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Employment at Fisher Paykel Healthcare

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Report Submitted : 2024-03-19

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Assigned Marks : 25 / 25 (Grade : A)

Hours Verified : 480

Marker : [redacted]

Student : [redacted]

Specialisation : Electrical & Electronic Engineering

Student Group : [redacted]

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[redacted]

Scoring Rubric

Section One	**Passed Section** If you pass Section One you still need to pass Section Two.			**Failed Section** If you fail Section One you will be asked to resubmit the report.			5/5
Section Two	**Passed Section** If you pass Section Two you will still need to pass Section Three			**Failed Section** If you fail Section Two you will be asked to revise and resubmit the report.			5/5
Section Three Part A : Structure of the Report	Excellent	Above Average	Satisfactory	Room for Improvement	Below Average	No Marks	5/5
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Existing Admin Verified hours

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[redacted]

Verified Hours | Hours Type

ENGGEN499 Practical Work Report

[redacted]

Company address: [redacted]

Department: [redacted]

Team: [redacted]

Supervisor: [redacted]

Work Period: 20 November 2023 — 23 February 2024

Holiday break: 23 December 2023 — 7 January 2024

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Executive Summary

This report describes my experience as an intern at Fisher & Paykel Healthcare (FPH) in the summer of 2023-2024. FPH is a leading developer and manufacturer of medical devices specialising in respiratory care. Following an introduction, the report briefly covers some background information about FPH. After this, all work done is presented in detail. A reflection on my time at the company and key things I learnt — followed by a brief conclusion — concludes the report.

During my internship, I worked in the 820 humidifier team, where I focused on the development of the soak bench — a device test bench — for the humidifier. In particular, my supervisor [redacted] had allocated me the task of improving the humidity sensing on the soak bench. These improvements entailed designing numerous PCBs (including a flexible PCB), developing software for a microcontroller, and assembling the improved soak bench components. Work done comprised of electronics design, software development, PCB design, hands-on work, documentation, and presentations.

A key takeaway from this internship, apart from the technical skills I practiced, was the importance of soft skills. I discovered how vital good communication and teamwork is; without these, it is easy to waste time doing the wrong thing or doubling up work with someone else. Moreover, the importance of good documentation — which communicates to future colleagues about your work — is critical to minimize future time wastage.

Overall, my experience at FPH was immensely rewarding. Being my first time working in industry, I gathered valuable experiences. Through this internship, I discovered the subtle differences between working in industry versus academia. Now that I have worked in both academia and industry, and have had a chance to practice what I have learned in industry, I am much more confident as a professional engineer.

Acknowledgements

I would like to acknowledge:

- The company, Fisher & Paykel Healthcare, for their excellent hosting of the interns.
- My supervisor, [redacted], for giving me this role and for his consistently excellent guidance throughout the internship. He took time to meet with my intern team weekly, and provide constructive feedback whenever we needed it.
- My intern teammates — [redacted] and [redacted] — for working really hard throughout the entire internship, doing their part to an excellent standard, and making my summer as an intern so much less lonely.
- My colleagues in the 820 ES team — [redacted], and [redacted] — who guided and helped us a lot during the project. They were key to the project being completed to the standard it was.
- My best friend and now 820 ES full time engineer, [redacted], who helped me a bunch with hands-on work.

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1: Introduction

During the summer of 2023-2024, I interned at Fisher & Paykel Healthcare (FPH). FPH is a leading company in the healthcare sector, focusing primarily on the design & manufacture of medical respiratory devices. Products by FPH consist primarily of humidifiers and obstructive sleep apnea (OSA) treatment devices.

For my internship, I worked in electrical systems (ES) team in the 820 humidifier group. Humidifiers are an ancillary device for ventilation. They are required for humidifying the air fed by ventilators into patients. Since the patient's airway is either partially (non-invasive) or fully bypassed (invasive) during ventilation, the humidifying capabilities of the patient's respiratory system is compromised, which would result in the patient breathing dry air in the absence of a humidifier. Therefore, humidifiers are critical for the patient's health, safety and comfort during ventilation.

