UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG
Faculty of Engineering and the Built Environment

Vacation Work Assessment Certificate

This covering sheet must be attached to your detailed Vacation Work Report as the first page of the report. Both the covering sheet and the last page of the Vacation Work Report must be signed by your supervisor/ employer and handed to the School Administrative Officer in your branch **BY THE SUBMISSION DATE ANNOUNCED BY THE SCHOOL.**

STUDENT NAME: ..……*Nduvho…Edward…Ramashia*.………………..………………………...………

STUDENT NUMBER: …*1490804*…………..………………………………………………...................

EMAIL ADDRESS: …… Nduvho.Ramashia@gmail.com …….TELEPHONE NO: … *063 853 3355* ……

YEAR OF STUDY: …… *Second* ….SCHOOL (and option if applicable)…*Elec and Infor Engineering......*

EMPLOYER'S NAME: …*Professor Scott Hazelhurst*..……………………………………………..……

EMPLOYER'S ADDRESS: … *School of Electrical and Information Engineering*………………………….

……………………………….. *University of the Witwatersrand, Johannesburg* ......……………………….

……………………………….. *Private Bag 3, 2050 Wits, South Africa* ………………...………………..….

EMPLOYER'S TELEPHONE NO: … *011 717 6181* …….………….…………….................................

DATE ENTERED SERVICE: … *03 / 12 / 2020* …..…   DATE LEFT SERVICE: … *25 / 02 / 2021* ………

OUTLINE OF WORK DONE: …*Testing, observing and exploring the ATmega4809 micro-controller, the MCU to possibly replace the current WITS ELEN2021 micro-controller in use. The work also involved amending and enriching the course' lab materials*………………………………………………………..

HAS THE STUDENT PERFORMED SATISFACTORILY? Yes

GENERAL CONDUCT: Did all work allocated – showed initative

……………………………………………………………………………………...……………………….

SUPERVISOR'S/EMPLOYER'S SIGNATURE: S Hazelhurst

DATE: 13 March 2021 SUPERVISOR'S/EMPLOYER'S NAME: Scott Hazelhurst……………………………….

SUPERVISOR'S/EMPLOYER'S CONTACT NO: 7-6181

COMPANY STAMP:

ATMEGA4809 EXPLORATION AND ELEN2021 2021 LABS MATERIAL AMENDMENTS

Nduvho E. Ramashia

School of Electrical & Information Engineering, University of the Witwatersrand, Private Bag 3, 2050, Johannesburg, South Africa

Abstract: The purpose of this document is to provide evidence to the work done by the student for the WITS course ELEN1998 - Vacation work I. That includes specific tasks done and when they were completed. The were two main tasks done. The first task being observing and exploring the ATmega4809 micro-controller unit. The ATmega4809 was then compared with the ATmega328P, which had been in use by the WITS Electrical and Information Engineering students. The ATmega4809 is relatively more advanced compared to the ATmega328P. It has more computing power and overall more control/flexibility. The other main task was carefully reading through the ELEN2021 lab materials and actually doing the labs. This was done to make sure the material was ready and all set for the future ELEN2021 students. This also involved adding other possible solutions to the labs, where any was thought of.

Key words: Vacation-Work

1. INTRODUCTION

This document details the work done for the University of the Witwatersrand school of Electrical and Information Engineering course ELEN1998-2020, Vacation Work I. The details of the employer and the employer's objective are given in section 2. This includes the main objectives of the work done. The technical aspects of the work done are discussed in section 3. Section 4 gives a brief overview of professional ethics involved. In section 5, social and economics issues relevant to the work are discussed. Finally, in the last section, section 6, the time management overview id=s then given, showing week-by-week tasks.

2. THE ORGANIZATION

2.1 The Organization's organogram

Figure 1 shows the organisation's organogram. The top tile holds the organisation itself. Below the organisation, university, are different faculties within the organisation. After that, only the faculty, school and course of interest are mapped. These eventually leads to the supervisor and the employee, the employees being the two hired undergraduate students.

