Summary of Comments on Practical Work Report

Student Name..... **Markers Initials**_____

	Ranking			
Structure of the Report (compliance issue) All instruction about format have been followed, and all the prescribed sections are present	5	4	3	2 OR 1
Quality of the Report Grammar and spelling are good. The language is fluent, and flows well, no proof reading errors.	5	4	3 OR 2	1
Presentation of the Report The report is well focussed, balanced, interesting and contains an appropriate amount of detail. Illustrations are useful.	5	4 OR 3	2	1
Scope of Report Well-chosen and relevant to a Practical Work Report	3	2	1	0
TOTAL VALUE OF MARKS				

OVERALL Grade for this Report

Total Marks greater than 14	A
Total Marks greater than 10	B
Total marks greater than 6	C
You are required to resubmit this report.	D

It is recommended that you contact the Student Learning Unit for advice on the writing of this report

THE UNIVERSITY OF AUCKLAND
FACULTY OF ENGINEERING

CERTIFICATE OF PRACTICAL WORK

Student Family Name		First Name	
Student ID Number		Specialisation	Electrical & Electronic
Part Completed	1 ☐ 2 ☐	3 ☐	☐
Full Company Name	Fisher and Paykel Healthcare		
Company Physical Address	15 Maurice Paykel Place East Tamaki, Auckland		
Company Postal Address	15 Maurice Paykel Place, Paykel Building East Tamaki, Auckland, 2013		
Company Website Address	http://www.fphcare.co.nz		
Company Phone Number	+64 9 5740100	Company Fax Number	+64 9 574 0158
Supervisor Name and Designation	Snr Product Development Engineer	Supervisor e mail address	
Period Worked	From 17-Nov-2014	To 13-Feb 2015	

Nature of Work (To be classified showing the hours for each classification)	Hours General	Hours Sub Prof
Development/Documentation of SMT Prototype Line	[illegible]	20
Pick and place system to populate PCBs	15	
Circuit Modification & Testing	100	100
Inventory Control, Reconciliation and Sorting	100	100
Supplier Communication	40	
Total Hours Worked	255	220

Report of Engineer in Charge

Signature		Date	13 Feb 15
Student Progress	Perfect	Student Diligence	Very good
Student Attendance	Perfect	Remarks	Kai was an excelent member of our team

FOR OFFICE USE

Name of Marker				
Reports Approved	General Hours		Sub Professional Hours	
Hours Credited	General Hours		Sub Professional Hours	
Grade ☐	Signature		Date	

THE UNIVERSITY OF AUCKLAND
FACULTY OF ENGINEERING

PRACTICAL WORK REPORT

Department of Electrical and Computer Engineering

Fisher & Paykel HEALTHCARE

Student:
Date: 28th July 2016
Work Period: 17th Nov 2014 – 13th Feb 2015
Company Details: Fisher and Paykel Healthcare
Paykel Building
15 Maurice Paykel Place
East Tamaki, Auckland

Executive Summary

The following report details an internship undertaken at Fisher and Paykel Healthcare. In this report, an overview of the company and its organizational structure is discussed. This is followed by a detailed description of the various tasks I was assigned during this internship and the skills obtained. Finally, a reflection on learning completes this report.

Fisher and Paykel Healthcare is a leading innovator involved with the design and manufacture of healthcare products. The internship was mainly involved with the department of Respiratory Acute Care (RAC) under the electronics team. As an Assistant Product Development Engineer, I was assigned a variety of tasks. These ranged from the testing and debugging of PCBs to creating and organizing an inventory system and the documentation of process for a SMT prototype line. Throughout these tasks, I learned various skills associated with professional engineering equipment, such as soldering irons, oscilloscopes and SMT pick and place machines.

Throughout the internship, I discovered the importance of communication and teamwork. Communication was an integral part of company success and learning to interact with different personalities to achieve company goals was crucial in allowing me to be proficient at my job.

