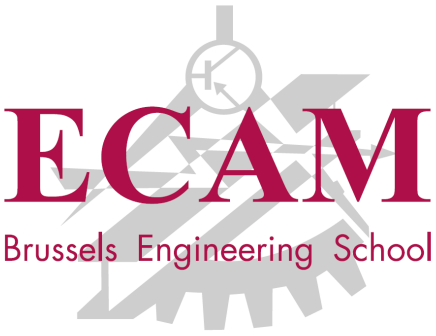

Internship report

My experience of the six weeks passed as an intern at the bureau of Macq company

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May 26, 2017

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Internship mentor: Vincent Raman

Firm presented in this document:

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Internship performed at the Evere office

from 17 April 2017 to 26 May 2017.

Specials thanks to Camille, Koenraad, and Jean-Luc for being my dear colleagues during those six weeks in the hardware team.

Contents

1 Preface

As part of the third bachelor year in industrial science at the Institut École Centrale des Arts et Métiers (ECAM), I got the opportunity to perform an internship in a firm of my personal choice. I found an internship in my favorite technical field—electronic conceptions—at the Belgian manufacturer of automated solutions: Macq. This document tells the tale of the six weeks I spent at its office and what I've learned from there. As well as a short presentation of the company by an insider's point of view with informations collected from the assets provided by the company.

2 The collaborating enterprise — Introducing Macq

It would be rude to talk about the company without introducing its history and future plans first, or as I prefer to say: "where they came from and where they go". At least, where they're planning to.

2.1 Introduction

Macq is a company specialized in traffic administration and general automation[1] founded in 1923 by Clément Macq. For over 90 years and three generation, it went from a small familial company with a single man keen of radio telecommunication [4], to a small and medium size enterprise (SME) employing 65 salaried workers[2]. Its main office is located in Brussels, in the industrial zone of the Evere district. There's also a french branch office located in the south of France. Nowadays, this branch only serves has a customer service relay as all the research and development is made in Brussels.

2.2 A success story

The Macq story is first and foremost a success story. Clément Macq was an entrepreneur avant-garde when he decided to found his company in August 1923 with his first radio receiver. In March 1946, mass spectroscopy introduced the company in the electronic industrial world. In 1961, they achieved to produce the first digital voltmeter in Europe. An important date in the history of Macq is 1968 because this year, they developed their

[1] Activity code 26200 – Manufacture of computers and peripheral equipment.

[2] From the Central Balance Sheet Office, company number BE 0402.226.831.

first generation of programmable automaton. In 1997: Macq became an ISO9001 company, allow the company to play in the big leagues, and in 2010: Macq électronique became simply known as Macq when dropping its 50 workers limitation.

Today, Macq proudly shows its references such as: the teleprocessing of Liege and the Luxembourg crossroads; the tunnel management of the Hong-Kong bay; the automation of fret tolls at the Eurotunnel; and more over. By the means of these references, Macq can cite as their clients famous companies including: Thales, SNCB, Eurovision, Bayer, Electrabel, and Tractebel.

I'm adding a hiatus to cite Tractebel, who's is the sponsor of my assigned project. Tractebel is an international company, with Belgian roots, providing worldwide life-cycle consultancy and engineering in power, nuclear, gas, industry and infrastructure for the GDF SUEZ Group—within GDF SUEZ Energy Services—as well as for national and international institutions and customers in public or private markets.[3]

2.3 Organizational structure

The company is structured in fours units (see Figure 1): human resources & business support; products; projects; and sales. My internship mentor position is team leader of the product development unit. Therefor, this was the unit to which I've been assigned to. The Macq family is the owner of the company, thus making François Macq the legit CEO. Everyone else is beneath him. Although it can be said that the research & development and the security departments are above the four mentioned before. The division between the projects and the products departments is worth mentioning. The products unit is responsible for the development of new products such as cameras or radars. The projects unit is entrusted with individual project requests from clients. A link exists between the products unit and the projects one: the projects team uses products created by the products team to develop custom solutions for clients.