2.2 The Employer's Objectives

The WITS school of Electrical and Information Engineering is looking into changing the the micro-controller unit (MCU) used by its ELEN2021 second year students. This is a change from using the ATmega328P MCU to either the ATmega4809 or the AVR128da48 if not both.

The two, new MCUs are relatively more advanced compared to the ATmega328P. They have more features and overall capabilities. The new, possible replacements of the ATmega328P MCU needed testing and overall exploration, which is where the two students came in.

The work also involved carefully reading through the course's academic year 2021 lab materials, making sure everything was in the intended order and proposed solutions working as expected.

3. THE TECHNICAL WORK DONE

The work done can be divided into two parts, namely 'observing the new micro-controller unit', and 'readying and optimizing the lab materials for future ELEN2021 students'.

3.1 Observing and exploring the new MCU

The new MCUs were explored, their features thoroughly looked into. Their overall features were then compared with those of the ATmega328P, which had been in use years prior 2020, inclusive.

Their differences included memory chip sizes, number of peripherals like timers/counters and I/O ports, with the

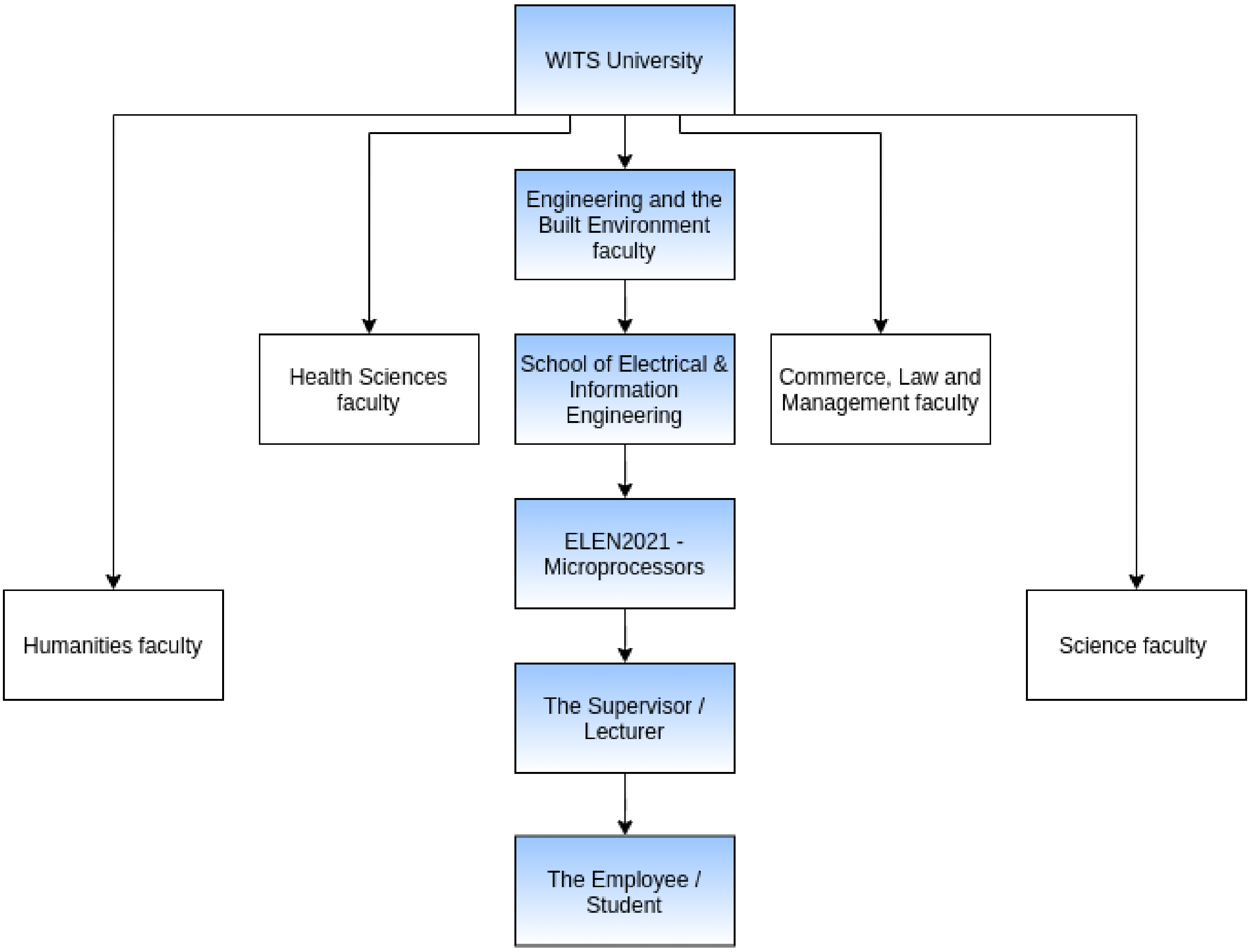

Figure 1 : The organogram.

new MCUs found to be better that the ATmega328P. An extensive report about their most notable differences was composed and sent to the supervisor/lecturer, and can be found in the appendix.

Testing and exploring the new MCUs involved implementing a temperature monitor project using the new MCU. The project was about implementing a temperature monitor using the MCU and the MCP9700 transducer. It was about using the MCU to read in an analog output from the transducer, the MCP9700, process it, and then show its temperature equivalent on 2 or more seven-segment displays.

The work involved setting and configuring the MCU's timers and its ADC unit to get the required temperature reading displayed on 7-segment displays.

To archive this:

- 1 x ATmega4809 on a curiosity-nano PCB
- 2 x Timer/Counters
- 11x Output pins
- 1 x Analog input pin
- 1 x ADC peripheral
- 3 x Transistors
- 11x Resistors
- 3 x Seven-segment displays.

were used. The temperature was displayed on 3 seven-segment displays to 3 significant figure.

Of the 2 timers, 1 was used to determine the temperature refresh rate, with the one used when displaying the temperature. It was used to determine for how long each display is ON, to make it seem like 3 displays are ON at the same time, to the human eye.

The 3 seven-segment displays had 8 common connections. These were connected to the MCU's 8 pins. They were for sending the digits to the displays. The displays also each had a switching transistor connected to their ground pins.

