

ESD Assignment 2- Robbie Herbert

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Electronic Product Design – Part 2

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Abstract

Within this assignment the brief was to design the monitoring system, which was specified in part one, using specific software to allow for manufacture, and proof of concept for the environmental monitoring system.

Using Easy PC, CATIA and Proteus designs have been created for the PCB which has been specified in part one. Easy PC has been used to create components (sensors) to be used on the PCB design. The components created are SEN66, AM1009, USEQGSEAN8L180, FT742-SM Ultrasonic and MPL3115A2. These components were created using the manufacturers datasheets to allow for life like models, sensors are also justified within the design with existing journal papers using them in projects [11-13,25]. Easy PC was also used to Create the tracks for the PCB to allow for the design to be manufactured using IPC standards. Proteus has also been used; this software was used to create prototypes to design the PCB to understand how to standardise the layout for a single node design [19].

Finally, CATIA V5 was used, this helped to design an enclosure for the PCB and sensors so that the sensors can be mounted inside the enclosure, if the sensor cannot be mounted onto the PCB, also an exit for the connection to the FT742 ultrasonic sensor which monitors wind speed and direction.

Key Findings through this task has been the I2C communication protocol is a much easier method than RS485 in practical systems, however other communication protocols such as SPI are better for high speed and RS485 is much more reliable however has a larger footprint due to the need for a MAX485[10]. A second finding is that voltage regulators are a good choice of regulation as their footprint is small, however the efficiency is poor so a better choice for power would be a switching regulator or a buck converter to keep efficiency high and heat low [5]. Another key finding is that LoRa, although is a good protocol to use with the system, there are other protocols which can be used for public safety such as P25 Phase 2, this is often used for high stress and critical situations, which the monitoring could turn into if things develop [14].

Contents

1	Introduction	6
2	Designs	7
2.1.	Proteus Designs.....	7
2.2.	Easy PC PCB designs	8
2.3.	Standards.....	9
2.4.	Designs.....	9
3	Integration.....	16
3.1.	Enclosure Designs.....	17
4	Software.....	19
4.1.	Software Block Diagram.....	20
5	Cost.....	21
6	Specification.....	22
7	Improvements	23
7.1.	Communication.....	23
7.2.	Sensors	23
7.3.	Power	23
8	Conclusion.....	24
9	References	25
10	Appendix.....	29

List of Figures

Figure 1 PCB HUB.....	10
Figure 2 HUB 3D Model.	11
Figure 3 PCB HUB Schematic	12
Figure 4 PCB Nodes	13
Figure 5 Node 3D Model.	14
Figure 6 Node Schematic.....	15
Figure 7 CATIA Enclosure.....	17
Figure 8 Visio Enclosure Diagram	18
Figure 9 Node Software Diagram	20

List of Tables

Table 1 Sensor Cost	21
Table 2 Total Cost.....	21
Table 3 Main Components Used.....	22

Appendices

Appendix 1 PIC18F26K42.....	29
Appendix 2 LCD Display	29
Appendix 3 PIC32 Datasheet.....	29
Appendix 4 USEQGSEAN8L180 Datasheet.....	29
Appendix 5 SEN66 Datasheet	29
Appendix 6 AM1009 Datasheet.....	29
Appendix 7 MPL3115A2 Datasheet.....	29
Appendix 8 FT742-SM Datasheet	29
Appendix 9 CAD with AM1009- largest sensor.....	30
Appendix 10 Isometric view of enclosure	31
Appendix 12 Initial Node Design	32
Appendix 13 3.3V Regulator	33
Appendix 14 LCD Component Header.....	34
Appendix 15 PIC32MZ2048EFH064 Component	35
Appendix 16 SD Component.....	36
Appendix 17 RF-LoRa-7 Component.....	37
Appendix 18 FT742-SM Component	38
Appendix 19 MPL3115A2ST1 Component	39
Appendix 20 SEN66 Component.....	40
Appendix 21 AM1009 Component.....	41
Appendix 22 USEQGSEAN8L180 Component.....	42
Appendix 23 PIC18F26K42 component.....	43
Appendix 24 HUB Power Circuit.....	44
Appendix 25 LCD to PIC Connections	45
Appendix 26 LoRa and SD to PIC.....	46
Appendix 27 NODE Power Circuit	47
Appendix 28 PIC to MAX485 & FTM742-SM.....	48
Appendix 29 LoRa to PIC.....	49
Appendix 30 Connected Sensors	50
Appendix 31 Connected Sensor.....	51
Appendix 32 Proteus HUB	52
Appendix 33 Proteus USEQGSEAN8L180 Node	53
Appendix 34 Proteus MPL3115A2ST1 Node	54
Appendix 35 Proteus SEN66 Node.....	55
Appendix 36 Proteus AM1009 Node.....	56
Appendix 37 Proteus FT742-SM Node	57
Appendix 38 Cable Gland.....	58

Acronyms, Abbreviations and Units

Ω	Ohms
%	Percent
μ	Micro
V	Volts
AC	Alternating Current
$^{\circ}\text{C}$	Celsius
pk	Peak
DC	Direct Current
ms	Milli-seconds
Hz	Hertz
I/O	Input/Output
IP	Ingress Protection
FSD	Full Scale Deflection
IOT	Internet of Things
LoRa	Long Range

1 Introduction

Within this report, there are eight main sections, the first of which is the proteus design, this shows a schematic diagram of the nodes and the central hub. The second section shows the easy PC designs, this helps to show placement, copper tracks, space for components, programming, PCB connections to external components, size of the PCB and the fixings used on the enclosure. The following sections include enclosure designs, software description, costs of the nodes, a comparison to part one and finally a discussion of suggested improvements for the system. Producing these designs, sources, guidelines, and standards have been used to ensure that the system works correctly as stated in the specification and the software. The software used to complete these tasks are Proteus, Easy-PC 2000, CATIA V5 and MS Visio. Resources used to complete these tasks are component data sheets and references from google scholar to help support the choices made and improvements needed for the system.

2 Designs

2.1. Proteus Designs

Using proteus design software each of the nodes have been created so that they are all interchangeable so that the system can work with any of the sensors in place. The central node is a separate design on proteus using the PIC chosen for the hub.

The first four designs are the SEN66, the AM1009, the MPL3115A2 and the USEQSEAN8L180 design, this design uses I2C and the lora module chosen in part 1. Many designs are similar due to the use of I2C and the same components such as voltage regulation. All components are standardised within the Easy PC designs, by combining the designs from proteus because the nodes are easily manufacturable, reliable and simple for the operators to build. Due to the use of I2C references have been used on the method to make the connections properly and to the correct standard [8]. The final design is the FT742-SM Ultrasonic, this is the most dissimilar design to the other sensors as it uses RS485 which calls a need for a MAX485 transceiver to be able to communicate to the PIC which is a proved concept [15].

The hub was also created in proteus, as this is only one node in the system it is different to the rest so there is much less needed on the system, the LoRa module is switched to a receive module only due to the hub only being used to display and log information given by the nodes. The display used is a regular LCD however a more advanced display should be used to display the information such as the compass for wind direction and the values for NO_x. All designs for the nodes and the hub can be seen in the appendix 32-37.

2.2. Easy PC PCB designs

The easy PC designs utilise a schematic for the traces. The node and HUB PCBs show the routing between components, the dimensions and spacing of all components, Connectors, and finally fixing locations.

One of the first considerations was the PIC microcontroller software, the PICs are be programmed before to help reduce space used on the PCB so their footprint is not too big as the PCB has increased in size due to the standardisation of the nodes due to using voltage regulators and other components so there is one PCB design for all nodes [18]. There is an issue with this however, the PIC is not reprogrammable which may cause issues in the future.



The first thing that was completed was to create all sensors, using manufacturers datasheets the pinouts and all dimensions have been used and designed in Easy PC to make the component as realistic as possible for the design. As seen in the Appendix the component schematic designs and PCB designs with PIN identification for all sensors, PIC18, PIC32, the 3.3v voltage regulator and the LoRa module (some sensors are mounted outside of the enclosure or within the enclosure not on the PCB, so headers are used).

After all components have been created the Proteus designs were used to create the PCB schematic, the schematic has been standardised the design so that all sensors/sensor input/output pins are be connected to the PCB. For sensors like the SEN 66 and the AM1009, these are not soldered onto the board however have headers to connect wires to and the sensor is mounted to the enclosure. The FT742-sm also has a slightly different connection as the sensor is outside of the enclosure so the connections are to headers and to the relevant locations such as voltage, ground and the MAX485 transceiver [17]. Decoupling capacitors have been used within the design as per the manufacturers datasheets to help with power ripples and have a smoother input voltage for the sensors, these are all located at the power source and there is at least one for each sensor [1].

The PCB schematic of the nodes mostly use I2C for the sensors, these are all be connected to the same PIC pins for ease of design and manufacture [8]. Which is shown in both the schematic and the exploded view of the PCB to show the top layer, components and tracks. Each of the views shown in the appendix is the view of the standard PCB node with layers hidden to show tracks and the ground pour.

Certain sources have been used (IPC STANDARDS) to follow PCB design techniques and guidelines. These sources have been used to ensure that the PCB has been made properly with ways to minimise parasitic effects and optimise the layout of the PCB [3]. A second source has been used to look at other design defects to avoid similar issues, some of these issues include component faults with soldering techniques, PCB defects as the mounting of the PCB is not secure and finally temperature changes due to component locations or debris [4].

Two separate designs were made of the node design, this is due to component placement issues, initially there was a third layer in the first design which wasn't wanted, the second design was able to optimise the placement and tracks to stop the requirement of a third layer for connecting components following the guidelines stated below and other sources such as Barzdenas et al, [16].

2.3. Standards

Specific standards [19] when designing have been used such as the :

- IPC-A-600 - used to create a uniform design to ensure that it is a high-quality PCB through design and manufacture [19].
- IPC-6012 – this has been used to ensure that the PCBs electrical and thermal properties are okay and can handle the stresses that the environment/components would put the board through [19].
- IPC-A-610 – this has been used to ensure that component placement is correct and stops issues such as alignment [19].
- IPC-2221- this has been used to ensure that materials, layout and spacing are all correct so that errors are reduced and manufacture is simple [19].
- IPC-7711/7721- this has been used to ensure that designs have been made with possible rework and repair in mind during the lifespan of the PCB [19].

2.4. Designs

As seen below in the Figures the Easy PC design of the hub and the standardized node- closer images are seen within the appendix.

