De Vonk

Periodical of E.T.S.V. Scintilla

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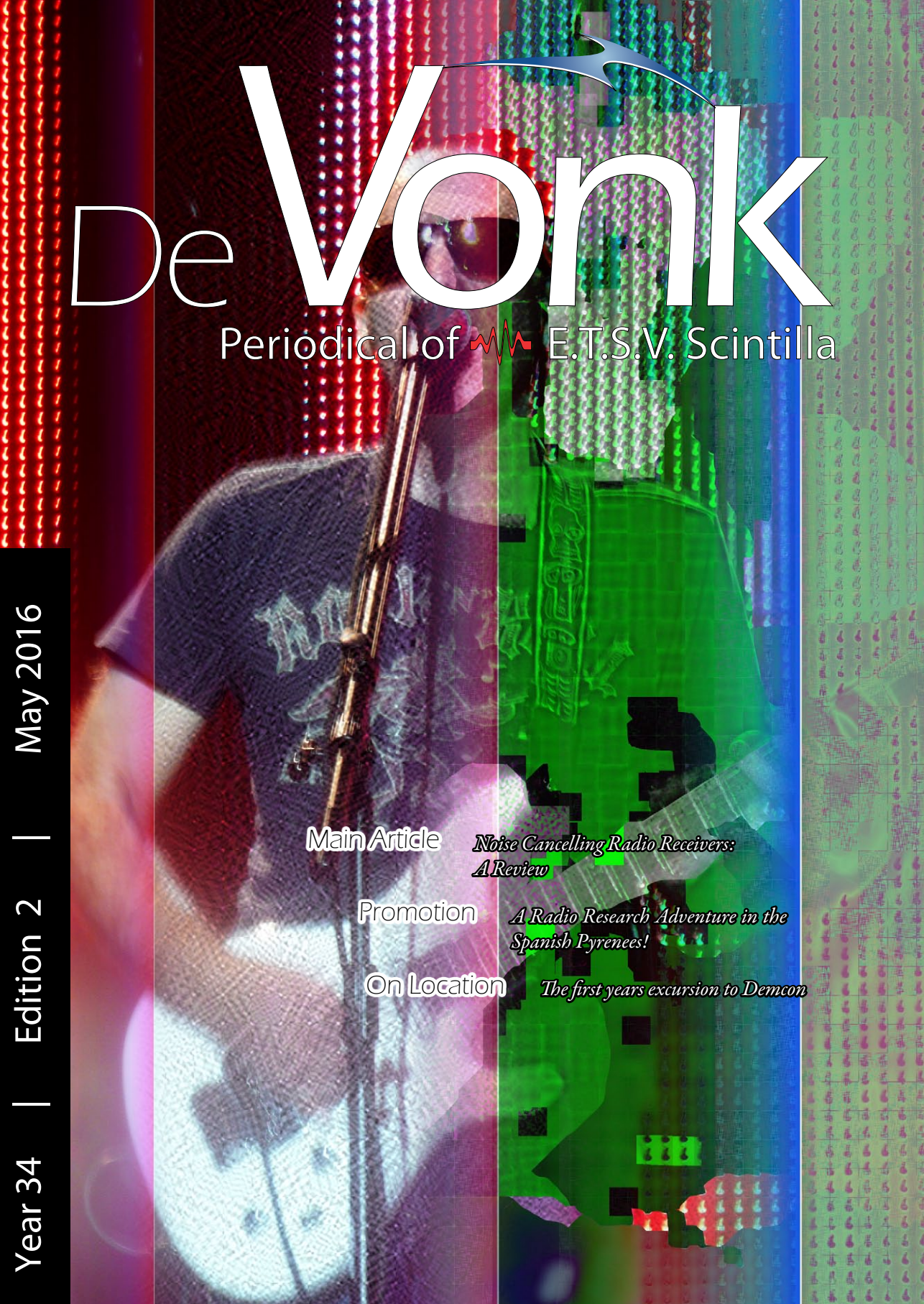

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Presidential note

Author: Shing Long Lin

The days are lasting a little bit longer again and it is nice to see the sun now and then. Even though winter has its merits, like the holidays and skiing (which you can read more about later in this Vonk!), personally I am more of a summer person. Spring not so much, since my hay fever is making my transition from winter to summer my own personal hell.

The Arab spring (nice transition huh) seems to have brought all kinds of hell with it as well. Since you probably are tired of reading about all this, I will save you the story, but all in all it seems that a lack of a good plan caused the disorganized mayhem that, for example, Syria is at this moment. So making plans seems to be an important thing. An ironic thing to say for someone who should be studying for his exams while writing this piece, but that does not make it less true. As you may know, we are currently very much in the process of forming a group of candidates for the 87th board. An enjoyable task for almost every board, since it truly is a pleasure to see the enthusiasm, in so many people, for taking care of our beloved association. Even better, I found out that multiple generations of board enthusiasts are already standing in line for a spot: a heart-warming sight for every Scintillian.

By the time you read this, my second General Assembly will have taken place a while ago. Although it is a slightly frightening sight for every but the bravest board member, this meeting is one of the prouder moments for him as well. Engaged and committed members provide their critical insight into current affairs with small talk, some feedback and a beer afterwards. A tradition which keeps the system running.

Back to the summer, my favourite season. Being outside in the sun, cooling down in the pool and one of the best parts: barbeques. I can't wait to schedule the first of the barbeques we have at Scintilla.

Planning seems to be the critical component in everything that goes right. Find a new board in time, schedule an evening for some democracy and throw a barbeque now and then to remind people how good pork on a grill tastes and there we are: not a Jihadist in Scintilla's ranks!

Dames en heren,
Op de koningin, op Scintilla!

Shing Long Lin
President

Bier Bingo
Wednesday May 18th
18:00, Educafé

Eind-P BBQ
Thursday June 2nd
16:00, O&O plein

SCALA's Zomer BBQ
Thursday June 16th
17:30, O&O Plein

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Editorial

Achterhoek

It is one of those evenings where we as committee are working on a new Vonk. Only this time it is with craft beer from the OPEL, which is a pleasant coincidence. They are still drinking beer downstairs, but we are working hard to get the next Vonk published as quickly as possible.

We just had a week off, so we get a fresh start. In the week off I finally moved to the campus. I moved to a lovely house contrary to my house before. I also went to Achterhoek in my week off so I also speak with an Achterhoeks accent right now just like every Monday. And on every Friday my accent is almost gone. In the beginning I thought that since I went to Enschede, there would be more people with an Achterhoeks accent, but I got disappointed. A lot of students think that it is weird that I do not speak 'normal' Dutch, but I think that they are wrong. And if they are right, I think it is beautiful to have an accent. So you can hear where you come from. I am proud of my Achterhoekse accent!

Lynn

news

News for the electrical engineer

SPOOKY INTERFERENCE AT A DISTANCE: MESA+ RESEARCHERS DISCOVER NEW FUNDAMENTAL QUANTUM MECHANICAL PROPERTY

Author: E. Strambini, K.S. Makarenko*, G. Abulizi, M.P. de Jong and W.G. van der Wiel,*

Geometric reduction of dynamical nonlocality in nanoscale quantum circuits, Sci. Rep. 5, 18827; doi: 10.1038/srep18827 (2015).
**These authors contributed equally to this work.*

Nanotechnologists at the University of Twente research institute MESA+ have discovered a new fundamental property of electrical currents in very small metal circuits. They show how electrons can spread out over the circuit like waves and cause interference effects at places where no electrical current is driven. The geometry of the circuit plays a key role in this so-called nonlocal effect. The interference is a direct consequence of the quantum mechanical wave character of electrons and the specific geometry of the circuit. For designers of quantum computers it is an effect to take account of. The results are published in the British journal Scientific Reports.

Interference is a common phenomenon in nature and occurs when one or more propagating waves interact coherently. Interference of sound, light or water waves is well known, but also the carriers of electrical current – electrons – can interfere. It shows that electrons need to be considered as waves as well, at least in nanoscale circuits at extremely low temperatures: a canonical example of the quantum mechanical wave-particle duality.

GOLD RING

The researchers from the University of Twente have demonstrated electron interference in a gold ring with a diameter of only 500 nanometers (a nanometer is a million times smaller than a millimeter). One side of the ring was connected to a miniature wire through which an electrical current can be driven. On the other side, the ring was connected to a wire with a voltmeter attached to it. When a current was applied, and a varying magnetic field was sent through the ring, the researchers detected electron interference at the other side of the ring, even though no net current flowed through the ring.
This shows that the electron waves can "leak" into the ring, and change the electrical properties elsewhere in the circuit, even when classically one does not expect anything to happen. Although the gold ring is diffusive (meaning that the electron mean free path is much smaller than the ring), the effect was surprisingly pronounced.

QUANTUM INFORMATION PROCESSING

The result is a direct consequence of the fact that the quantum equations of motion are nonlocal. That nature is nonlocal is also well-known from another kind of nonlocality: the counterintuitive ability of objects to instantaneously know about each other's state, even when separated by large distances. Einstein referred to it as: "spooky action at a distance". The Twente results help to further understand the first type of nonlocality, referred to as dynamical nonlocality, which plays a key role in all quantum interference experiments. It is very well known that quantum interference is affected by decoherence (where the physical environment causes loss of phase memory), and by performing a "which-path-measurement" (removing the dynamical nonlocality and hence destroying the interference pattern). Now the researchers from the University of Twente have discovered a new way to affect the dynamical nonlocality. Namely the geometry of the circuit. Understanding this fundamental effect is important for future quantum information processing. For example when creating a quantum computer.

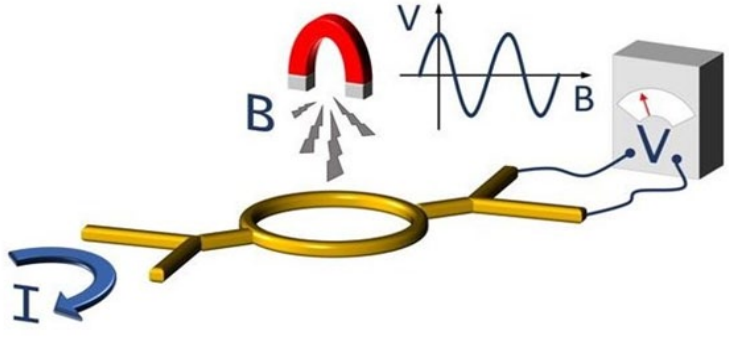
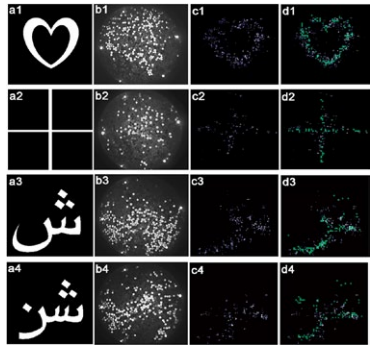


Figure: Schematic representation of the nonlocal electron interference experiment. A dc current is driven from the upper left to the lower left contact. A nonlocal, oscillating voltage is measured between the upper and lower right contacts due the magnetic-field induced single-electron interference in the 500 nanometer ring in the middle.



Acoustic tweezer

Author: Editorial Team

A research group at the university of Pennsylvania State Univeristy has developed an Acoustic tweezer setup for moving living cells. In contrast with optical tweezers which use a singnificant amount of power and can damage living cells, acoustic tweezers can move cells without damaging or marking then. Another advantage is that accoustic tweezers can be fabricated on a microfluidic chip using simple piezoelectric transducers. This allows for intergration in common lab-on-a-chip setups. The setup can also be directly tuned during operation, which allows very high accuracy to be attained. The accoustic tweezers work by generating a 3d trapping node using two superimposed orthogonal standing accoustic waves.

Source: http://tinyurl.com/vonk3421

Random fiber imaging

Author: Editorial Team

At the MIT Media Lab, researchers have developed an imaging device that consists of loose optical fiber, without any lenses or protective housing.

By connecting one end of the fiber to a set of photodetectors, the other end can remain free. This free end can then be placed in difficutlt to reach places. The individual position of the fibers don't need to correspond to the location of the photodetectors. By using a time of flight measurement the system can determine the fibers relative location. This location information can then be used to create an image of the environment on the other side of the bundle. The resolution of the system is limited by the number of fibers, so while the prototype has only 33 by 33 pixels, with 300 um fibers, the resolution could be greatly improved by using state of the art optical fibers. Another option to improve the resolution of the image would be to intergrate the fiber bundle into an interferometer, which would yield a lot more information about the environment.

Source: http://tinyurl.com/vonk3422

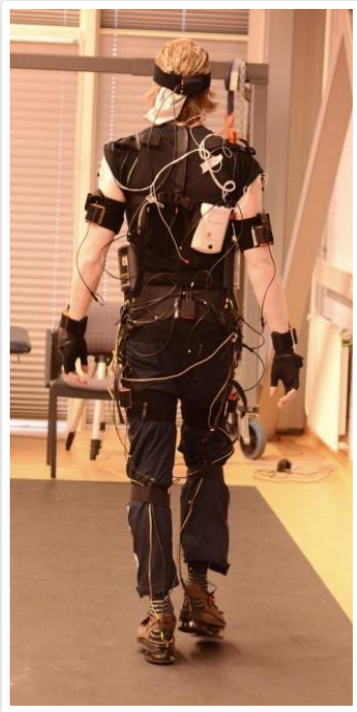
The EU project INTERACTION

Author: Peter Veltink, BSS, University of Twente

Rehabilitation of people who suffered a stroke is directed to learning them to optimize their daily-life functioning, given their disabilities. Their abilities to control their body movements is an essential function in this respect. People who suffered a stroke have affected movement control in one half of their body. In most cases, their ability to control body movements improves partly in the period after stroke. The rehabilitation therapy they obtain has the objective to learn them how they can use their affected arm and hand optimally in combination with their healthy arm and how they can safely and functionally ambulate given their remaining disabilities.

When these people return home after their clinical rehabilitation period, no information about their daily-life functioning is available to the clinicians anymore. If this information would be available to clinicians, they could continue to advise the stroke people when and wherever necessary. Also, automatic coaching by intelligent on-body systems would be feasible. This requires that the quality of body movement can be sensed and evaluated on-body during daily-life.