FPH's 820 humidifier is one of their older products, and is targeted at financially disadvantaged populations given its simplicity and hence low price. Due to its simplicity, it lacks many features that more advanced humidifiers, such as the 950, possess. Notably, the 820 lacks patient-end (PE) humidity and temperature sensing and thus uses open-loop control instead of closed-loop control.

In this internship, I and two fellow interns were assigned the task of improving the soak bench, which furthers the work of previous interns. The soak bench is used to automate the testing of the 820 humidifier, and will be explained in detail in Section 3. Each of us was tasked with improving a specific aspect of the soak bench. I was tasked with improving the patient end (PE) humidity and temperature sensing on the soak bench, which entailed designing a flexible PCB. Software development, PCB assembly, and documentation also constituted large portions of the internship. A presentation of work done was made to the 820 team near the conclusion of the internship.

Throughout my internship, I gained lots of experience in electronics design, software design, and practical work. Consistent communication with colleagues was critical for work to run smoothly and stay on track. Being my first time working at a company, this internship taught me several key differences between doing projects at university versus at a company.

2: Fisher & Paykel Healthcare

Fisher & Paykel Healthcare (FPH) is a leading global provider of innovative medical devices and systems, specializing in respiratory care, acute care, and surgery. Having started with a basic humidifier prototype in 1969, FPH has been a major player in the humidifier product space for more than 50 years. Products of FPH are shown in Figure 1. At FPH, the core company values — Internationalism, Life, Commitment, Relationships, and Originality — are heavily emphasized. To facilitate internal operations such as communication and various services, FPH has a staff intranet.

Figure 1: *Products of F&P Healthcare. Source: Welcome Induction Booklet p.12*

This remainder of this section will provide an overview of the workplace layout, staff organization structure, and key aspects of the buildings, plant layout, technical facilities, and amenities for staff at FPH.

2.1: Workplace layout

On its campus, FPH has four buildings — Stewart, O'Hare, Paykel, and Daniell — which are each named after a notable FPH staff member. I worked in the Paykel building for my internship. A map of the campus showing these buildings is in Figure 2.

[redacted]

Figure 2: *Campus layout of FPH, showing its various buildings. Source: Welcome Induction Booklet p.8*

Buildings at FPH are organized into open workspaces called pods. In my internship, I worked in Pod 9 of the Paykel Building. Open workspaces are interspersed with dedicated meeting areas, providing employees with flexibility in choosing the most suitable environment for their tasks. This encourages communication among different teams and departments; the fact that everyone can see what others are doing reduces the chances of people slacking off. Additionally, the buildings have several laboratories, testing facilities, workshops, and manufacturing facilities, so you're never far away from any part of the product development process.

2.2: Staff organization

FPH staff is organized in a hierarchical structure. From the top down:

- Managing director and CEO — [redacted]: Manages and directs the entire company
- 820 team leader — [redacted]: Directs and oversees the engineering of the 820 humidifier.
- 820 electrical systems (ES) team leader — [redacted]: Leads the electrical, computer and software engineering aspects of the engineering of the 820.
- My supervisor — [redacted]: Lead the work for me and the two other interns. He is likely the 820 ES team co-leader since he was leading the team meetings when [redacted] was absent.

My supervisor is the only person who I interacted directly with as a intern.

2.3: Amenities for staff

The Paykel building has the following amenities for staff:

- Bathrooms/toilets — There are bathrooms in close proximity to any pod, so you are never far away from a bathroom. A large main bathroom including showers and a changing room is also provided.

- Subsidized high quality cafeteria food — Food is supplied for morning tea and lunch at the Paykel Cafe and Rua Cafe, the latter being the flashier and more expensive option. The subsidization means you only pay about half of what you would pay outside of the company.
- Dry-cleaning services
- Lockers
- In-building clinic, to treat any health problems or injuries you may have at work.

Additionally, the FPH campus has plenty of free parking so if you drive to work, you are guaranteed to find a parking spot near your building. There is both underground parking and above ground parking; in the underground parking, parking spots equipped with EV charging are provided.

3: Work done

As shown in Figure 3, the soak bench centers around the FEZ Duino microcontroller development board which operates the sensors, controls water filling, and communicates with a local webpage called Balaur[1] via FPH's proprietary communication protocol SmartTalk. Automated water filling is required because the 820 humidifier does not have automatic water filling.