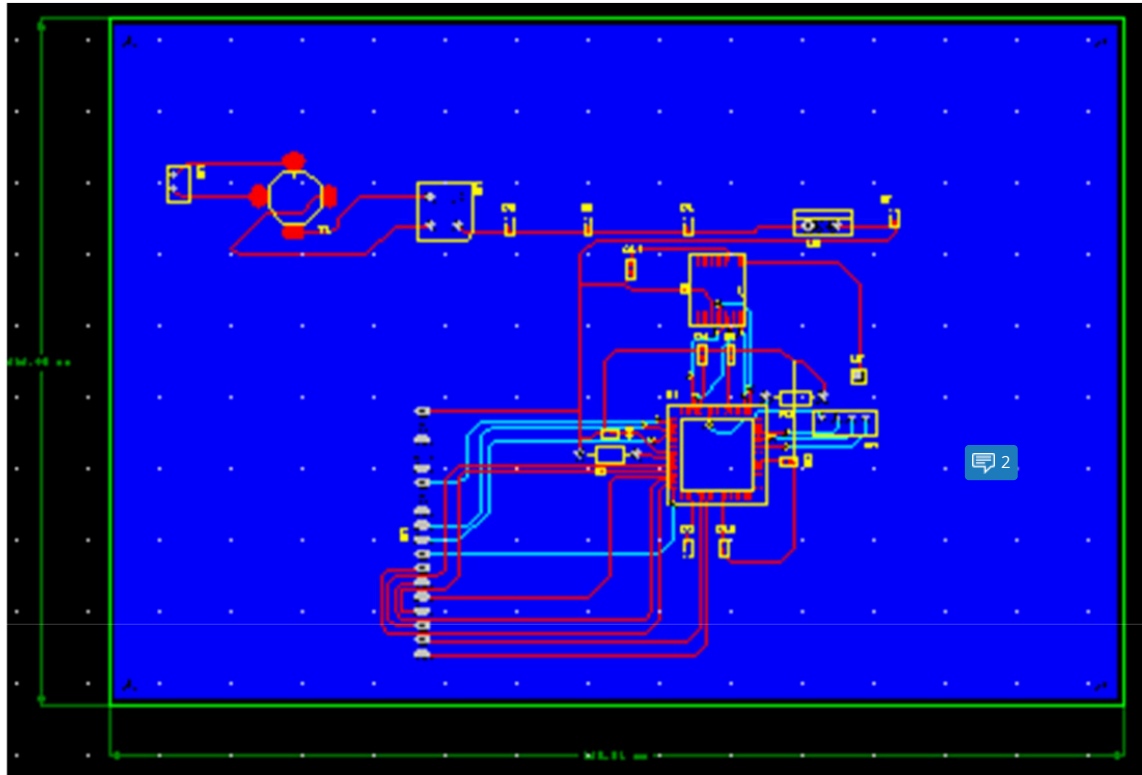


Figure 1 PCB HUB

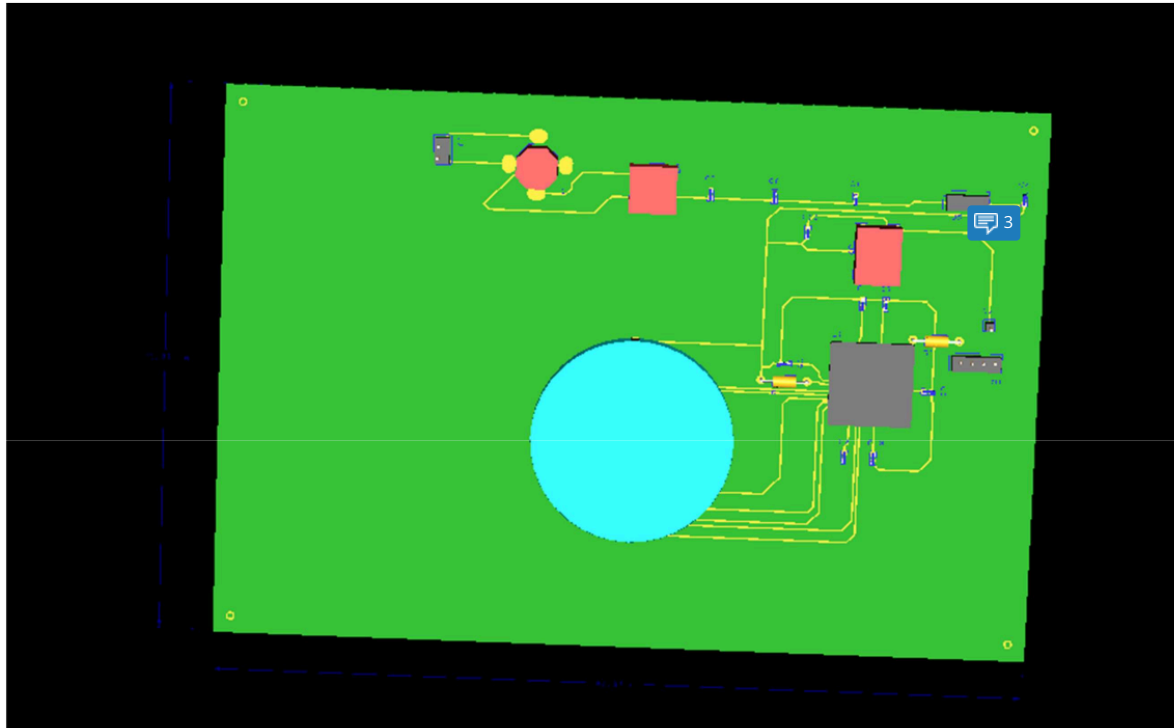


Figure 2 HUB 3D Model.

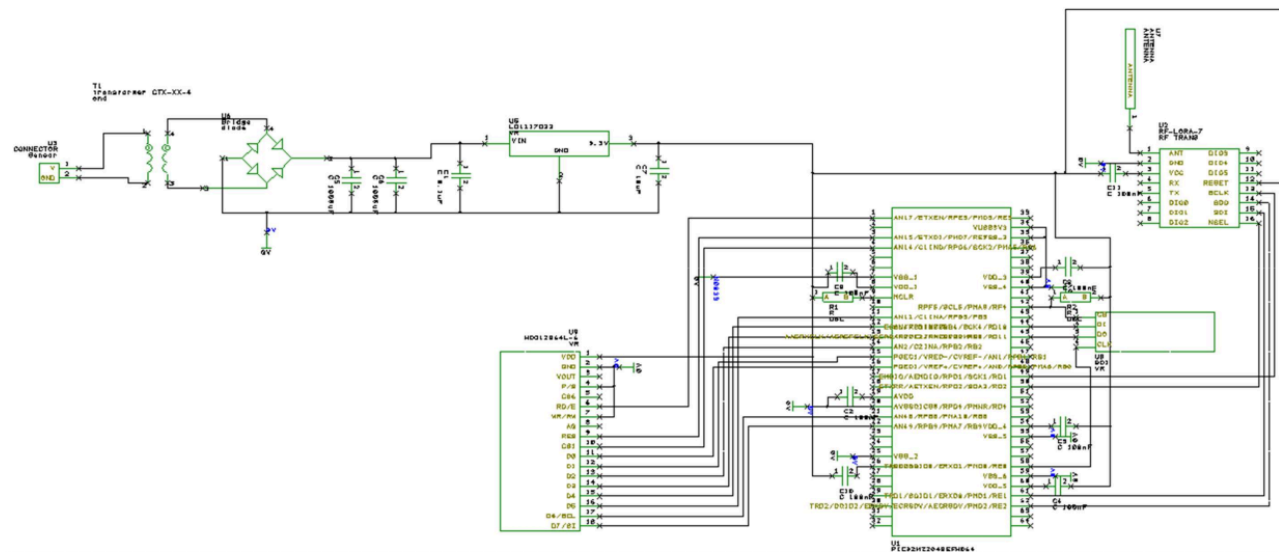


Figure 3 PCB HUB Schematic

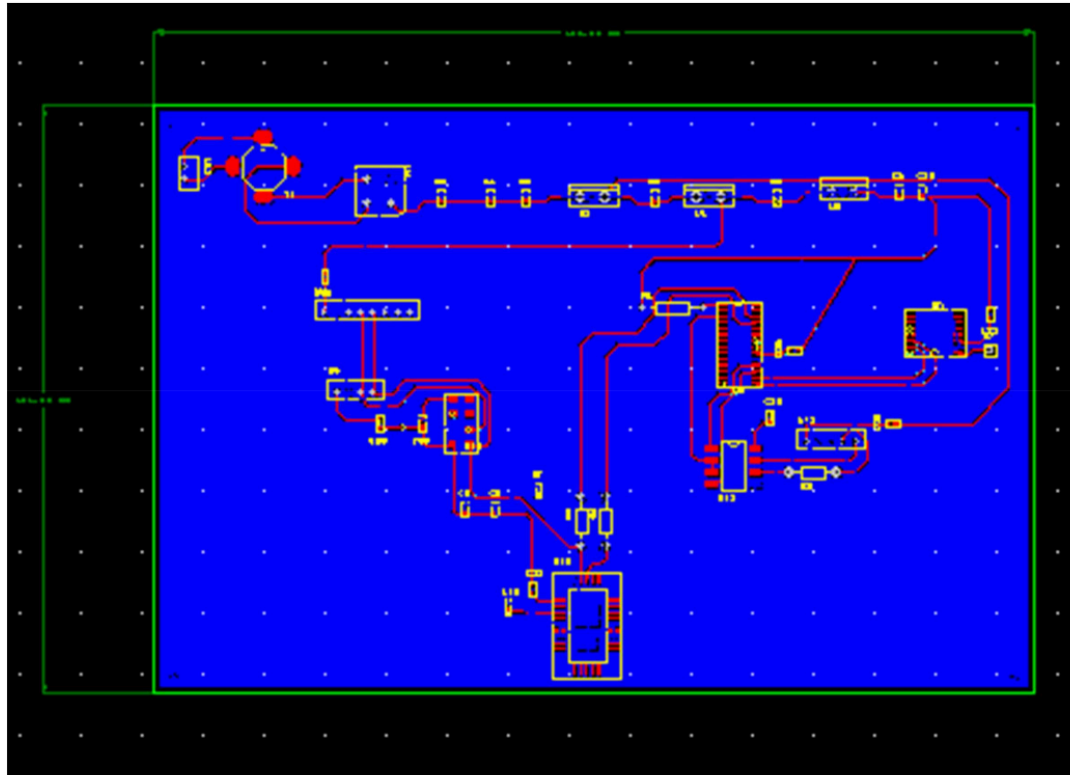


Figure 4 PCB Nodes

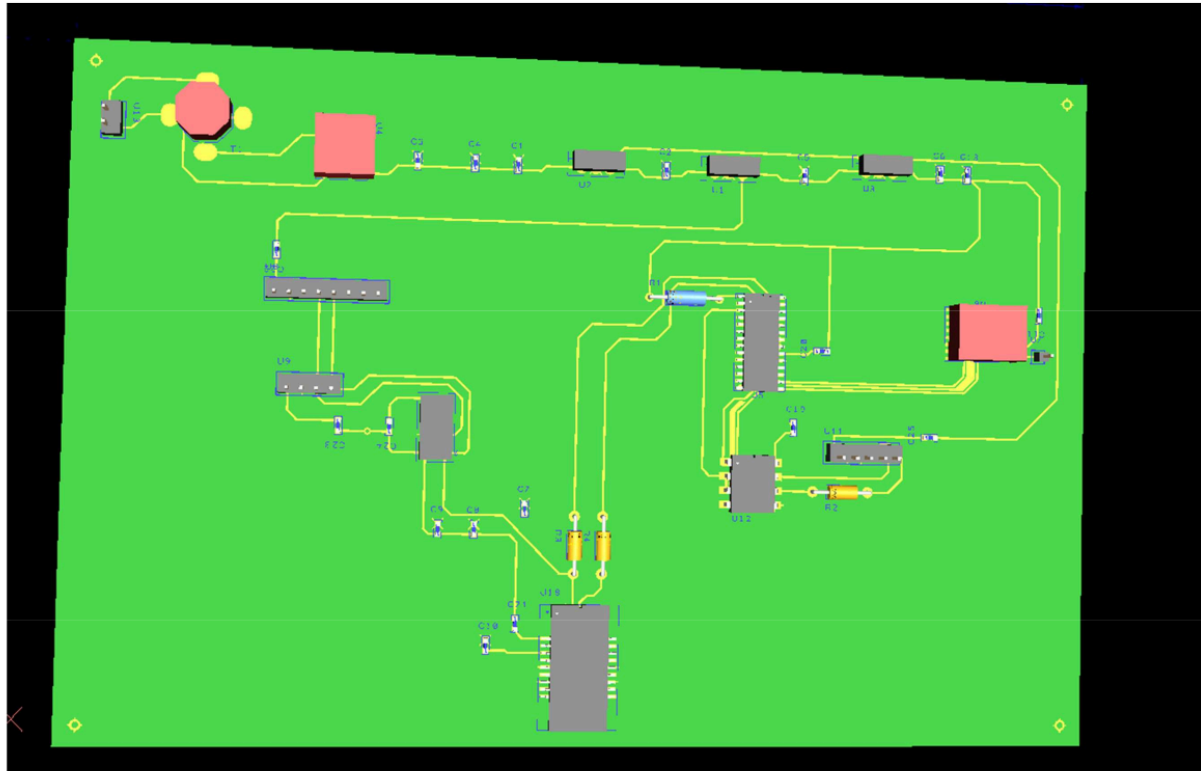


Figure 5 Node 3D Model.