[3] http://www.tractebel-engie.com/

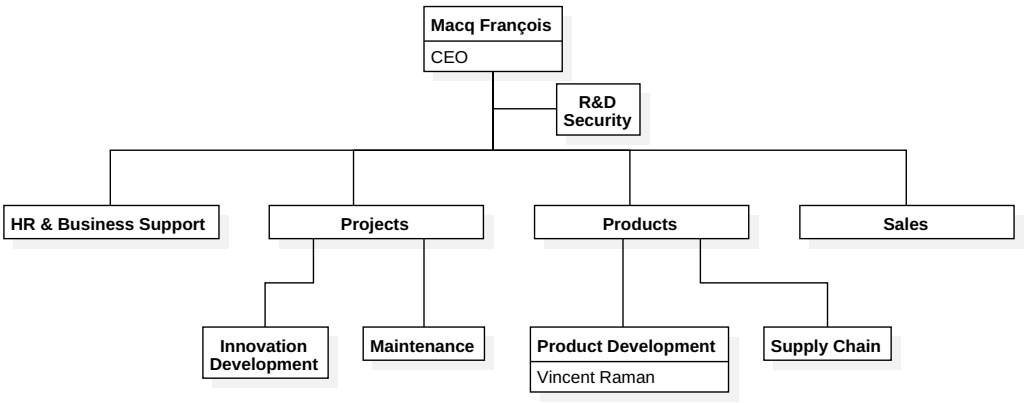


Figure 1: Organizational breakdown of departments

2.4 Technical standards

In the enterprise world, companies must form partnership to be competitive and produce innovative and highly valued products [2]. When doing so, they want to be assured of the competent management of their partners. To address this demand, labels have been made for a centralized institution to control the quality of companies and attribute widely recognized labels to them. One of those label is the ISO9001: A merging of guidance and tools to express the quality of a company management[4]. This norm is mandatory to be able to access the market of large multinational corporations and form contracts with since it is a guarantee of economical stability and reliability [6]. In today's industrial electronic field, one is forced to partner with these.

As cited in Section 2.2, Macq gained the ISO9001 label in 1997. They succeeded at extending its issuance to the 2008 version of the norm: ISO9001:2008, more constraining and a greater guarantee from the company. Looking ahead, they're trying to reach the 2015 version of the certification. Constantly updating their label is a pledge of quality and a competitive move against the concurrency.

2.5 Ecological policies

Macq may not be the most forward company to go full green, but they're setting up ecologic policies for printing and consumable junk. For example, every printed documents that will stay within the company is printing in black and white, double sided, with recycled paper. Color printing is reserved for clients by respect for the latter. At the beginning of my internship period, they still had disposable plastic cups next by the drinking fountains.

[4] https://www.iso.org/iso-9001-quality-management.html

During my internship, I noticed that these disposable plastic cups were progressively replaced by washable ones, as they already do for the coffee. Each morning, employee who desire to drink coffee, take a cup from the armoire. Once this coffee drinker has finished its drink, he then leave the cup in the sink at the kitchen company. The cup will be washed in the dishwasher at the company and be clean by tomorrow for its next use.

3 The internship objectives — Specific internship goals

Section 3 lists the expressed objectives of the activity note as subsections. Each one is a report of my personal opinions and does not reflect the official statements of Macq.

3.1 Discover the company

One on the objective of every internship is to discovery a company in the field of which the intern is currently studying. Though this subsection may be redundant with Section 2, I'll express my personal experience instead of relaying the official promotion. The inside of a company may vary a lot from another because of its size, its history, and its human resources policy. For these points, I've been pleased with Macq because of its small and friendly environment that's expected from a familial company. It's a bilingual workspace and everybody respect the language of its coworker. In the morning, I've met people who would walk around the office and salute everyone. And by the office, I even mean separate open space. I've never meet this behaviour in my previous student jobs at bigger offices. At noon, you'll find two wide tables at the lunchroom on which people from different departments will sit next to each other and talk about various subjects outside the scope of work like politics and banters. The weirdest custom is probably the frequent company barbecues always organized by interns and new employees. And the nicest benefit was the always ready-to-pour coffee available from the morning to the end of the shift. Perhaps, the close relation that every employees maintain between each other was certainly one of the reason the coffee tasted so pleasurable.