[redacted]

Figure 3: *System diagram for the soak bench*

I had the task of improving the patient end (PE) humidity and temperature sensing. This sensing is required because the 820 device lacks PE sensing and thus uses open-loop control, so getting PE data is critical for verifying, validating, and tuning the 820 humidifier's performance. The sensing uses a I^2C sensor which interfaces with the FEZ Duino via a 1-wire to I^2C bridge ("converter") [2]. Consequently, I had to research the communication protocols I^2C and 1-wire to understand how they worked. Last year's intern had designed a PCB using the DS28E17 converter with the SHT45 humidity sensor, shown in Figure 4a. To improve on this, my first task was to investigate alternatives to those components and see if there's anything better we can use. After doing that, I concluded the best sensors were the ones we already used, so we stuck with SHT45. The converter was changed to DS28E18 because DS28E17 was out of stock everywhere.

[1] Balaur is hosted by a Raspberry Pi and allows a PC connected to Balaur to wirelessly control the FEZ Duino.

My fellow intern, [redacted], was tasked with implementing an air flow sensor on the same system. Since the air flow sensor also uses I^2C, we ended up spending a lot of time getting the system to work with multiple I^2C sensors, as the previous system could only accommodate a single I^2C sensor. This entailed developing new PCBs and heavily reworking the FEZ Duino software. Han and I collaborated on most tasks during our time at FPH because our work overlapped significantly.

[redacted]

(a) *Old version* **(b)** *New version*

Figure 4: *SHT45 sensor PCB*

Based on the SHT45 sensor PCB, a colleague designed an over-mould which fit with the PCB. The assembled PCB with the over-mould is shown in Figure 5b.

[redacted]

(a) *Old version* **(b)** *New version*

Figure 5: *Tube assembly with humidity sensor*

Throughout the internship, I carried out a wide variety of tasks — PCB design, software development, PCB assembly, and documentation. During the PCB design and software development processes, I was required to read and understand the datasheets of electronic components so that I could use the components correctly. Presentations to colleagues about our project were made near the end of our internship. Detailed descriptions of those tasks are as follows.

3.1: PCB design

Note that I was not in charge of ordering the PCBs; a colleague of mine ordered all the components and PCBs we used. I simply needed to generate all the fabrication files required for the PCB to be manufactured.

3.1.1: Humidity sensor PCB

My supervisor tasked me with revising the existing (rigid) sensor PCB (Figure 4a) to be a flexible PCB. A flexible PCB is superior because it is thinner so the portion of the PCB in the tube does not affect the air flow as much, resulting in greater measurement accuracy. Furthermore, being a flexible PCB, it can be moulded more nicely into a tube connector and there is more flexibility regarding how the sensor is integrated into the patient-end. The final design is shown in Figure 4b.

Figure 6: *First version of humidity sensor flexible PCB*

To design the flexible PCB, I had to research design considerations for flexible PCBs. The first version of the PCB, shown in Figure 6, had no stiffener. Here, the whole PCB was the same layer stackup, so it was reasonably easy to get manufactured[3]. However, due to that PCB being paper thin, the through-hole connector was able to be pulled out along with the pads using moderate force, leaving behind the three holes on the left in Figure 6. Therefore, the first version was not robust enough.

To make the PCB more robust, I added stiffener to the portions of the PCB where there was likely to be large mechanical stress such as under the connector and mounting holes. This is shown in Figure 7. However, since the PCB had stiffener only in some parts, there are different

[2] The FEZ Duino does not directly connect to the sensor through I^{2}C due to the long distance between the sensor and the FEZ Duino. I^{2}C is designed for short distance communication only and would be unreliable through long cables, whereas 1-wire is reliable for long distances.

[3] I did not need to worry about providing a drawing with the different layer stack regions and the the manufacturer takes care of the PCB thickness.

layer stack regions. As a result, I had to learn how to get such a PCB manufactured, which entailed creating a layer stack table and master drawing. With some help from my colleagues, I got a second version of the flexible PCB sent out, which had a master drawing as shown in Figure 8.