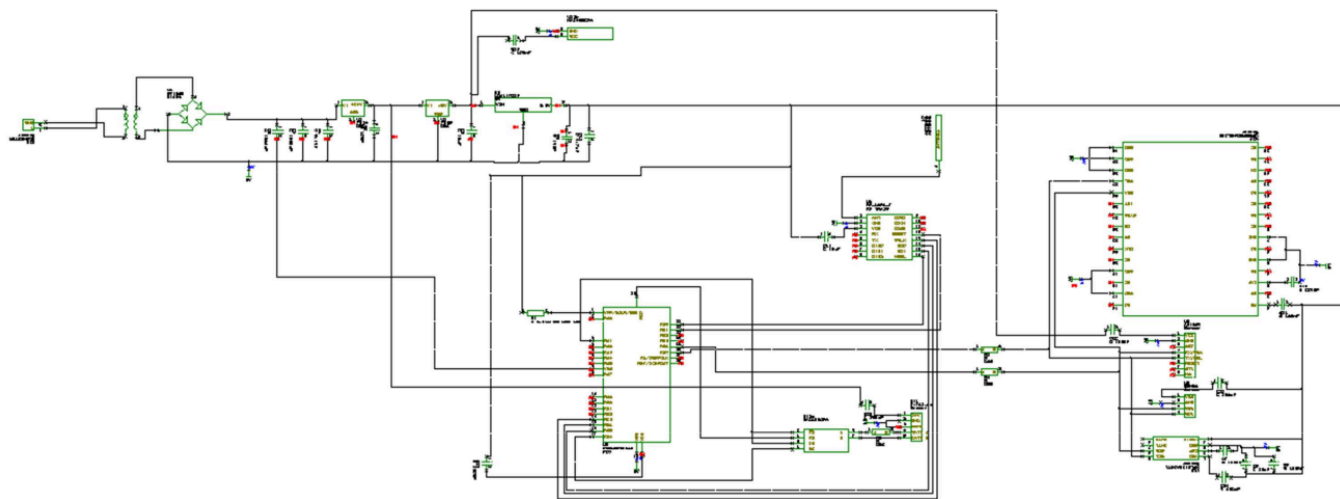


Figure 6 Node Schematic

3 Integration

Using 3D design on CATIA the mounting of the PCB can be seen in the figure below. The figure shows the space within the enclosure for the sensors to be fitted and shows that using reference of other IP45 rated enclosures such as the KDM enclosure [36]. The PCB and the sensor sizes have given an overall dimension for the footprint of the enclosure allowing all of the components to fit comfortably within the designed enclosure. Cap. Error fixture sizes chosen were M3 (ISO 10642) for both the hub and the nodes so that the enclosure could be standard also after the design the screw was also chosen for precision and it being lightweight [21]. Visio was also used to show dimensions and how the PCB fits within the enclosure with the antenna and Radiall connector which is IP rated and used within aerospace technologies and similar PCB projects [18]. The antenna choice has also been made due to showing strength and reliability within a 1.2 KM range, using a custom length whip antenna [24]. for the FT-742-SM the sensor enclosure will also have a gland to allow the cable to enter the box Shown in Appendix 37.

3.1. Enclosure Designs

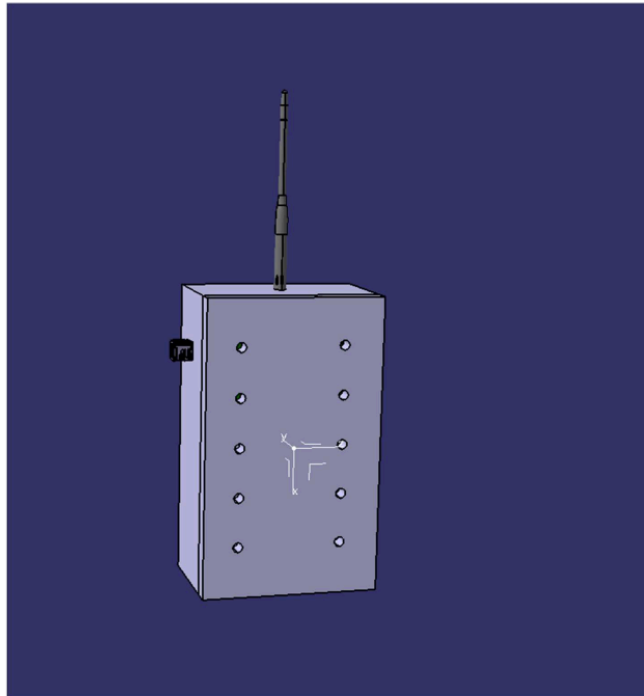


Figure 7 CATIA Enclosure

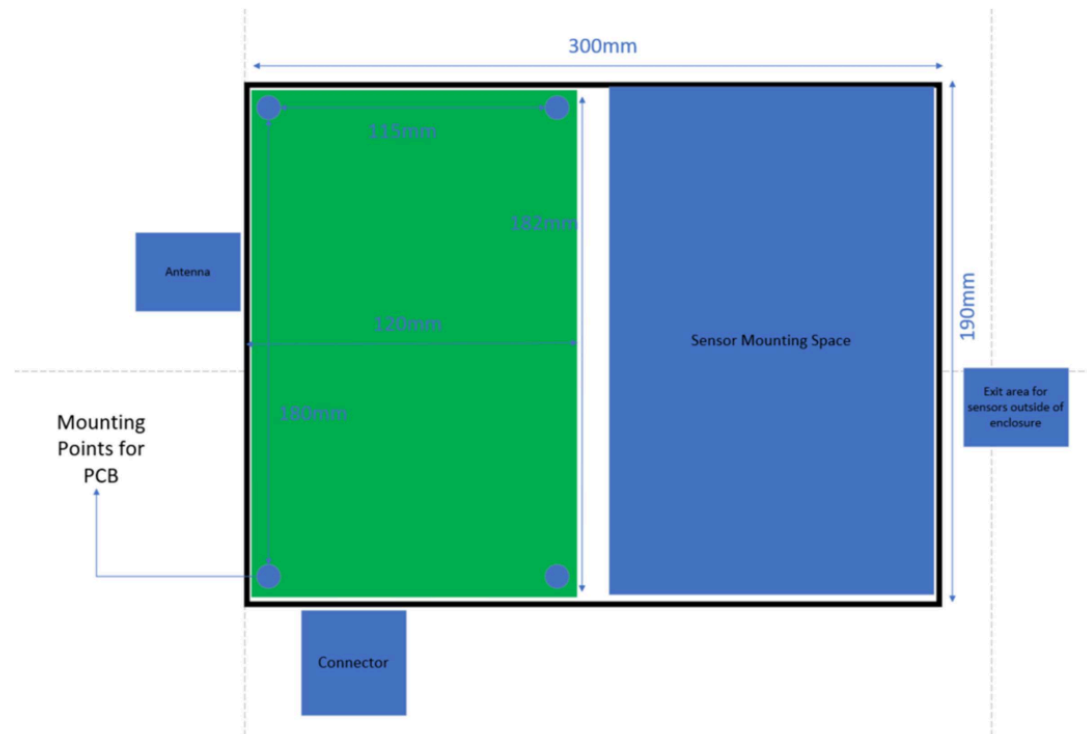


Figure 8 Visio Enclosure Diagram

4 Software

The software created firstly defines all components and PIC pins to inputs and outputs respectively, the second steps would be to initialise the communication protocol between the sensor and the PIC, so I2C and UART is initialised for the specific sensors and the MAX485-used for data conversion to be readable for the PIC [17,22], each of the sensor nodes PICs have a have slightly different code for when to allow communication to the LoRa module for transmission of data to the central hub.

The HUB code is vastly different from the nodes; the PIC uses pins allocated as both receivers and emitters of data to allow for the hub to notify the nodes when to wake up and to gather data to be displayed. The hub then receives the data gathered by the nodes and log the data in the SD card- the SD card has been used because of cost effectiveness and ease of data logging as shown in [23]; the PIC also sends the data to the display to update the information shown on the display accordingly to the new data gathered from the system. A simple diagram of the working of the software is shown below.

4.1. Software Block Diagram

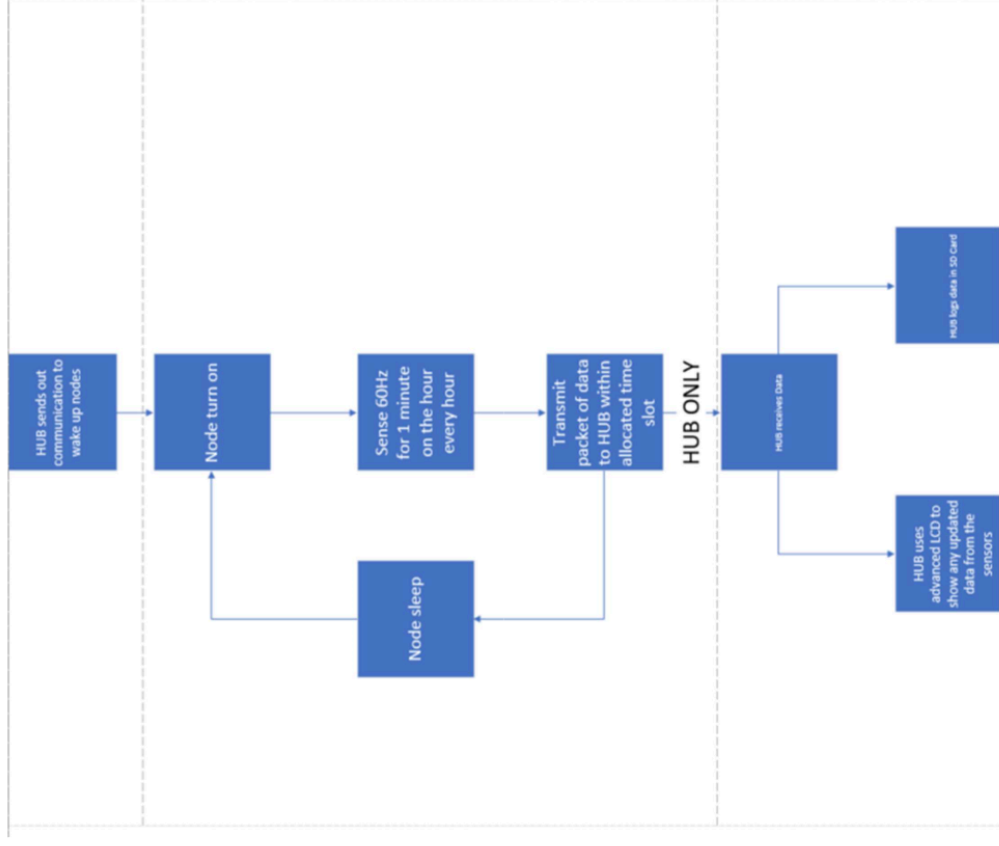


Figure 9 Node Software Diagram

5 Cost

Each of the nodes is a slightly different cost, this is mainly due to the sensor as all the enclosures and PCBs are standard. The cost of each sensor is as follows:

Sensor	Cost
AM1009	~£60
SEN66	£51
FT742-SM Ultrasonic	~£340
MPL3115A2	~£10
USEQGSEAN8L180	~£15
SD CARD/MODULE	~£5
LoRa Module	~£10
Display	£25
MAX485	£1
Antenna	£23

Table 1 Sensor Cost

The cost of each node is as follows for individual nodes and the full system depending on the requirements and what people want to buy:

Node #	Sensor	PCB Cost	Total Cost
Node 1	AM1009	£17.27	£110.27
Node 2	SEN66	£17.27	£101.27
Node 3	FT742-SM Ultrasonic + MAX 485	£17.27	£391.27
Node 4	MPL3115A2	£17.27	£60.27
Node 5	USEQGSEAN8L180	£17.27	£65.17
HUB	SD CARD/MODULE/Display	£17.27	£80.27
System	ALL- 6 lora modules, 6 PCBs, 1 MAX485 and all sensors	£34.54	£739.54

Table 2 Total Cost

6 Specification

In comparison to part 1, the sensors used and the radio module has not changed. The enclosure has gone through a design process as shown in section 3 as a bespoke enclosure is needed for the PCB and sensors due to the irregular sizing of the PCB and Mounting of the sensors. The connector has also not been changed and is used for all nodes including the hub to keep a standard. The power system chosen has also stayed. The design of the system works to the specifications of part one. However, there are many improvements the system can go through to become optimised, these improvements include the communication, power and sensors shown within section 7.

As seen in the table below all components chosen and specified in part one are within the PCB designs.

Sensor
AM1009
SEN66
FT742-SM Ultrasonic
MPL3115A2
USEQGEAN8L180
SD CARD/MODULE
LoRa Module
Display
MAX485

Table 3 Main Components Used

7 Improvements

To improve the system there are specific areas which can be improved upon. Seen in the headings below are the most critical changes to improve the system's function and sustainability for future use.

7.1. Communication

To improve this system a better protocol for communications should have been used. Currently the data is transmitted in a cascading effect, one set of data is transmitted then the PICs wait and transmit a second set of data; to improve the system the PICs should all transmit data simultaneously, such as frequency division duplexing [26]. This will improve speed and efficiency and would also help to get more data so the nodes could wake up more often and update the data on the hub faster on the display.

7.2. Sensors

To improve upon the cost other sensors could have been chosen. However, due to the specification of the customer requirements and to make sure that the sensors are able to withstand the environment these specific sensors have been chosen. A second improvement which could have been achieved is to find a standard communication protocol between all sensors to achieve a simpler design which would in effect also have made the PCB footprint smaller. With a different communication method, the speed of data would also be faster with use of SPI. Optical wave guide based sensors could have been used instead to monitor the air quality due to them being able to sense almost all of the quantities needed such as CO₂ and NH₃ [27].

7.3. Power

Although the choice to use mains power was used in the first part, the more sustainable route and to make the system fully tamper proof a rechargeable battery should have been used. This would decrease the wattage and improve efficiency as the regulators or buck converter could still be used to get the required voltages for the sensors as a larger battery would still be required for the different voltages that the components use such as the PIC and LoRa module [2]. Another improvement that could be made is rather than having the whole power circuit, a standard voltage for all sensors could be found and a switching voltage regulator could be used to increase efficiency of the power circuit as the current design with the different regulators is losing efficiency with heat [5]. To be more sustainable, Maharjan et al [6], shows use of vibration to harvest energy or human movements, as the location of this system

is in the steelworks where there is constant heavy machinery working, this is a possibility to use, the nodes which are in quieter areas could also use a solar panel to recharge the battery. Another source Rehman et al[7], shows use of solar power for portable charging which in concept can be used to power the battery for the nodes to keep the battery at an adequate level of charge.

8 Conclusion

In Conclusion, the designs for the node, hub and enclosure, would all work if manufactured, there are however distinct issues which are prevalent with this system due to what has been chosen in part one. The fundamental issues encountered are the choice of AM1009, this is lacking in journal papers and has a lack in test results or use in projects. SEN66 also has a similar issue, however the previous generations have literature to support their use, this sensor is a slight upgrade due to similarity and an addition of one more quantity to sense. The other three sensors (FT742-SM Ultrasonic, MPL3115A2, USEQGSEAN8L180) have been used in other projects of similarity to monitor the environment [11-13, 25]. Another issue encountered as previously stated in improvements is heat, due to the regulation chosen [5]. The heat is a loss which could be critical in dangerous situations so a different power conversion should be used such as a buck converter. Another pitfall is the lack of an advanced display used within the designs, a display is used, however, to get a better view of the system a display Pinout for a monitor to show the graphics would be a better choice. A final issue that has been encountered is the communication method, although it is simple and easy to use, the method makes the system work slower, which could be improved by using other communication methods such as frequency division duplexing.

To conclude, this system made works, however it is not perfect and can be vastly improved using better power methods, better communication methods and different sensors more vastly used in monitoring the environment such as optical waveguide-based sensors [27].

- [1] J. Li, S. Li, L. Wang, and H. Wang, "A modulation method for decoupling capacitance reduction in single-stage dual-active-bridge microinverters," *IEEE Transactions on Power Electronics*, vol. 41, no. 1, pp. 1087–1101, Jan. 2026. doi:10.1109/tpe1.2025.3604742
- [2] A. S. Samosir, T. Sutikno, and L. Mardiyah, "Simple formula for designing the PID controller of a DC-DC buck converter," *International Journal of Power Electronics and Drive Systems (IJPEDS)*, vol. 14, no. 1, p. 327, Mar. 2023. doi:10.11591/ijpeds.v14.i1.pp327-336
- [3] M. Bucolo et al., "Model identification to validate printed circuit boards for power applications: A new technique," *IEEE Access*, vol. 10, pp. 31760–31774, 2022. doi:10.1109/access.2022.3160449
- [4] V. U. Sankar, G. Lakshmi, and Y. S. Sankar, "A review of various defects in PCB," *Journal of Electronic Testing*, vol. 38, no. 5, pp. 481–491, Sep. 2022. doi:10.1007/s10836-022-06026-7
- [5] M. A. Sobhan Bhuiyan et al., "CMOS low-dropout voltage Regulator Design Trends: An overview," *Electronics*, vol. 11, no. 2, p. 193, Jan. 2022. doi:10.3390/electronics11020193
- [6] P. Maharjan et al., "A fully functional Universal self-chargeable power module for portable/wearable electronics and self-powered IOT applications," *Advanced Energy Materials*, vol. 10, no. 48, Oct. 2020. doi:10.1002/aenm.202002782
- [7] A. ur Rehman et al., "A solar-powered multi-functional portable charging device (SPMFPCD) with internet-of-things (iot)-based real-time monitoring—an innovative scheme towards energy access and Management," *Green Technologies and Sustainability*, vol. 3, no. 1, p. 100134, Jan. 2025. doi:10.1016/j.grets.2024.100134
- [8] J. Wu, "A Basic Guide to I2C," Texas Instruments, https://www.ti.com/lit/an/sbaa565/sbaa565.pdf?ts=1755115761670&ref_url=https%253A%252F%252Fwww.ti.com%252F (accessed Jan. 26, 2026).
- [9] H. Kuang, "Design of an intelligent instrument communication system based on RS485 bus," *2024 International Conference on Integrated Circuits and Communication Systems (ICICACS)*, pp. 1–5, Feb. 2024. doi:10.1109/icicacs60521.2024.10499077

- [10] G. R. Kanagachidambaresan and B. N., "Communication protocols," *Maker Innovations Series*, pp. 73–112, 2023. doi:10.1007/978-1-4842-9007-1_3
- [11] M. R. Sheykhazimi, M. R. Nayeri, M. T. Masouleh, and A. Kalhor, "Design, prototyping and performance analysis of a barometric-based soft force sensor," *2025 33rd International Conference on Electrical Engineering (ICEE)*, pp. 01–08, May 2025. doi:10.1109/icee67339.2025.11213923
- [12] C. Park et al., "Verification of UAV meteorological observation against a tall meteorological tower, May 2025. doi:10.5194/iceu12-672
- [13] J. D. Zavala Andrade, R. Chavez Morales, E. D. Rivera Ortiz, D. María Zamora Rodríguez, and B. M. Ventura, "Development of a portable air quality sensor prototype for real-time environmental analysis," *2024 IEEE 42nd Central America and Panama Convention (CONCAPAN XLII)*, pp. 1–8, Nov. 2024. doi:10.1109/concapan63470.2024.10933861
- [14] M. Eron, "Land Mobile Communication at high frequency, very high frequency, and ultrahigh frequency," *IEEE Microwave Magazine*, pp. 2–8, 2025. doi:10.1109/mmm.2025.3577983
- [15] C. A. Rocha et al., "A long term evolution CAT-M based gateway for Serial Modbus Communication in industrial internet of things systems," *2025 16th IEEE International Conference on Industry Applications (INDUSCON)*, pp. 1–8, Oct. 2025. doi:10.1109/induscon66435.2025.11241377
- [16] V. Barzdenas and A. Vasjanov, "A method of optimizing characteristic impedance compensation using cut-outs in high-density PCB designs," *Sensors*, vol. 22, no. 3, p. 964, Jan. 2022. doi:10.3390/s22030964
- [17] P. Chen, "Data Acquisition System based on Serial Port," *Journal of Theory and Practice of Engineering Science*, vol. 4, no. 03, pp. 87–98, Mar. 2024. doi:10.53469/jtpes.2024.04(03).09
- [18] M. Filipašić and M. Dadić, "An open tem cell design using PCB material and analysis of stands on Electromagnetic Field Uniformity," *2025 5th International Conference on Smart Grid Metrology (SMAGRIMET)*, pp. 1–6, Apr. 2025. doi:10.1109/smagrimet66590.2025.11030060

