The University of Manchester

School of Electrical and Electronic Engineering

With Industrial Experience Report

Final Report

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Executive Summary

This report discusses my year-long engineering internship with the company called Nexperia and provides a detailed description of my year-long internship work experience.

I applied for an internship in my 3rd year at university to acquire practical knowledge in an industrial environment, to gain insight into the work dynamics of an electronics company and to better understand what career path I would like to pursue in the future as an engineer. My motivation was to learn new skills by doing and to experience working full-time as an engineer. The Company's motivation was to familiarise working students with in-house tools and procedures that would equip them with the necessary skills and knowledge for future employment.

My project was to revamp and add new functionality to an automated semiconductor device design software that was built for in-house use in the past. This project presented a great opportunity to deepen my understanding about the physics of semiconductor devices, to improve my programming skills and to experience working on a year-long project.

My achievements include demonstrating ability to understand and analyse the fundamental design process of the Company and applying engineering techniques to successfully model the design process in code. Further achievements include the demonstration of effective interpersonal presentation skills while delivering presentations about my project to the members of the R&D department.

I believe that my time with Nexperia was extremely educative. I learned a wide range of new skills that I needed to make a meaningful contribution to the Company's work in the industrial environment. I picked up a great deal of knowledge through working on my project and attending meetings with my team and line manager. I experienced the work culture of a multinational corporation and the everyday life of an engineer. All of these lead me to conclude that this is the type of work environment and company where I could imagine myself starting a career in technology after graduation.

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1. Introduction

At the University of Manchester, electronic and electrical engineering students are offered the opportunity to undertake a year-long internship in their 3rd year as part of their degree. The so-called industrial placement is a great opportunity to develop technical skills in an industrial environment, outside of an academic environment.

I applied to an internship to develop new engineering skills, to experience working in full-time as an engineer and to gain insight into the inner workings of a multinational electronics company. I hoped to get a better understanding about what career path I would like to pursue in the future as an engineer and to develop practical skills that would complement my academic theoretical knowledge.

This report discusses my experience of the year-long internship I spent with the company called Nexperia and provides a detailed description of the main activities related to my project. The activities are discussed through the examples of the With Industrial Experience (WIE) competencies listed in the WIE handbook. This deliverable builds on top of my Preparatory Report that covered my time with Nexperia from September 2018 to January 2019, and extends it with the discussion of the time span from February 2019 to July 2019. This report also incorporates information already delivered to my academic supervisor in the form of presentations during his two on-site visits.

2. The company and its organisation

Nexperia is a global leader in designing and manufacturing discretes, logic and MOSFET devices. The company had originally been part of Philips, before it became a business unit of NXP. It became an independent technology company in 2017 with approximately 11 000 employees by the end of that year (‘Nexperia’, 2019). The Company’s main customers include Huawei, Dyson and Bosch among many other industry leader technology companies. The Company’s headquarter is located in Nijmegen, Netherlands. The front end fabrication and R&D facilities are located in Hamburg, Germany and Manchester, UK while the assembly and testing facilities are located in China and the Philippines. (nexperia.com, 2017)

I worked in the Advanced Devices Group where the main activities include researching and developing new trench-based power MOSFET technologies, the statistical analysis of product manufacturing data and the physical and behavioural modelling of power MOSFET devices. The Advanced Devices Group is one of the three sub-groups of the superior group called Innovation Group. The Innovation Group is part of the superior group called MOS Business Group that is one of the main business units of Nexperia. The MOS Business Group is entirely located in Manchester, UK, more precisely in Hazel Grove, a town near Stockport. The site accommodates two fabrication plants with clean rooms and a main office building. The main office building is depicted in Figure 1.

Figure 1: Nexperia Manchester site [photo] (Source: marketingstockport.co.uk)

My team, the Advanced Devices Group, gather once in a month for a team meeting where everyone gives a short summary about their current projects and shares their latest successes and struggles. These meetings are coordinated by Phil who is a technical director of the Power MOS business at the Company, the team leader of the Advanced Devices Group and my line manager as well. In these meetings, I usually gave an update about my project and talked about problems I came up against. More often than not, one of my teammates or Phil could help me out with useful advices that significantly sped up my work.

