders. Het diner was



opengesteld voor alle bezoekers van het Lustrumgala en het “jongste Erelid”, zoals hij het zelf noemt, was geen Erelid van Bestuur, maar een Erelid van Vereeniging. Professor Lou van der Sluis nam uiteraard graag het woord tijdens het Lustrumgaladiner en zorgde zo voor vermaak in de zaal. De oorzaak hiervan zullen wij u niet langer onthouden:

Auteur: Prof. Lou van der Sluis

Dat er onderscheid gemaakt wordt tussen Erelid van Vereeniging en Erelid van Bestuur dat wist ik, maar dat er ook nog zo iets bestond als jongste Erelid, wist ik niet.

Jan van der Pol viel mij na de installatie bij het feliciteren snikkend in de armen, hij was jongste erelid af. Het jongste erelidmaatschap duurt 5 jaar. Vergelijk huisjongste: vuilnis buiten zetten, drank aanvullen, telefoon opnemen, deur opendoen, ik weet er alles van. Thuis doe ik het nog steeds, hoewel ik met afstand geen huisjongste meer ben. Maar nu woon ik als huisoudste in een meisjes-huis, vandaar. Wat is nu de taak van het jongste erelid? Ik vermoed dat als tijdens een nachtelijke bestuursvergadering het bier op is het bestuur het jongste erelid belt met het dringende verzoek daar verandering in te brengen. Ik slaap sinds 26 maart, de dag van de installatie, dan ook met de telefoon naast het bed, om onmiddellijk een kratje Hertog Jan (standaard gekoeld op voorraad) met mijn 4-wheel drive (speciaal voor dit doel aangeschaft, want ook als het winter is wordt er door het bestuur vergaderd) naar de drooggevalen bestuursvergadering te chaufferen. Gisteren werd me, door oud-president Frank Gorte, een nieuwe taak duidelijk gemaakt: het houden van een tafelspeech tijdens het galadiner. Om mij niet al te onrustig te laten worden kwam de aanzegging een etmaal van te voren. Frank mijn hartelijke dank voor je inlevingsvermogen, had ik het eerder geweten dan had ik toch wat slapeloze nachten gehad!

Dit zijn de lasten van het erelidmaatschap. Er zijn echter ook lusten. Ik heb Delft Integraal gehaald, wordt nog steeds gefeliciteerd, bestuurlijke deuren gaan wat gemakkelijker open en in overvolle agenda's wordt sneller een gaatje gevonden. Dat klinkt allemaal mooi, en dat is het natuurlijk ook, maar ik moet er nog wel aan wennen. In Nootdorp wordt ik bij de fietsenmaker met égarde ontvangen als ik een probleempje met de derailleur heb en bij Albert Heijn doet men nu standaard een extra kassa voor mij open als ik met mijn karretje aan kom rollen. Kortom het erelidmaatschap maakt het leven wat geriefelijker. Ik kan het daarom een ieder aanraden! Het kost niks en brengt zoveel!

Zo was er laatst bij ons in het dorp een worstelwedstrijd, georganiseerd door de plaatselijke worstelvereniging Luctor et Emergo. Voor de niet gymnasiasten onder u en voor hen wier wiegje niet in Zeeland heeft gestaan, geef ik even de vertaling: “Ik worstel en kom boven”.

Daar ikzelf nogal dragelijk worstel, wat mij bij meningsverschillen met de Decaan uitstekend van pas komt, ben ik onlangs op een donderdagavond naar het worsteltoernooi in de Jan Janssen sporthal gegaan, in gezelschap van Arie Bombarie, kampioen van Edam (NH) en Willem Borstkas, oud kampioen van Lisse (ZH). Beiden verdienstelijke worstelaars met wie ik het altijd goed heb kunnen vinden.