Overall, it was an amazing experience to work at Fisher and Paykel and it was an honour to participate in the development of an exciting product. The skills I have obtained from this experience make this internship extremely valuable and being exposed to a professional engineering environment has given me a deeper understanding in the product development process.

Acknowledgements

I would like to express my sincere gratitude towards all my co-workers that have offered their time, knowledge, effort and patience during this internship.

In particular, I would like to thank:

- my supervisor, with regards to all the guidance, support and kindness he has provided during my time at Fisher and Paykel Healthcare and always making sure I was well looked after.
- , my co-workers, for their continual assistance albeit their busy schedules and their willingness to impart their knowledge.
- my manager, for giving me the opportunity to work in the electronics team and allowing me to participate in the development process of professional engineers.
- , my co-interns, for their companionship, aid and support during this internship.

Having this opportunity to work alongside such kind, hardworking and knowledgeable people was an honour and provided a once-in-a-lifetime learning experience. I've had an amazing experience working at Fisher and Paykel Healthcare and will value the assortment of skills I have obtained throughout this internship.

Contents

Table of Figures

1. Introduction

Fisher and Paykel Healthcare (F&P) is a leading innovator involved in the design and manufacture of healthcare products. The company provides products for the treatment of Obstructive Sleep Apnea (OSA) and Respiratory Acute Care (RAC). In addition, F&P have products for Surgical Humidification, Oxygen Therapy and other supplementary healthcare services.

The internship was carried under the department of Respiratory Acute Care in their Electronics Team as an Assistant Product Development Engineer. The product in development was a respiratory humidifier, which is designed to humidify the gases a patient receives during surgery, oxygen therapy, among other health treatment, ensuring they are not dehydrated during healthcare and providing comfortable oxygen delivery. Primarily, work was carried out on the sensor, control board and power electronics aspects of the device, in addition to software testing. Note: The actual product name is omitted in this report to adhere to confidentiality requirements and will be referred to as the respiratory humidifier.

An Acute Respiratory Infection is an infection that interferes with the normal routine breathing of the individual, leading to difficulties in oxygen intake and therefore low blood oxygen levels. The infection usually begins in the nose, trachea and/or lungs, however, if not treated, can spread to the entire respiratory system. If the patient cannot breathe adequately, this will affect the amount of oxygen that is supplied to the blood and system organs. Metabolic demands of the body may be unable to be achieved, leading to serious consequences.

Acute Respiratory Care is most important for children, seniors and individuals with immune disorders. Fisher and Paykel Healthcare design a series of advanced humidification therapy systems, which restore the natural balance of the body, while providing patient comfort and tolerance of treatment. This is achieved through a heated humidification process that delivers a mix of humidified air and oxygen which increases respiratory efficiency. A popular product designed by F&P with regards to Acute Respiratory Care is the Optiflow™ range which "offers the ability to comfortably deliver a complete range of oxygen concentrations and flows to extend the traditional boundaries of oxygen therapy".

Humidification plays a central role in the context of respiratory care. There two levels of humidity involved with the respiratory process: Optimal Humidity and Essential Humidity. The appropriate humidity is then delivered based on the point of care to provide the most efficient and effective way to deliver humidified air. Figure 1 shows a patient using an Optiflow product for the delivery of humidified air.

Figure 1 Patient using the Optiflow device

2. Fisher and Paykel Healthcare

2.1 History

Fisher and Paykel was originally established in 1934 as an importer of refrigerators and washing machines from America. In 1938, the New Zealand government banned importing of complete machines but continued to allow the importing of machinery parts. As a result, Fisher and Paykel decided to change their approach and began assembling appliances. Eventually, this led on to development and manufacturing of original products in the mid 1960's. In the late 1960's, Fisher and Paykel looked at business sectors that could benefit from their electronic expertise. The healthcare sector was identified and subsequently Fisher and Paykel began to expand their services. In 1971, a prototype respiratory humidifier was developed in New Zealand, changing the method by which humidified air was delivered to hospitalised patients. Continuous innovation and development of new products have evolved Fisher and Paykel to the successful company it is today.