3.2 Join an active project

First thing first, I couldn't have the pleasure to stroll around the office. As soon as I found a chair to sit myself on, I got assigned to the current project. As project sponsored by Tractebel—who's already a satisfied client of Macq (Section 2.2)—of partially replacing

the alarm cabinets of the Doel power plant. A project named “Doel 1&2”, as I will refer to as now. To put some context, the Belgian federal government decided to expand of ten more years the lifespan of nuclear power plants in Belgium. This decision has had an effect of forcing Electrabel—the company in charge of the power plant—to renew its construction, as the equipment such as the monitoring cabinets, had a determined functioning lifespan. To fulfil security norms, Electrabel (by the means of Tractebel) has ordered new alarm cabinets to be made from Macq. Here comes my assignment, while racks are being mounted in cabinet and cards are being designed to fill these racks, I must help to produce tester cards to ensure that the scope statement of the alarms is respected. To do so, my colleague Alexander and myself, soldered many components on card, programmed PIC micro-controllers, and redacted numerous documents.

3.3 Discover the engineering field

Engineer is the most fascinating job in the world full of idiosyncrasies. Proselytes will say that one lives everyday anew in the engineering field. I disagree because it took me weeks to solve a single frustrating issue. I sure do enjoy using measuring devices and other sophisticated equipments but the joy won’t ease the pain of harvesting unmatched data. However, this is an aspect of the engineering work. As the development process includes procedures to handle unexpected design malfunctions. Most of them consists of expanding the due date to allow further investigations on problems.

Apart from practical aspects of the engineer field, I also learned management and group order for projects. From the weekly meeting, I understood that you cannot go with the hope of your fellow project members to get coordinating information by themselves. Frequent meetings are required to enforce synchronization between actors. Communication is key.

4 The attributed jobs — Tasks affected and performed

The company would have no interest in welcoming interns if they didn’t gain anything from it. My colleague Alexander and I were both assigned to help with tester card for Doel 1&2, and to do so we performed different tasks with two majors divisions: soldering prototypes and programming micro-controllers.

4.1 Soldering surface mounted devices

I soldered two types of cards: some where prototype designs that are close to their releasing state, others are tester cards that are made to ensure the manufacturing quality of the previous. The goal is to check whether all the required features are well implemented in cards after production.

One question that may spawn in the reader mind is: "why are they soldering cards themselves?". It's right that, as PCB prototype can be commanded to PCB producers, soldering jobs could also be made industrially by tiers. The price can climb up to 3000€ for a single card, but the real issue is the three weeks delay introduced by the soldering tier. The project schedule cannot allow that. Time can also be lost with handmade soldering because of short-circuit corrections. However, it'll always be faster than delegating the job.

I've soldered components which fingerprints are from the smallest of the industry: such as TLMS LED measuring 0.8mm×1.6mm; or the 20-lead plastic TSSOP which is 6.4mm wide and 6.5mm long. Those were the first SMD components I've personally soldered which, I consider, are very difficult to handle. Though I've found IC components to be easier to sold than dipoles.

4.2 Programming a microcontroller

The six weeks of my stage were filled with programmation everyday. Programmations for PIC micro-controllers from Microchip[5]. This part of my internship is quite important—because of the time it took me—and deservers further clarification.

4.2.1 Job description

As mentioned in Section 3.2, I joined the Doel 1&2 project to assist in the development of tester cards. The cards to be tested are alarm cards. Thus, the tester cards must generate signals representing alarm triggers. Cards must also be able to read these signals to ensure of their correctness. Plentiful of signals must be handled separately. Unfortunately, no PIC micro-controllers have enough general purpose I/O pins to control each signal separately. To solve this issue, general purpose I/O expander from Microchip[6] have been used. As the amount of expander is copious, the only way to control all the expanders is through

[5]The model 8-bits MCU PIC16F1947.

[6]The 8-bits I/O expander model MCP23S08.

a commonly shared communication protocol. The model installed only supports the SPI protocol. Quite a difficulty to overcome as I've never implemented SPI control commands from scratch myself.