Het programma begon met een gevecht van drie ronden tussen de heren Jacobs (80 kg) en Parnera (83 kg). Het was heel aardig, maar toch niet wat Arie, Willem en ik worstelen noemen. Het was te weinig erop of eronder, als ik het voor de leek zo mag uitdrukken. »

Bij het echte worstelen, zegt Arie, zijn er twee mogelijkheden: of je wint of je gaat voor een half jaar onder de wol. Om een van deze twee uitersten te bereiken, is nodig een gewicht van tenminste 110 kg. Eerst dan is men aan het eigenlijke pletten toe. Bij een gewicht van 80 kg vervalt je al snel in het zogenaamde knoopwerk. Zo ook hier. Er waren ogenblikken dat de heren Jacobs en Parnera zo onontwarbaar in elkaar verstrikt zaten, dat de situatie voor hen zelf totaal onoverzichtelijk was. Op een gegeven moment kwam het hoofd van Jacobs boven een verwarde massa armen en benen uitsteken, gejaagd spiedend naar een lichaamsdeel waarvan hij zeker wist dat het aan zijn tegenstander toebehoorde. Tenslotte begon hij, aangemoedigd door kreten uit het publiek, op goed geluk een voor de hand liggend been om te draaien, te laat bemerkend dat het deel uitmaakte van zijn eigen persoonlijkheid.

Zulke vergissingen zijn onvermijdbaar als men het niet in de ruimte zoekt. Echte worstelaars zoeken het altijd in de ruimte. Ik heb eens in Chicago de grote Bill Thompson (117 kg) aan het werk gezien. Het was een hartverheffende aanblik. Hij pakte zijn tegenstander bij een been en zwiepte hem eenvoudig het publiek in. Dat is klare taal. Dat is wat wij worstelaars vakwerk noemen. Maar hiervan was in Nootdorp geen sprake. Het was en bleef knoopwerk op korte afstand.

Daarom zagen we verlangend uit naar de ontmoeting tussen Teddy Rollboy, wereldkampioen (135 kg) en de Roemeen Plancka (127 kg), die na de pauze zou plaatsgrijpen. Zelden heb ik twee zulke mensen aanschouwd. Als twee traag bewegende plumpuddingen waggelden zij het trapje op en namen ieder op een stoeltje in de ring plaats. Het stoeltje van Plancka hield het uit, doch het stalen krukje van Rollboy zakte als bordpapier ineen. De reus stond glimlachend op en ging tegen een pilaar leunen. De pilaar viel om. Dat zijn kerels. Daar heb je houvast aan. Kijk, nu geeft hij een der juryleden (de heer Determeyer) een hand en schudt deze hartelijk. Een ogenblik later houdt hij het armpje van Determeyer los in de rechterhand en kijkt er verbaasd naar. De scheidsrechter geeft hem een berisping. Om te bewijzen dat hij het niet expres deed, klopt Rollboy hem vriendelijk op de schouder: het volgende ogenblik wordt de man met totaal ontwricht bovenlijf de zaal uit gedragen. Gelukkig is er een plaatsvervanger die, niet zonder bezorgdheid, zijn taak overneemt. Hij blaast onmiddellijk op een fluitje en daar rijst de heer Plancka van zijn krukje op. Ook geen kerel om ruzie mee te krijgen. Hij kan, volgens het programmaboekje, een vertrekkende trein met één hand tegenhouden. En hoewel ik het nut of voordeel hiervan niet duidelijk inzie, zo moet toch erkend worden dat het niet ieders werk is.

De heer Plancka rekt zich uit en geeft het publiek een knipoogje. Het schijnt dus een aardige man te zijn, geneigd tot scherts en luim. Er zit iets bijzonder beminnelijks in het feit dat een man van 127 kg knipoogt. Want hij hoeft het helemaal niet te doen. Een man van zijn gewicht vindt ook zonder zulke attenties zijn weg door het leven wel. Maar hij doet het toch en wordt onmiddellijk beloond met de kreet: "Vooruit Jan kraak 'm". En nu gaat het er op los. Zonder enige verdere inleiding grijpt Rollboy zijn tegenstander bij het middel, heft hem als een baal meel omhoog, en werpt hem de jury in. Hierna beklimt Plancka op zijn beurt het podium, pakt het been van zijn tegenstander en slingert hem rond met een gemak als ware hij een vendelzwaaijer. Deze en dergelijke staaltjes worden nog een tijd lang voortgezet. Er wordt hiermee niets ernstigs bedoeld, legt Arie mij uit, het zijn wat handgrepen en vingeroefeningen om er in te komen. Aan het eigenlijke beroepswerk zijn we nog niet toe.