- [19] C. Zhu, "The difference between IPC-6012, IPC-A-600, and IPC-A-610 - Wellerpcb.com," Weller PCB, <https://wellerpcb.com/the-difference-between-ipc-6012-ipc-a-600-and-ipc-a-610/> (accessed Jan. 28, 2026).
- [20] Ö. Birinci and N. Yildiran, "Flyback converter design with EMC Improvement For Railway Applications," *International Journal of Power Electronics*, vol. 21, no. 2, pp. 151–169, 2025. doi:10.1504/ijpelec.2025.144693
- [21] I. J. Pérez-Olguín, C. C. Fernández-Gaxiola, L. A. Rodríguez-Picón, and L. C. Méndez-González, "Characterization and dataset compilation of torque–angle curve behavior for M2/M3 screws," *Data*, vol. 9, no. 10, p. 115, Oct. 2024. doi:10.3390/data9100115
- [22] R. K. Agrawal and V. R. Mishra, "The design of High Speed Uart," 2013 IEEE CONFERENCE ON INFORMATION AND COMMUNICATION TECHNOLOGIES, pp. 388–390, Apr. 2013. doi:10.1109/cict.2013.6558126
- [23] W. He and M. T. Iqbal, "Power consumption minimization of a low-cost IOT data logger for Photovoltaic System," *Journal of Electronics and Electrical Engineering*, Dec. 2023. doi:10.37256/jeec.2220233795
- [24] M. Wagih and P. Birley, "Towards improved IOT lora-wan connectivity using broadband omnidirectional antennas," 2022 16th European Conference on Antennas and Propagation (EuCAP), pp. 1–5, Mar. 2022. doi:10.23919/eucap53622.2022.9768906
- [25] S. S. Martins, "INSTRUMENTAÇÃO PARA DIAGNÓSTICO DE ASMA E DOENÇAS RESPIRATÓRIAS EM CRIANÇAS ATRAVÉS DA ANÁLISE DE AR EXALADO," Proquest, <https://run.unl.pt/server/api/core/bitstreams/395cab38-2bbe-42a3-8dd5-c66dfa0ed810/content> (accessed Jan. 28, 2026).
- [26] J. Jose et al., "Performance analysis and optimization of Frequency Division duplex based virtual full-duplex communication systems," *Ad Hoc Networks*, vol. 154, p. 103379, Mar. 2024. doi:10.1016/j.adhoc.2023.103379
- [27] M. A. Butt et al., "Environmental monitoring: A comprehensive review on optical waveguide and fiber-based sensors," *Biosensors*, vol. 12, no. 11, p. 1038, Nov. 2022. doi:10.3390/bios12111038
- [28] Microchip, "Pic18(L)F26/27/45/46/47/55/56/57K42 Data sheet," Microchip, <https://www1.microchip.com/downloads/aemDocuments/documents/MCU08/ProductDocuments>

ts/DataSheets/PIC18(L)F26-27-45-46-47-55-56-57K42-Data-Sheet-40001919G.pdf (accessed Jan. 29, 2026).

[29] Amazon, “Amazon.com: Generic New 15.6" WXGA HD led replacement laptop LCD screen compatible with LP156WH2 (TL)(E1) / LP156WH2-TLE1 : Electronics,” Amazon, <https://www.amazon.com/Generic-Replacement-Compatible-LP156WH2-LP156WH2-TLE1/dp/B0096D68VC> (accessed Jan. 29, 2026).

[30] Microchip, “PIC32MZ embedded connectivity with Floating Point Unit (EF) Family Data Sheet EF manual - 60001320B,” Microchip, <https://usermanual.wiki/Document/PIC32MZ20EF20Data20Manual202060001320B.402733663/help> (accessed Jan. 29, 2026).

[31] KEMET, “QGS pyroelectric infrared gas sensors, I2C-SMD,” Mouser, https://content.kemet.com/datasheets/KEM_SE0214_QGS.pdf (accessed Jan. 29, 2026).

[32] CUBIC, “AM1009,” novitronic, <https://www.novitronic.com/en/product-categories/sensors/gas-and-particle-sensors/am1009> (accessed Jan. 29, 2026).

[33] NXP, “MPL3115A2 i2c precision pressure sensor with altimetry rev. 8.1 — 17 may 2024,” NXP, <https://www.nxp.com/docs/en/data-sheet/MPL3115A2.pdf> (accessed Jan. 29, 2026).

[34] Forest Technology, “AXXXX_EN-FT742-SM-Datasheet - Forest Technology Systems,” Forest Technology, <https://ftinc.com/wp-content/uploads/2017/05/FT742-SM-Wind-Sensor-Datasheet.pdf> (accessed Jan. 29, 2026).

[35] RAYCOM, “WISYCOM sma whip antenna - custom length,” RAYCOM, <https://www.raycom.co.uk/product/wisycom-sma-whip-antenna-custom-length/> (accessed Jan. 29, 2026).

[36] KDM, “IP45 enclosure, IP45 rating resource , custom IP45 enclosure supplier,” kdmsteel, <https://www.kdmsteel.com/ip45-enclosure/> (accessed Jan. 30, 2026).

10 Appendix

[PIC18\(LF26/27/45/46/47/55/56/57K42 Data Sheet](#)

Appendix 1 [PC18F26K42](#)

[New 15.6" LED FHD Glossy Display Panel Compatible with LP156WFD SP L1,](#)
[LP156WFD SP M2 Notebook Laptop Non Touch Screen with 40 Pins Connector – Sold By](#)
[Wikiparts : Amazon.co.uk: Computers & Accessories](#)

Appendix 2 [LCD Display](#)

[PIC32MZ Embedded Connectivity with Floating Point Unit \(EF\) Family Data Sheet](#)

Appendix 3 [PIC32 Datasheet](#)

[KEM_SE0214_QGS.pdf](#)

Appendix 4 [USEQGSEAN8L180 Datasheet](#)

[SEN6x - Datasheet](#)

Appendix 5 [SEN66 Datasheet](#)

[Microsoft Word - AM1009 Integrated Air Quality Sensor Module Specification](#)

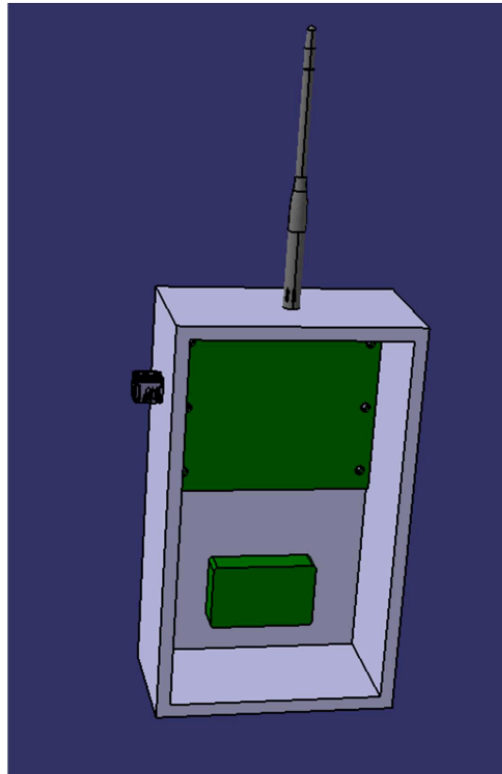
Appendix 6 [AM1009 Datasheet](#)

[MPL3115A2, I2C precision pressure sensor with altrimetry - data sheet](#)

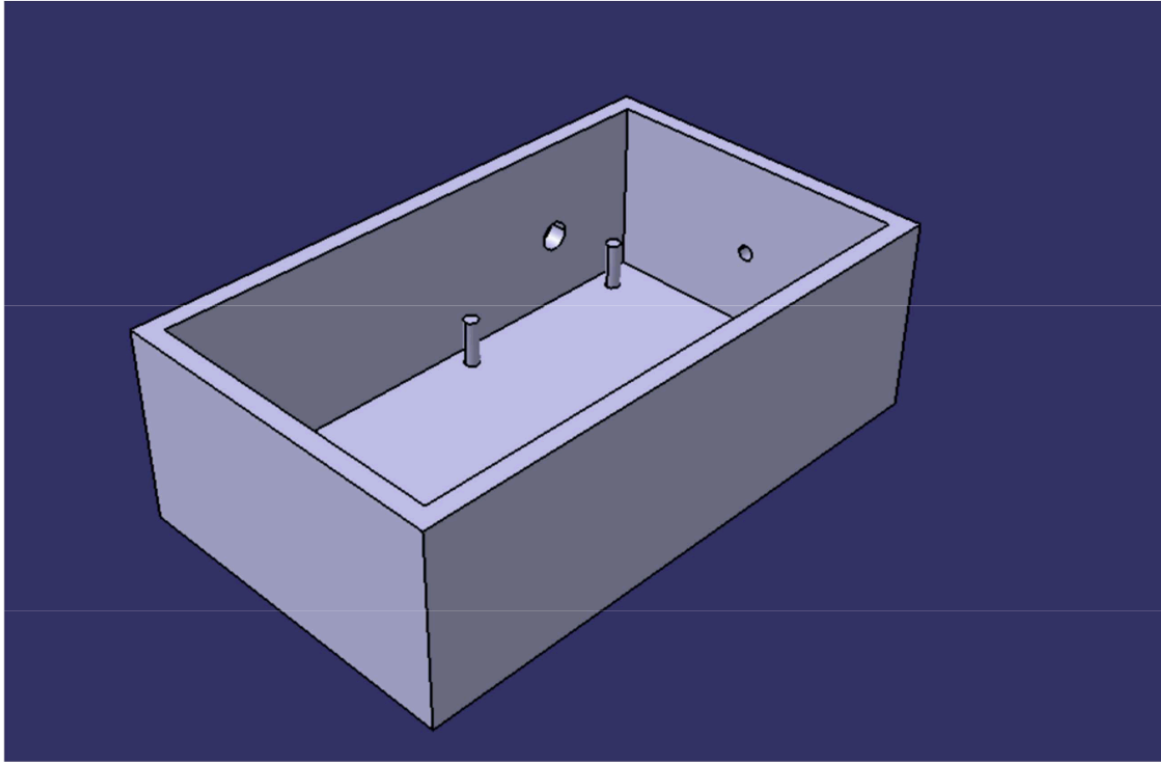
Appendix 7 [MPL3115A2 Datasheet](#)

[AXXXX_EN-FT742-SM-Datasheet - DRAFT.indd](#)

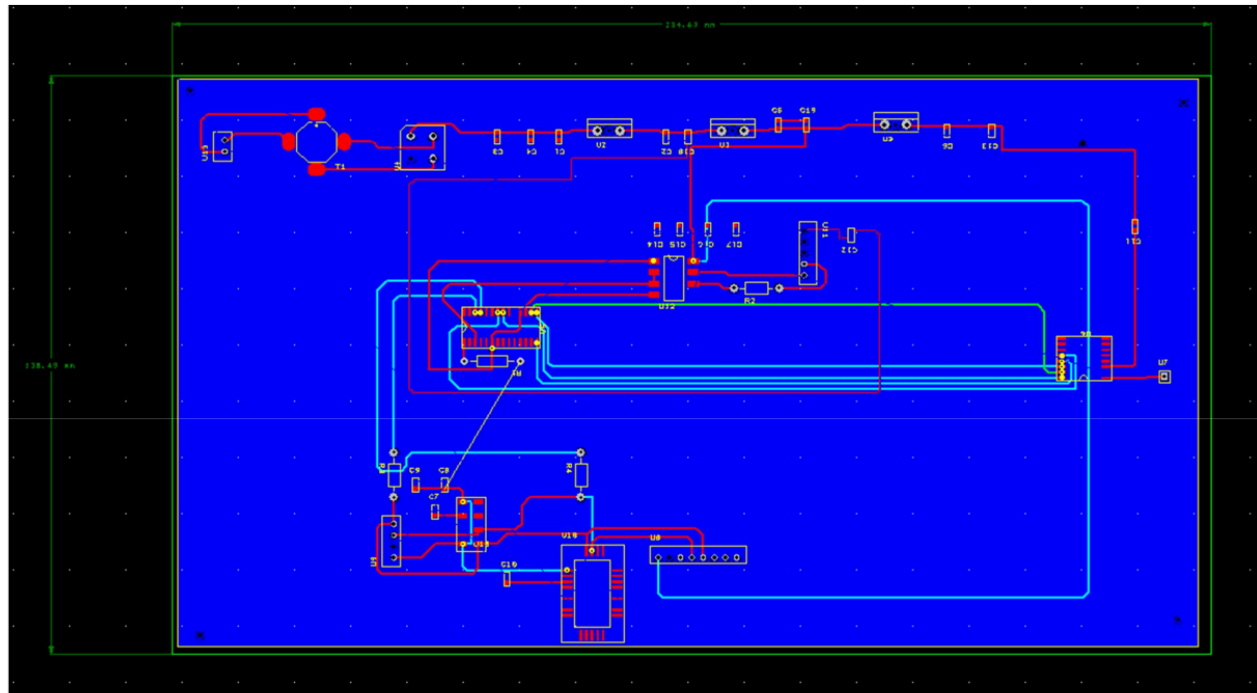
Appendix 8 [FT742-SM Datasheet](#)