The Innovation Group, which incorporates the Advanced Devices Group, also gather once a month for the so-called Innovation Technical Review Board (ITRB) where selected teams or departments present about their current projects. The selection is based on a rotating basis and my team presented three times during the course of my year-long internship. Interestingly enough, colleagues from Hamburg occasionally presented as well through Skype. I had the opportunity to present twice in the ITRB meetings to more than 30 members of the R&D department (see in the 3. My project and the WIE competencies chapter).

Every once in three months, the CEO of the company visits the Manchester site to give a presentation about the current activities of the Company's management team, the Company's financial performance and exclusive news about new product releases and new business partnerships. In these meetings, employees can address questions directly to the CEO of the Company. I am fond of the idea of the CEO visiting the different sites of a multinational company in order to directly interact with the company's employees. I believe that it is an excellent way to keep up an efficient information flow through the Company's hierarchy.

The most frequent type of meeting I attended was the 1:1 meeting with my line manager, where I gave updates about my project and we discussed the current problems and future improvements. The dialogues in these meetings helped me find solutions to problems and make my project a success.

In addition to the above-mentioned recurring meetings, on-site technical trainings very often took place. For instance, I attended a series of presentations about the operation of MOSFETs in linear and avalanche mode. These trainings are open to all employees of the Company and aim to provide the universal knowledge that is necessary in the semiconductor industry.

Apart from the meetings, people come together outside of the office as well. The Company organises several social activities for employees and their families. One of such activities is the so-called Business Innovation Competition (BIC). The BIC is an annual event where self-organised teams submit entreating but technically informative posters and deliver presentations about their projects to win the main prize. The event is always held in an initially secret location – usually a hotel's conference room - near Manchester. At the end of the day-long conference, the Company invites employees for a dinner that usually ends in a masquerade ball. With some of my fellow intern and graduate colleagues, we formed a team and entered the competition with a poster about how Nexperia differentiates itself from competitors in the power MOSFET market. The preparation of the poster helped me gain insight into the past, present and future of the Company. Furthermore, I learned more about the most successful products that helped the Company gain a competitive edge in the market. It also helped us build a community with the interns and the graduates.

The Company's work ethics and business practices are built on its fundamental values. The fundamental values are: Passion, Professionalism, Perseverance and Performance. The annual performance reports, the employee self-evaluation forms and basically every aspect of the work is somehow related to these values. In other words, Nexperia aim to conduct its business while living by these values. The values can be found written around in the office building at the Manchester site. An example is shown in Figure 2.

Figure 2: Nexperia values written on a wall in the Manchester office (Source: nexperia.com)

The work environment resembles that of a huge multinational company, but there are elements that make it more humane and appealing to employees. The dress code is business smart except for Fridays that is a dress-down day. The Company's hierarchy is fairly complicated to understand, but the CEO quite often visits the Manchester site in person. The work hours are taken extremely seriously but employees can manage their own time outside the core working hours. This is made possible by the flexi-time system that lets employees choose the starting and finishing times within the agreed limits. All in all, there is a personal touch added to the multinational corporate culture that makes the Company an enjoyable and relaxed place to work.

3. My project and the WIE competencies

My project was to revamp and add new functionality to a semiconductor device design software built in the past for in-house use. The software is a design tool that design engineers can use to speed up the power MOSFET device design process. The tool can be used to generate an optimised design given certain input parameters This design can serve as a better starting point of the design process than starting a design from scratch. The tool also provides a quick way for marketers to check different theoretical designs and to provide feedback to customer inquiries without the need of an engineer's input and expertise. In addition to these use cases, the general idea behind the tool is to help the Company gradually turn the in-house design workflow into a fully automated process – something that many other projects within the Company focus on.

The design tool takes a set of user inputs, technology specifications and device packaging options, and returns an optimised trench power MOSFET design. The tool uses mathematical models and the third-party simulation software to return the most optimal design. The user interacts with the design tool via an accessible and easy-to-use user interface. The user interface has the usual attributes that one would expect – responsive design, interactivity and unambiguous options. Figure 3 shows the user interface of the design tool. In the top-left of the figure, the user can enter the user specific inputs such as the dimensions of the MOSFET device. Under the user defined inputs, the technology specifications and the packaging requirements can be provided using the interactive line edit fields and buttons. On the right, users can see a list of editable variables derived from the combination of the left-hand side inputs.