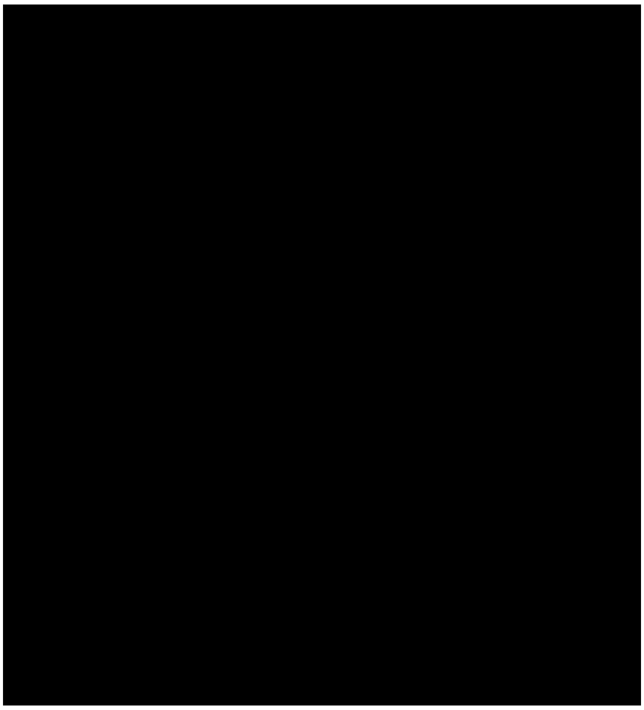

Figure 7: *Bottom side of my stiffened flexible PCB, showing the stiffener*

Figure 8: *Snippet of the master drawing of my final flexible PCB*

Unfortunately, the stiffened flexible PCB was still not very mechanically robust, because we did not put stiffener under the sensor. Consequently, the traces to the sensor kept breaking when we bent the PCB too much. Due to the lack of stiffener under the sensor and the sensor's small footprint, the sensor was hard to solder. Adding stiffener under the sensor and making the sensor's pads larger would have made our lives a lot easier. Therefore, designing this PCB has taught me the importance of mechanical and assembly considerations in the PCB design process; it not only has to work, but be robust and easy to assemble.

3.1.2: Converter PCB

Based on the designed humidity sensing PCB, a rigid PCB with only the DS28E18 converter (Figure 9) was designed. With this PCB, any I^2C sensor can be used with the DS28E18, not just the SHT45. The PCB was sent out with the first version of the flexible PCB so that I could use it early on to debug my code for the converter. This PCB's mechanical aspects were later revised by [redacted] to interface with the air flow sensors.

[redacted]

(a) *First version I designed*

[redacted]

(b) *Mechanical revision by* [redacted] *for flow sensing*

Figure 9: *DS28E18 converter PCB*

3.1.3: Water feeder shield

The water feeder shield is a shield PCB for the FEZ Duino which houses all necessary circuitry and connectors for the operation of the sensors and water filling. On the old water feeder shield in Figure 10, all connections external devices such as sensors were made by the screw connectors. Since the screw connectors are cumbersome to use and require exposed wires to screw into them — in addition to it being unclear where to plug what — the screw connectors were ditched for much nicer Molex crimped connectors as shown in Figure 11. Though these improvements were made in Version 1, the PCB dimensions and connector placement had to revised in Version 2 so that the PCB was usable in the final water feeder system.

Figure 10: *Old water feeder shield by the previous intern*

(a) *Version 1* **(b)** *Version 2*

Figure 11: *Assembled new water feeder shield PCBs*

3.2: Practical work

Throughout this internship, I had to solder many PCBs which contained very small SMT components. On the sensor PCBs, there were small SMT ICs which had very fine pitch and pads underneath the chip, which I soldered using solder paste and a hot air station. Furthermore, I soldered a substantial number of 0603 size components, whereas the smallest I had soldered prior to the internship was 0805. I also got experience in using a reflow oven, into which I placed PCBs which I had applied solder paste to and placed components on.