Appendix 9 CAD with AM1009- largest sensor

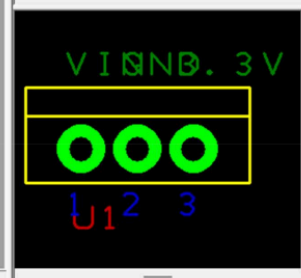
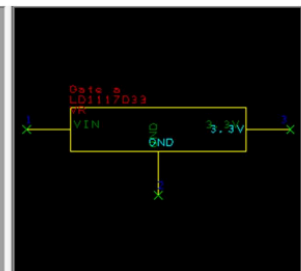


Appendix 10 Isometric view of enclosure



Appendix 11 Initial Node Design

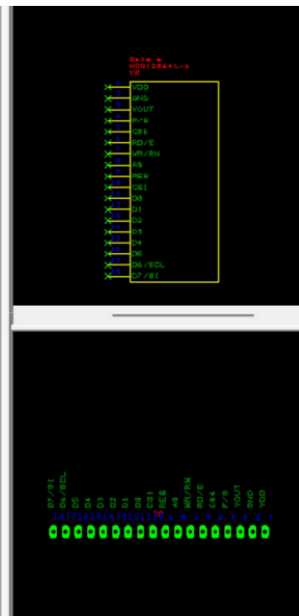
Sch Symbol	Sch Symbol	Sch Terminal	Pcb Symbol	Component Pin	Net (Class)
Name	Terminal Name	Number	Pad Number	Name/Number	Name
LD1117D33	VIN	1	1	1	
	GND	2	2	2	
	3.3V	3	3	3	



Assignments Packages Gates Values Properties

Appendix 12 3.3V Regulator

Sch Symbol	Sch Terminal	Pcb Symbol	Component Pin	Net (Class)
Terminal Name	Number	Pad Number	Name/Number	Name
VDD	1	1	1	
GND	2	2	2	
VOUT	3	3	3	
P/S	4	4	4	
C86	5	5	5	
RD/E	6	6	6	
WR/RW	7	7	7	
A0	8	8	8	
RES	9	9	9	
CS1	10	10	10	
D0	11	11	11	
D1	12	12	12	
D2	13	13	13	
D3	14	14	14	
D4	15	15	15	
D5	16	16	16	
D6/SCL	17	17	17	
D7/SI	18	18	18	

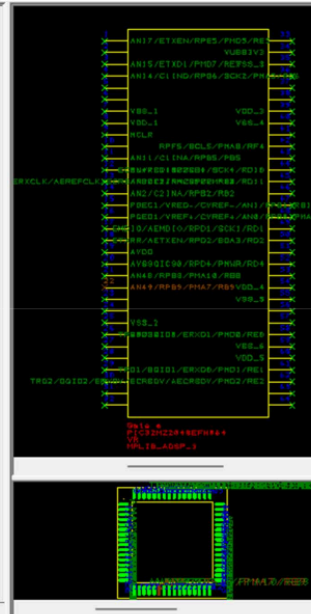


Appendix 13 LCD Component Header

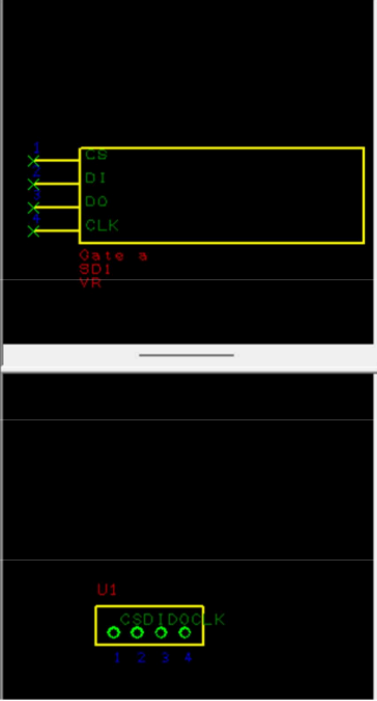
Sch Symbol	Sch Terminal	Pcb Symbol	Component Pin	Net (Class)
Terminal Name	Number	Pad Number	Name/Number	Name
AN17/ETXEN/RP	1	1	1	
	2	2	2	
AN15/ETXD1/PM	3	3	3	
AN14/C1IND/RP	4	4	4	
	5	5	5	
	6	6	6	
VSS_1	7	7	7	
VDD_1	8	8	8	
MCLR	9	9	9	
	10	10	10	
AN11/C1INA/RP	11	11	11	
AN4/C1INB/RB4	12	12	12	
AN3/C2INA/RP	13	13	13	
AN2/C2INA/RP	14	14	14	
PGE1/VRED-/C	15	15	15	
PGE1/VREF+/C	16	16	16	
	17	17	17	
	18	18	18	
AVDD	19	19	19	
AVSS	20	20	20	
AN48/RPB8/PM	21	21	21	
AN49/RPB9/PM	22	22	22	
	23	23	23	
	24	24	24	

ackages / Gates / Values / Properties /

Appendix 14 PIC32MZ2048EFH064 Component

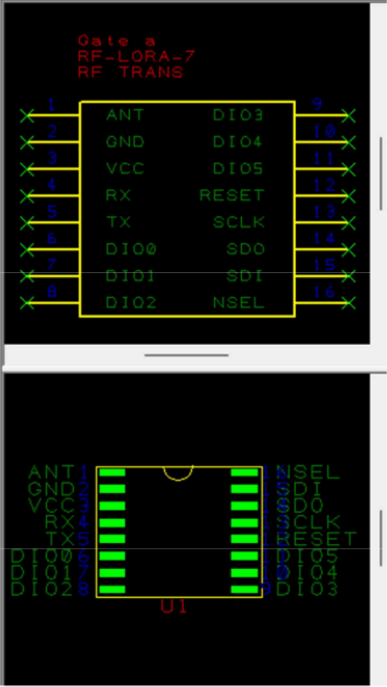


Sch Symbol	Sch Terminal	Pcb Symbol	Component Pin	Net (Class)
Terminal Name	Number	Pad Number	Name/Number	Name
CS	1	1	1	
DI	2	2	2	
DO	3	3	3	
CLK	4	4	4	



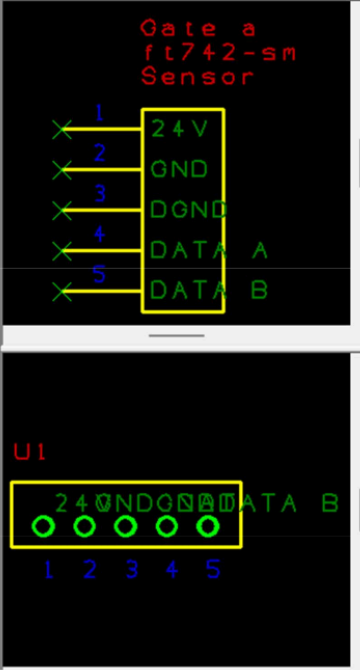
Appendix 15 SD Component

Sch Symbol	Sch Terminal	Pcb Symbol	Component Pin	Net (Class)
Terminal Name	Number	Pad Number	Name/Number	Name
ANT	1	1	1	
GND	2	2	2	
VCC	3	3	3	
RX	4	4	4	
TX	5	5	5	
DIO0	6	6	6	
DIO1	7	7	7	
DIO2	8	8	8	
DIO3	9	9	9	
DIO4	10	10	10	
DIO5	11	11	11	
RESET	12	12	12	
SCLK	13	13	13	
SDO	14	14	14	
SDI	15	15	15	
NSEL	16	16	16	



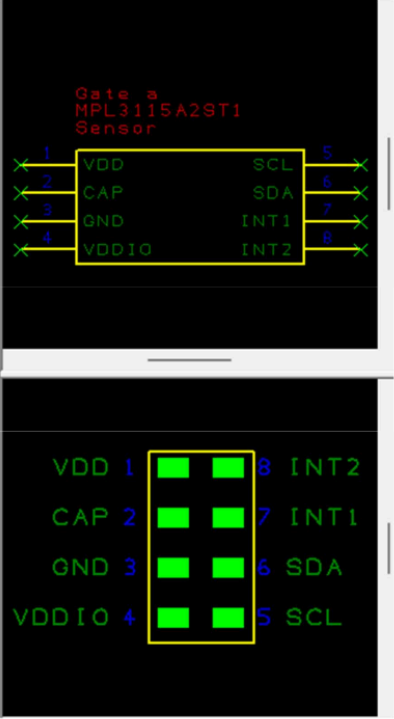
Appendix 16 RF-LoRa-7 Component

Sch Symbol	Sch Terminal	Pcb Symbol	Component Pin	Net (Class)
Terminal Name	Number	Pad Number	Name/Number	Name
24V	1	1	1	
GND	2	2	2	
DGND	3	3	3	
DATA A	4	4	4	
DATA B	5	5	5	