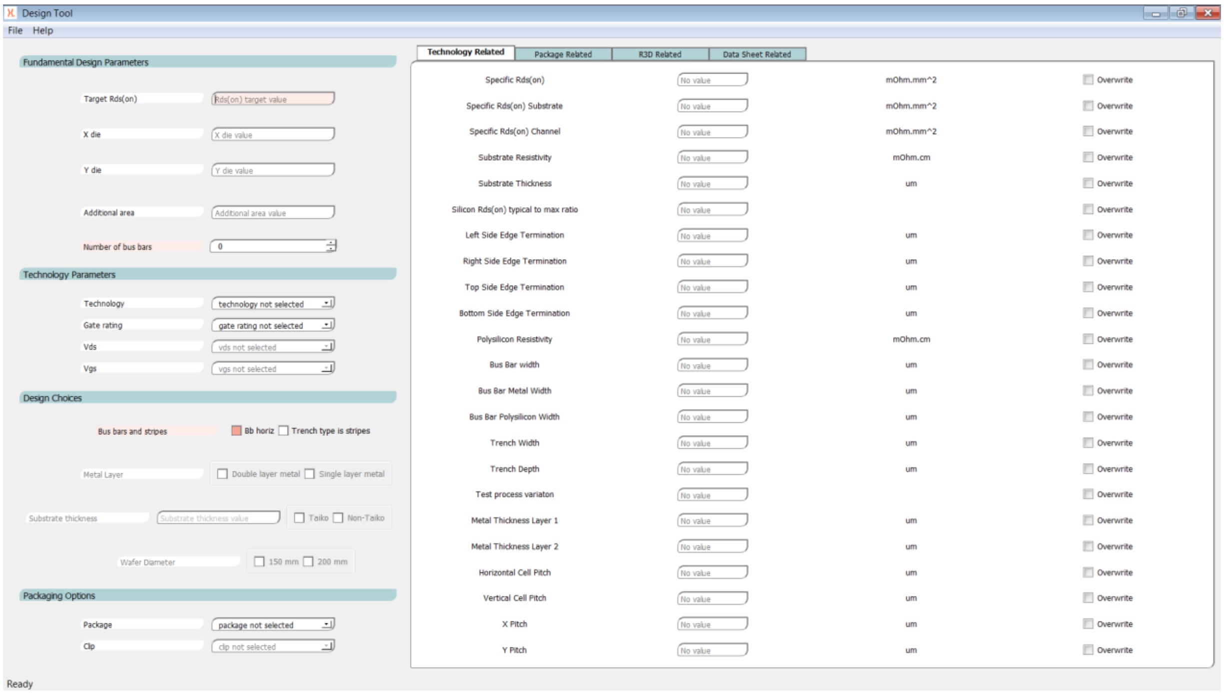

Figure 3: The user interface of the design tool

A wide range of tools were used in the development of the software. The fundamental programming language, Python, was selected for its simplicity, huge developer community and easy-to-use packages. Among the many Python packages used in the project, the most important ones include pandas for data operations, numpy and scipy for scientific computation and pyqt for interfacing with the Qt software development kit for building user interfaces. In addition to these packages, third-party software was also integrated into the design tool such as R3D, a resistive 3D extraction and analysis product, and klayout, an open-source IC layout viewer and editor. The multi-platform design tool was engineered for use in Unix and Windows environments.

The project comprised multiple sub-tasks with different time requirements. In the beginning of my internship, I first needed to learn coding Python and understand the in-house design process of the Company. Having acquired a decent understanding of Python and the elements of the design process, I spent my time from September 2018 to February 2019 on building the prototype of the design tool. The prototype was finished by the time of my first ITRB performance in February 2019 when I delivered a presentation about the design tool and demonstrated how to use it.