To connect the FEZ Duino shield to other devices, we made numerous crimped cables such as those in Figure 12. Skills used in doing so were: crimping, wire stripping, heat shrinking using hot air, and hot glue. Heat shrinks were applied over the connector to provide mechanical robustness. Hot glue was applied to the cable using a hot glue gun prior to putting the heat shrink on, so that the heat shrink would adhere to the cable.

[redacted]

Figure 12: *Box containing some cables we made*

Lacquer was applied to the humidity sensor and its neighbouring components on the flexible PCB to protect against the high humidity inside the patient-end of the tube from damaging the components and causing short circuits during operation. This was done by placing the PCB inside the paint booth of the Model Shop, where there is ventilation, spraying on the lacquer, and leaving it to dry on the PCB.

3.3: Software development

A major part of our work was developing software for the FEZ Duino development board. This was done in Visual Studio as shown in Figure 13. Though this was not explicitly prescribed as a task by my supervisor, [redacted] and I completely overhauled the existing software developed by previous interns. This was because the existing software was messy, difficult to follow, and almost impossible to extend. Most importantly, it required significant reworking to use multiple I^2C sensors (both the humidity and air flow sensor), because the previous intern had the software hard-coded for only the humidity sensor. We spent several weeks reworking the software, eventually getting it to work with multiple I^2C sensors and being compatible with the DS28E18. In the software, object-oriented programming (OOP) was used extensively. Additionally, I implemented exception handling for handling sensor communication errors, so that the FEZ Duino could identify whether a sensor is disconnected and automatically attempt to reconnect[4]. This feature turned out to not only be important for the soak bench operation, but also facilitated efficient testing of our sensor PCBs.

[4] The previous intern inferred sensor communication errors from unexpected sensor readings, which is confusing and difficult to extend to multiple sensors.

[redacted]

Figure 13: *Project open in Visual Studio*

3.4: Documentation

The previous interns did not document their work clearly, so a lot of what they had done was unclear lacked justifications and reasoning. Consequently, in the first few weeks, I wasted considerable amounts of time attempting to understand what they had done. For example, the previous interns had chosen to use the FEZ Duino microcontroller development board but had not stated why it was chosen. As a result, I wasted a week attempting to use the Arduino Uno instead, thinking it was more fit-for-purpose, only to meet with a colleague thereafter where we formulated solid justifications for the use of the FEZ Duino of all things. Moreover, the previous interns' software was poorly written and documented, with nearly no comments, which made it very difficult to understand and extend. Finally, the guides on assembling the soak bench system were unclear; a colleague stated once that the guide was extremely difficult to follow. Therefore, the abysmal documentation of past interns wasted time and made it hard for colleagues to continue their work.

Given this, I sought to improve the documentation. This entailed justifying and explaining everything I did clearly, so that people who continue my work don't end up trying things which are sub-optimal or won't work. Detailed guides on assembling the soak bench system and its PCBs were written, so that colleagues can assemble the system easily. Consequently, colleagues who pick up my work can quickly get up to speed with what's going on; this is desirable for the company because it increases the colleague's work output.

3.5: Presentations

A week before the end of the internship, we (me and the two fellow interns) made a presentation to the entire 820 ES team in a Knowledge Sharing session. In making this presentation, I learnt how to make effective presentation slides and use animations in PowerPoint. When we first drafted the presentation, the presentation was far too long because we tried to go into too much unnecessary detail which the audience would not understand or care about. After getting rid of the unnecessary detail, the presentation was within the time limit. This taught me to be concise and focus on the important points in presentations.

It is worth noting that [redacted] and I also made a quick 10 minute presentation on the software side to some other people. Additionally, we did a quick demo of our assembled hardware in both presentations.

4: Reflection

During my time at FPH, I learnt a lot in both technical and non-technical areas.

4.1: Technical skills

In this internship, I improved in hardware, software, and hands-on work.

Regarding hardware, I gathered understanding around the digital communication protocols of 1-wire and I^2C. Additionally, through designing the flexible humidity sensing PCB, I learnt numerous lessons regarding PCB design. One of the lessons regarding PCB design was preparing a PCB design with multiple layer stack regions for manufacture. Moreover, after falling into the pitfalls of not adding stiffener and making the sensor footprint difficult to solder to, I discovered the sheer importance of mechanical and assembly considerations in the PCB design process. I learnt that the PCB not only has to work, but be robust and easy to assemble.