The goal of the EU INTERACTION project was therefore to measure and evaluate the quality of body movement during daily-life of people who had a stroke and to make this information available to clinicians on a distance. For this purpose, clinically-relevant metrics were developed in collaboration with clinicians to quantify the quality of arm function and gait during daily-life.
The technical partners in the INTERACTION projects subsequently developed a sensing system integrated in clothing (smart textiles) and telemonitoring facilities. The experimental tests during daily-life functioning of people who had a stroke indicated that their daily-life movements differed in essential aspects from how they were trained during rehabilitation. These modified movement patterns were often non-optimal and even potentially dangerous. Safety may, for example, be impeded if



they do not lift their affected leg adequately during gait. It also appeared that the deviations in the daily-life movement patterns were different between people, and therefore would require personal advise. The supports that continued monitoring and training of arm and ambulation functions during daily-life by on-body sensing and coaching technology is important to ensure optimal motor function of these stroke survivors during daily-life.

The EU project INTERACTION was performed by six partners in the Netherlands, Italy and Switzerland. This team included two university technology groups (University of Twente, University of Pisa), two clinical groups (Roessingh Research and Development in Enschede and Neurological clinic of the University of Zurich), and two companies (Xsens Technologies in Enschede and Smartex in Pisa). The project was coordinated by Prof. Veltink of the University of Twente. This research is currently continued in the framework of the new STW Perspectief program neuroCIMT.

Research in transmit-reference systems

Author:Ibrahim Bilal, TE, University of Twente

The numbers of wireless devices have expanded exponentially in the past decade. It is predicted that in the year 2020, we will have a thousand wireless devices serving each person. The energy consumed by these communication devices will be substantial. In particular, this poses a significant problem for wireless sensor networks (WSNs) deployed in remote harsh environments, whose batteries cannot be easily replaced. Therefore, envisioning such a future necessitates research in both power and bandwidth-efficient communication schemes.

At the group of Telecommunication Engineering, researchers are investigating Transmit Reference (TR) – a new kind of low-power communication scheme which can be a potential candidate for the WSNs targeting low date-rate applications such as weather and natural disaster monitoring. TR is a wideband spread spectrum communication scheme in which the transmitter sends the spreading signal along with the spreading information signal. At the receiver, detection is based on a simple self-correlation operation without the complex equalization and lengthy synchronization process. This results in a highly simplified receiver, thus reducing the costs of both circuitry and power.

To investigate scalability of a TR system, bachelor student Bertold Ian Bitachon did his assignment in the group. He investigated multiple-access (MA) scenarios and the near-far problem associated with it. Analytical results were derived which showed that in a MA scenario, interference from simultaneous links critically impacts system performance. At the network layer, careful power adaptations and time-allocation for the transmitting nodes is required. The research was materialized in the form of a conference paper, which was accepted at the IEEE Symposium on Communications and Vehicular Technology in the Benelux (IEEE SCVT 2015). The paper was presented by Bertold at the University of Luxembourg in November 2015.

Green Energy

Author: Editorial Team

A team led by William Chueh and Nicholas Melosh of the Stanford material science and engineering group, have made a discovery to allow solar power to provide storable and green energy, by using metal oxides.
Using solar cells to create hydrogen is a way to store solar power. One can then use the hydrogen to power fuel cells to power the grid at night. It has been shown that metal oxides are less efficient at converting photons to electricity, however the research group has shown that metal oxide photovoltaic cells become more efficient at converting water into hydrogen and oxygen as they become warmer, the exact opposite of silicon based solar cells.
This would mean that a cheap, readily available material would be perfect to use for splitting water, when they are used at high temperatures. The current experiments have been performed on Bismuth vanadium oxide, titanium oxide and iron oxide. Especially the last material is commonly available, as rust.
This discovery can refocus research attention on metal oxides as a cost effective alternative to silicon solar cells.

Noise Cancelling Radio Receivers: A Review

Author: Eric Klumperink
Bram Nauta
ICD group

Traditional radio receivers are narrowband and dedicated to a single frequency band, while relying on LC-tanks. In contrast, Software Defined Radios target a flexibly programmable frequency. The broadband Noise Cancelling circuit technique, discovered and developed in Twente, has proven useful to achieve this target, as it breaks the traditional trade-off between low noise and broadband impedance matching. Different variants exist, with noise cancellation in the voltage or current domain, either at RF or after frequency translation to baseband. This article reviews the noise cancelling technique and its increasing role in inductorless interference robust software defined radio receivers.

Introduction

The term Radio is traditionally associated with "broadcast radio" in the well-known AM and FM radio bands. However, radio frequency (RF) communication is now predominantly used for other wireless communication applications. Especially the growth in the number of mobile devices like smartphones, laptops and tablets has led to huge wireless data streams, especially for internet access and more recently Cloud services. It is well known that this wireless revolution has been enabled by Moore's Law which provides ever more computing power on affordable CMOS chips, making smartphones true computer platforms. What is perhaps less known, is that changes in radio architecture have also fuelled the wireless consumer chip revolution, enabling fully integrated CMOS radio transceivers. To understand how fundamental this change in architecture is, it is illustrative to compare a traditional super-heterodyne radio receiver, with a modern CMOS radio receiver, as shown in Figure 1.

As one might suspect, one difference is that radio waves are no longer converted to analog sound, but rather to digital bits. However, not only the final output is digital, but also a lot of the radio signal processing that realizes radio channel selectivity and demodulation. Actually, it has been proposed to convert the antenna signal directly to digital to realize a true "Software Radio" [1]. This is attractive as it allows for ultimate flexibility and fits to Moore's law that makes ever more digital processing possible. Unfor-

"The changes in radio architecture have also fuelled the wireless consumer chip revolution, enabling fully integrated CMOS radio transceivers."

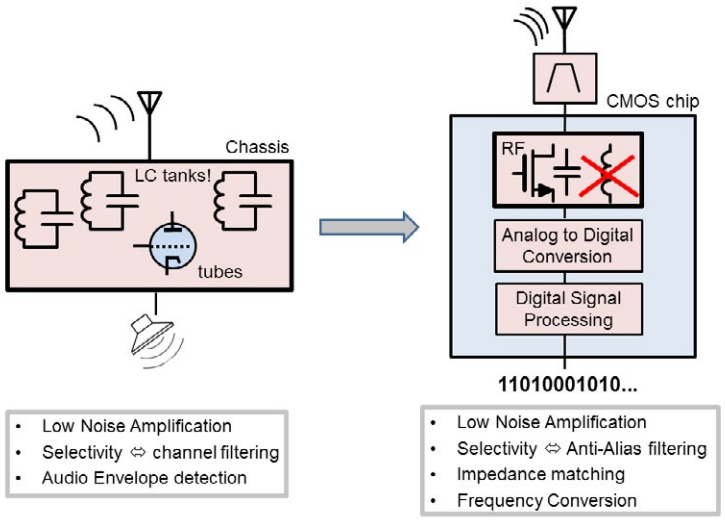


Figure 1: Comparison of a a traditional super-heterodyne radio receiver with a modern CMOS variant.

tunately, for most applications this puts unrealistic demands on the analog to digital converter. As RF signals can easily vary from well below $1\mu V_{rms}$ to almost 1V, i.e. a very high dynamic range is needed, namely 10^6 in voltage and 10^{12} in power (120dB!). As each extra bit in an ADC allows for about 6dB extra Signal-to-Noise ratio, around 20bits resolution would be required! This is (just) feasible to digitize audio frequencies, but not at sample rates of 12GS/s, that would be needed for Nyquist sampling of all the frequency bands up to 6GHz. Such A/D converters are still far from feasible

> "It is this low noise amplification combined with frequency selectivity that is the core functionality of a radio receiver."

and if feasible would require hundreds of Watts [1]. Hence a modern CMOS radio receiver down-converts the RF signal to baseband, where A/D conversion is feasible and power efficient. As antenna signals can be very weak, amplification with very low noise is clearly wanted before A/D conversion. Furthermore, anti-alias filtering is crucial to avoid strong out-of-band signals to alias on top of the wanted signal and overwhelm it. It is this low noise amplification combined with frequency selectivity that is the core functionality of a radio receiver. In the super-heterodyne receiver this selectivity is realized by extensive use of LC-tanks or other resonators. An LC tank with high quality factor Q operating close to its resonance frequency behaves like a very selective band-pass filter. High Q LC-tanks also have low loss and hardly add noise. This has made the super-heterodyne receiver the architecture of choice for most of the last century, and it still is used in many applications. However, if low cost is crucial and full integration on a CMOS chip is wanted, then other solutions are needed. One reason is the poor quality factor of inductor coils in the low GHz range, due to the high metal resistance of thin metal layers in CMOS technologies. Moreover, a single coil may take as much chip area as a complete microprocessor core! Hence, inductor-less radio architectures as alternative for the super-heterodyne radio receiver have been pursued during the last decades.

Fully integrated CMOS radios now usually rely on a homodyne architecture, which directly down-converts the RF-signal to baseband, around 0 Hz ("zero-IF" architecture). At baseband, simple low-pass filtering can now be used for anti-alias filtering, while high dynamic range A/D conversion is feasible at 10-100 mW power level. However, a very challenging RF front-end design problem remains: how to realize low noise amplification and frequency conversion with high dynamic range, to cope with strong interferers ("blockers"), without using on-chip inductors. Most mobile phones still rely on external RF band-filters, often realized exploiting Surface Acoustic Waves ("SAW filters"). However, attempts are made to realize SAW-less receivers, to reduce both the cost and size of external components. Moreover, for dynamic spectrum access with cognitive or software define radios, more flexibility is wanted. Fixed frequency filters limit the flexibility and hence new radio receiver architectures are being explored. Their goal is increased flexibility in receive frequency realized without relying on inductors. This article will review radio receiver architecture innovations that exploit noise cancellation, a technique allowing for broadband impedance matching without paying a noise penalty. This noise cancelling technique

> "However, if low cost is crucial and full integration on a CMOS chip is wanted, then other solutions are needed."

was originally discovered [2] and improved [3, 4] in the IC Design group at the University of Twente and developed further by many other research groups and companies. Especially after the publication in [4], this technique has received many citations (see for instance http://scholar.google.nl and search for "Eric Klumperink" or "Bram Nauta")

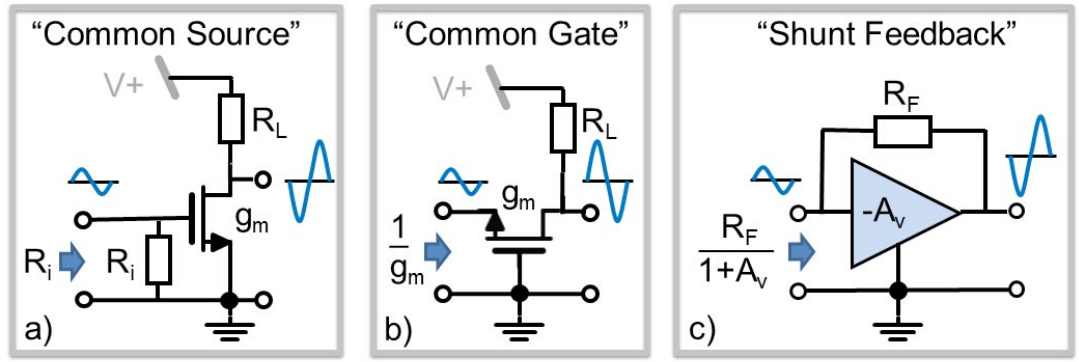


Figure 2: (a) Common source circuit, (b) common gate circuit, (c) amplifier with shunt feedback.

and is now included in RF textbooks [5]. A recent publication [6] clearly demonstrates its impact on integration in CMOS: only 0.42 mm^2 chip area is needed in 40nm CMOS to realize 7 inductor-less noise cancelling receivers.

> "Fixed frequency filters limit the flexibility and hence new radio receiver architectures are being explored."

This chip, produced by MediaTek, supports triple-mode and six-band TDD cellular bands in a modern phone. In the next section we will first briefly review classical inductor-less broadband radio receiver techniques and then introduce the noise cancellation technique and some of its later variants like frequency translated noise cancellation.

Classical Broadband Receiver Techniques

If we decide not to use inductors and essentially realize a wideband receiver, the classical solution is a broadband Low Noise Amplifier (LNA) followed by a mixer for frequency conversion, driven by a Local Oscillator (LO). Passive hard switching mixers (e.g. diode mixers or MOSFET switches) are preferred for their linearity and high dynamic range, but introduce conversion loss and high noise figure due to losses and noise folding. A preceding LNA hence realizes low noise pre-amplification, while also isolating the mixer from the antenna to suppress LO-radiation. Moreover, it realizes impedance matching to terminate an (external) filter or transmission line from the antenna with a "matching resistance", to avoid reflections and standing wave phenomena. Usually this matching resistance is 50ohm for commonly used antennas, SAW-filters and RF measurement equipment.

To understand the broadband LNA design problem better, it is illustrative to have a look at Figure 2 with 3 well-known text-book amplifier configurations. These are the main classical broadband LNA solutions realizing impedance matching and low noise amplification. The circuit in Figure 2a is known as "Common Source" stage, as the source terminal of the MOSFET (arrow side) is grounded and shared by the input and output port. The MOSFET realizes V-I conversion from gate-voltage to drain-current with transconductance g_m, while resistor R_L realizes I-V conversion, so that the voltage gain is $-g_mR_L$. For impedance matching to 50ohm, a resistor R_i of 50Ω is added. As this resistance generates the same amount of thermal noise as the noise available from a 50ohm antenna, noise power is doubled and hence Signal to Noise ratio is degraded by 3dB, so that the theoretical minimum noise figure is 3dB. This 3dB hence often serves as baseline to judge whether noise figure is labelled good or bad. The MOSFET and R_L exacerbate noise, so that typically a Noise Figure of 5-6dB results. The popular "Common Gate" circuit in Figure 2b is slightly better, as it needs less components that add noise: it reuses the same MOSFET not only to realize V-I conversion (gm) but also input impedance matching ($=1/g_m$). Now we get a non-inverting voltage gain g_mR_L, at somewhat lower noise figure, e.g. about 4dB.

> "Although 1 dB extra noise might at first sight not seem much to worry about, maintaining link budget would require about 26% extra transmit power."

These noise figure values compare poorly to the 1-2dB achieved with inductor

based LNAs used in early generations of mobile phones. To compete with such noise performance, we would like inductorless receivers to achieve a noise figure well below 3dB for good connectivity. Although 1 dB extra noise might at first sight not seem much to worry about, maintaining link budget would require about 26% extra transmit power, which is a lot if the transmit power is already at >1 Watt level!