The the transistor's base pins were connected to the MCU pins. Their collector pins connected to the displays' ground pins. Their emitter pins to ground. This was done to enable switching ON 1 display at a time. That was achieved by sending a high signal to only 1 transistor at a time, making sure only 1 (the intended) display is ON and receives the digit being sent through the other 8 pins at the given time/cycle. Sending a high signal to only 1 transistor at a time made sure that only 1 display's circuit was complete at a time, thus displays the digit. A complete circuit diagram can be found on appendix B.

To utilize the MCU's features and capabilities, the fewest possible output pins where used. This was done so as to make sure that more pins where left available for other uses/functions while the temperature is being read/monitored. This was done with in mind that the MCU could be later programmed to do something more in reaction to the results of the temperature being monitored, thus making the chip more compatible with relatively more real-life systems, as it can give a response to the variable being monitored while still displaying it, with more ease. This however came at a power cost as it meant the CPU was up and running most of the time compared to if more pins had been used.

3.2 Lab materials enrichment

The work also involved making sure that the lab manual for the course's academic year 2021 was all set and ready. This involved making sure all links to online resources were all good, up and running. It involved actually doing the all the labs, including the new and added labs, labs that were not done the years prior.

It also involved making sure all questions where clear and non equivocal for the student's level, and adding more information that could be useful to students. This also involved adding more possible ways of solving the lab tasks, where any was though of. Grammatical errors were corrected also, as well as making sure all the notes and tasks were as intended.

The lab works done involved configuring timers to count up to about a minute without the need for external crystal oscillators. This was achieved by using other timers to create low frequency clocks through pin-toggling, which was then used as input frequency for other timers, enabling them to have relatively much longer periods.

Working on the labs included implementing a B8ZS encoder and decoder. This involved programming the MCU to retrieve data from program memory, encode the data, and then send the data using the dual-rail encoding. It also involved programming a second MCU to receive and decode the data from the first MCU.