In 2001, Fisher and Paykel Industries Limited split into two separate companies; Fisher and Paykel Healthcare and Fisher and Paykel Appliances. Fisher and Paykel Healthcare have since specialised in the healthcare sector, developing products to support and deliver care to patients internationally.

2.2 Company Values

Fisher and Paykel are dedicated to improving the care and outcomes through inspired and world-leading healthcare solutions. They understand the importance of respiratory humidification to patients and have a commitment to continuously improve and innovate solutions to deliver high quality healthcare worldwide. The company has five important values:

1. **Life**
   Improving patients' lives and providing a high quality of life for employees.

2. **Relationships**
   Caring for patients, customers, suppliers, shareholders, the environment and each other.

3. **Internationalism**
   Being global in people, thinking and behaviours.

4. **Commitment**
   Being self-motivated, and having a desire to make a real contribution.

5. **Originality**
   Encouraging original thinking to create innovative solutions leading to better products, processes and services

2.3 Company Structure

Fisher and Paykel Healthcare consists of a very complex company hierarchy. As F&P is a very large company, employing well over 3000 employees, the company has a CEO and comprises of many departments, including Finance, Quality and Regulatory, Engineering, Human Resources and Information and Communication Technology, appointing executives for each respective department.

At the very top of the hierarchy, the CEO, Lewis Gradon oversees the company strategy and direction and decides whether or not to go forward with major corporate decisions.

Under the engineering department, Andrew Somervell, who is the Vice President of products and technology, oversees the development of the healthcare product range including the design, marketing and production of the products.

is the Research and Development Manager who is in charge of the respiratory humidifier. He was responsible for overseeing the design and manufacture processes of the product, in addition to managing the testing and software development teams.

is the Project Administrator for the respiratory humidifier. She was involved with the financial and marketing aspects of the respiratory humidifier. All purchases relating to the product would be recorded and documented through her.

is the manager of the respiratory humidifier's electronics team and was responsible for managing the product development engineers in the team, ensuring the development of the product was meeting deadlines. He was also in charge of communicating the progress of the electronic team with other team managers.

As Fisher and Paykel Healthcare is an extremely large company, there are numerous layers in the management hierarchy and employees mainly interact with their direct managers. During my internship, was my direct manager, however, I had regular contact with both

2.4 Company Layout

Fisher and Paykel Healthcare consists of three buildings; O'Hare, Stewart and Paykel buildings. In addition the company has a number of sales offices across many countries as their products are sold in over 120 countries worldwide. Finally, F&P have a smaller manufacturing plant in Mexico.

The three buildings are primarily associated with the development and manufacturing of products related to a specific part of healthcare. The O'Hare and Paykel Buildings are involved with Respiratory Acute Care (RAC), with O'Hare specialising in the Airvo product range whilst the Stewart building is focused on Obstructive Sleep Apnea (OSA). I worked in the Paykel Building and an exterior view is shown in Figure 2.

Figure 2 Paykel Building [2]

The Paykel Building is divided into smaller "pods" consisting of a handful of teams. The "pod" I worked in consisted of a mechanical, electronics and process team. Each pod was divided into open-plan offices. A view of the pod from my workspace is shown in Figure 3 along with the layout of the Paykel Building in Figure 4. In addition, the Paykel Building also contained a warehouse, for storage of raw materials and a manufacturing plant for the production of respiratory humidifier prototypes.