To achieve <3dB Noise Figure, a classical solution is the "shunt-feedback" stage (Figure 2c). The input impedance is lowered by negative feedback, so that, seen at the input, shunt resistance R_F gets divided by a factor $(1+A_v)$ ("Miller effect"). As R_F can now be much higher than 50ohm so that it has much lower current noise than a 50ohm resistor, <3dB Noise Figure can now be achieved. However, at GHz frequencies it is difficult to realize enough gain, while at low loop gain negative feedback loses many of its benefits. More problematically, multi-stage amplifiers have stability issues, which are exacerbated by the fact that the antenna impedance may vary significantly over frequency. In contrast, noise cancelling is an feed-forward technique and hence doesn't have such stability risks.

> "At GHz frequencies it is difficult to realize enough gain, while at low loop gain negative feedback loses many of its benefits."

Noise Cancellation

We will now introduce a circuit in which noise is cancelled, but signal is not. Figure 3 shows one of the simplest Noise Cancelling LNA implementations, consisting of a parallel operating Common Gate and Common Source stage with equal gains. This doubles the overall gain and produces a balanced differential output from a single-ended (non-balanced) input. The signal coming from an antenna or other signal source is modelled as a voltage source with series resistance R_s, usually 50ohm. Bias voltages and a bias current block ensure transistors operate in the right operating region to realize a transconductance gm (indicated in grey in figures, but not further discussed here for simplicity). The Common Gate stage realizes impedance matching and non-inverting voltage gain (see Figure 2b). The Common Source amplifier senses the input voltage and produces an inverting amplification (see Figure 2a) designed to have the same gain. The noise cancellation property is illustrated in Figure 3b. The noise current of the Common Gate transistor i_n flows through both R_L and R_S, producing two fully correlated opposite polarity voltages on its input (R_s) and output (R_L). The Common source stage senses the input voltage and amplifies it with the same, but inverting gain. Overall two fully correlated common mode noise voltages result, which cancel at the differential output.

> "In essence this technique decouples noise and input impedance matching so that broadband resistive impedance matching is realized, without paying a price in term of noise figure."

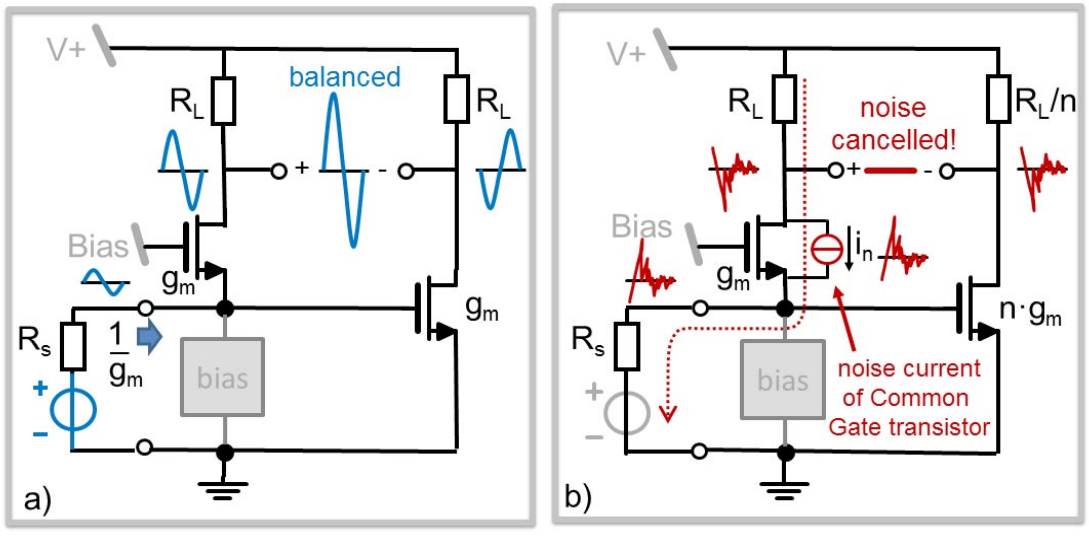


Figure 3: Single-end signal source producing two anti-phase output signals

Note that the single-end signal source in Figure 3a produces two anti-phase output signals that add to each other if the output is sensed differentially by the next circuit. In this way, a single ended input to a filter or antenna is supported, while a differential output signal results, i.e. on chip single-to-differential conversion or "balancing" is realized ("BALUN" functionality). Hence, no external BALUN is needed, which would otherwise introduce 1-2dB signal loss, directly adding to the noise figure. Moreover, the distortion of the Common Gate matching transistor, which can be modelled as a parallel current source, is also cancelled just as the noise. Hence simultaneous balancing, noise cancelling and distortion cancellation is achieved. In essence this technique decouples noise and input impedance matching so that broadband resistive impedance matching is realized, without paying a price in term of noise figure. Note however, that only the noise and distortion of the Common Gate matching device is cancelled. It is critical that the common source stage is low noise and very linear, as it will now dominate noise and distortion [7]. Fortunately, the transconductance of the Common Source transistor can be increased without affecting the matching resistance. Hence, the Common Source stage is usually scaled up in transconductance to n^*g_m, while its load resistance is lowered to R_L/n to maintain equal gain for the two parallel stages [7].

Various Topologies

Several variants of the noise cancellation receivers have been proposed over time. Figure 4 shows a few, along with the general concept in Figure 4a with block "Z-match" that matches its input impedance to R_s of the antenna or input signal source. The noise of this matching device generates a noise voltage across source resistance R_s, which is sensed together with the input signal by the upper signal path to the output. The lower signal path to the output also senses both the noise and signal, but does this at another terminal of the matching device. Note that in all cases: 1) there are two fully correlated noise contributions, both originating from the same matching device, that cancel at the output; 2) the wanted signal is injected in another way than the noise of the matching device, so that signal contributions add, while noise cancels. As indicated by the blocks with question marks, there are many different ways to implement the signal processing blocks to the output. This is not only because different circuit implementations exist, but also because the output can be in the voltage or current domain, at the same frequency or at another frequency (see the next section on frequency translated noise cancelation). A few implementations will be discussed briefly below.

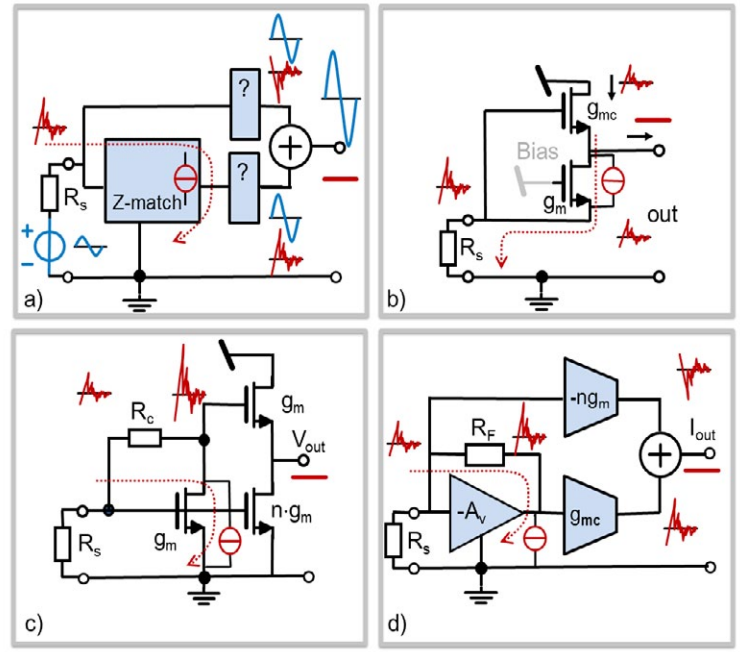


Figure 4: Some variants of the noise cancellation receivers.

Figure 4b shows a simple 2-transistor implementation of the originally discovered noise cancellation circuit topology (see [2], page 162). It resulted from systematic generation of all possible circuit topologies exploiting two transconductance devices, based on graph theory [2, 3]. The lower transistor acts as a Common Gate device for input impedance matching, while the upper transistor senses and cancels the noise via transconductance g_{mc}. Although this circuit has some attractive properties like a gain independent noise figure and high linearity at low power consumption [3], it does NOT have a noise figure lower than 3dB. This is because the upper transistor needs to have $g_{mc}=g_m$ to cancel the noise of the matching device. Unfortunately, for this "equal g_m" condition, the upper device adds about the same noise than a Common Gate stage would without noise cancelling. Hence

main article

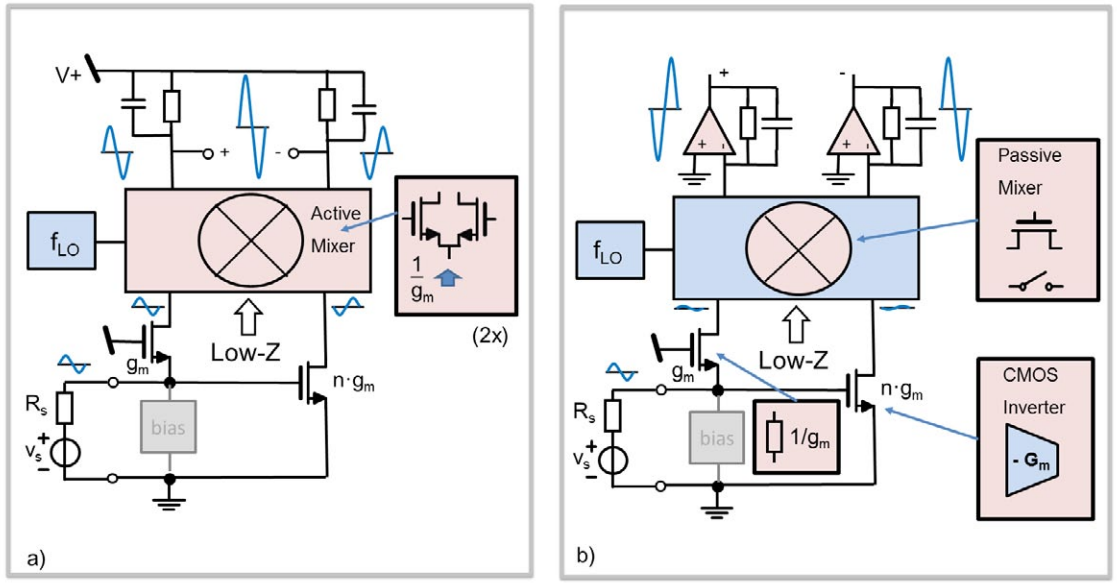


Figure 5: The first published frequency translational noise cancelling receiver

an extra degree of freedom is wanted to allow for scaling up the auxiliary noise cancelling path.

The circuit in Figure 4c offers this extra degree of freedom, and was the first

> "This can have significant benefits for linearity and blocker handling, especially when this is combined with high linearity current mixers and frequency translated filtering."

achieving a noise figure below 3dB [4] (first published at the conference ISSCC 2002, where it was awarded the "Van Vessem" best paper award). Actually broadband noise figure <2dB was achieved from 250MHz to 1GHz, competitive to narrowband LC-based receivers. Here a common source amplifier with unity current feedback via resistor R_c realizes an input impedance of $1/g_m=R_s$, while also realizing a voltage gain $1-g_mR_c$. Note that this is direct local feedback across one transconductor gm without stability risks, in contrast to the shunt feedback over a voltage amplifier in Figure 2c. The transistor with transconductance n^*g_m senses the noise at the input and cancels the noise coming via the upper signal path if $R_c=(n-1)R_s$ [4]. Due to the voltage gain in the matching stage and due to the scaled up sensing transistor, noise figure can now be lowered to well below 3dB, albeit at the cost of extra power consumption (bias current is also n times higher). One might wonder what happens with noise figure if the antenna impedance varies, i.e. cancellation is no longer perfect. It can be shown that ±20% variation in antenna impedance only raises NF from 1.8dB to 2dB [4].

As a last example consider the circuit in Figure 4d, which is used in a commercial MediaTek chip containing 7 noise cancelling LNAs [6]. Again an impedance matching stage is used with two paths to the output, but now the addition is done in the current domain. Overall we realize now low noise V-I conversion, i.e. a Low Noise Transconductance Amplifier. This can have significant benefits for linearity and blocker handling, especially when this is combined with high linearity current mixers and frequency translated filtering as will be discussed next.

Frequency Translated Noise Cancellation

Although the noise cancelling LNAs with voltage gain have many attractive properties, there are also challenges, especially if we need to handle strong blockers up to 0dBm (1mW) power, as required for out-of-band blockers for GSM and 2G-3G-4G standards. This 1mW in 50ohm corresponds to a peak-to-peak voltage of about 600mV, which is a significant voltage swing for a CMOS chip operating at a standard 1Volt voltage supply for device reliability reasons. Note that even a very low voltage amplification of 2x (6dB) would already hard-clip the output of a voltage amplifier to the 1 Volt supply! Another problem occurs when we aim to realize high bandwidth in the presence of significant capacitive loading at the output. It is then critical to use low resistance levels as bandwidth is inversely proportional to the RC time-constant. As a solutions, we proposed to avoid voltage gain at RF, and move it to baseband, as done in the BLIXER (Balun-LNA-mIXER) circuit shown in Figure 5a [8]. Here a current domain mixer is inserted between the transistor core of Figure 3 and the Resistive load. Now at RF only V-I conversion takes place, followed by a frequency down-conversion mixer and then I-V conversion in baseband. The noise cancelling still occurs, but now after frequency translation. Later this has been named "frequency translated noise cancelling" [9]. As the gain is now realized in baseband instead of RF, load capacitance that would traditionally limit the (RF-)bandwidth of the I-V conversion, is no longer a problem. Actually, we want a large capacitance at the output, to suppress strong out-of-band blockers by low-pass filtering. After sufficient attenuation of the strongest blockers by filtering, we can then allow for extra (baseband) gain and further low-pass filtering without clipping to the low supply voltage. In a zero-IF receiver with ADC, the low-pass filtering provides anti-alias filtering and relaxes ADC dynamic range and sampling rate requirements. If we prefer to realize most of the channel selectivity before the ADC, this is also feasible by adding extra OPAMP-RC filter stages. Note that this is not possible at RF, as the required Q for a band-pass filter with center frequency f_{center} and -3dB bandwidth BW is f_{center}/BW. Even for a wideband radio standard like WCDMA with 20MHz bandwidth around 2GHz center frequency, a Q of 100 would be required, which is infeasible (inductor Q values are typically <15 for on chip inductors at a few GHz).

Figure 5a shows the first published frequency translational noise cancelling receiver [8], which can easily be extended to an I/Q zero-IF receiver, exploiting two mixers and LO-signals with 25% duty cycle [8] (not shown for simplicity). In this BLIXER topology, the mixers were realized as active mixers, like in the well-known Gilbert Mixer [5]. Due to the low input impedance, the signal swing at the RF side of the mixer is low and the RF bandwidth can be extended to beyond 10GHz in 65nm, without using inductors [8]. The mixer core is realized as a differential pair driven at the gate by steep square-wave signals at the LO-frequency fLO. Note that such square-wave signals are nicely compatible with digital generation, allowing for flexibly programmable digital frequency synthesizers compatible with software defined radio.