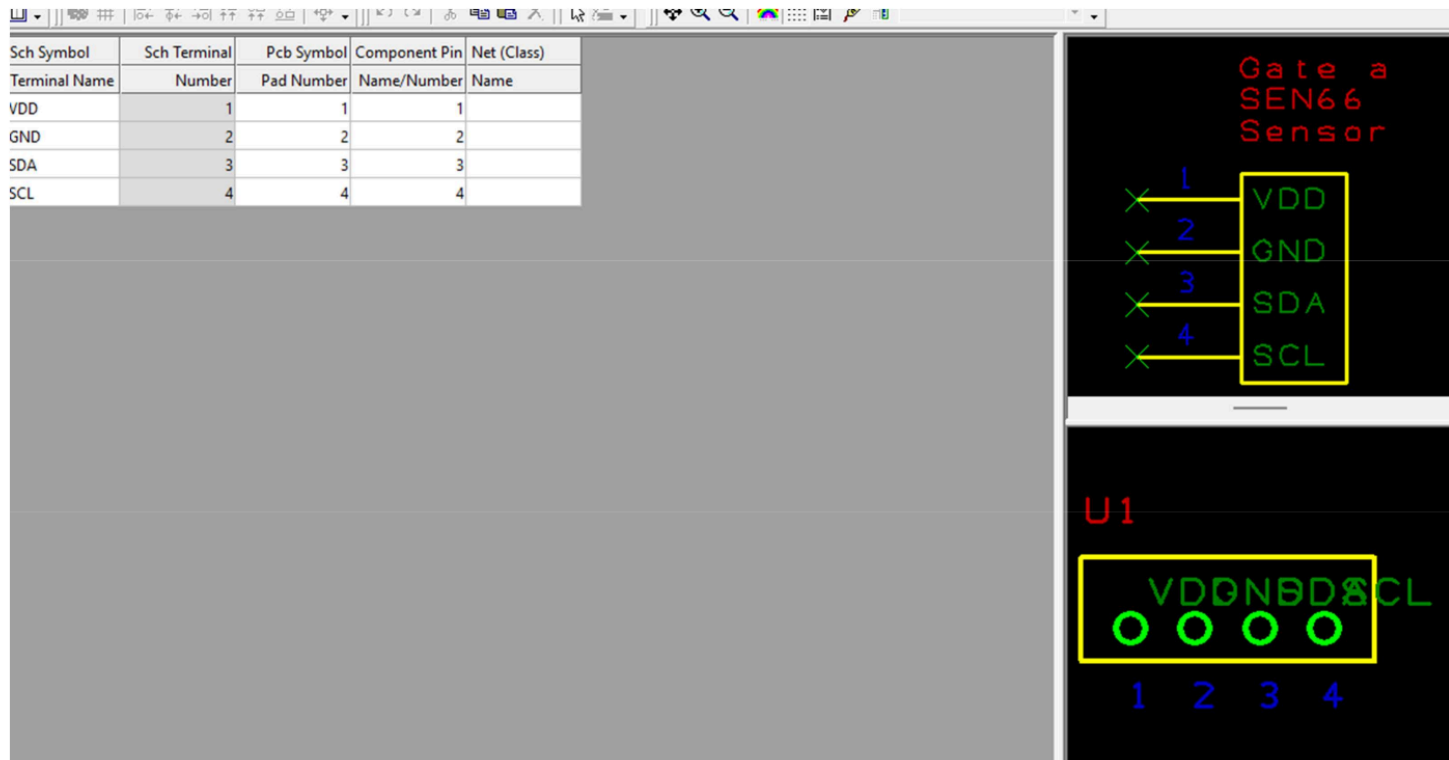


Appendix 17 FT742-SM Component

Sch Symbol	Sch Terminal	Pcb Symbol	Component Pin	Net (Class)
Terminal Name	Number	Pad Number	Name/Number	Name
VDD	1	1	1	
CAP	2	2	2	
GND	3	3	3	
VDDIO	4	4	4	
SCL	5	5	5	
SDA	6	6	6	
INT1	7	7	7	
INT2	8	8	8	

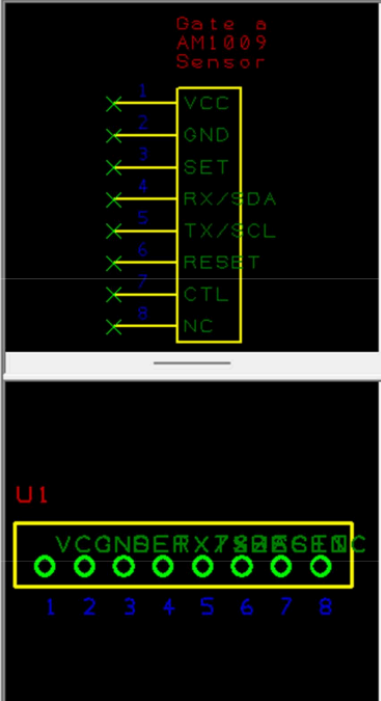


Appendix 18 MPL3115A2ST1 Component



Appendix 19 SEN66 Component

Sch Symbol	Sch Terminal	Pcb Symbol	Component Pin	Net (Class)
Terminal Name	Number	Pad Number	Name/Number	Name
VCC	1	1	1	
GND	2	2	2	
SET	3	3	3	
RX/SDA	4	4	4	
TX/SCL	5	5	5	
RESET	6	6	6	
CTL	7	7	7	
NC	8	8	8	

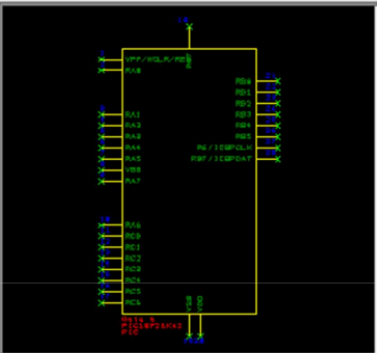
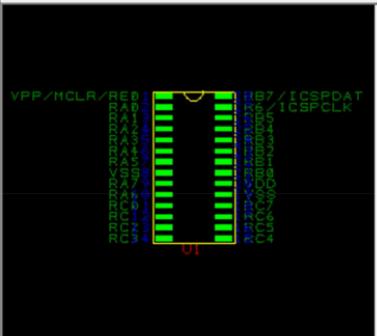


Appendix 20 AM1009 Component

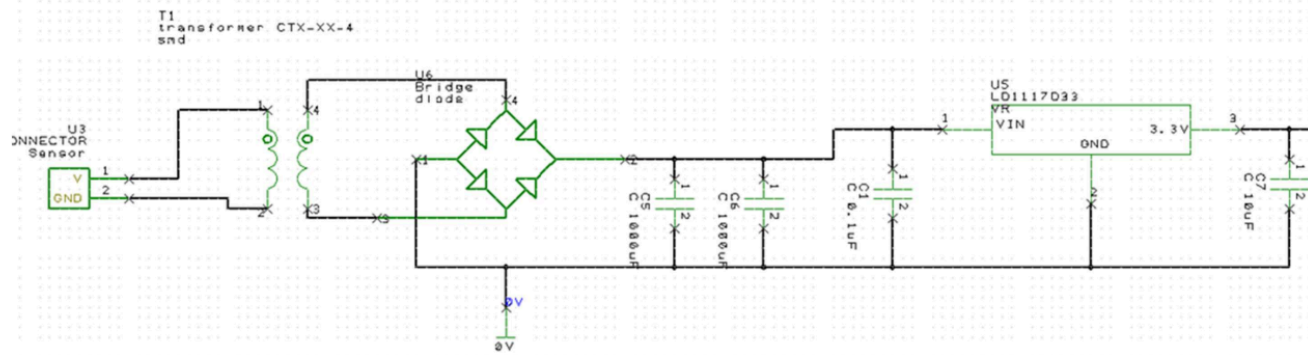
Sch Symbol	Sch Terminal	Pcb Symbol	Component Pin	Net (Class)	
Terminal Name	Number	Pad Number	Name/Number	Name	
VS	1	1	1		
NC	2	2	2		
CAP	3	3	3		
NC	4	4	4		
GND	5	5	5		
NC	6	6	6		
GND	7	7	7		
NC	8	8	8		
NC	9	9	9		
NC	10	10	10		
NC	11	11	11		
NC	12	12	12		
CN	13	13	13		
NC	14	14	14		
NC	15	15	15		
NC	16	16	16		
GND	17	17	17		
NC	18	18	18		
GND	19	19	19		
NC	20	20	20		
CLK	21	21	21		
NC	22	22	22		
CS	23	23	23		
SYNC	24	24	24		

Appendix 21 USEQGSEAN8L180 Component

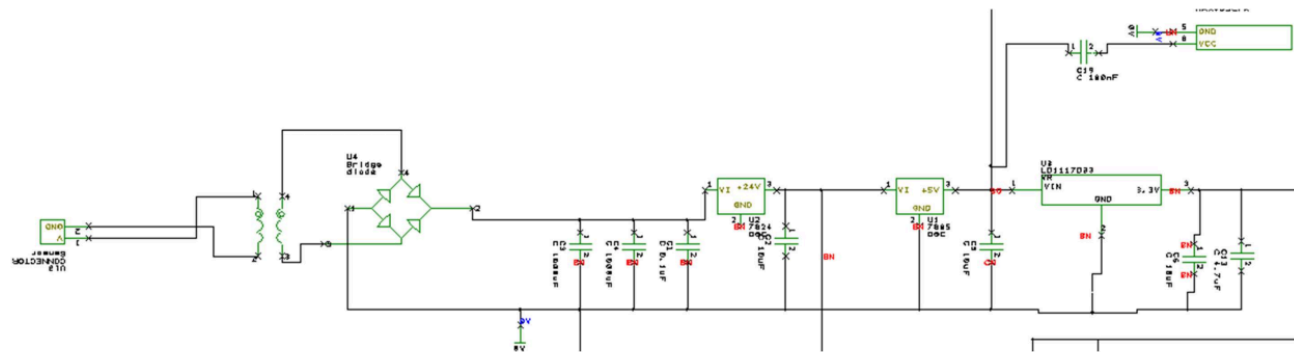
Sch Symbol	Sch Terminal	Pcb Symbol	Component Pin	Net (Class)	
Terminal Name	Number	Pad Number	Name/Number	Name	
VPP/MCLR/RE0	1	1	1		
RA0	2	2	2		
RA1	3	3	3		
RA2	4	4	4		
RA3	5	5	5		
RA4	6	6	6		
RA5	7	7	7		
VSS	8	8	8		
RA7	9	9	9		
RA6	10	10	10		
RC0	11	11	11		
RC1	12	12	12		
RC2	13	13	13		
RC3	14	14	14		
RC4	15	15	15		
RC5	16	16	16		
RC6	17	17	17		
RC7	18	18	18		
VSS	19	19	19		
VDD	20	20	20		
RB0	21	21	21		
RB1	22	22	22		
RB2	23	23	23		
RB3	24	24	24		