I had to find a clever way myself to implement test routines from basic SPI opcodes from the I/O expander devices. I used what I've learned to do from the 5 past years: create abstraction layers to simplify the task. I went from registers configurations on expander modules to C configuration functions, to write and read pin functions, to an api to send and read signals. This driver I wrote was then used by my supervisors to code test routines.

4.2.2 Routines generator

After implementing SPI routines, I've realised that these basics routines must have already been implemented by someone else, or even better, the manufacturer itself. By a quick search on the manufacturer website, I discovered an automatic tool to generate the configuration and control routines for SPI communication on the micro-controller. This tool is named Microchip Code Configurator (MCC for short)[7] and can also be used to configure every modules from the PIC such as: the GPIO pins, the oscillator, or the interruptions. It will be a great advantage in the future to set up a micro-controllers faster with assurance.

4.2.3 Issue and solution

I've lose countless hours of my internship trying to make a single I/O expander chip respond over the SPI bus. No matter my determination to inspect the voltage variation on the bus with accurate measurement tools or a serial debugger, every actions undertaken under my observations didn't conclude to success. After three weeks of failing attempts, my supervisor at Macq handed my an other card to program. My wrath knew no bounds when I understood that the issue didn't come from my work but by an electrical problem on the board.

5 The learned skills — New technics learned

One of the objectives of doing internships is to learn new skills. Those skills are usually mandatory qualities that a post graduate must acquire to be considered suitable by

[7] http://www.microchip.com/mplab/mplab-code-configurator

recruiters. This section will cite the technical skills that I've learned during my internship and that I consider to be must-haves in the electronic industry.

5.1 Drag Soldering, SMD soldering, and usage of Flux

Soldering through-hole components is a vestige of the past as the through-hole technology is considered nowadays as bulky [7]. To be more in phase with today's technology, one should be able to solder surface mounted components. The first issue I've met was with passive components such as resistors; capacitors; and inductors. They are so light-weighted that touching them with a soldering iron is enough to deport them from their respective pads. I quickly realised that to attach such tiny elements to the card, I must develop a new procedure apart from the one used with through-hole components. Here's the best way I found: 1. Put a tin drop on a pad; 2. Grab the component with a surgical clamp; 3. Melt the drop on the pad; 4. While it is still liquid, drag the component in the drop; 5. Now that it's fixed, put another tin drop on the other pad.

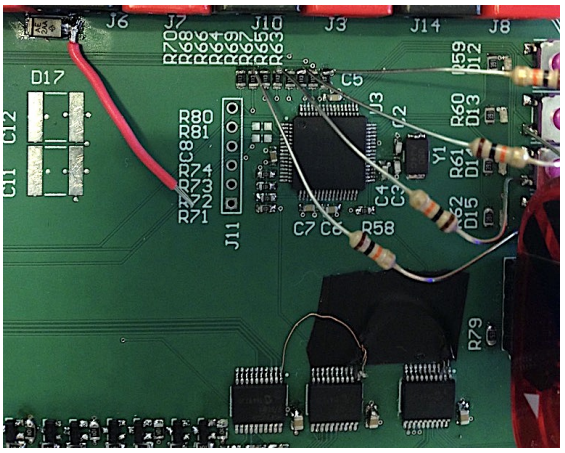


Figure 2: Photography of SOIC packaged components soldered by myself. The card being a prototype, some physical hacks were used to fix design issues.

Sometimes, the pad is so thin that a tin drop cannot be attached to the copper, the drop will roll on the tip of the soldering iron. It is for this issue that a liquid—named flux—is spread on the surface to solder. Flux is a chemical solution mostly composed of dihydroabietyl alcohol. If the tin drop is not attaching to the tiny solder pad, it's because its surface is corroded. Flux is used to strip the corrosion from the copper and enhance electric contacts [1]. It is a widespread substance in the electronic assembly industry, although its usage may expose to health hazards [3].

