GLOSSARY

Autonomous Mobile Robot (AMR): A mobile robot that can drive, navigate, localize, and map the surroundings itself with help of sensors only without any static guides.

Behavior Tree (BT): A behavior tree is a mathematical model of plan execution based in computer science, robotics, control systems and video games.

LiDAR: Abbreviation of Light Detection and Ranging. A sensing device that can measure distance with certain accuracy.

Navigation 2 (Nav2): A Package that is used for autonomous navigation, and obstacle avoidance.

Robot Operating System 2 (ROS2): Abbreviation of Robot Operating System 2. A set of software library and tools for building robot applications.

REFERENCES

Ademovic, A., n.d. *An Introduction to Robot Operating System: The Ultimate Robot Application Framework.* [Online]

Available at: https://www.toptal.com/robotics/introduction-to-robot-operating-system
[Accessed 19 January 2023].

Alatise, M. B. & Hancke, G. P., 2020. A Review on Challenges of Autonomous Mobile Robot and Sensor Fusion Methods. *IEEE Access,* Volume 8, pp. 39830-39846.

Anon., n.d. *AGV vs. AMR - What's the Difference?.* [Online]
Available at: https://www.mobile-industrial-robots.com/insights/get-started-with-amrs/agv-vs-amr-whats-the-difference/
[Accessed 23 January 2023].

Anon., n.d. *micro-ROS.* [Online]
Available at: https://micro.ros.org/
[Accessed 12 January 2023].

Anon., n.d. *ROS - Robot Operating System.* [Online]
Available at: https://www.ros.org/
[Accessed 18 January 2023].

Colledanchise, M. & Natale, L., 2021. Handling Concurrency in Behavior Trees. *IEEE Transactions on Robotics.*

Colledanchise, M. & Ögren, P., 2017. How Behavior Trees Modularize Hybrid Control Systems and Generalize Sequential Behavior Compositions, the Subsumption Architecture and Decision Tree. *IEEE Transactions on robotics,* 33(2), pp. 372-389.

Dortmans, E. & Punter, T., 2022. Behavior Trees for Smart Robots Practical Guidelines for Robot Software Development. *Journal of Robotics,* 7 September.Volume 2022.

Ghzouli, R. et al., 2015. Behavior Trees and State Machines in Robotics Applications. *Journal of LATEX Class Files,* Volume 14.

Ichsan, M., 2022. *Mechanical Improvement on Autonomous Mobile Robot.* s.l.:Swiss German University.

Jonathan, M., 2022. *Development of Indoor Logistic Autonomous Mobile Robot Based on Robot Operating System 2.* s.l.:Swiss German University.

Millikan, R. A. & Bishop, E. S., 1917. *Elements of Electricity: A Practical Discussion of the Fundamental Laws and Phenomena of Electricity and Their Practical Applications in the Business and Industrial World.* Chicago: American Technical Society.

Quigley, M. et al., 2009. *ROS: an open-source Robot Operating System.* s.l.:s.n.
Rovida, F., Grossmann, B. & Krüger, V., 2017. *Extended Behavior Trees for Quick Definition of Flexible Robotic Tasks.* Vancouver: Internaional Conference on Intelligent Robots and Systems.

Rubio, F., Valero, F. & Llopis-Albert, C., 2019. A review of mobile robots: Concepts, methods, theoretical framework, and applications. *International Journal of Advanced Robotic Systems.*

Tannaka, G. M., 2023. *Development of Indoor Logistic Autonomous Mobile Robot Using Behavior Tree in ROS2.* s.l.:Swiss German University.

Witono, N. A., 2021. *Development of Scaled-Down Self-Driving Car for Last Mile Delivery Based on ROS2.* s.l.:Swiss German University.

Yao, F., Alkan, B., Ahmad, B. & Harrison, R., 2020. Improving Just-in-Time Delivery Perfromance of IoT-Enabled Flexible Manufacturing Systems with AGV Based Material Transportation. *Sensors,* 20(21).

Zghair, N. A. K. & Al-Araji, A. S., 2021. A one decade survey of autonomous mobile robot systems. *International Journal of Electrical and Computer Engineering (IJECE),* 11(6), pp. 4891-4906.