Regarding software, I learnt how to put many of software development principles taught in university into practice. Those principles were object-oriented programming (OOP) — abstraction, and inheritance — and exception handling. Additionally, I developed a complete program in C#, a programming language which was new to me but was very similar to Java which was taught in university. Applying university content on a real-world project gave me an immense confidence boost in software development.

Regarding hands-on work, I learnt how to better solder surface mount components, solder using a reflow oven, and make crimped cables. Prior to this internship, I did not know how to properly crimp wires, but now I am very good at doing so. In making cables, I have also learnt how to use the hot glue gun, do heat shrinking, and properly do wire stripping. Since I was quite poor at soldering, the difficult soldering (tiny sensors and ICs) was mostly done by my peers. Nevertheless, I observed how they executed it (e.g. soldering using solder paste and hot air) and thus would be more confident in doing it myself in the future.

4.2: Soft skills

In my internship, I learnt that time is extremely valuable to a company; it is in the company's best interests to have their employees work as efficiently as possible, so that the maximum amount of work can be done as quickly as possible in the least amount of time. Therefore, company work must be treated differently to university and personal projects. Initially, I was too entrenched in the desire to minimize cost of electronic components — as we should in financially constrained university and personal projects — without considering the development and assembly time. My supervisor emphasized that cost doesn't really matter because we were designing a one-off system (not in the actual product), and that completing the work quickly is what matters most. After that, I learnt that cost isn't always important and is heavily context-dependent.

Following my experience with the poor documentation of previous interns, I learnt how vital good documentation of work is. This was shown by how we wasted a lot of time trying to understand what they did and attempting things which wouldn't work, because the previous interns did not document the justifications for their decisions. Therefore, good documentation

— detailing all designs and justifications — is extremely important to minimize time wastage for future work.

4.3: Work life

The internship at FPH started excellently with all interns receiving an induction session. This introduced us to the company, taught us guidelines for work (e.g. how to properly sign and date work) and walked us through health and safety guidelines. Throughout the inductions, a key takeaway was that no matter what you do, you must make sure it is safe first and foremost; even if you are chasing a deadline, you must not rush and circumvent health and safety measures since that could harm you. I also learnt the importance of respecting the intelluctual property (IP) rights of the company, by withholding from exposing confidential content outside of the company. In general, the inductions taught me to always be patient in everything I do, and think properly about how and whether I should do the task before rushing to do so.

At FPH, teamwork and communication are heavily emphasized. Given the hierarchical staff organization where a large group is divided down into numerous small teams, having the ability to work in your own sub-team and knowing how your work integrates into the entire project is important. Each week, our team leader [redacted] held meetings with the team to go over what tasks have been completed and what tasks need to be done next, so that everyone can stay on track. My supervisor also held weekly meetings with me and my fellow interns to monitor our progress and keep us on track. Microsoft Teams is used for communication inside FPH, and all employees are more-or-less expected to remain active on Microsoft Teams so that all employees can keep in touch. Overall, communication is critical for teamwork to function properly at FPH.

Working at FPH was quite chill and relaxed, given the flexible working hours and casual dress code. At lunch time, colleagues in my team usually get together for lunch, where we have conversations about topics unrelated to work. We also often went for walks outside and got to see the eels which was really cool.

5: Conclusion

After my first experience working at a company at Fisher & Paykel Healthcare, I have gained substantial experience in applying what was taught at university. Throughout my 12-week long project on the 820 humidifier's soak bench, I partook in a wide range of tasks comprised of PCB design, software development, hands-on work, documentation, and presentations. A key takeaway from my internship was the differences between working on a company project versus a university project. To summarize, key skills I practiced during the internship were:

- Project management
- Electronics and computer systems design
- PCB design, from which I learnt to design a flexible PCB
- Software development using C# and employing OOP constructs
- Hands-on work: Soldering, crimping, etc.
- Detailed documentation of work done
- Making and giving presentations

All in all, my time at FPH was thoroughly rewarding, and has immensely boosted my confidence as a professional engineer.