In the second half of the project, I needed to update the tool's database and create a Graphical User Interface (GUI). To update the database, I analysed product manufacturing and measurement data with statistical methods. The statistical analysis was carried out using Python and Minitab. Simultaneously, I finished a better version of the design tool by May 2019. With the better version being ready, I started developing the user interface that was necessary to enable users to interact with the software. The GUI development was a new experience for me as it required a deep understanding of Object-Oriented Programming in Python. A nearly finished version of the GUI was presented in my second ITRB presentation in July 2019. From July 2019 to August 2019, I was having meetings with the actual users of the software – the designers working for Nexperia - to get feedback on requested features and get an idea about necessary further improvements. The final software was a fully functional design tool with a user-friendly interface. Throughout the course of the 12 months, I was simultaneously working on the documentation of the software that was intended for users and the next student to maintain and further improve the product.

In the following couple of paragraphs, different activities related to my project are discussed with references to the WIE competences. In

Table 1, the mapping between the activities and the WIE competences is shown.

Competence Criteria ID	**Competence to be marked upon**	**Competence Criteria Description**	**Activity demonstrating the competence**
A	Yes (1st in the order after the table in this chapter)	Demonstrate ability to understand and analyse engineering challenges	Carrying out a factorial design of experiment to improve the performance of the software
D	Yes (2nd in the order after the table in this chapter)	Demonstrate effective interpersonal presentation and technical writing skills	The two Innovation Technical Review Board (ITRB) presentations
C	No (3rd in the order after the table in this chapter)	Provide technical or commercial guidance, knowledge-sharing or leadership to peers or assistance	Writing the documentation of software
B	No (4th in the order after the table in this chapter)	Demonstrate ability to apply engineering techniques to industrial challenges	The statistical analysis of raw product measurement data to extract valuable information and improve the performance of the software

Table 1: The mapping between activities and the WIE competencies

A memorable part of the project was carrying out a factorial design of experiment. In this experiment, I aimed to model the spreading resistance in general designs. MOSFET device designs in the Company mostly have clip bonded packages in which the clip never entirely covers the active silicon area of the MOSFET. This gives rise to the spreading resistance that is the result of the current spreading at the interface of the active area and the clip. In many cases, the spreading resistance makes a significant contribution to the MOSFET on-resistance. The factorial design of experiment was carried out to see how different parameters of a design affect the spreading resistance and to find a suitable way to model the effect of the spreading resistance. Carrying out various versions of the experiment, I found the most significant parameters and excluded the least significant ones. Using the most significant parameters, I built a model of the spreading resistance that improved the accuracy of the design tool. I strongly believe that this is an example of understanding and analysing a complex engineering challenge. I added value to my project and improved the design tool software by carrying out this experiment (Competence A). Figure 4 shows the visualised results of an experiment setup. In this setup, the MOSFET channel resistivity and the metal layer thickness are kept constant, while the gap between the clip's edge and the active area's edge varies. The colour code shows how the spreading resistance varies as a function of the size of the gap.