Maar nu fronst Rollboy de wenkbrauwen en maakt zich gereed om het zogenaamde pletten ter hand te nemen. Hiertoe legt hij zijn tegenstander bedachtzaam voor zich op de grond en gaat tot het inleidende bonken over. Hier zien we duidelijk wat een gewicht van 135 kg vermag. Maar Plancka is ook niet van gisteren en met een meesterlijke schroefbeweging kronkelt hij zich onder de wereldkampioen uit, klemmt diens hoofd als een tang tussen zijn benen en begint te mangelen. Het ziet er voor de heer Rollboy niet plezierig uit. Doch met een verrukkelijke en onfeilbaar uitgevoerde Zweedse zwieper keilt hij zijn tegenstander de lucht in, vangt hem als een bal weer op, neemt hem meteen in de hele Nelson en vloert hem ten slotte met beide schouders tegen het canvas. De partij is uit.

Vervolgens richt de wereldkampioen zich, bij monde van de voorzitter van de Nootdorpse worstelvereniging, de uitnodiging tot het publiek om zich met hem te meten. Onmiddellijk trek ik mijn jasje, kousen en schoenen uit en betreed, aangevoerd door de kreten van Arie en Willem, het podium. Ik zie mijn tegenstander verbleken, als ik mij van mijn overhemd ontdoe. Maar nu is het te laat. Hij zal nu hebben wat er bij staat. Als ik ook mijn flanelletje uittrek, barst de heer Rollboy in snikken uit. Hij zegt dat hij het niet zo bedoeld heeft. Het was een grapje legt hij uit. Nu goed dat is iets anders. Als hij maar goed begrijpt dat er met ereleden van de Electrotechnische Vereeniging, niet te schertsen valt.

Prof. Lou van der Sluis, Jongste Ereid der Electrotechnische Vereeniging

(met dank aan Godfried Bomans) 🍷

WIJ VERBINDEN MENSEN EN KENNIS

ONZE VISIE

Innovatie heeft vooruitgang gebracht: een welvarende samenleving en een competitief bedrijfsleven. Veranderende verhoudingen in de wereld en schaarste op gebieden als energie, grondstoffen, ruimte en gezondheid vragen echter om doorbraken in denken en doen. Technologische en sociale innovaties zijn daarbij noodzakelijk. Dit betekent een combinatie van alfa-, bèta- en gammatechnologie. De grenzen tussen domeinen, disciplines en landen zullen verdwijnen en maken plaats voor nationale en internationale samenwerking.

TNO beschikt over deze combinatie van technologieën en wil midden in de samenleving staan om haar kennis optimaal te kunnen toepassen voor en met de overheid en het bedrijfsleven. Onze medewerkers beschikken daartoe over de juiste mix van nieuwsgierigheid, creativiteit en idealisme.

ONZE MISSIE

TNO verbindt mensen en kennis om innovaties te creëren die de concurrentiekracht van bedrijven en het welzijn van de samenleving duurzaam versterken.

TNO innovation
for life

TNO.NL

ONZE THEMA'S

INFORMATIE- MAATSCHAPPIJ

EEN INFORMATIESTRUCTUUR WAARIN BURGERS,
BEDRIJVEN EN OVERHEID VERBONDEN ZIJN

ENERGIE

DUURZAME BESCHIKBAARHEID VAN ENERGIE

INTEGRALE VEILIGHEID

EEN VEILIGER GEVOEL VAN LEVEN

INDUSTRIËLE INNOVATIE

NIEUWE CONCURRENTIEKRACHT VOOR
DE INDUSTRIE

GEBOUWDE OMGEVING

EEN DUURZAME EN LEEFBARE STAD

MOBILITEIT

SLIMMERE MOBILITEIT

GEZOND LEVEN

GEZOND MEEDOEN IN ONZE SAMENLEVING



Link yourself to the power of TenneT

Netwerken: daar gaat het om bij TenneT. Letterlijk en figuurlijk. We zijn de eerste grensoverschrijdende elektriciteitstransporteur van Europa met 20.000 kilometer aan hoogspanningsnetwerken in Nederland en Duitsland. Onze focus is gericht op de ontwikkeling van een Noordwest-Europese energiemarkt en de integratie van duurzame energie. Tegelijkertijd staat de continuïteit

van de elektriciteitsvoorziening voorop. 24 uur per dag, 7 dagen per week. We zoeken de samenwerking met professionals die interesse hebben in een unieke uitdaging. Wil jij op hoog niveau aan de slag in je vak? Bij een bedrijf dat in meerdere opzichten netwerken verbindt? Link yourself en ga vandaag nog naar

www.werkenbijTenneT.nl

TenneT zoekt:

Ambitieuze technici en andere professionals