4. PROFESSIONAL ETHICS INVOLVED

Given that work was done remotely, it required professional discipline since there was no daily or hourly monitoring. The employees had ethical duties to the supervisor/employer to do the work and do it properly. It all fell to the employees to actually do the work even when there was no one monitoring. Also the work had to be done right and properly since it was to be relayed on or used by students. It had to be done properly because of the consequences that would have fallen on to the students because of the employees not doing the work right and properly.

The work also had the need for efficiency as it was to be done within the given number of days. This also needed a good personal conduct since time management was a necessity.

5. SOCIAL AND ECONOMIC ISSUES RELEVANT TO THE WORK

Social issues relevant to the work included:

- Improved educational material
- Choosing the right device for students

The work done involved micro-controllers programming, which improves tasks automation. This automation in turn improves efficiency for many tasks that can be automated, thus improving the economy growth.

The involved automation does however come at a cost to those who relay on the jobs that can be automated.

6. TIME MANAGEMENT OVERVIEW

The work done was done over the period of 6 weeks. Table 1 below shows the main tasks completed for each week.

Table 1 : Week-by-week tasks division

Week	Date	Task(s) done for each week
Week 1	03 December - 10 December	• Thoroughly read the two data-sheets. • Noted down the technical differences between the 2 MCUs
Week 2	10 December - 17 December	• Composed a technical report for the supervisor/lecture about the most notable differences of the 2 MCUs
Week 3	20 December - 24 December	• Implemented the temperature monitor using the new MCU, the ATmega4809.
Week 4	18 January - 25 January	• Finalized the temperature monitor implementation.
Week 5	25 January - 01 February	• Read through the lab manual and start implementing the labs.
Week 6	01 February - 08 February	• Continued working on the labs.
Week 7	08 February - 15 February	• Continued working on the labs.
Week 8	15 February - 19 February	• Finished up the labs • Added necessary comments on all written codes. • Uploaded the codes to the Github repository.

7. CONCLUSION

The ATmega4809 micro-controller is relatively more advanced than the ATmega328P. Using less MCU pins makes the MCU more portable with most real-life systems. This configuration also consumes more power compared to the configuration where more pins are used since the ut requires the CPU to be wake and running most of the time.

Appendix

A The differences between the ATmega4809 and the ATmega328P

The Difference Between the ATmega4809-AFR and the ATmega328P

Nduvho E. Ramashia
Student Number 1490804

Dec 18, 2020

1 Introduction

This document details some notable differences between the ATmega328P and the ATmega4809-AFR micro-controller. The ATmega4809-AFR is a 48KB flash memory industrial micro-controller with a temperature range of -40 to 128 degree Celsius.

2 Hardware Differences

The ATmega4809 is part of a megaAVR-0-series and uses the AVR processor. Its processor can go up to 20MHz in speed. The ATmega328P on the other hand maxs at 16MHz. They both have on-chip 2-cycle multiplier.

2.1 Memory

Both micro-controllers come with fundamental memory chips built-in.

2.1.1 Flash Memory

The ATmega4809 comes equipped with a 48KBytes flash memory chip. The ATmega328P on the other hand comes with a 32KBytes flash memory chip.

The flash memory chips on both micro-controllers have a write/erase endurance of 10 000 cycles.

Table 1: Flash memories' details

	ATmega4809	ATmega328P
Size	48KB	32KB
R/E endurance	10 000	10 000

2.1.2 Static RAM

The ATmega4809-AFR comes with a 6KBytes SRAM chip while on the other hand the ATmega328P comes with a 2KBytes SRAM chip.

2.1.3 EEPROM

Both the ATmega4809 and the ATmega328P come equipped with EEPROMs with at least 100 000 cycles write/erase endurance.

The ATmega4809-AFR comes with a 256Bytes EEPROM chip and the ATmega328P comes with a 1KBytes EEPROM chip.

The 4809-AFR has an extra [64B] page of EEPROM memory, the User Row, USERROW, unlike the 328P.