5.2 Unsoldering SMD

Soldering is part of the job, but mistakes happen, and being able to unsolder is a complementary skill to soldering. Although unsolder through-hole components is quite easy, unsolder SMD components require a decisive choice to be made. I sadly discovered by

myself that one cannot save both the component and the PCB (see Figure 3). May it be by overheating the components or spreading tin instead of sucking it, the component will perish. As discarding the PCB would also mean discarding every elements already soldered, it's more common to discard the targeted component instead of the card. For dipoles, sucking the tin on each pad pose no issue. SOIC packages, on the other hand, require a more delicate handling. With the help of a sharp blade, one must cut every single pin of the package without perforate the PCB upper layout, then remove the plastic package, before using the soldering iron to pull each pin one-by-one from their respective pad. By doing so, one should be able to sold a new component at the same place.

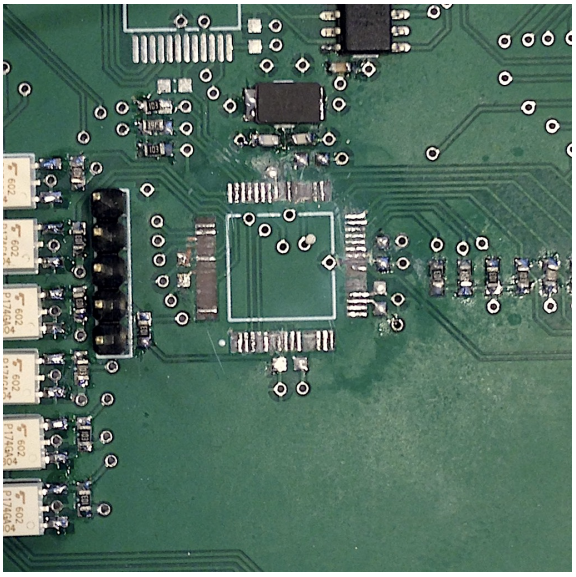


Figure 3: Aftermath of indelicate unsoldering of a micro-controller. The copper pads are teared which makes the PCB useless.

5.3 Detecting the correct voltage supply

Everyday, I watched schematics. I frequently met what seemed to be standard circuitry to perform basic tasks. Such circuitry includes detecting a fixed voltage to enable an auxiliary circuit, and detect wire breaks among the circuitry. I decided to explain these cited technics in my report, beginning with "How to detect a fixed voltage to close another circuit?".

Dealing with digital electronics requires precise voltages. Such necessities are shown —for example—in micro-controllers with the Brown-Out Reset module[8] and Power-On-Reset module[9]. For the Doel 1&2 project, correct voltages are needed to ensure proper

[8]Make the device enter sleep mode if the voltage drops below a critical level.

[9]Send a reset signal when the device receives the correct voltage to operate in compliant conditions.

operations of comparators assigned to detect alarm signals. A voltage detector example circuit is proposed at Figure 4. This design exploits three blocks: An operational amplifier mounted as a voltage comparator, a voltage divider, and a photo-coupler. Vcc is a shared voltage level. A fixed voltage defined by the Zener diode is applied on the positive input of the operational amplifier, due to the constant voltage drop property of Zener diodes. A voltage divider is built with the intent to set the reference operating voltage plus the Zener dropped voltage on the negative input of the amplifier. When the power voltage is not high enough to be considered suitable, the output voltage of the op. amp. is set high, thus small to not at all current is drained from Vcc to the op. amp. output, not letting the photo-coupler close the In-Out circuit. At the other case: when a high enough voltage is supplied, the output of the op. amp. becomes low enough—related to the Vcc level—to drain a current able to activate to photo-coupler, which will close the secondary circuit.

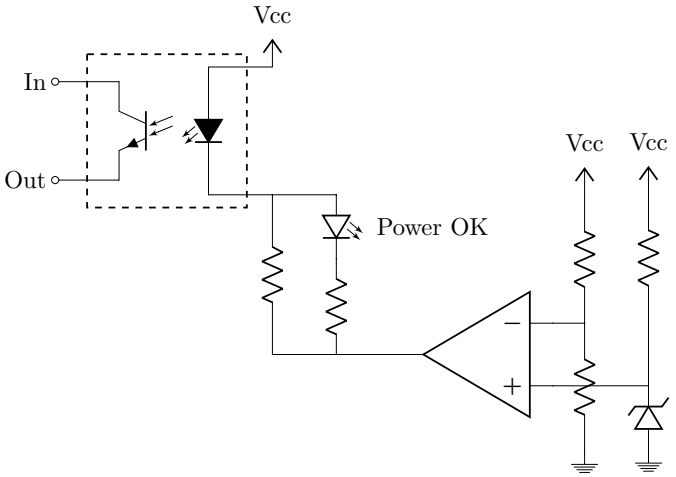


Figure 4: Schematic of a voltage detector circuit.