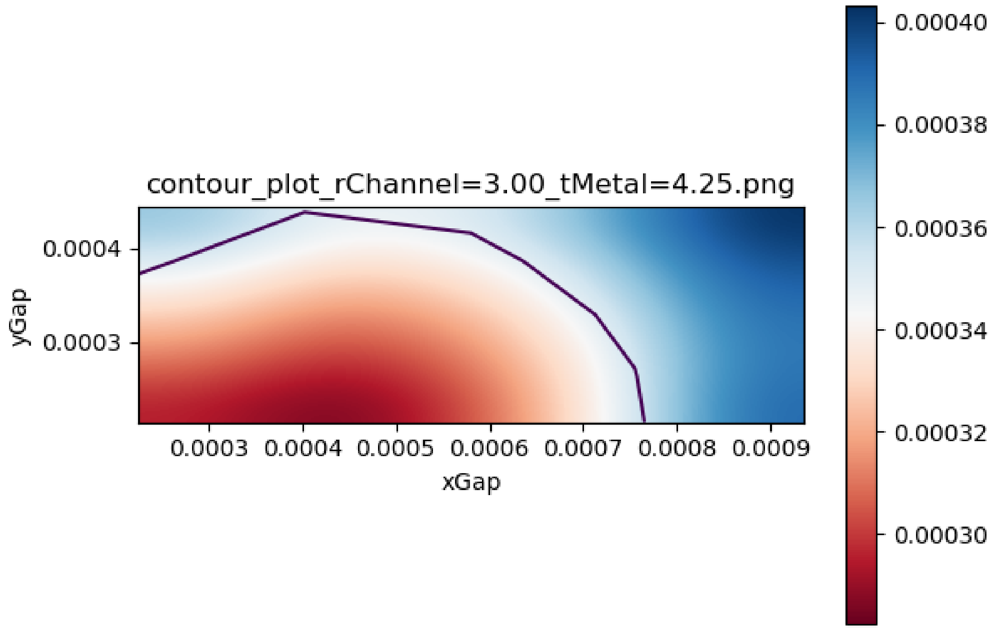

Figure 4: Visualised results of the factorial design of experiment

Another part of the project that was of high importance to me was presenting about my work in the monthly ITRB meetings. I had the opportunity to present about my project twice in the Company's R&D meeting throughout the 12 months. These two presentations are examples of the demonstration of effective interpersonal presentation and technical writing skills (Competence D). The first presentation took place in February 2019 and the second one was in July 2019. In these meetings, more than 30 people participated alongside with international colleagues through Skype. I introduced the design tool project to the R&D department to generate interest in the first meeting. I talked about the original design tool and the motivation behind updating it and adding new functionality to it. I also demonstrated how to use it through some real-life designs. In the second presentation, I presented the final version of the design tool with a nearly finished user interface. The second presentation was more about the demonstration of the tool rather than talking about it. I was really anxious before the first presentation and it affected my performance in the first couple of minutes. The second presentation went significantly smoother and I could feel that I improved in presentation skills. One of the slides of my first ITRB presentation is show in Figure 5.

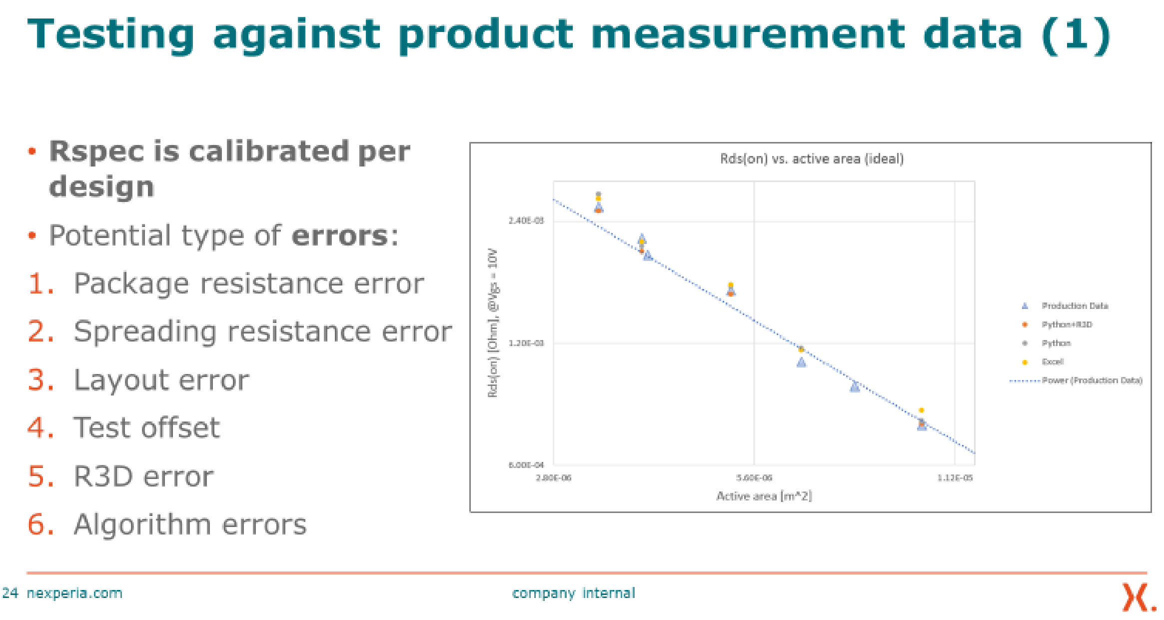

Figure 5: A presentation slide from my first ITRB presentation

In the presentation slide, the final conclusion of the entire presentation is drawn. The final conclusion is based on the comparison between the performance of design tool and real-life product measurement data. The chart shows that the design tool's accuracy approaches the accuracy of real-life measurement data. This means that the design tool yields an optimal design close to real life designs, proving that the prototype of the software was well-built.