> "We have improved interference robustness of a receiver by realizing a Low Noise Transconductance Amplification instead of the traditional voltage amplifying Low Noise Amplifier."

We have now relaxed a bandwidth problem, but perhaps even more importantly, we have improved interference robustness of a receiver by realizing a Low Noise Transconductance Amplification ("LNTA") instead of the traditional voltage amplifying Low Noise Amplifier (LNA). A key reason why moving to the current domain helps, is the limited voltage swing that is available on a CMOS chip with a standard supply voltage of about 1Volt. As there is no hard limit on current, we can cope with strong interferers in the current domain. The key to interference robustness is threefold [10]: 1) a high linearity LNTA followed by 2) high linearity current mixing and 3) simultaneous channel filtering and I-V conversion in baseband.

Improving Interference Robustness

As shown in [9], the Frequency Translated Noise Cancellation concept can be taken a few steps further in terms of interference robustness by the steps illustrated in Figure 5b. Passive MOSFET mixers exploiting MOSFETs as switches are known for their excellent linearity and low frequency 1/f noise [5,[9-11], [8] and are hence preferred over active mixers for zero-IF receivers. By using OPAMP-RC transimpedance amplifiers at baseband, a virtual ground node is created at the OPAMP input, which is a convenient very low-ohmic current-summing point. As a result, the common gate stage can now be replaced by a simple 50ohm resistor that combines impedance matching with very high linearity V-I conversion of the RF-voltage to current. To realize noise cancelling of the noise of the resistor, an auxiliary noise sensing and cancelling path is needed. Both the noise and the linearity of this V-I converter is now crucial for the overall achievable dynamic range. CMOS inverters can be used as linear V-I converters [12] and can achieve low noise figure in a power efficient way. They have favorable class-AB large signal behavior which avoids hard-clipping and renders very high Signal to Noise Ratio Normalized to Power Consumption, not far from the theoretical maximum of 165dB [13]. This is because both the N- and PMOS transistor in an inverter contribute useful transconductance, while sharing one bias current. When designed carefully for high linearity, exploiting "derivative superposition" high IIP3 values above 10dBm are possible [9, 10]. However, this high linearity is sensitive to Process, Voltage and Temperature variations, and calibration is likely needed to gua-

rantee such high linearity over different operating conditions.

Conclusion

This article has reviewed the noise cancelling technique discovered and developed in Twente, and its impact on fully integrated software defined radio receivers to realize low noise figure and high interference robustness. In essence, the noise cancellation technique allows for wideband impedance matching without a noise penalty, as the noise of the matching device is cancelled. This allows for noise figures well below 3dB without using any costly and inflexible inductors. Simultaneous balancing, noise cancellation and distortion cancellation is also possible. Different implementations exist with cancelling in the voltage or current domain, either at the RF frequency or after frequency translation to baseband. When the cancellation is implemented in the current domain very high signal swings can be handled without voltage clipping to the low standard voltage supply of nanometer CMOS processes. When combined with a highly linear passive current mixer, interference robustness can be improved further by moving the I-V conversion to baseband, where it can be combined with channel filtering. Overall, this enables compact software defined multi-band terminals realizable at low cost.

> "This allows for noise figures well below 3dB without using any costly and inflexible inductors."

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Advertorial: Witteveen + Bos

Author: Gert Bonestroo, Okke Sanderink

Gert Bonestroo MSc: Electrical Engineering and ICT

Gert Bonestroo is a project engineer within the field of electrical engineering and ICT at Witteveen+Bos. He obtained his MSc in Electrical Engineering from the University of Twente in the year 2012. Since 2013 he is employed at Witteveen+Bos in the city of Deventer.

As a student

To obtain his MSc in Electrical Engineering Gert took the longest (and in his opinion most beautiful) route which one could think of. Before he went to the higher general secondary education (HAVO) he achieved a diploma in ICT at the intermediate vocational education (MBO).

After finishing high school and also electrical engineering at a higher vocational education (HBO) he still felt unsatisfied to start working at a company, so he decided to start studying electrical engineering at an academic level at the University of Twente. During his study he also married his wife and moved to a nice and cosy town called Enter. In this period, his wife gave birth to their first children. Also because of the delay in his study, he started working as a student at Thales in Hengelo. After obtaining his MSc degree from the University of Twente, Gert left Thales and started working at Imotec.

> "He needed a challenge in a working environment with a broad focus on multidisciplinary projects."

After Graduation

During both his study and his work at Thales and Imotec Gert discovered that he required a broader perspective within the field of (electrical) engineering. Until that moment his tasks were very specific and highly focused on technological improvements. Though, he needed a challenge in a working environment with a broad focus on multidisciplinary projects and a strong top-down approach. He started looking for such a job and encountered a vacancy on the Internet entitled "Project engineer in electrical engineering and ICT" at Witteveen+Bos. After reading this vacancy he encountered a clear match between him and Witteveen+Bos and wrote his application.

Working at Witteveen+Bos

Gert works within the group of Electrical Engineering & ICT Infrastructure. Within this group projects are carried out for infrastructural objects, like movable bridges, locks and tunnels. One of the aspects the group is focused on is the control systems of these objects. Gert's work within projects stretches from the very beginning of a project until the final end of it. For example, preliminary-designs are made in the group, but also guidance of the contractor is part of the

work.
In the first year Gert was working at Witteveen+Bos he was asked to guide the contractor on building multiple sewage pumping stations for the municipality of Hardenberg. Gert enjoyed this project very much, also for understanding that communication skills are very important when working with other parties, like contractors and the government.
Gert was also involved in the realisation of the Spoorzone Delft, which is a project by ProRail. Whether you like working in the earlier phases of projects (making designs) or later phases (guiding, testing), Gert experiences the possibilities are endless at Witteveen+Bos. It adds even up when you combine all these phases: a broad technical job!

Okke Sanderink Ir: Mechanical Engineer

Okke Sanderink is a mechanical engineer at Witteveen+Bos. He obtained his MSc in Mechanical engineering at the University of Twente in the year 2012. Since 2013 he is employed at Witteveen+Bos at the office in Utrecht.

As a student

During his study with a specialisation in Engineering Fluid Dynamics, Okke mainly focussed on his courses and other assignments and of course enjoyed being a student. He did not really spend a lot of energy in orientating on the labour market. For his Master thesis he intentionally chose to do a research thesis on the university. Okke wanted to experience what it was like to do scientific research. In fact he already knew he wanted to work for a commercial company after his graduation, but because of this he chose to do research first. Okke liked the scientific profundity, but realised that he also wanted to develop other skills.

After graduation

For Okke the great thing about studying mechanical engineering at the UT was that he could apply the newly gained knowledge directly in projects. He always enjoyed the well known projects A, B, C, R, T and F, mainly because you strive to reach a solution as a team. This finally resulted in his application at Witteveen+Bos. Engineering and consultancy companies also work on projects and they do this in multidisciplinary teams. Multiple disciplines need to be combined to find the optimal solution. At that time, Witteveen+Bos had a job opportunity as mechanical engineer that catched his attention.

Working at Witteveen+Bos

Okke graduated in fluid dynamics, which is also exactly the main focus in his job. Okke works on projects like turbines and pumps. In the projects he has recently worked on, these turbines are part of several types of civil constructions. Okke's role is to provide these constructions with direction and propulsion, which requires both civil and electrical engineering. He is not only working on pumps, but also on the stiffness and strength of constructions like railway overhead power cables, coverings and steel constructions on bridges. Okke experiences that at Witteveen+Bos you are not only working on the technical aspects, you also cooperate with different colleagues and external stakeholders. Interfaces and initial concepts need to be tuned, which results in a dynamic and challenging job.

In the projects Okke works on at the moment, he cooperates with several colleagues like electrical and structural engineers. This facilitates a broad development of Okke's knowledge as well as of his personal skills, which is exactly what Okke desires for in a job. And because Okke works on multiple projects at the same time, this development is going even faster.

> "At Witteveen+Bos you are not only working on the technical aspects, you also cooperate with different colleagues and external stakeholders."

Working at Witteveen+Bos means working in an organisation with a flat structure. The doors of the offices are literally always open to invite employees to interact and to discuss the challenges they are facing. This stimulates sharing knowledge. Because the employees see each other as equals, the culture is informal. Okke hopes to further develop himself within the company so he can be involved more and more in socially relevant projects. He feels lucky that he is given the opportunity to chose his own path within the company.

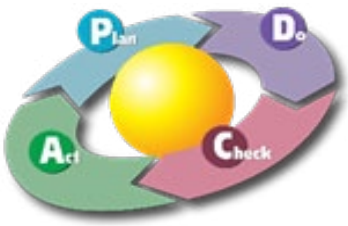
Infinite evaluations

Author: Niels Leijen

After getting yet another evaluation form either by email or via the old analog way. One might wonder: why are there so infinitely many evaluations during the study and what happens with these things? Are they used at all or do they just end up in a dusty old drawer?

In the university, different methods are used in order to teach the students the necessary knowledge that one needs to have in order to finish their studies and become a working member of society and do some amazing discoveries along the way. There is the old, and by some loved, lectures. Furthermore projects are being used in order to master the subject or to extend your knowledge, and of course PBLs with presentations, just to name some.

Before any subject that uses any kind of these methods, first some preparations have to be made. After that, it has to be taught and finally it has to be evaluated and, if possible or necessary, improved. This cycle of planning, teaching, evaluating and improving is often called the PDCA (Plan, Do, Check, Action) model.



In the past it sometimes happened that the Planning, Doing, and Checking went as it should. However the Acting/improving of the subject was often forgotten. This does not have to mean that a subject degrades by not acting on any of the feedback received, but it does mean that it does not improves as well. This caused that subjects that went smoothly did not continue going smoothly, but also that the subjects that were going a little less smoothly kept causing the same problems each time.

> "Why are there so infinitely many evaluations during the study and what happens with these things?"

Currently the evaluations held by the OKC (Education Quality Committee), Evasys and the NSE (see "types of evaluations" for more clarification) are taken more seriously. Every single one of them is discussed in the meetings of the OLC* (education committee) and then they go into a subject 's record, which has all the info about a certain subject. After that the feedback received would be summarized and then be passed onto the respective teachers. If everything went well the teacher got a thumbs up and was told to keep up the good work. However if it did not go as it should they can expect some serious, and maybe even unpleasant, talks and some serious consequences if it happens again.

The fact is that there are currently some subjects that do not go as they should and also some new modules that probably will have some startup issues. Just know that the teachers and their coordinators are doing their best to improve the subjects. However, as with all things in education, it is not fixed in one night and the results of their efforts to improve their subject mostly show in the year after. So when one might do the subject feeling slightly unsatisfied, he might

Definitions:
* OLC – Educational Committee, the coordinating body of all the bachelor and master programs of EE.

just love the subject in the next year. Of course not a lot of people would love to experience this, due to the fact that this means they failed the subject, but that might just be the sad reality for the teachers teaching the subject.

Types of evaluations

Evasys

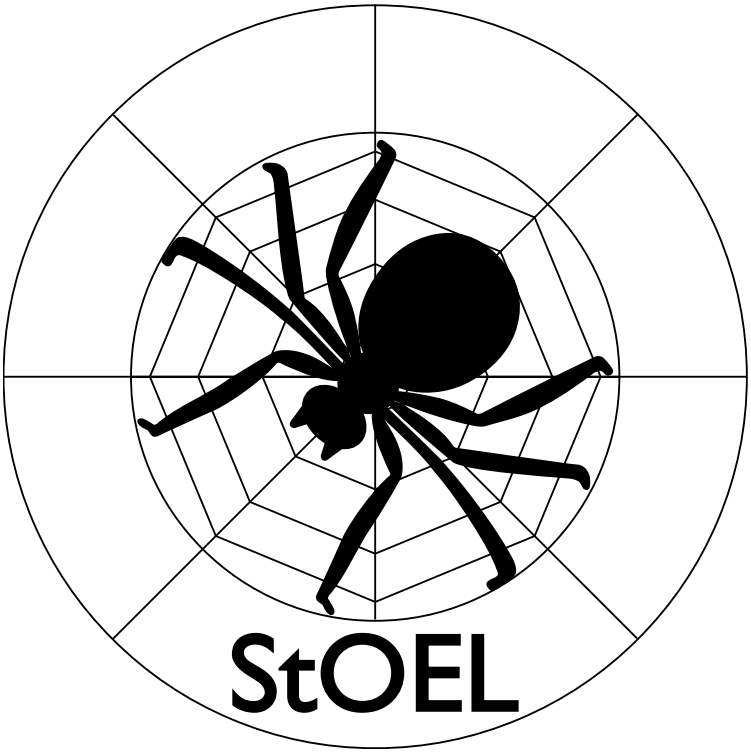
This is the evaluation system used by the university that sends at the end of every module, or in the master once every half a year, a questionnaire to fill in by the student. The module specific problems can be spotted and solved by using this evaluation.

OKC (Educational Quality Committee)

This is an evaluation by a group of teachers that are assigned to evaluate a subject by either the teacher of the subject themselves or if the module is given for the first time. If this evaluation is going on, every week a questionnaire is send to the students and if possible the subject will be improved during the same module. In essence, this is the same as Evasys but a lot faster.

NSE (National Student Survey)

This is the nationwide survey that is spread underneath all the students in the Netherlands. This is the only survey of the three that is not bounded to only the Electrical Engineering. The more general problems show in this survey, also the reason that there are now info lunches every now and then is due to this survey.



Updates from StOEL

Complaints

- Changed project guidelines

During the project of the 6th module, the guidelines of how the hovercraft should behave changed mid-project. This caused that the control system that was created for the crafts had to be changed after two weeks of working on it.
Solution: After some emails to the person responsible for the project, the guidelines changed back to the original ones that were earlier stated in the manual.

- Re-exam regulation ESD

The regulation of ESD retakes were stated in such a way that it was possible to fail the course by retaking a test. This was due a minimum grade rule that was not on the original exam.
Solution: The minimum grade rule was removed from the retakes and with this the possibility to fail the course after retaking a test.

Current Activities

- Solving lack of workspace

Frewi is currently trying to create more workspace in and around the Zilverling. Current plans are adding extra tables in the Educafé and trying to get study rooms in the Zilverling. More info later.