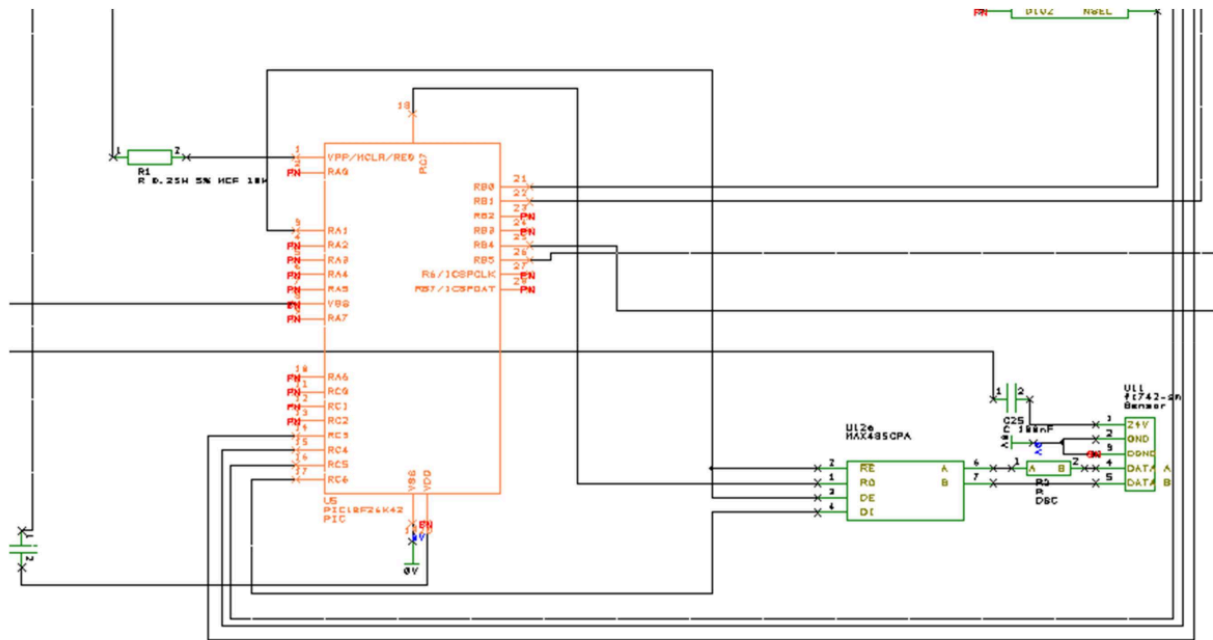
Appendix 22 PIC18F26K42 component



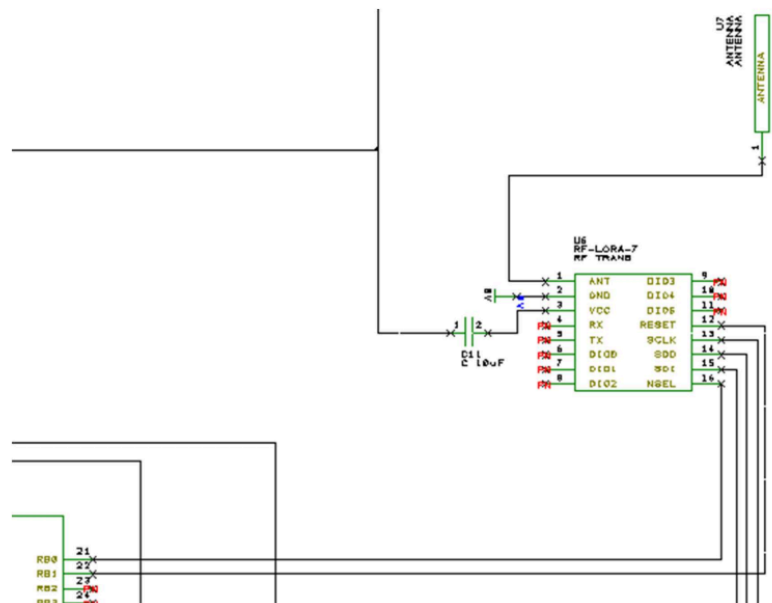
Appendix 23 HUB Power Circuit



Appendix 26 NODE Power Circuit

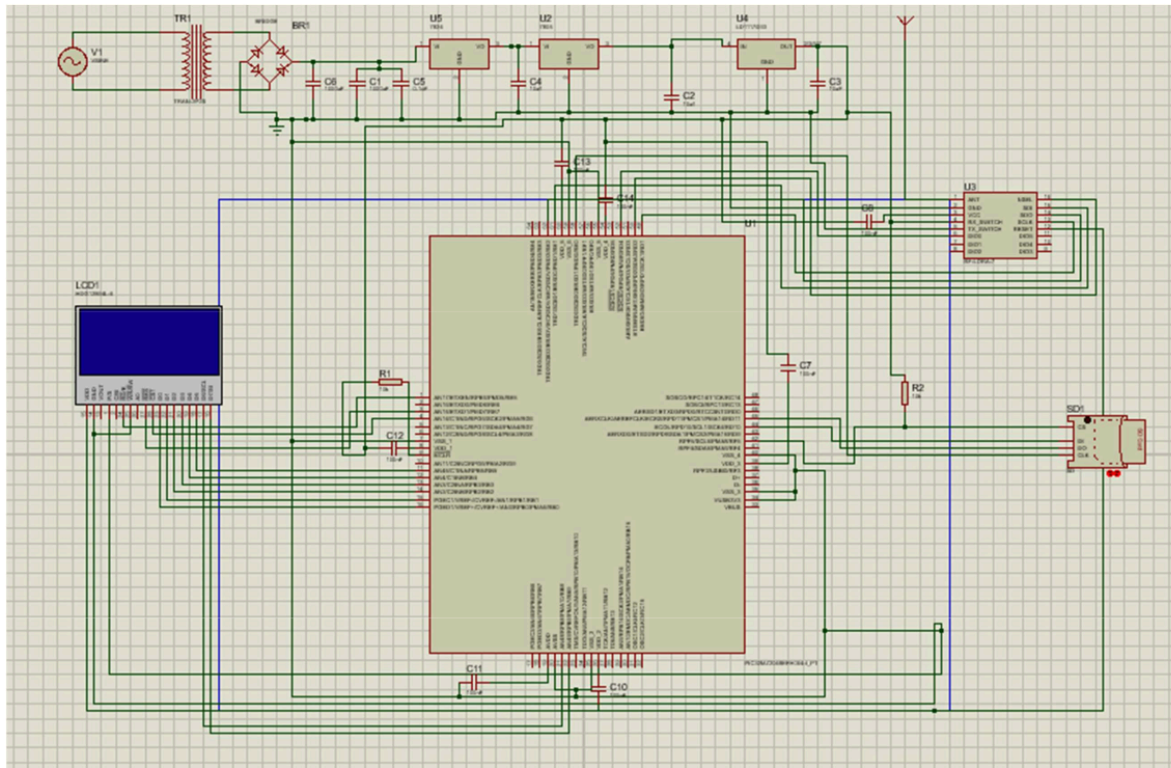


Appendix 27 PIC to MAX485 & FTM742-SM

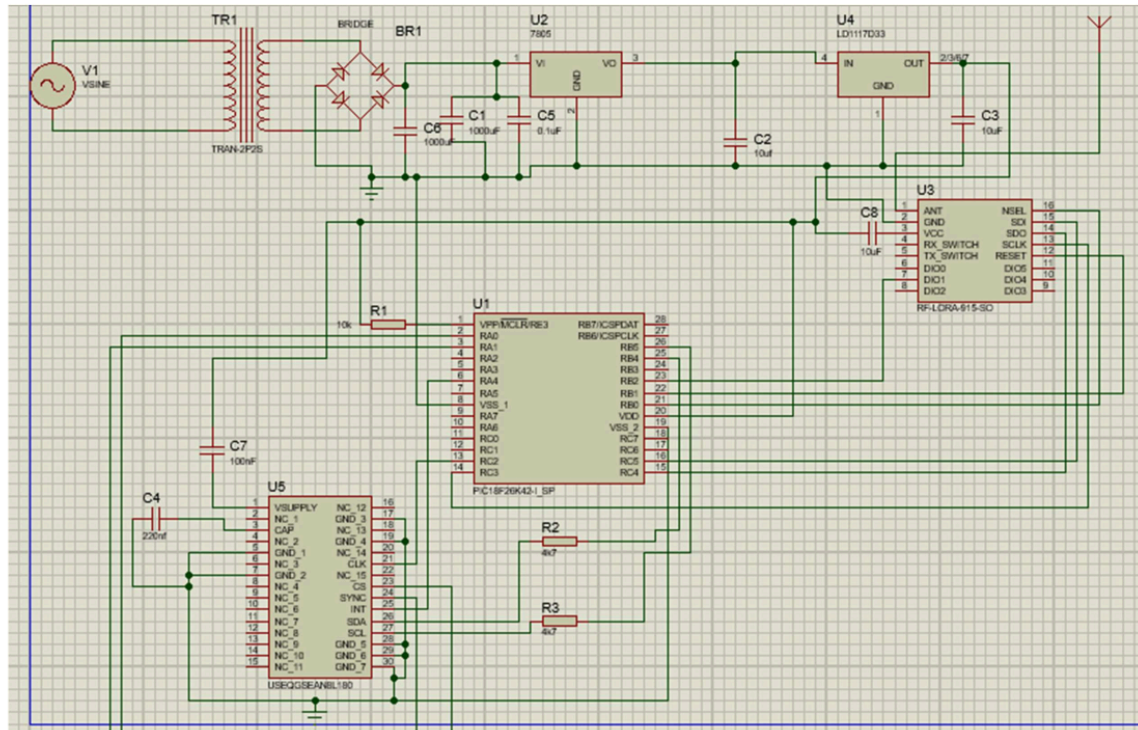


Appendix 28 LoRa to PIC

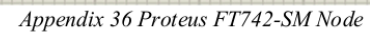




Appendix 31 Proteus HUB



Appendix 32 Proteus USEQGSEAN8L180 Node



RS PRO Black Nylon Cable Gland, M20 Thread, 6mm min., 12mm max., IP68

RS Stock No.: 669-4664 | Distrelec Article No.: 303-91-128 | Brand: [RS PRO](#)

RS PRO



Appendix 37 Cable Gland

! Bulk discount available

Subtotal (1 bag of 5 units)*

£6.66
(exc. VAT)

£7.99
(inc. VAT)

Bag(s)

Select or type quantity

1 +

[Check delivery dates](#)

[Add to basket](#)

FREE delivery for orders over £50.00

In Stock

- 4,047 unit(s) ready to ship
- Plus 116 unit(s) ready to ship from another location

ESD Assignment 2- Robbie Herbert

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

77 /100

PAGE 1

PAGE 2

QM

Sp.
Spelling error

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8



Comment 1

This seems like an odd thing to trade off. Why not use surface mount devices as they are generally much smaller, or just use a bigger box? In circuit programming is

PAGE 9



Comment 2

This image is not clear. The trick to having clear images is to make it the right size before you copy it. As it is, none of the text is readable and the tracks are not clearly defined. Also there is a vast amount of space on this board which could have been used for a programming connector.



Comment 3

Why have all the components moved to the side compared to the image above?

What is the round component?



Cap. Error
Capitalization

PAGE 24

PAGE 25

PAGE 26

PAGE 27

PAGE 28

PAGE 29

PAGE 30

PAGE 31

PAGE 32

PAGE 33

PAGE 34

PAGE 35

PAGE 36

PAGE 37

PAGE 38

PAGE 39

PAGE 40

PAGE 41

PAGE 42

PAGE 43

PAGE 44

PAGE 45

PAGE 46

PAGE 47

PAGE 48

PAGE 49

PAGE 50

PAGE 51

PAGE 52

PAGE 53

PAGE 54

PAGE 55

PAGE 56

PAGE 57

PAGE 58

GRADING FORM: SMU GENERIC_SMOSEY

ROBBIE HERBERT

77

ENGAGEMENT WITH LITERATURE

including reading, referencing, academic conventions and academic honesty



There are no marks available for this section

0

KNOWLEDGE & UNDERSTANDING

Knowledge of the basic underlying concepts and principles of a subject.



Good PCB designs, although there is a lot of empty space on the boards. Generally well thought out. Some of the images could have been clearer

6

COGNITIVE & INTELLECTUAL

Evaluate underlying concepts and principles of a subject and interpret qualitative and quantitative data in order to develop lines of argument and make sound judgements.



Your design is viable. You have thought about the form and function of each part in the system. Your system looks as though it will perform to the required specifications

24

PRACTICAL APPLICATION SKILLS

Different approaches to solving problems in particular contexts.



Very good work. Costing could be more accurate though as it seems like some of the costs are estimated or rounded off. Excellent quality design

40

TRANSFERABLE SKILLS

Communicate the results of their study/work accurately and reliably, and with structured and coherent arguments; the qualities needed for employment requiring the exercise of some personal responsibility within a structured and managed environment.



Can communicate professionally confidently and consistently in a suitable format. Work is coherent, very fluent and is presented professionally. Demonstrates excellent graduate employment skills and an appetite for further development.

7