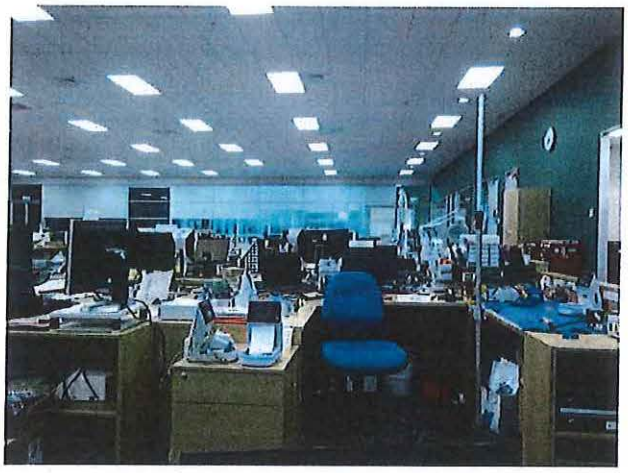

Figure 3 Open-Plan Offices in the "Pod"

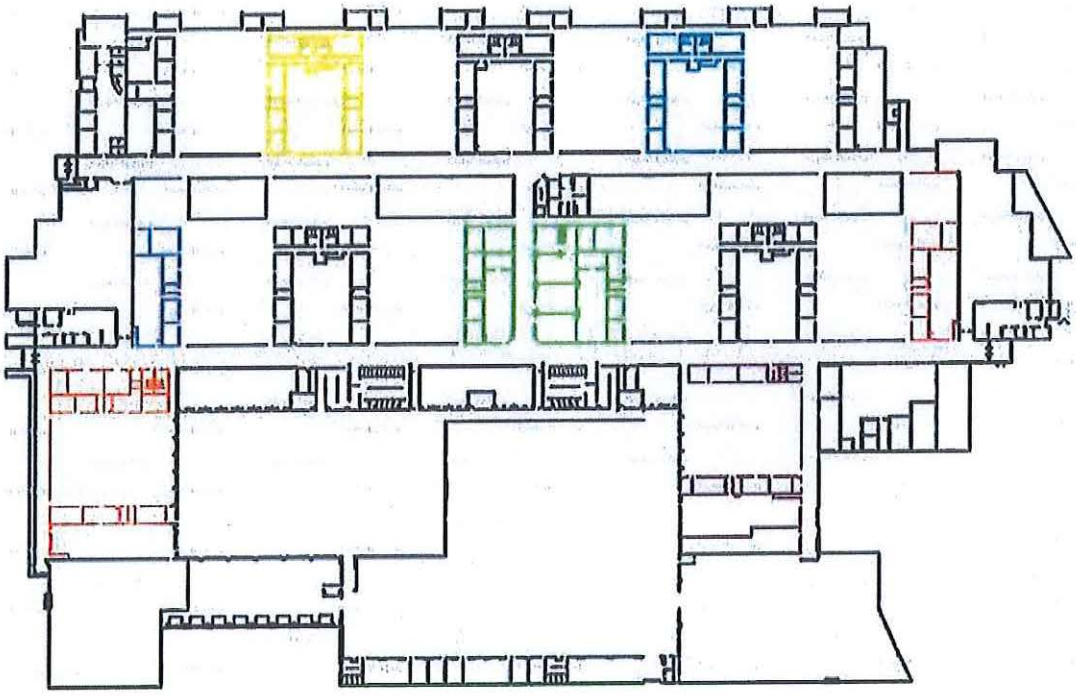

Figure 4 Layout of Paykel Building

3 Practical Work Performed

3.1 General Work

Product development involves significant amounts of testing and debugging. Several of the jobs I was assigned during my internship were involved in the verifying the correct functioning of the product. This involved soldering and de-soldering of components on prototype Printed Circuit Boards (PCBs). The very first job assigned to me during my time at Fisher and Paykel was de-soldering some specific components on a set of PCBs. This batch of prototype PCBs were designed incorrectly, however, simply disposing of them would be a significant waste of resources to the company. Therefore, to modify this batch of PCBs to a usable state, I was required to de-solder a specific set of components using a tweezer soldering iron. Through removing these specific components, this batch of PCBs were then usable by the senior engineers to further continue their product development.