Do you have a complaint or something else that the StOEL should know? Mail than to:
stoel@scintilla.utwente.nl

The first year's excursion to Demcon

Author: Shing Long Lin

Extremely precise, on the edge of what is possible or extremely reliable because human lives are at stake. That is how Demcon's products can be described after our visit to their office in Enschede.

After they had sweated two weeks over the second freshmen's project, the solar inverter, we took the first year students for a visit to Demcon. Demcon's description of themselves is a 'high-end technology supplier of products and systems, with as focus areas high-tech systems, industrial systems and medical devices'. Later on the concept was explained: 'When somebody has an idea, they tell us what they need and then we design and make it.'

After we arrived at Demcon's Enschede location, we were given a presentation about how Demcon works and what it does. The speaker was originally a mechanical engineer, but he also studied at the University of Twente and got his PhD making nanostructures in MEMS. A large part of Demcon's employees are highly educated, with about two thirds having had a university education or higher.

Next we were shown several demos of some medical products. First up was a blood pressure measuring system. Normally this is done by the well known balloon around the arm, which is then inflated. The disadvantage of this simple method however is that this pressure is not real time. Also it is rather cumbersome to do multiple measurements, since you have to inflate and deflate the balloon all the time. Demcon developed a device with a tiny balloon and an oscillating pressure valve which can be worn around the finger to accurately measure the blood pressure in real time. However, as many of us have experienced, demonstrations do not always go quite as well as you would expect them to be and the machine displayed some 'demo-effect'.

> "When somebody has an idea, they tell us what they need and then we design and make it!" (Demcon)

Next they showed us a machine which is meant to replace the painful prodding that is currently done to inspect patient for rheumatic arthritis. After suppressing the blood flow in the wrists for a short moment, the machine shines two reasonably high powered lasers (red and infrared) through the hands with rotating mirrors and from the amount of light that is absorbed by the hands, an analysis can be made with FPGA's. This all can be done in 2,5 minutes and thus makes a doctor's visit much more efficient. We were not quite sure whether higher displayed values were worse than lower ones, but some people in our group definitely had more signs of weird hands than others.

After these demonstrations, we concluded our visit with a drink, well timed on the Friday afternoon. Demcon had just had their New Year's drink the day before, so we were offered a few special beers, if we could tend the bar in return, a deal we happily accepted. During the drink, several people stated that they would like to see a little more of the company, so the Demcon employees set up a quick impromptu tour around their lab, showing us the working spaces and several testing set ups. All in all it looked a lot like a better lit version of our West Zaal, but with a cool mechanical workshop attached to it as well!

Apparently Demcon's CEO showed up as well afterwards, although I did not talk with him. We had a few more drinks with the Demcon employees and this concluded our rather short but enjoyable excursion to Demcon.

Scinterklaas

SCALA Boom

O Scalaboom
O Scalaboom
Wat is je lichtslang wonderschoon

Ik zag je in de hema staan
Toen zat er nog geen bierlucht aan

O Scalaboom
O Scalaboom
Wat is je lichtslang wonderschoon

Cantus

Kerstdiner

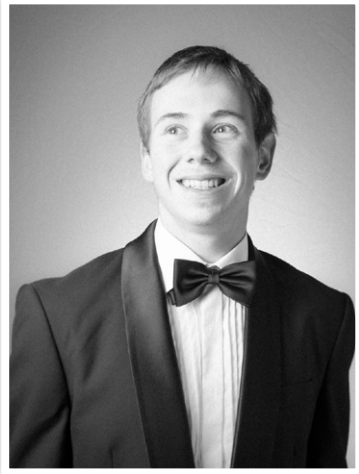
Karaokeborrel

Valentijnsborrel

Module 2

Author: Timo Haarman

This second chapter in our EE bachelor, Electric Circuits, was all about Circuit Analysis. Now we (should) know a lot more about designing electrical circuits and calculating the properties of those.



The module had a really constant program, with the same timetable each week, which made planning other things very easy. We had a lot of contact hours, every day from 8:45 till 17:30, except on the afternoons after the CA lectures. The CA lectures and tutorials were all very clear and the lecturers were very keen to help you with solving problems. Only one time the lecture was way too long, when we had to listen to the lecture about bode plots for more than 3 hours in a row (with breaks).

Every week on Friday there was a CA-test, for which a lot of people didn't get pass grades instantly, but had to review them in special organized review meetings. The review meetings were very good to get a clear view of the errors you made, and often helped to get a good mark at the exam, which was kind of a resit for the weekly tests. In a review meeting, you had to make the exam exercises again, but now with the help of the lecture notes. When you showed you had sufficient knowledge of the subject, the lecturers gave you a pass grade for the review.

> "Also our journaling skills made a lot of progress."

The tests themselves were relatively short, but they represented the material from the lectures very good.

In the labs the theory from the lectures and tutorials got clearer by bringing it in practice. Also our journaling skills made a lot of progress. Only problem was that some of the teaching assistants were a lot stricter than others, which delivered some perhaps not appropriate marks when comparing journals with each other. Not for all the labs it was clear what the eventual purpose of the lab was, it seemed that the labs were used as filling the time sometimes.

> "This really helps during the final project, where we had to develop a solar power converter."

The "pre-project" and "project organization and report" sessions helped to give us an indication of what had to be achieved in the final project. This really helps during the final project, where we had to develop a solar power converter.

In the pre-project we had to build parts of the power converter, mostly using MOSFETs, and let them check by the student assistants. This makes the direction of the project already a lot clearer.

In the project organization and report sessions we learned how to write a good report and we already wrote the main part of the final report, which gave us more time during the project to focus on technical/practical things.

The final project seemed a bit boring when we first heard of it, but it actually proves to be a real challenge, especially to get the most efficient circuit. It's like a battle between all groups to create the best thing.

> "It's like a battle between all groups to create the best thing."

Altogether this proved to be a very interesting module, which brought our EE knowledge really up to a new level, especially in the field of analyzing circuits.

Making a car drive on hydrogen

Author: Friso v.d. Boom

Green Team Twente is a student team which develops and builds a fuel-efficient hydrogen car. They have been competing in international competitions for fuel-efficiency since 2011. The powertrain of their car is quite interesting, and even differs a lot from powertrains found in battery electric vehicles.

An overview

First things first, how does a hydrogen car actually use the energy from the hydrogen to power the motors?
The powertrain of our car, the H2.Zero, starts with the fuel tank, a one liter gas canister filled with pure hydrogen up to 200 bar. This gas is brought into one side of the fuel-cell, whilst on the other side of a membrane air is pumped into the system. The hydrogen molecules react with a catalyst and split up into two hydrogen atoms and two electrons. The hydrogen moves through the membrane to bond with the oxygen from the air, by forming covalent bonds with two extra electrons. The result of this reaction is a small amount of water vapor and, more importantly, a voltage over the cell.
This voltage is boosted by the boost converter, which stores energy in supercapacitors. These supercapacitors act as a buffer for the energy. This energy can then be used by the motor controllers to power the motors. The motors can also be used to regain energy from braking.

Efficiency of the fuel cell

One of the biggest challenges when designing a hydrogen powered car is keeping the efficiency of the fuel cell as high as possible. Complications arise when having to deal with the momentum of the gas particles, the chemical reaction and the necessary power consumption of the pumps. This means that the efficiency of the fuel cell is strongly dependent on the current drawn from the fuel cell. In short, it is important to keep the current draw as low and as consistent as possible. This poses a problem when the motors draw high peak currents during acceleration or uphill driving.

Buffering energy

This is where the buffer comes into play. The buffer consists of multiple capacitors capable of very quick discharging. This enables us to deliver more power to the motors than the fuel cell can supply, and slowly recharge the buffer afterwards. With the long climb in the new track in London the buffer will need to be bigger than previous years; the more energy fits in the buffer, the longer the car can climb before needing excess power from the fuel cell.
Designing the buffer comes with some complications on its own. Firstly, the

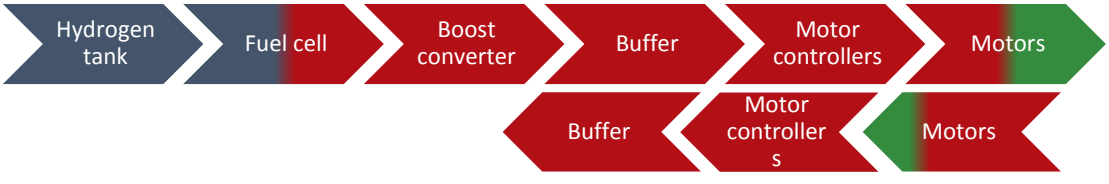


Diagram of the energy flow.

parasitical resistance of the capacitors introduces quadratic losses with the current moving through the capacitors. Second, the capacitors have a nasty habit of losing charge over time. These two characteristics both contribute to the problem of having some of the capacitors charged more than others. This introduces the chance of overvolting one of the capacitors which can lead to, well, I'm sure we've all seen capacitor failure whilst messing around in the Westzaal. This is why it is important to implement a balancing system to make sure the capacitors are equally charged at all times.

Charging the Buffer with a boost converter

The charging of the buffer is also quite tricky. The boost converter is responsible for boosting the fuel cell voltage to a stable 48 and making sure the buffer never gets depleted, without drawing too much current. This makes designing the software quite challenging, since the system will need to be able to regulate this behavior autonomously. The boost converter also has a CAN connection to tweak and monitor the performance on the fly during testing and driving. This also enables us to display vital information about the boost converter on the dashboard of the car.

Another thing to take into consideration is the efficiency of the boost converter itself. To make sure the losses are minimal, the boost converter will use the optimum switching frequency to reduce switching losses. Furthermore, the boost converter features a multiphase synchronous design, with up to 4 phases to minimize ripple losses. The prototype of the boost converter also includes a test bench which features GaN FETs instead of silicon FETs, to test the effect of these on the overall efficiency.

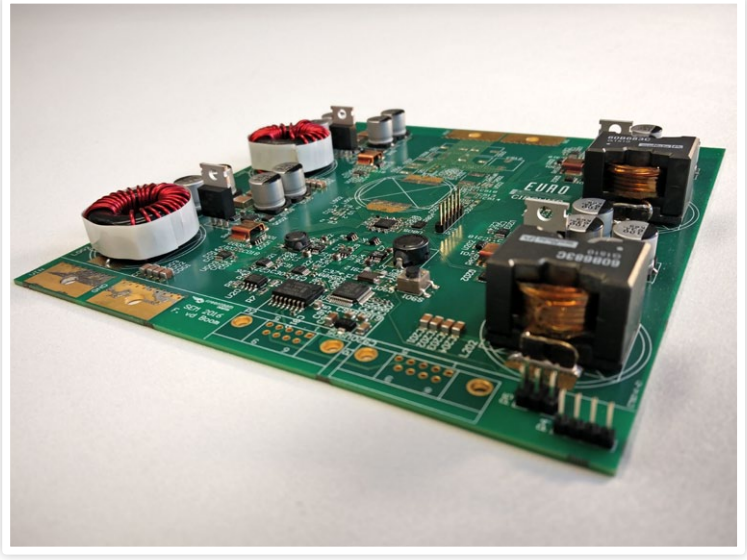
Controlling the motors with 99% efficiency

The boost converter is not the only system with GaN FETs, the design of the motor controllers also features an H bridge with these FETs, which enables us to achieve an efficiency of 99%. The motor controllers are responsible for accelerating, reversing, controlling the clutch and regenerative braking. The H2.Zero features an extra pedal for regenerative braking, which sets the motor controllers to regenerative mode and recharges the buffer. This improves the control our driver has over the car, since he can use his left foot for regenerative braking. The other foot used to control the accelerator and the mechanical brake pedals. Aside from regenerative braking, the H2.Zero is capable of mechanical braking in emergency situations.

Looking ahead to the races

Of course, the question is whether the H2.Zero will be up to the challenge. Of course, this strongly depends on the upcoming competition. On paper we have a lot of potential to finish in a top position this year, assuming we don't experience catastrophic failure of the vital systems. One way or another, the team is determined to set a result this year. We are going head to head with very competent teams, and it is going to be a thrilling race up until the final results. Keep an eye out for the next edition of the Vonk if you want to read more about the boost converter, and be sure to check out greenteamtwente.nl and our Facebook or Twitter to keep up to date with the team.

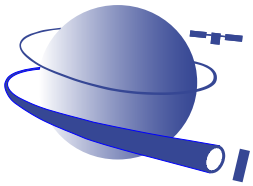
> "One way or another, the team is determined to set a result this year."



The boostconverter.

A Radio Research Adventure in the Spanish Pyrenees!

Authors: Ben A. Witvliet, Erik van Maanen, Geert Jan Laanstra



TELECOMMUNICATION ENGINEERING

Radio communication has proven its relevance during emergency situations. In the Telecommunication Engineering chair research on radio communication methods, channel modeling and radio applications is carried out. One of the research topics is radio wave propagation in the HF frequency domain. Main researcher in this area is Ben Witvliet, who recently received his PhD degree. In this article special measurements in Spain will be described. Between 5 and 17 February 2016 Erik van Maanen, Geert Jan Laanstra (SCS chair) and Ben Witvliet (TE chair) were in Spain for empirical research on ionospheric radio wave propagation. They were working under primitive circumstances in the open field, in hard and cold wind, with a lot of time pressure and concerned if everything would work as it should. With a large number of devices working together but spread over an area of 200 x 200 km in a complex and precise scientific experiment. The measurements were done in cooperation with researchers of the LaSalle Ramon Llull University of Barcelona (URL). In this article the complete story and an impression of the adventure is presented.

Introduction

The research presented here focuses on telecommunication for emergency and humanitarian communications using the ionosphere as a natural reflector. The ionospheric radio wave propagation mechanism studied is called "Near Vertical Incidence Skywave" (NVIS). The ionosphere is a natural plasma layer between approximately 80 and 800 km in height, where the air atmosphere is ionized by extreme UV and X-ray radiation of the sun. When the transmit frequency is below the critical frequency of the ionosphere, radio waves emitted straight up are reflected by the ionosphere, and a continuous coverage area with a radius of at least 200 km, an area larger than The Netherlands. This is visualized in Fig. 1. The field strength in the coverage area does not decay with distance, but is more or less homogenous. As the reflection height is substantial (up to 350 km), the elevation angles are steep, typically 75-90 degrees. In this research these elevation angles were measured and

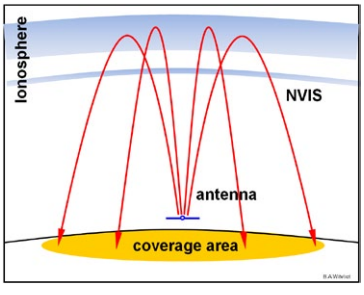


Fig. 1: Radio waves emitted straight up are reflected by the ionosphere, creating a coverage area with a radius of at least 200 km.

the antenna pattern was optimized for those angles, with different optima for reception (which is limited by ambient electromagnetic noise) and transmission [1]. Antenna polarization proved to be another important parameter to consider. The ionosphere, being a plasma under influence of the earth magnetic field, only supports radio propagation for left-hand (LHCP) and right-hand circularly polarized (RHCP) waves.