2.2 Peripherals

2.2.1 Timers

The ATmega4809 has a total of five 16-bit timers. It has got 2 types of timer, namely Type A and Type B, making Timer/Counter A (TCA) and Timer/Counter B (TCB).

It has 1xTCA and 4xTCBs.

The features of ATmega4809's TCA include:

- 16-bit Timer/Counter
- Three compare channels
- Count on Event
- Timer Overflow Interrupts/Events
- Waveform Generation:

  - Frequency generation
  - Dual-slope PWM

- Can be two 8-bit T/Cs when in split mode, each with 3 compare channels

The features of TCB include:

- 16-bit periodic interrupt
- 16-bit timer-out check
- 16-bit Input capture

The ATmega328P on the other hand has two 8-bit Timer/Counters and one 16-bit Timer/Counter whose features include:

8-bit Timer/Counter0 (with PWM):

- Two Independent Output Compare Units
- Phase Correct with PWM
- Variable PWM Period
- frequency Generator

16-bit Timer/Counter1 (with PWM):

- Two Independent Output Compare Units
- Allows 16-bit PWM
- External Event Counter

The two MCUs have similar timer/counter features. The 4809 does however have notably more timer/counters and more compare channels, making it more flexible and more capable as it can have more timer/counters and more compare channels active at any given time.

While the 328P does not have the Event System, it does however have the 'External Event Counter' feature on one of its timers, which can make up for the 'Count on Event' feature on the 4809 timer/-counters.

The 4809 timers can utilize the Event System with features like 'Timer Overflow Events', which gives it the edge over the 328P.

In short, the 4809 is in timer/counter area better in most (if not every) ways as it has more timers, and its timer/counters are with some advantageous features, which the 328P does not have.

Both the 4809 and the 328P have a 16-bit Real-Time Counters, the 328P's however uses the same registers as its 16-bit timer/counter, which is an inconvenience when the 16-bit timer/counter is needed.

2.2.2 Analog-to-Digital Converters

The 4809 has got a **16-channels 10-bit** ADC, and the 328P a **8-channels 10-bit** ADC. The 4809 also has more select-able internal ADC reference voltages compared to the 328P which only has one. Besides the free-running and the single conversion mode, which the 328P also has, the 4809 also has the Optional Event Triggered Conversion, making it giving its ADC more options than the 328P.

2.2.3 Other notable peripherals' features

The 4809 also differs from the 328P in that it has got the (8 channels) Event System, which the 328P does not have. The 4809 also has the Configurable Custom Logic (CCL), with four programmable Look-up Tables (LUT), which again the 328P does not have. Table 2 below shows some of the major differences between the ATmega328P and the ATmega4809 MCU.

Table 2: Some of the major differences between the 328P and the 4809

Feature	**328P**	**4809**
PORTS	3(B-D)	6(A-F)
GPI/O (pins)	23	41
USARTS	1	4
Chip Pins	48	32
CCL(LUTs)	–	1(4)
Instructions	131	135
Max. CPU speed	16MHz	20MHz
Event Sys.(yes/no)	no	yes

3 Conclusion

The 4809 is notably more advanced than the 328P. It is faster, has got more ports, the CCL which the 328P does not have. It also has more timer/-counters and the Event System, which enables chips like the ADC and Timer/Counters to do things the 328P cannot to.