5.4 Detecting slopes

This circuit is part of an anomaly detecting system to monitor wires that should have stable voltage. The objective is to detect an abrupt change in voltage (i.e. a slope) which can only occur from an anomaly. To do so, the circuit show in Figure 5 is set up. At the beginning, the signal point (named Slope in Figure 5) is at its high state, the voltage is high. When a sudden change in state occurs (i.e. a slope appears). The point after the capacitor will go through a direct value drop followed by a slow charging of the capacitor, which will looks like a ramp on an oscilloscope. The inverting Schmitt trigger behind will produce a pulse from the edges of the ramp that will be transmitted to the wire breaks

detecting circuit. This circuit is basically a slope-to-pulse converter.

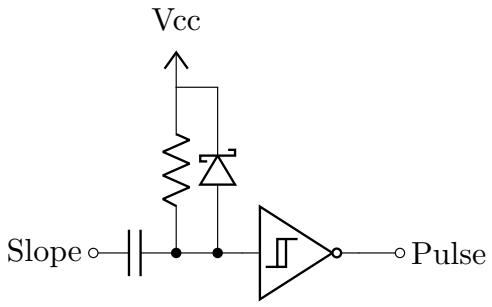


Figure 5: Schematic of a slope detector. Observe that an inverting Schmitt trigger is used.

5.5 Detecting wire breaks

Alarms are a peculiar type of circuitry since it's a monitoring system that needs to be monitored itself to ensure its proper operating. Being monitored means, for example, to verify that a single wire is not disconnected. From an engineer perspective, it could be implemented by letting a continuous current flow through the wire and detect its presence. Such implementation is described in Figure 6. A continuous current comes from the Signal label, and set a high voltage on the gate of the NMOS transistor, breaking the connection between the drain and the source. When the current stops, the NMOS transistor drop its drain to the ground, also closing the drain-source path of the next transistor, making a contact between Vcc and the ground. Thus, making an other current flow through the photo-coupler. The photo-coupler is activated, connecting the other side of the device. A third current now flows through the LED, alerting an operator that the connection to the Signal wire has been lost. A button named J1 is installed to allow an operator to simulate a wire break and ensure that its control panel is working as intended.

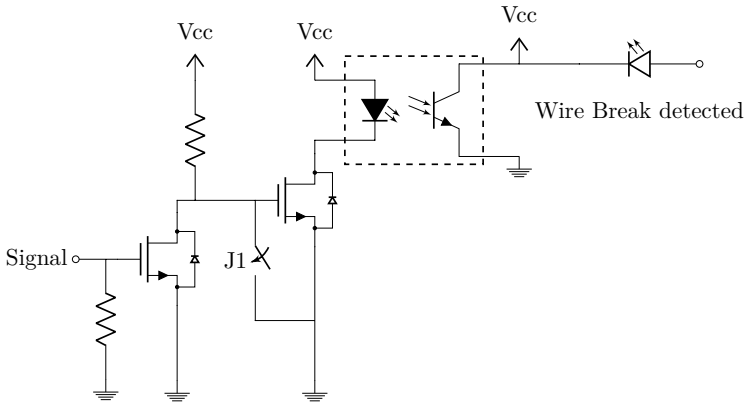


Figure 6: Schematic of a wire break circuit.

5.6 Using an astable multivibrator to generate square signals

Alarm indicators are made of LED panels. Some are off, others steady, and suspicious ones blink. To make a LED blink, a square signal is required. Pulse-With-Modulation is frequently used to comply with this task, however a PWM capable system is resource-intensive and an over engineered solution to blink a LED. Instead, I've learned about a simple circuit using a single 555 timer to generate a square signal show in Figure 7. The inside of a 555 timer can be abstract to two inputs connected to a comparator, which is connected to a latch, itself connected to the output. The square signal is generated by letting a capacitor charge to an upper threshold—defined by a voltage divider connected to the comparator—then the latch open the circuit, discharging the capacitor until the lower threshold is reached, then the capacitor charge again, looping the process. The repetitive toggle of the latch generates a square signal with the width depending of the capacitor charging time.