Linearly polarized waves sent upward result in two circularly polarized (CP) waves of opposite rotation sense, traveling separate paths through the ionosphere, with different delays [2, 3]. Adapting the polarization of the antenna results in reduction of multipath fading, and the use of two CP antennas permits diversity schemes or MIMO to increase throughput [4, 5].
During the morning interval when NVIS propagation just starts, when the critical frequency of the ionosphere ri-

> "The research showed the existence of two physically isolated radio paths on one frequency!"

ses due to the incoming radiation of the sun, the RHCP wave is the first to be reflected, while the LHCP still transits through the ionosphere and gets lost in space. In the first experiments this interval - which was nicknamed as the 'Happy Hour' – was used to measure the isolation between the LHCP and RHCP waves traveling in the ionosphere [6]. In later experiments it was proved that at least 20-25 dB of isolation subsisted throughout the day, making dual CP antennas an interesting candidate for HF MIMO applications. The research showed the existence of two physically isolated radio paths on one frequency!

Fig. 2: Beacon locations in The Netherlands.

However, all the experiments were performed in The Netherlands, on a North-South path from Lucaswolde, near Groningen, to Ambt Delden, near Enschede. As the "magneto-ionic" phenomenon, responsible for the polarization splitting, depends on the angle of the radio waves with respect to the earth's magnetic field, it had to be proven that the results were valid for other azimuth angles and distances, and for different magnetic field angles.

Fig. 3 Beacon locations in Spain.

How can that be done?

To prove that the concept works on other paths and in other parts of Europe, 8 programmable beacon transmitters were made that are easily transportable and that can even be installed by one person if desired [7]. The beacons will be installed in a rough circle around the measurement receiver, at distances varying from 50 to 150 km. By measuring the polarization of the signals of these beacons, it is proven that the effect can also be achieved with different azimuth angles and distances. Once this was done in The Netherlands, all the equipment was packed in a van, to repeat the experiment in Spain. These experiment could have been done in several places in the Northern hemisphere. Spain was chosen, because of the existing contact with researchers from the LaSalle Ramon Lllull University of Barcelona. They have done impressive work on ionospheric radio communication, reading out sensors in Antarctica from Spain over a distance of 17.000 km [8] and they had just started research into NVIS propagation [9].

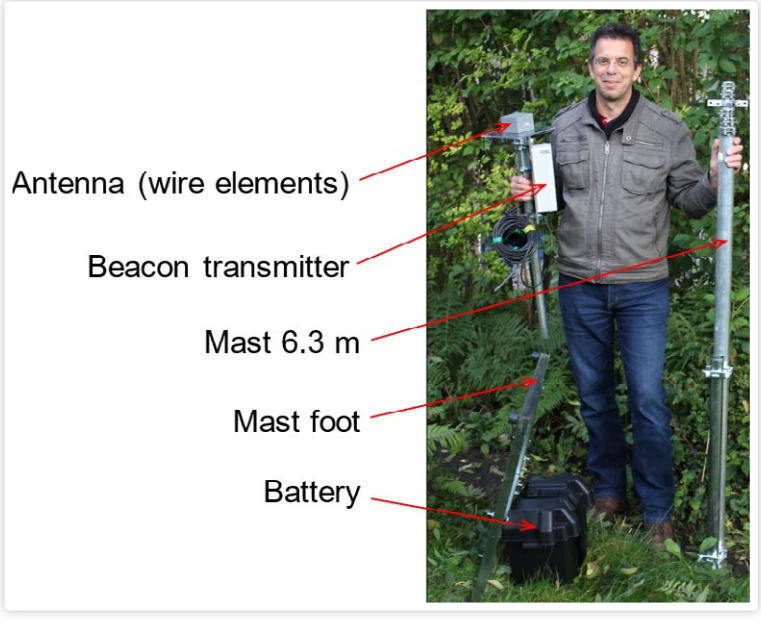


Fig. 4: The author shows a hybrid beacon-antenna system in its transportable form.

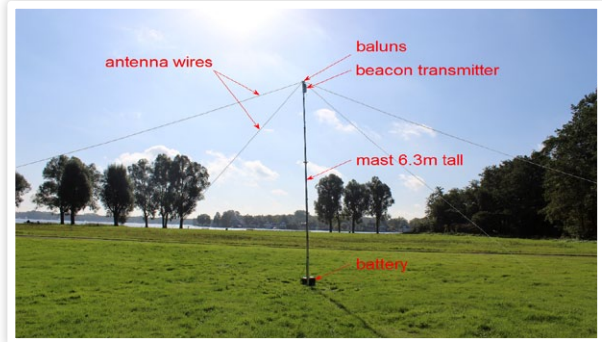


Fig. 5: An installed and operational hybrid beacon transmitter-antenna system during pre¬liminary testing near Groningen.

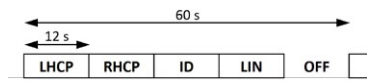


Fig. 6: The beacons transmit in left-hand circular polarization (LHCP), right-hand circular polarization (RHCP) and linear polarization (LIN). Beacon identification (ID) is done in Morse code. The "off" interval is used for receiver synchronization.

Very precise measurements require a lot of preparation

It sounds simple, but this experiment involves very precise and scientifically documented measurements, which in turn requires a lot of preparation. Beacon and measurement locations were selected in The Netherlands (Fig. 2) and Spain (Fig. 3). Those in Spain where selected using Skype and Google Earth, one by one examining possible locations that the expert form Barcelona came up with and explaining the environmental details to look for, such as nearby power lines and metal fences that would

> "By then eight very compact and transportable HF beacon transmitters operating on a car battery were realized that could be installed by a single person."

Fig. 7: Hired van with 8 antenna masts, 16 antennas, 32 of guy wires, 64 ground pins, 8 beacon transmitters, 10 batteries, 2 measure¬ment receivers, and 2 tool sets.

Fig. 8: The automated measurement receiver system on a flat terrain at 700 meters above sea level near St. Marti de Sesguiolles. The Montserrat Mountains can be seen at the horizon, Barcelona is behind them. Radio noise level is very low at this location.

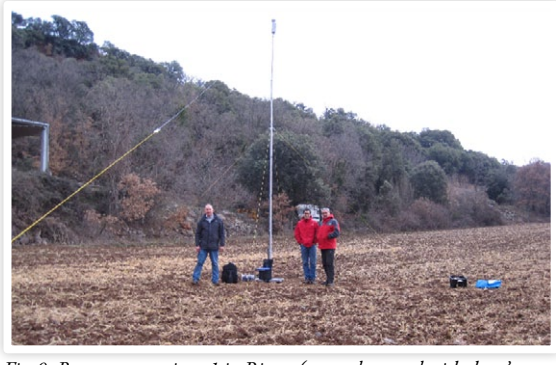


Fig. 9: Beacon transmitter 1 in Rivert (ground covered with sheep's dung).

Fig. 10: Beacon transmitter 2 in the mountain pass of Cal Cerdanyola in the Pyrenees.

Fig. 11: Beacon transmitter 3 in La Masia, on high ground North of Barcelona.

distort the polarization of the beacons, or nearby schools or roads where the beacon antennas and materials would risk to be damaged or 'reused for other purposes'. This process resulted in 6 excellent beacon locations.

For the measurement receiver an area with a low level of ambient electromagnetic noise (radio noise) was desired. The lower the radio noise, the better the measurement system sensitivity. And a high receive signal-to-noise ratio (SNR) would result in higher measurement accuracy. The Spanish counterparts drove several hundred kilometers to measure the radio noise level at the preferred measurement location in St. Marti de Sesguiolles, somewhere in the Pyrenees. Building the equipment and preliminary testing took from December 2014 until January 2016. But by then 8 very compact and transportable HF (3-10 MHz) beacon transmitters operating on a car battery were realized that could be installed even by a single person. One of the beacon is shown in Fig. 4 and 5, both in its transportable form and installed and ready for use. Each beacon alternatingly transmits in left-hand circular, right-hand circular and linear polarization, as can be seen in Fig. 6. This sequence and other presets are stored in the beacon itself, which is fully autonomous and controlled by an Atmel processor. The polarization is very precisely programmable. And for the first time a high performance dual channel software defined radio (SDR) receiver [10] could be used, streaming measurement samples of both 3 kHz channels to disk at a speed of 6000 measurements per second. A huge improvement compared with the professional measurement receiver that was used previously, attaining only 2 meas-urements per second. Now it was possible to measure polarization - or isolation between two CP channels - on a per sample basis.

Long Days and Tough Work - on Holy Ground

With a hired van, stacked with equipment (Fig. 7), we drove south, to arrive 2 days and 1800 km later in St. Marti de Sesguiolles, at 700 m above sea level, in the outskirts of the Pyrenees. Home base for the next 9 days was a monastery, with austere cells and equally austere beds. After a team meeting and a guest colloquium at the University of Barcelona, the measurement receiver system was installed on a flat piece of land on the top of a hill next to a cliff (Fig. 8). Notwithstanding the excellent location for the measurements and regardless of

Fig. 12: Beacon transmitter 4 in Castellet, close to the Mediterranean coast.

Fig. 13: Beacon transmitter 5 in Mas Anguera, a hill-side farm in the Pyrenees.

Fig. 14: Beacon transmitter 6 installed on a vacant building site in Menarguens.

the beautiful view, this was not fun! It was raining lightly and the wind was cold, strong (force 7) and gusty.

As found out later, the landowner who had given the permission did not own this piece of land (!).Fortunately the Spanish team members managed to track down the righteous owner, the Bishop of Vic, and secured his permission. So the equipment was installed on holy ground, now with the blessing of the Bishop.

The next day two mixed Spanish-Dutch teams, each in their own van, went on their way to install 6 beacon transmitters roughly in a circle with a radius between 50 km and 100 km around the measurement receiver system (Fig. 9-14). Together both teams drove 900 km, a large part of which consisted of small and turning mountain roads. Even a few kilometers of dirt road on the slope of a mountain were braved, best be described as an "off road training track". One of the fields on which the beacons were installed had been recently fertilized by spreading sheep's dung (use your imagination). Installation of all beacons proved just possible in one day, working from sunrise to sunset, eating and drinking was done while driving.

With everything set up, the experiment ran for two days from 07:00-19:00 hours. Monitoring the experiment meant sitting in a van on a grass field in the middle of nowhere, checking if the automated system worked properly and analyzing the first measurement data coming in. The receiver was installed before dawn and disassembled again at dusk.

Successful measurements!

One of the concerns in this measurement campaign was the ionospheric radio wave propagation, which is variable and depends on the solar radiation. The equipment was calibrated for a frequency just above 7 MHz, where the beacons could operate under the amateur radio license of the LaSalle Radio Club. However, propagation was on the decline, and there were many days that only 2-4 hours of effective NVIS propagation on 7 MHz was present, and some days were totally unusable. The entire system could be recalibrated at 5.3 MHz, an operation that would take 2 full days of precise work. But finally it was decided to take the chance and add an additional measurement day if one of those 'unusable' days was encountered.

To great relief the propagation improved considerably the day before the measurements, and could even be considered excellent on the two days of our measurements. The signal of the small (2 Watts) beacon transmitters could be observed during 10 hours each day, with a signal-to-noise ratio of 50 to 60 dB. Figure 15 shows the 6 beacon transmitters side-by-side in the frequency spectrum.

Since the 7 MHz amateur radio frequency band was used, several local radio amateurs visited the site to admire the compact and efficient beacon system and ask questions. One of them reported that he had excellent reception on an USB-dongle SDR receiver with a

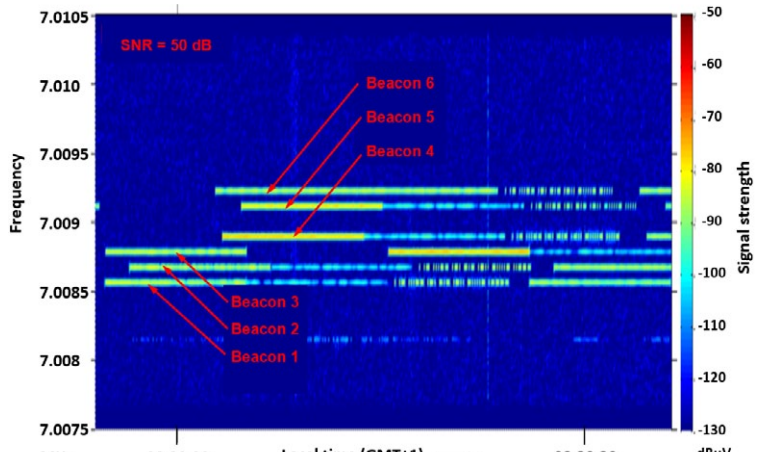


Fig. 15: A short fragment (50 seconds) of the recorded spectrogram, showing 6 beacon transmitters. Frequency difference between the beacons is 100 Hz.

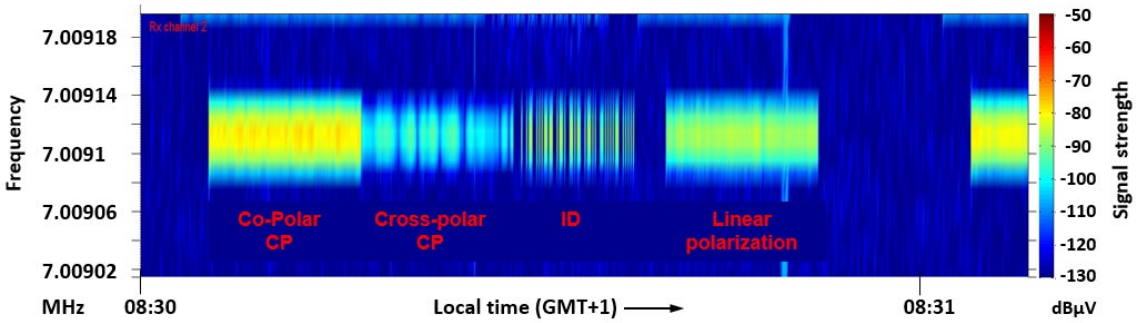


Fig. 16: A detail of the measurement during the "Happy Hour" propagation interval. The ionosphere acts like a polarization filter and RHCP waves (first 12 seconds) arrive >20dB stronger than LHCP waves (the next 12 seconds). Note: the reflection by the ionosphere reverses the polarization.

random piece of wire as antenna, in the middle of (very noisy) Barcelona.