At Fisher and Paykel, I was instructed on how to use a pick and place SMT machine. This was originally a machine I had no experience with. However, I was tasked with the job of populating numerous PCBs manually using the SMT machine. The process began with spreading soldering

paste across a metal stencil with the PCB located underneath as shown in Figure 5. If the metal stencil was not perfectly aligned with the PCB underneath, the solder paste would not be spread

Figure 5 Spreading Soldering Paste

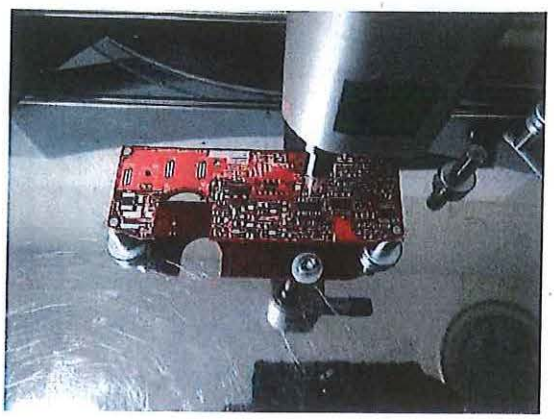

Figure 6 Placing Components Using the SMT Machine

across the pads. If this event occurred, I was required to wipe the PCB clean with some Isopropyl Alcohol (IPA) to remove the solder paste. Then, I would repeat the solder spreading process. Once the pads on the PCB under the metal stencil were filled with soldering paste, I had to ready the components to populate the PCB by picking them from their appropriate storage location. Once the components were ready, I then used the SMT machine to slowly pick and place components carefully on the PCB pads as shown above in Figure 6. Upon completely populating the PCB with all the components necessary, the PCB was then inserted into a reflow oven as shown in Figure 7.

Figure 7 Reflow Oven

The PCB would then undergo a reflow soldering process to harden the solder and firmly affix the necessary components onto the PCB, making it ready for testing. This process was repeated

several times across many different PCBs. In addition, the foot pedal attached to the SMT machine was broken, rendering the solder dispensing part of the machine nonfunctional. I was tasked with finding and fixing this problem. It required me to open up the foot pedal and analyse how it worked in conjunction with the SMT machine. Eventually, through a series of continuity tests, I discovered that one of the wire connections was damaged. Through some simple soldering, the SMT machine's solder dispensing function was recovered.

At Fisher and Paykel there was a lack of connector cables for the numerous signal generators present. Many of the existing cables were broken or in a state that was unfit for use. I was required to create a connector cable for a signal generator. This involved stripping a coaxial cable, and then connecting the respective positive and ground connections to a set of crocodile clips. Heat shrink and a glue gun were then used to enhance the flexibility and elasticity of the connection and improve the overall aesthetic quality. Furthermore, I was required to prepare these cables for another product development engineer so that more signal generators could be used concurrently.

Sound testing was an important part of testing the respiratory humidifier. The humidifier contained an alarm to indicate emergency situations and thorough testing was required to be performed on the speaker. Me and another intern were tasked with evaluating the suitability of several speakers from different companies. We would travel to the anechoic chamber with the specific speaker soldered onto the prototype PCB and forcibly trigger the alarm. The sound strength of the speaker was then tested and recorded. This was done through using an in-house program which evaluated the Fast Fourier Transform of the sound picked up by mics set up around the speaker in the anechoic chamber. In addition, several different alarm sounds were also tested to assess the most effective notification sound. Several other conditions were also tested, such as putting the speaker through the reflow process 2-3 times to evaluate its performance under stress conditions. From the information we collected, the senior engineers were then able to choose the appropriate speaker and sound file for use in the final product.

At Fisher and Paykel, my supervisor wished to test an "if" scenario. The scenario to be tested was "if the safety circuit on the humidifier failed, how would this affect the patient?" Therefore I was required to bypass the safety circuit and conduct a small experiment on the integrity of the circuitry. By bypassing the safety circuit, I measured, using the integrated software, the temperatures of a simulated patient. It was found that the temperatures reached up to ~50 degrees which melted the rubber grommets around the thermal temperature sensors and therefore cause injury to the patient. I was required to prepare a report detailing my testing method, results and recommendations with regards to the safety circuit. This then allowed my supervisor to redesign the system and reduce its reliance on the safety circuit.