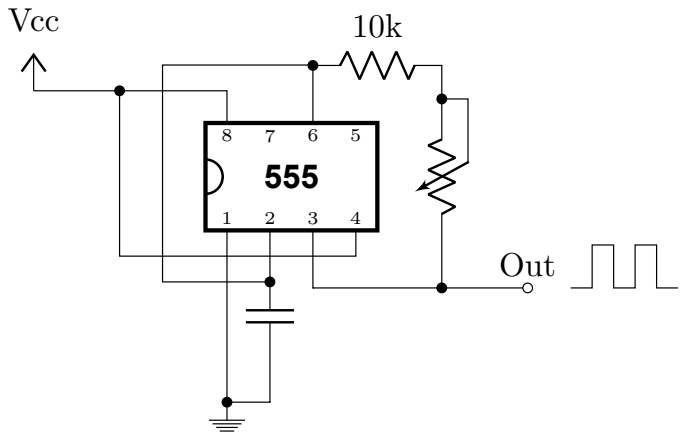


Figure 7: Schematic of an astable multivibrator using an integrated circuit of timer 555

6 Extras

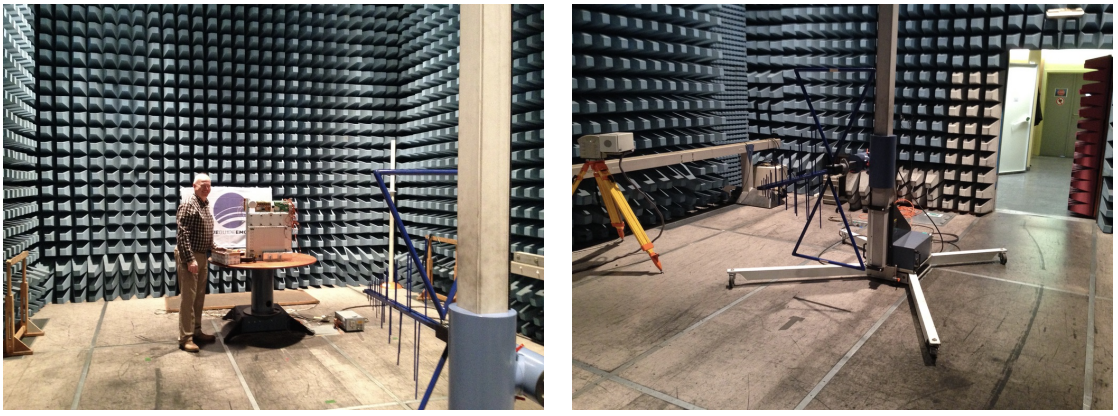
Section 6 regroups subjects I couldn't place in other sections.

6.1 Measuring EMC emissions at Erpe-Mere

One of the demands of the client was to ensure that an upper limit of electromagnetic emissions will not be emit by the cabinet (i.e. Electromagnetic Compatibility [EMC]). When working with electric signals, electromagnetic emissions are emitted by the circuitry. The potential risk exposed is for the emission of a signal to create a clone

of the original one in another circuity and thus interfering with the function of the other system by creating false data [5]. When working for the nuclear field, the restriction of cabinet emissions are extremely strict. To ensure that the threshold are not overstepped, when went to the old pioneer EMC laboratory to measure the emissions. The laboratory name is Blue Guide EMC Lab[10] and is situated in the industrial zone of Epre-Mere in the flemish region of Belgium. They are equipped with an anechoic chamber which is basically a room isolated from all electromagnetic emissions from the outside (see Figure 9). The tests lasted for about one hour. What were measured are the average power of frequency peaks on the electromagnetic spectrum, and the rejection of harmonic frequencies to the socket plug. The frequencies range measured is from a dozen of kilohertz to two gigahertz. The results from the experimentation cannot be disclosed, but we were enjoyed to discover that the constraints were respected.