The least interesting but probably one of the most important activities related to the project was writing the documentation of the software. The documentation mainly served two purposes. Firstly, it was a user manual providing technical and commercial guidance on how to use the design tool and how to make the most of its capabilities (Competence C). Secondly, it was a knowledge-sharing document that describes all of the components of the software with the aim to enable the next student to efficiently maintain and further develop it (Competence C). The documentation included a description of the functions used in the code, a discussion of the mathematical approximations and models, as well as the step-by-step explanation of the algorithms.

An unexpectedly interesting activity related to the project was analysing raw product manufacturing data to extract valuable information and update the old database of the software. This part of the project was an example of applying statistical engineering techniques to the industrial challenge of extracting valuable information from raw manufacturing data (Competence B). In the analysis, I used TIBCO Spotfire – a statistical analysis software – and Python's scientific stack. To extract the information, I carried out exploratory data analysis meaning that I did not make any prior assumptions before the data analysis, I just empirically explored the underlying structure of the data. I focused on finding the underlying distribution of the data, identifying outliers and anomalies as well as drawing educated conclusions of the results. I learned a lot about distributions – in particular the normal distribution – and various statistical techniques. As a result of the analysis, I could update the database of the software and improve the accuracy of the design tool.

The expectation of me was that I would deliver a better version of the old design tool with extended functionality in the form of a proper software. This seemed a bit too ambitious to me in the beginning as I had not had much experience in software development, but I successfully lived up to the expectations and managed to deliver a new more accurate design tool. The difficulty of the work was acceptable as I had the necessary time to complete sub-tasks and I was given time to learn to use the necessary tools. The most intense periods were the ones before the two ITRB presentations when I had to complete a great deal of tasks within a short span of time.

The project was a great opportunity to learn about the design process of power trench MOSFETs and to improve my programming skills. I acquired a great deal of knowledge in how to coordinate a year-long project and learned to build and handle complex software. I understood that mathematics is mostly used to approximate phenomenon and processes of the real-world and I experienced the benefits of using abstraction in mathematical modelling. I glimpsed into how new technologies are developed at Nexperia and analysed real-world manufacturing data to extract valuable and actionable insights from it.

4. Summary and reflections

Despite the many good elements of the internship, it did not start out the way I expected. First of all, in my interview in May 2018, I was offered the intern position believing that it would be an engineering internship with a focus on electronics. To my surprise, in September 2019 when I started, I was told that there had been changes made to certain projects within the Company and that they wanted me to work on the design tool that later became my year-long project. I was told that the project would require experience in programming in Python as a well as a solid understanding of the physics of MOSFET devices. Fortunately enough, I had taught myself a bit of Python and had a good understanding of MOSFETs from the relevant modules in my previous years at university. Consequently, I accepted this new position since I knew that I had all necessary knowledge to make a start. Secondly, I thought that I would work in a team of a couple of people. This was partly true as I worked really closely with my line manager, but my real teammate left the Company in February due to unforeseen reasons and was not replaced till the end of my internship. This left me virtually alone from at the half of my internship onwards. Working alone had its advantages and drawbacks. For instance, I was given more freedom to do the work the way I preferred and to implement features I deemed necessary. On the other hand, if I made a mistake or fell behind time, I was the only one responsible for it. These unexpected surprises did affect my performance usually in a positive, but occasionally in a negative way.

All in all, I had an amazing experience with Nexperia during my internship in the past 12 months. I strongly believe that working in industry for a year was extremely educative in terms of understanding work ethics and experiencing the multinational corporate culture. I gained new practical skills that complement my academic knowledge from university, and I glimpsed into the inner workings of a multinational electronics company. I am really proud of the work I have done and I hope that I could make a valuable contribution to the Company’s performance via delivering my project on time. I found the work environment and the inclusivity of the Company really appealing. All of these lead me to conclude that this is the type of work environment and company where I could imagine myself starting a career in technology after graduation.

5. References

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