Debugging is an integral part of any engineering project. I was assigned to debug a control PCB testing jig. Using the software, Labview, in conjunction with oscilloscopes and multimeters, I was tasked with finding the problems associated with the test jig. The process involved connecting the control PCB to the testing jig, checking all the connections through continuity tests and then

checking a series of software tests through Labview. These software tests involved verifying startup signals, safety checks among other tests. If any problems occurred, I would have to figure out the problem through the use of an oscilloscope, checking that the consistency between software and physical signals.

The electronics team of the respiratory humidifier had a warehouse for the storage of spare components. This was extremely disorganised, and I was required to sort and categorise many components. Me and another intern were tasked with going through an assortment of components ranging from SMT resistors to integrated circuits (ICs) to transformers to tidy up the warehouse from its disordered state. This was interesting as there were many components that I had not encountered during my university studies and gave me an insight into how industry components looked like. In addition, I learned about the variety of functions that ICs could perform and how they are used in product design.

3.2 Sub-Professional Work

The warehouse of the electronics team did not have a proper organizing system in place. As a result, me and another intern were tasked with creating an inventory control system. After categorizing and sorting the collection of components, we entered each individual component into an inventory database created on Microsoft Excel. A software with the functionality to search for components and find the component's corresponding location was then created. We also had to contact suppliers to find a method of storing the components in a way that effectively utilises space and provides ease of access. A solution was to store components in special component boxes as shown in Figure 8, allowing users to easily identify components and extract them from their corresponding location.

Figure 8 Component Storage Boxes

Through this process, a new inventory control system was created, comprising of a software database and physical storage system. This would also provide the pathway for future interns to improve upon, as a previous inventory system did not exist.

The PCB of the respiratory humidifier contained a boost converter IC and safety circuit. During my internship, I was tasked with designing and evaluating the efficiency of the overall boost converter. This involved performing calculations to choose the components required create the boost converter and then practically testing the efficiency. During the early stages, through the use of non-optimal components, the efficiency of the boost converter was found to be approximately 60%. After a few iterations, through tweaking the design, swapping components, simulation and testing, the overall performance of the boost converter was improved to ~85%. The testing process of the boost converter involved isolating the converter from the rest of the circuit and passing an input voltage into the converter. The input current was also measured to calculate the input power. The output voltage and current was then measured, using a precision multimeter to obtain the output power and efficiency of the circuit. This process was repeated several times, and through comparing theoretical results obtained by the manufacturer to practical results, the efficiency of design was improved. In addition, a safety circuit was tested and designed to ensure the boost converter performed as expected. The safety circuit was designed so that the boost converter circuit would not exceed a certain threshold voltage and act as an additional regulation device, forcing the converter to perform as expected.

During my internship at Fisher and Paykel, I had the responsibility of creating a self-education process for the SMT prototype line. The SMT prototype line comprises of solder dispensing, pick and place and reflow processes. I was tasked with instructing other engineers on how to use the machines associated with creating prototype PCBs using SMT components. I was required to communicate with different engineers from different departments and show them how to handle and use the machines. In addition, I created several posters detailing the overall process, allowing engineers to self-learn if required. I was also in charge of instructing engineers on how to use the advanced function pack of the oscilloscope. I drafted a document detailing the usage of the oscilloscope in decoding CAN, LIN, I^2C and other communication methods.

To test the respiratory humidifier's control PCB's response to different frequencies, I was tasked with the design and testing of a pink noise generator. Pink noise was chosen as each octave in the frequency domain carries an equal amount of noise energy. I prototyped and tested the pink noise generator on veroboard, verifying its functionality. I then tested and measured the frequency response of the control PCB to the pink noise generator. However, it was found that the designed pink noise generator produced noise energy that was significantly lower than necessary to trigger any type of response. After several design iterations, I finally managed to design a pink noise generator that produced enough noise energy to be of use. After testing this with the control PCB, it was found that the control PCB could tolerate noise energy hence was robust enough to continue its routine operation while under the effects of noise.