Figure 8: Blue Guide EMC Lab logo



(a) (b)

Figure 9: Photos from the inside of the anechoic chamber at Blue Guide EMC Lab. The blue antenna shown in (b) is used to measure the emission and absorption of electromagnetic emissions of electronic components.

6.2 Organizing a barbecue for the company employee

A custom at Macq is forcing its newcomers to organise a barbecue for the whole company. It didn't matter how reluctant I've been to the task, we (my internship colleagues and I) wouldn't dare to break traditions. And so the last week of our internship period, we

[10] http://www.bgemc.com

organized a barbecue for 36 peoples including every persons we've met during the weeks we spent there. We couldn't make a better goodbye that regrouping everyone for diner and serving them grilled sausages. This adventure made me execute my last productive work for the company as I wrote a manual for future interns and new employee specifying the food quantity and locations to buy. I'm glad to know that I left a sign of my presence there.

7 Conclusion

To conclude this report, I'll cite the objectives list in my activity note that I achieved to fulfil or not:

- Discover the company:
  - ✓ Visit different departments of the company (basic task done the first week).
  - ✓ Meet the workforce (alongside with the previous item).
  - ✓ Discover the company management (I've meet the quality supervisor, the product team supervisor, and the HR supervisor).
- Discover the engineering field:
  - ✓ Join the project meeting (not weekly but I've joined every meeting I could).
- Participate in projects:
  - ✓ PIC16 programmation (I did it during six whole weeks).
  - ∼ Write test procedures for testers (I didn't write one wholly from A to Z but I've been pairing with my colleague to fill the documents).
  - × Write a F.A.T [Factory Acceptance Testing] (I did not have time to do this).
  - ✓ Following up the team and the advance on the Doel 1&2 project (this is what I did for the six weeks).

I fell like this internship taught me more about the profession than the eight months I passed behind the desk at school. I learned new practical skills and organizational ones such as group management and workload sharing. I've already used the new soldering technics I learned and feature of oscilloscopes I didn't even know existed. This internship made me confident about the desire to pursuit my career in this field. I thank Macq a lot for allowing me to live this experience and I'm already looking forward to my next internship in two years.

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Bruxelles, le 24 mai 2017

Temporary
Wrong dates

ATTESTATION

Je soussigné, I. van Wijk, RH Assistante de la S.A. MACQ, ayant son siège social rue de l'Aéronef 2 à 1140 Bruxelles, atteste par la présente que Monsieur Alexis NOOTENS, né le 11/07/1994 à Marche-En-Famenne (Belgique) et domicilie Rue des Jardins, 6 à 5580 Jemelle, a effectué un stage dans notre entreprise du 10/04/2017 au 26/05/2017 ainsi que son travail de fin d'études.

I. van Wijk,
RH Assistante

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24 avril 2017

Maître de stage : Vincent Raman
Équipe hardware : Camille Giaux
Koenraad Van den Eeckhout
Jean-Luc Van Michel
Superviseur : Sébastien Combéfis
Étudiant : Alexis Nootens

Entreprise : Macq sa/nv — Rue de l'Aéronef, 1140 Bruxelles
Période de stage : Du 17 avril 2017 au 26 mai 2017

Note d'activités

Objectifs généraux	Objectifs spécifiques
Découverte de l'entreprise	- Visite des différents départements de l'entreprise - Rencontre avec le personnel - Gestion de l'entreprise
Découverte du métier d'ingénieur	- Participation aux réunions du projet Doel 1&2 chaque lundi matin avec le client (Tractebel) et l'équipe hardware pour avoir un échange direct, de débattre sur des points encore en suspens et de prendre des décisions.
Participation à des projets	- Programmation de PIC16 et soudage des composants sur les PCB pour différents testeurs afin de réaliser des tests fonctionnels de l'armoire de qualification dans Doel 1&2. - Rédaction des procédures de tests sur les différents testeurs réalisés auparavant. - Rédaction d'un F.A.T (Factory Acceptance Testing) pour l'armoire de qualification. - Suivi de l'équipe et de l'avancement du Projet Doel 1&2.

Signature de l'étudiant

Signature du maître de stage