This caused a lot of people to rethink their concepts of propagation and antennas, and that is fun too! And the measurement data looks really good. Fig. 16 shows a detail of one of the beacon signals during 'Happy Hour'. CP channel isolation is better than 20 dB. Successful measurements therefore!

Wrapping up.

Once the measurements were completed, another 900 km tour was needed to disassemble all beacons and the measurement system, repack all the equipment and drive the 1800 km back to home. Very tired, but with a USB stick containing very valuable measurement data. And leaving a very enthusiastic group of staff members of the University of Barcelona behind. Back home, the equipment had to be sorted, cleaned and stocked for the next experiments.

The novel beacon transmitter system was published in a paper [7] on the European Conference on Antennas and Propagation on in Davos, Switzerland on 13 April 2016. The measurement data is now analyzed in depth: a lot of interesting details can be discovered in the measurements, uncovering details about NVIS propagation that have not been documented before. The results will be published in scientific articles later this year. So the work is not done yet.

But the most difficult part of the project has been executed successfully, and we are really proud that we pulled that off!

Acknowledgment

This research had not been possible without the help of volunteers from Radiocommunications Agency Netherlands and the LaSalle University of Barcelona. Travel and lodging was sponsored by the European Association on Antennas and Propagation (EurAAP) [11].

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Advertorial: Frames

Author: Frames

At Frames we provide the vital link between the well and the pipeline in the international oil and gas industry. Together, we design, build and deliver separation technology, oil and gas treatment, flow control and safeguarding systems and modules, even integrated solutions such as total plants. We work directly with you, one-on-one, to optimize upstream, onshore and offshore processes. We deliver advanced, technical and smart solutions.

Founded in 1984 and headquartered in the Netherlands, Frames has more than 500 employees working in 15 offices worldwide, each focused on a specific range of systems and solutions. Our fabrication capabilities are known worldwide, as is our commitment to protecting the environment and our people wherever we work. Our reputation and abilities are built on our know-how. You see that know-how in our solutions; in our global reach and experience; and in our team of educated, experienced and qualified employees.

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Companies in the oil and gas industry often have specific requirements, and prefer to have their production plants designed fully in line with their operational needs in order to achieve reliable and safe production. Frames has decades of experience in engineering and supplying custom-designed and modularized oil/gas treatment equipment that meets widely varying pipeline specifications.
Frames introduced a skid-mounted approach for most of its equipment in the 1980s. This was very common for offshore fields, but well off the beaten track for onshore fields. Since then, many of our customers have become well aware of the advantages of fabricating process equipment in a dedicated workshop without having the challenges of on-site fabrication. Over the years, we have supplied hundreds of skid-mounted solutions, thus increasing our capability to supply a full range of products.

> "The skid-mounted approach was very common for offshore fields, but well off the beaten track for onshore fields."

Total Plant Solutions

Over the past decade, Frames has expanded its portfolio by combining specific products into larger integrated solutions. This expansion has filled a gap in the market, as customers were looking for complete gas plants designed in line with their specific needs. As a result, we have supplied many modularized gas plants over the years.
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thus preventing unnecessary investment costs and schedule delays.

A typical customized, modularized gas plant consists of two important sections:

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- Utilities
- Control room
- Civil works
- On-site construction

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We understand that effective project management requires the precise coordination of a wide range of tasks, and by working together as a family of professionals we are committed to delivering the best outcomes for our clients.

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Frames has learned to execute its projects according to the highest safety standards. Having overall process knowledge, project execution and interface management experience, Frames offers complete package deals.

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> "We are providing high-quality systems and solutions to our customers across a wide range of oil and gas services."

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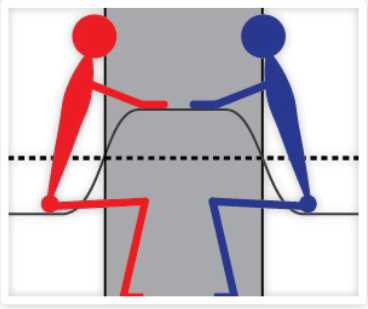
Junction

Authors: Maarten Thoonen
Mark van Holland

Stefano Stramigioli is a teacher, and chairman of the robotics and mechatronics groep here on the UT. Stefono born in Italy came over to the Netherlands, and tells about his experiences studying in Italy, and in the Netherlands, and his experiences teaching in on the UT.



What did you study, and where?

I studied partly in Italy, partly in the Netherlands. In Italy I got a degree in computer science on a level comparable with the HTS. After that, I did university, where I graduated Cum Laude in Electrical Engineering. I also was one of the first Erasmus students. With that program, I studied for a year at the University of Sussex in Brighton, which was a real fun experience. Back then you didn't have the bachelor and master system, but that was comparable to a master's degree.

After that I came to the Netherlands because of love. I first wanted to go to MIT, but in the end I went to the Netherlands. My girlfriend was from the area the UT is in, and the area really appealed to me, so I did my postgraduate at the UT. However, it wasn't really what I was looking for. So when I was proposed to be an AIO (assistant in opleiding, promovendus) in Delft, I moved to Delft. That was in 1995. There I graduated Cum Laude in analytical mechanics and applied mathematics. While I studied there, I also went a while to the MIT. Directly after I graduated in Delft, I was hired as teacher and chair. After I became a father I came back to UT, because I liked the area here so much.

Well, that was quite the opening.

Yes, I think one of my strengths is my enthusiasm. I also like to build things. I build a robotic arm when I was 16 years old. I did everything myself: the electronics, the controls. And there weren't nice compilers back then, everything was programmed in assembly on a Z80. I also designed and made the mechanics. I've always been a tinkerer, and I think that led to my love for the sciences. For that reason my interest is also really broad: I like mechanics, electronics, math...

So you got to electrical engineering because of your hobby?

Yes, before I made the robot I had a lab at home, and I saved money to buy an oscilloscope which could measure up to 20MHz, which of course now isn't worth a lot anymore, but my room was a table full of instruments, my oscilloscope, my self-made power supply and there I just made things. And even now, at home I still build a lot of things myself. I made my own table and chairs, I build a sauna, a sound proof room to make music, I just like to build things myself.

Did you do any internship during your studies?

Yes, I went to the MIT, the University of Sussex and the University of Arizona in Tucson. However, in Italy an internship was not part of the curriculum. The only chance back then to go somewhere else arose when the Erasmus program started. In my case I did the third year of my study at the University of Sussex. There they used an entirely other system as at the university in Italy, so it was quite a hassle to get all my study points approved, the subjects where different, etc. But after that I graduated Cum Laude in a shorter time than nominal. For that study nominal was five years, but I finished it in four and a half years.

Stefano Stramigioli

Age	47
Birth place	Bologna (Italy)
Favorite Color	Navy blue
Favorite Drink	Coffee and water

What kind of student were you?

I was a very chaotic student. I think that had something to do with my creativity, I have always been very creative, and I wanted to do a thousand things at once. That is still somewhat the case today, by the way. I was very focused on practical applications, until I started studying at the university. There I followed a course on mathematical analysis, for which I had to be able to prove 250 theorems for one oral exam. So you have nothing to complain about compared to that. You had to prove the theorems on the blackboard while about a hundred students were watching you. You had to prove things like that a differential equation has one unique solution, which was a two page proof. At the time, I didn't see what the use of all this was, but then it

> "If you just do a little bit of work all the time, and ask when you have questions, studying is actually quite simple."

downed on me: when you know all that stuff, and not just learn by head but actually understand it, you really learn how to think. If you want to get large muscles you have to go to the gym, but if you want to be smart you have to do things like that. Starting from that moment, the study was everything for me. The study became my hobby, so that was a big advantage.

However, I had the disadvantage that my girlfriend lived in the Netherlands at the time. So during the weeks, I just studied, and during the weekends I did everything else, like sports, going out with friends and visiting my girlfriend. But it was not like I did a lot of extra things. I had my sports, cycling and windsurfing and that kind of things, but no study associations or something. Those aren't really a thing in Italy, at least back then, maybe that has changed by now.

Do you have more hobbies?

Yes, my hobbies were study, computers, engineering and sports. Music I just started doing again a while ago, which stopped a bit during my studies unfortunately, otherwise I would've been a better drummer and guitarist by now. Though when I started dating my then girlfriend, now wife, here in the Netherlands, I came to the Netherlands about once per month. What I used to do then was leave with the pig transport at Thursday night in the direction of the Netherlands and hitch hike my way there, then I could be with her for one or two days, and then I headed back and came home by Tuesday. So that meant I missed all lectures from Thursday, Friday, Monday and Tuesday. After that I set my alarm at 5 o'clock every morning to study, and after my lectures I studied again until 10 o'clock in the evening so I

> "You're not doing studying for a mark, you're doing it because you want to understand it from the beginning to the end."

caught up. I recorded everything with a tape recorder, you know what a tape is, right? I also made written annotations. When I didn't understand anything, I wrote down the number of the tape I was recording to at that time and I listened to that part until I was back on track again. In the evening, I looked at what I didn't understand during the lectures, and studied that. The last week before the exam, I didn't have to do anything anymore, so I just played basketball with my friends, and that way I always scored 10's.

That's what I also try to say to students nowadays: if you just do a little bit of work all the time, and ask when you have questions, studying is actually quite simple. You just have to do it. You do need some motivation though, but I had that, for basically all subjects. There was only one subject I didn't like. That was economics. It was the only subject I struggled with a bit. Not because it was hard, remembering 250 theorems is way harder, but I didn't see the use of it. Learning those theorems was useful to me, but with I economics I just thought 'why am I doing this'.

What subjects do you teach at the moment?

I teach control engineering, part of multibody dynamics and control in the biorobotics module, which is a module you can do for module 9. I also teach the master subject modern robotics. That's also the field where I do my research. I also taught digital control and part of a module on mechatronics. If I had more time I would teach a lot more, as I find it to be a lot of fun. But time is my biggest frustration in life, I never seem to have enough of it. Unfortunately, I don't really have the time to do my own personal research anymore. Luckily, I still have my creativity though. In conversations with promovendi I always have a lot of ideas. Sporadically, I still do my own projects. Recently I got funding for a project of 4.5 million, which I just started on. My research varies from medical research like inspection and maintenance, and also theoretical research. I'd like to have a whole lot more time, but like I said, my frustration is always that I like way to many things, so I don't have enough time to do everything. I like teaching, students, making music, making things, sports... Also, and this is no joke, I have 1800 emails I still have to read.

What do you think about TOM?

Firstly, I feel sorry that the university has become a lot more school-like. You, as students, are treated a bit like children. I think that's a really bad trend. University is the highest level of education you can get, there should be expected something of the teacher, but also of the student, and students should be treated like adults. So not doing assignments and this and that, I actually think that's really bad. When you're here at university as a student, you should be here because you want to achieve something, to learn something. That's what a student should be helped with. TOM was initially achieved to be more effective for both students and teachers, but I have to conclude that it costs a lot of time, and there is also no real reduction in subjects. I feel like the teachers didn't really have a say in it, it just came from higher up and this is the way we're going to do things. Sometimes democracy is not really the best idea. Like Churchill said, democracy is the best form of government, except for all the others. Democracy is what there should be, but sometimes it's not really effective. Sometimes you just have to make decisions

> "I think one of my strengths is my enthusiasm."

and enforce them.

In the end, it's about learning, and not about finding tricks to make as many students as possible graduate. If you want to be an engineer, you have to do something. If you're not willing to do that, you shouldn't be an engineer.

I also always find that students don't really know how to effectively study. At the end of last module that question came up, and the student said indeed, we never really learned how to do that. I also see that if I help my daughter, who is doing VWO, there isn't really given a lot of attention to critical thinking, how you have to study, how to test yourself.

Stefano with RAM's rRobird

You lean a lot on your teachers. Already saying 'I'm not sure I understood' is a sign you are not able to critically evaluate yourself. And it's those skills that are the base of a university education. Not just doing the assignments given to you by the teacher, but thinking up your own assignments. You're adults, and you're here for your own future. When you don't have the right attitude, you're better off somewhere else, that's way more useful for society.

Did you already know during your studies that you wanted to be a teacher?

Good question, I have a nice anecdote about that. In the second year of my study in Italy, I had a subject called geometry. The matter itself was kind of dry, again proving hundreds of theorems. But the teacher was really good, he was able to make the lectures fun. That was a huge inspiration for me. The year was divided into multiple groups with each their own teacher, but everyone wanted to go to that teacher's lectures. He also gave courses on the theory of general relativity. You didn't get any extra points for attending them, but he made them so much fun and so interesting that people came anyways. When I was finishing my studies, I met him again. He asked me to give a lecture about a certain subject for geometry in the second year. So I had to give a lecture in the largest room they had, teaching about 300 students. For me it was kind of scary, but apparently it went really well, as I got a lot of positive feedback. At the end, the teacher said: 'now we're colleagues'. I liked it so much, explaining things and making things understandable, that I decided to become a teacher. The first subject I taught was control in Delft, were I was awarded an education prize. That's the same subject I now teach here.

> "Like Churchill said, democracy is the best form of government, except for all the others."

What are your hobbies?

I would have a lot more hobbies if I had the time, but for now it's music and sports. I cycle from Borne to here and back. Mostly I now play music. I started a band here with an AIO, a student, Ferdi van der Heijden and a singer who graduated last Friday, so now the band is dead and we need a new singer. In the longer run I'd also like to find a band from outside the UT, but I don't really have the time at the moment. I used to do a lot of DIY stuff, but that's become more of a chore than a hobby at the moment, so music and sports are the main things.

Do you have children?

Yes, my children and my family are of course also my hobby. I'm happily married with two children. One is a sixteen year old girl, who is an amazing singer. We'll probably see her at The Voice. My son is two years younger; he's almost fourteen years old now. He's a really good piano player, so there's always a lot of music at home. I also have two dogs, and a disabled cat. I really like animals. At the moment I live in Borne, which I find is a really nice village to live in.

What do you want to do in the future?

I do a lot of external stuff at IEEE and EU robotics next to all the stuff I do now, and in the future I'd like to find a better balance between work and leisure. At the moment I simply work too much, and sometimes it's a real challenge to combine everything I want to do.

Is there anything you have as a piece of advice for the students?