4 Reflection

4.1 Skills Developed

Throughout this internship, an assortment of skills were learnt. The most influential being the concept of patience. During my time at Fisher and Paykel, I learned that patience is an integral part of any learning process and that rushing work would only lead to a degradation in its quality. This applied to all skills including soldering, communication and software development. At the beginning of the internship, I was very nervous and felt like I lacked the skills to be proficient at my job. However, I soon realized that these skills were obtained with patience and the willingness to learn. When first asked to populate a PCB using the SMT, I assumed the complete PCB was required to be finished within the day. As such, I rushed the job and the quality was substandard. However, with a bit of patience, I improved on the skills necessary to do my job, improving the quality of current and future work.

Communication skills were also an integral part of my time at Fisher and Paykel. I learned how to conduct myself in a professional environment, how to interact with people with different personalities and that there was a time and place to talk to people. Being able to read the situation was an important part of communication. By reading the expressions or analysing the surroundings of people, I understood if they were available or whether I should return later. I also learned that depending on the person, a different conversation style was more suitable. Some individuals preferred a more professional speaking manner, while others were more comfortable with a relaxed, casual speaking style. This allowed me to maintain relatively good relationships with all my co-workers and learn about their different personalities.

Practical skills were also gained throughout the internship. The ability to use a soldering iron, pick and place SMT machine, oscilloscope, multimeter and other common engineering tools were gained. Microsoft Excel skills were extensively developed over the course of the internship through the ability to organize and process data and formula creation. Technical report writing skills were also improved using Microsoft Word to document experimental results and methodology.

4.2 The Company

Fisher and Paykel is a company that places great importance on teamwork. The open-plan design of the offices creates a relaxed friendly environment but encouraged interaction and collaboration. It was important that all the senior engineers understood the direction of the company and the design process. Meetings were scheduled weekly to ensure all senior engineers from the various teams were informed of design changes from other teams and could adjust their designs accordingly. Therefore communication was also an integral part of any employees skill set. Since Fisher and Paykel is a company that values teamwork, there were regular staff bonding events. These included Christmas lunches, team building events, and student welcome and farewell events. These events made me and other interns feel extremely welcomed to the company and

helped integrate us in our respective teams. In general, all staff were extremely friendly and willing to help, and it was evident staff was treated extremely well by both the company and other staff. It was an honour to be part of such an amazing community and participate in the development of a product that will benefit people in need.

5. Conclusion

Throughout my summer internship at Fisher and Paykel Healthcare, I learned various skills, ranging from patience and communication to practical skills such as the ability to use a SMT pick and place machine. This experience has helped develop both my personal skills and skills as an engineer and it was a pleasure working alongside such great people. Fisher and Paykel allowed me to participate in a strong team working environment while developing the necessary skills to be proficient at my job. To summarise, the skills I learned during my internship were:

- Communication and speaking skills
- Microsoft Excel and Word Skills
- Ability to use oscilloscope advanced functions
- Soldering skills – In particular SMT soldering
- How to use the equipment associated with SMT prototyping process
    - SMT Pick and Place Machine and Reflow Oven
- Setting up a test environment
- Knowledge of various components (ICs, SMT components, relays etc...)
- How to alter and modify PCBs

Overall, my experience at Fisher and Paykel was an enjoyable one and pathed the first step on my journey as a professional engineer.

6. Bibliography

1. *Fisher & Paykel Healthcare.* Retrieved July 29th 2015 from https://www.fphcare.co.nz/

2. *Mason & Wales Architects.* Retrieved July 29th 2015 from http://www.masonandwales.com/FP-Healthcare-Building-3