B A temperature monitor circuit diagram

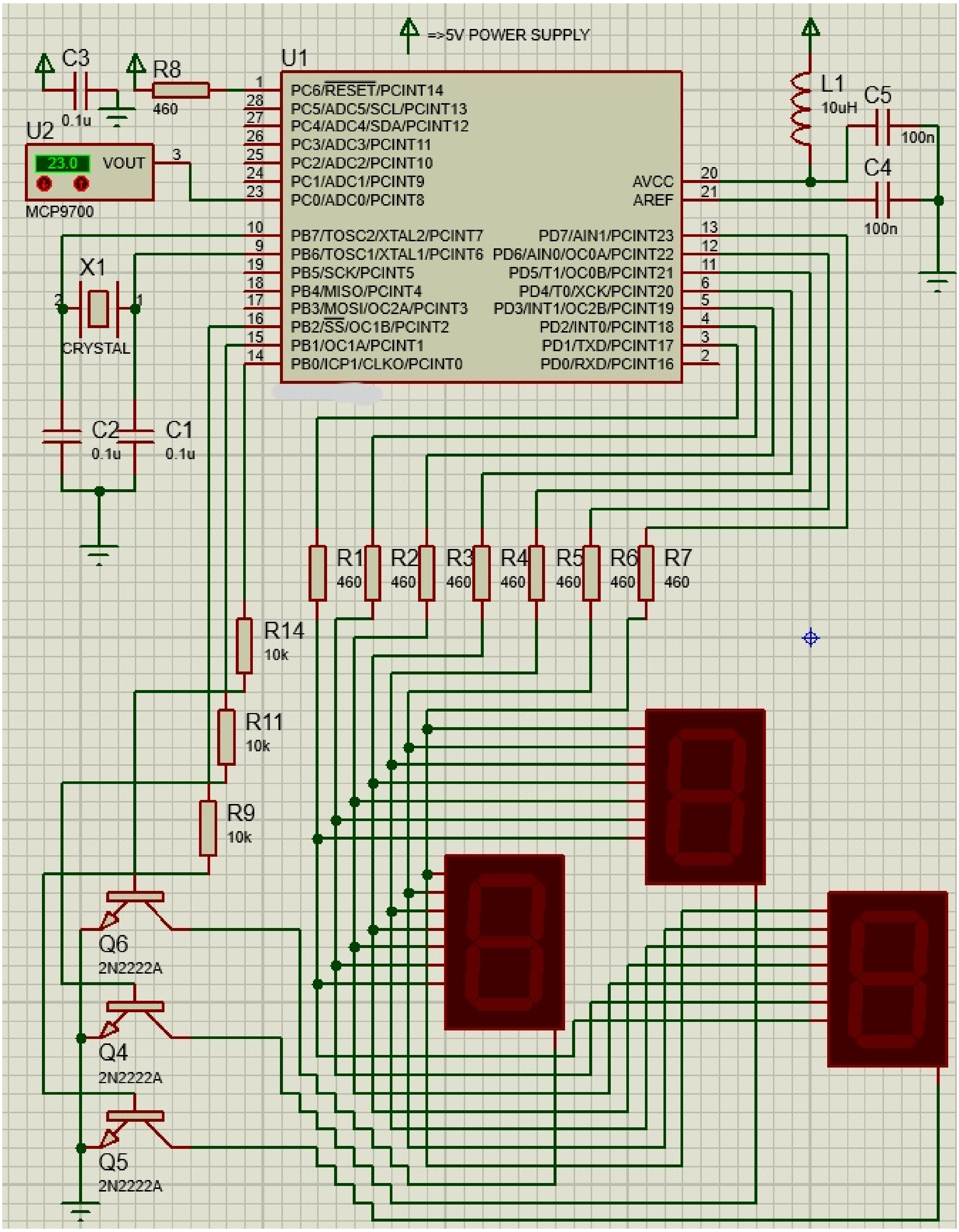

Figure 2 : Temperature monitor circuit diagram.

School of Electrical and Information Engineering
UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Private Bag 3, 2050 Wits, South Africa
Tel: +27 11 717 6181
Fax: +27 86 553 6657
Email: scott.hazelhurst@wits.ac.za

11 March 2021

Dr C Chabalala
School of Electrical and Information Engineering
University

Dear Dr Chabalala,

Mr N Ramashia

I confirm that Mr Ramashia worked as vacation work student for me over the 2020/2021 summer vacation in order to fulfil the requirements as specified in the vacation work certificate
`https://na2.documents.adobe.com/public/fs?aid=CBFCIBAA3AAABLblqZhAmVBfTVkuyV4deVPMvyfWBfmaZlO2hshjAJ0vILraAo8txiPfXGCyTsbG-Kt-hoOo%2A`
His work was of a very high standard.

Yours sincerely,

Scott Hazelhurst
Professor