Yes, it has to do with the things I said earlier. I also proposed to Mark Bentum to do a lecture in the beginning of the first year to give my opinion about how one should study. My advice is spending your time wisely. Studying is the most beautiful thing you can do in your life, you develop yourself, you learn a whole lot, and you shouldn't see it as a burden. If you see it a as burden, you're better off somewhere else. You're not doing it for some teacher, you're doing it for yourself. Try to score a 10; don't be content with a 6. You're not doing it for a mark, you're doing it because you want to understand it from the beginning to the end.

Skitilla

Author: Skitilla committee

For the first time in quite some years, Scintilla went on a winter sports trip again. The brand new committee Skitilla organised a trip to France in true Scintillian fashion: with lots of good old fashioned 'gezelligheid'. With 22 Scintillians in tow, a week full of memorable activities was held!

Since Scintilla hadn't had a skiing trip for quite a while, it was not quite sure whether the trip would be a success or whether there would even be enough interested people. In hindsight, we could have rested assured, since enthusiasm was high from the very start of October With the participant contracts signed,

all preparations could be made. The Friday before the spring holiday, we had our very long bus trip to our destination, Saint Sorlin. St Sorlin was a cute, hilly village in a part of the French Alps called the Sybelles. The church hardly stuck out between the other buildings, even though there was no high rise at all. Chalets and small stores lined the street all the way up to the resort we stayed in. Although this position this high up the mountain made the resort a little bit harder to find, it made for a perfect location the rest of the week. The ski slope which led to the three main lifts was about 5 minutes of walking away from our front door and there was a small, slightly tricky track which led all the way to the back of our apartment. A swimming pool with two Jacuzzis and a sauna was a minute away, we had a supermarket with a wide assortment of snacks and drink on the other side of the street. One of the,

> "A swimming pool with two Jacuzzis and a sauna was a minute away"

wait for it, two(!) bars in the village (and arguably the most fun one) was located straight underneath one of our apartments. Conveniently, this order of the facilities also gives a reasonable oversight of what our day to day program consisted of.

With the highest peaks of the mountains reaching up to 2600 meters, we had no trouble having fun in the snow. We spent our days touring around the area, having lunch in whatever village we ended up in around noon. Several days we encountered some challenges, with the sight sometimes reduced to a meter of 10. Some days we made our own challenges with our scavenger hunt, which had assignments like skiing in a train with at least 5 people or skiing pirouettes. And even though the heavy snowfall caused some headaches for the ride home, having almost a full meter of fresh snow on

the super sunny last day was quite a compensation. Gliding through the freshly powdered, untouched black slope with the sun and just a handful of friends to accompany me will be an unforgettable experience for sure. To the next year!

La Grotte du Yeti

Beneath the beautiful apartment we resided in, there was a club called "La Grotte du Yeti". With two happy hours a day, one between 4 and 5 and the other one in the evening between 9 and 10, this was not only a nice après ski club but

> "I just felt a certain chemistry between me and the goat" - ShingL

also a fun place to party in the evening. The DJ was not the best DJ, even though he was Dutch, but after a happy hour it didn't really matter anymore. Everybody sang the whole night with many English and Dutch songs, which were very well known by us and the other, mostly Dutch, people. In the Grotte you didn't have to pay directly with money, but with a special card. It was possible to store some money on this card and then use it to pay for your drink. A special thing about it was that when you loaded it ones with 100,- euro or more, it became a gold card which gives you some discount on your drinks. Luckily we had some of these gold cards for free with the apartment. Sadly enough, partly due to this card, you didn't know exactly how much you had spent that night. This way the grotte du yeti became an expensive place. After the club closed around half past one in the night, everybody went to bed quickly, because the next morning

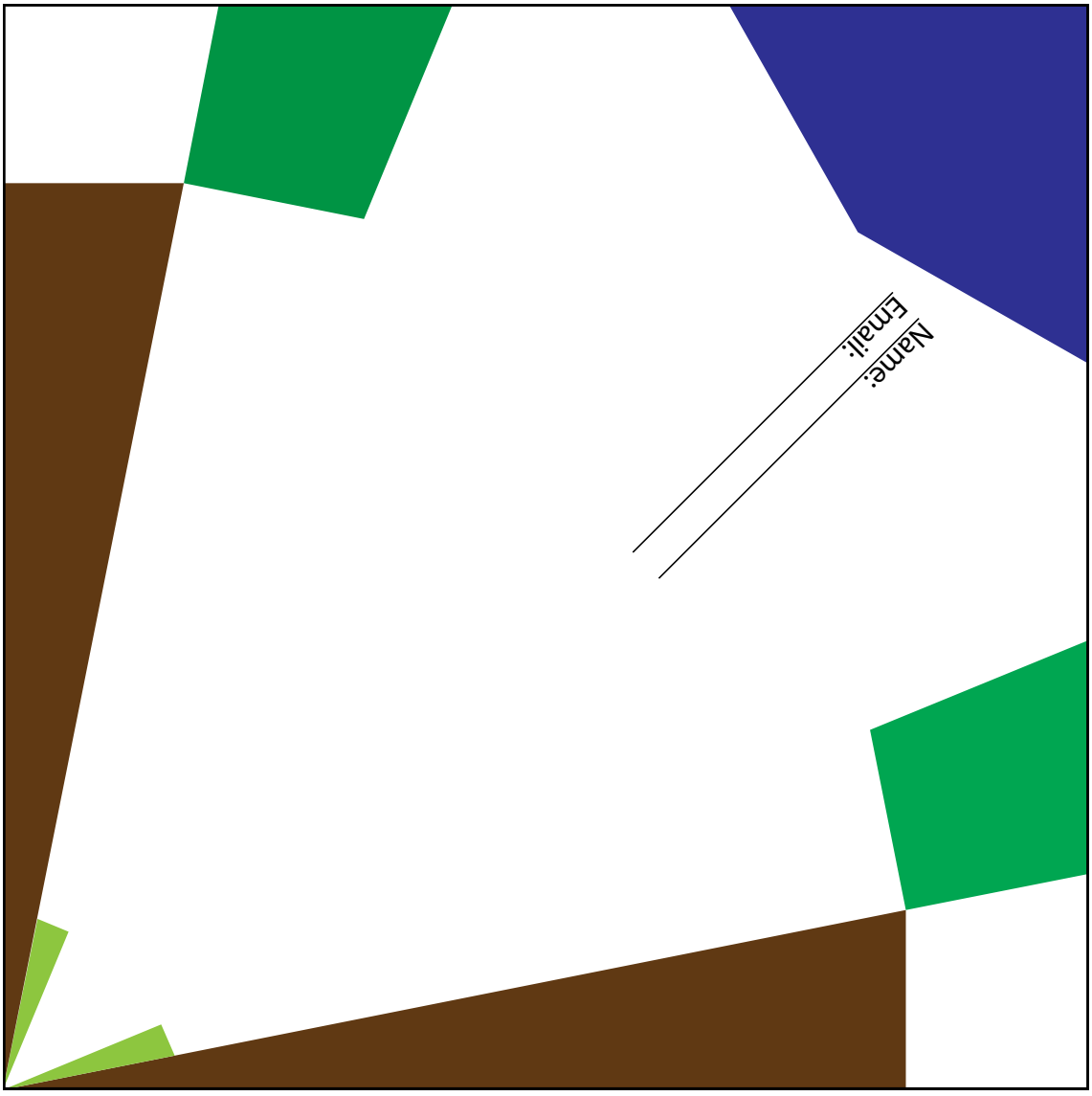
we had to be present at 8 a clock at the dinner table for breakfast again.

Koen's apres ski top 20:

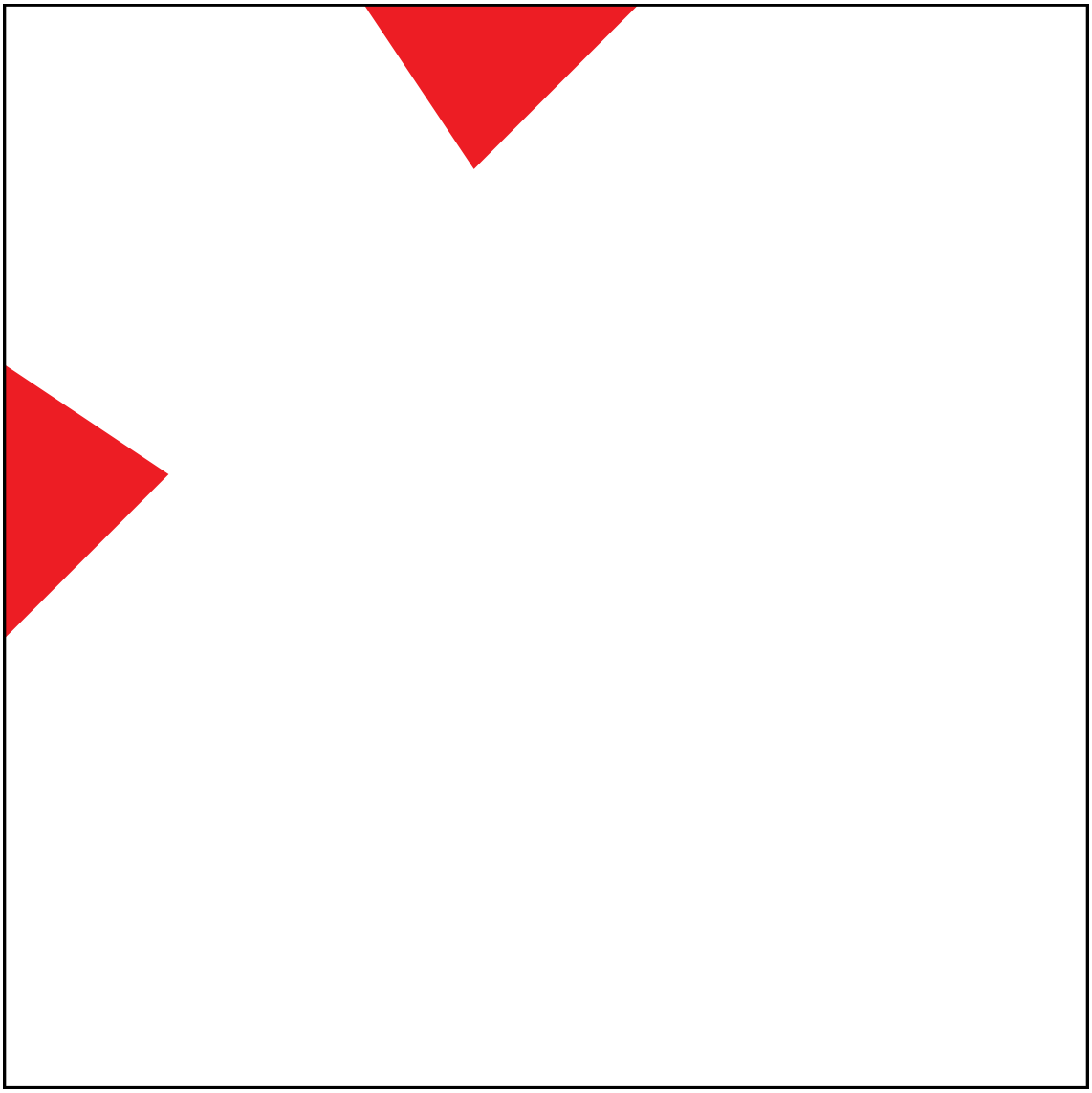
1. Dikke titten kartoffel salat - Ikke Hüftgold
2. Anton aus Tirol - Anton ft. DJ ötzi
3. Tirol - DJ ötzi
4. Boom boom boom - Vengaboys
5. Wannabe - Spice girls
6. Ein Stern - DJ Ötzi
7. Ich bin wie du - Marianne Weber
8. Barbie Girl - Aqua
9. Ich bin ein döner - Tim Toupet
10. YMCA - Village People
11. Ding Dong Song - Gunther and the sunshine girls
12. I want it that way - Backstreet Boys
13. Witch doctor - Cartoons
14. Hutje op de hei - Alpenzusjes
15. Kylie - Akcent
16. Tarzan and Jane - Toy Box
17. Sweet Caroline - DJ Ötzi
18. Jodel Jump - Zware jongens
19. Disco Pogo - Die Atzen Frauenarzt
20. Du hast die haare schön - Die Alpenkracher

Puuzle

Author: Truusje



In the last edition of The Vonk I needed help on some electrical problems. Thank you all for helping me finding the answers. The delicious pie is rewarded to Thomas Hoen! Congratulations!
This edition the Puuzle is related to the spring. During spring more birds are ariving in Northern Europe and people will go outside, surrounded by birdsongs. I want to enjoy the spring as well and ask you to hand in an origami folded swan. Fold you own swan, put your name on it and hand it in at the analog Vonk inbox in the Scintilla Room (or send it to Scintilla by analog mail) and maybe you will be the one winning a pie this time!



To doubt doubt.

Author: Jippe Rossen

"Dare to doubt". With these three short words I was bestowed on not too long ago. Some years ago I would probably not even have raised my shoulders when hearing these three words. But somehow the passing of time, or recent experiences have affected me in some way.

The catchphrase was used by a radio commercial for a newspaper 'Trouw' (which I have never even read). The full expression was: "Dare to doubt. Trouw, possibly Holland's best newspaper". I can safely say that I have no desire whatsoever to read this newspaper and even less so to talk about the paper itself, but it started me thinking of what doubt was anyway.

For instance the case about Abdeslam, who was supposed to have planned the attacks on Brussels and Paris, what role did doubt play in his life? With all the rational planning and organizing one would think that he was pretty confident about what he were to do. But it turned out that he changed his mind in the critical moment in Paris, he got rid of his bombs and left.

Apparently doubt can have a huge impact on the view of life and in the way you behave. But how does this work? How can it be explained that doubt still exists after all those years of evolution? Darwin probably would have said that doubt was a mechanism to ensure an individual's survival, which would also explain Abdeslam's last minute decision. The remarkable thing is however, that situations in which doubting leads to a change in behavior, usually the environment, or external factors, did not change. There is this mechanism that can override any rational thought or determination without the subject even knowing why, even though the course of action was carefully considered before.

I can consider myself quite a rational person and frankly this kind of scares me. When will my subconscious take over and override my rational thought? I just cannot stop to see life as an exam and doubt being this scary examiner that calls you back when you make a huge mistake. This luckily sounds mostly positive to us, but can there be other situations?

The last thought that popped into my head whilst writing this piece did cheer me up somewhat though. It might also be some nice food for thought if you find yourself in a boring lecture or a tiring journey: If an Artificial Intelligence were to be created, would it also develop a capability to doubt things? And if so, to what end? It cannot possibly be for survival, can it?

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