APPENDIX A – DATASHEETS

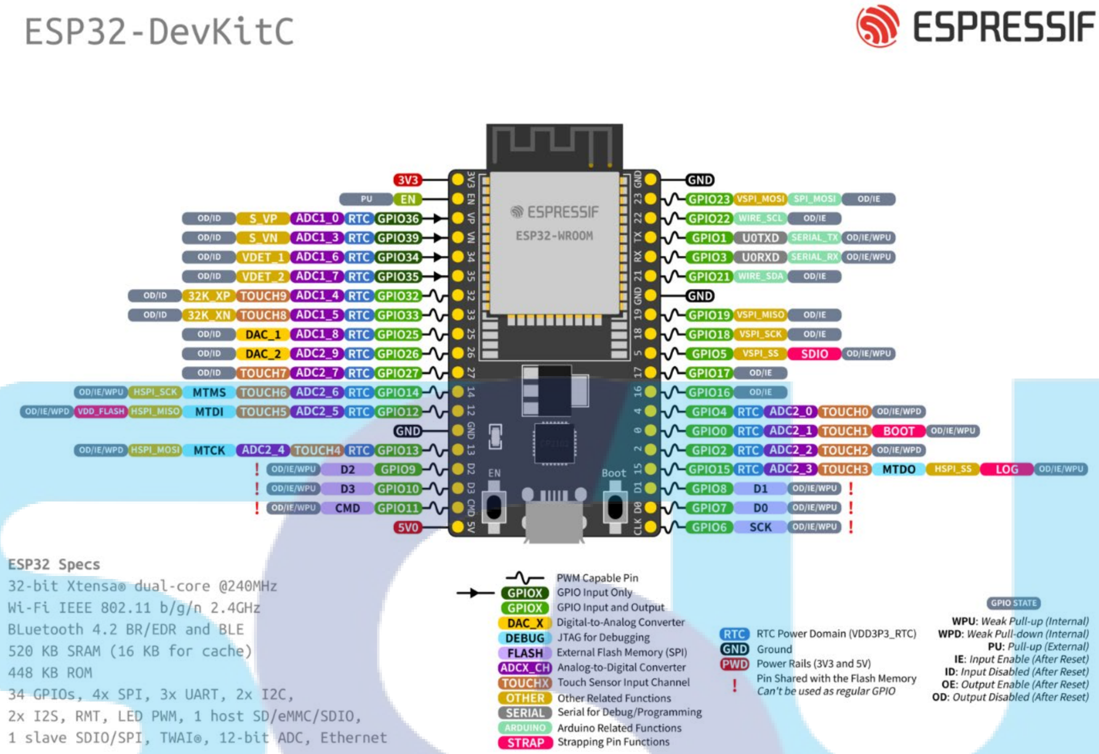
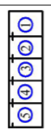


Figure A-1 ESP32-DevKitC Pinout

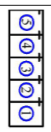
3. DRIVER INTERFACE AND WIRING

3.1. INTERFACE DEFINITION

3.1.1 Power wire and power supply input port of left motor

Port	Pin	Mark	Name	Function
	1	DC	Power supply interface	Power supply 24V-48V
	2	GND		
	3	U	Motor power interface	Wire connected to motor
	4	V		
	5	W		

3.1.2 Power wire and power supply input port of right motor

Port	Pin	Mark	Name	Function
	5	GND	Power supply interface	Power supply 24V-48V
	4	DC		
	3	W	Motor power interface	Wire connected to motor
	2	V		
	1	U		

3.1.3 Left/Right motor's incremental encoder and hall port J2/J6

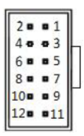
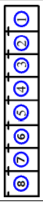
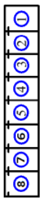
Port	Pin	Mark	Name	Function
	1	iA+	Encoder	
	2	iA-		
	3	iB+		
	4	iB-		
	5	RTC+	Temperature sensor	
	6	RTC-		
	7	V	Hall sensor	
	8	W		
	9	U		
	10	GND	Power ground	
	11	VCC	Power positive	Output to encoder and HALL
	12	GND	Power ground	

Figure A-2 ZLTECH 8015D Driver Ports 1

3.1.4 Motor control signal port J3

Port	Pin	Mark	Name	Function
	1	BGND-L	Left brake power-	Left brake control
	2	-BR-L	Left brake-	
	3	BDC-L	Left brake power+/Left brake+	
	4	BGND-R	Right brake power-	Right brake control
	5	-BR-R	Right brake-	
	6	BDC-R	Right brake power+/Right brake+	
	7	OUTPUT1	Internal pull up 5V output	Could be configured via CAN or 485
	8	OUTPUT2		

3.1.5 Motor control signal port J4

Port	Pin	Mark	Name	Function
	1	AOUT-L	Left motor encoder A	Left motor encoder output signal
	2	BOUT-L	Left motor encoder B	
	3	AOUT-R	Right motor encoder A	Right motor encoder output signal
	4	BOUT-R	Right motor encoder B	
	5	+5V	Encoder +5V power supply +, <100mA	External power output
	6	GND	Encoder +5V power supply -	
	7	INPUT1	Input signal, internally limited 5V input	Could be configured via CAN or 485
	8	INPUT2		

3.1.6 Communication port J5

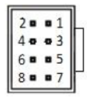
Port	Pin	Mark	Name	Function
	1	CANH	CANOPEN	
	3	CANL		
	2	A	RS485	
	4	B		
	5	CANH	CANOPEN	
	7	CANL		
	6	A	RS485	
	8	B		

Figure A-3 ZLTECH 8015D Driver Ports 2

APPENDIX B – ROS2 RQT GRAPHS

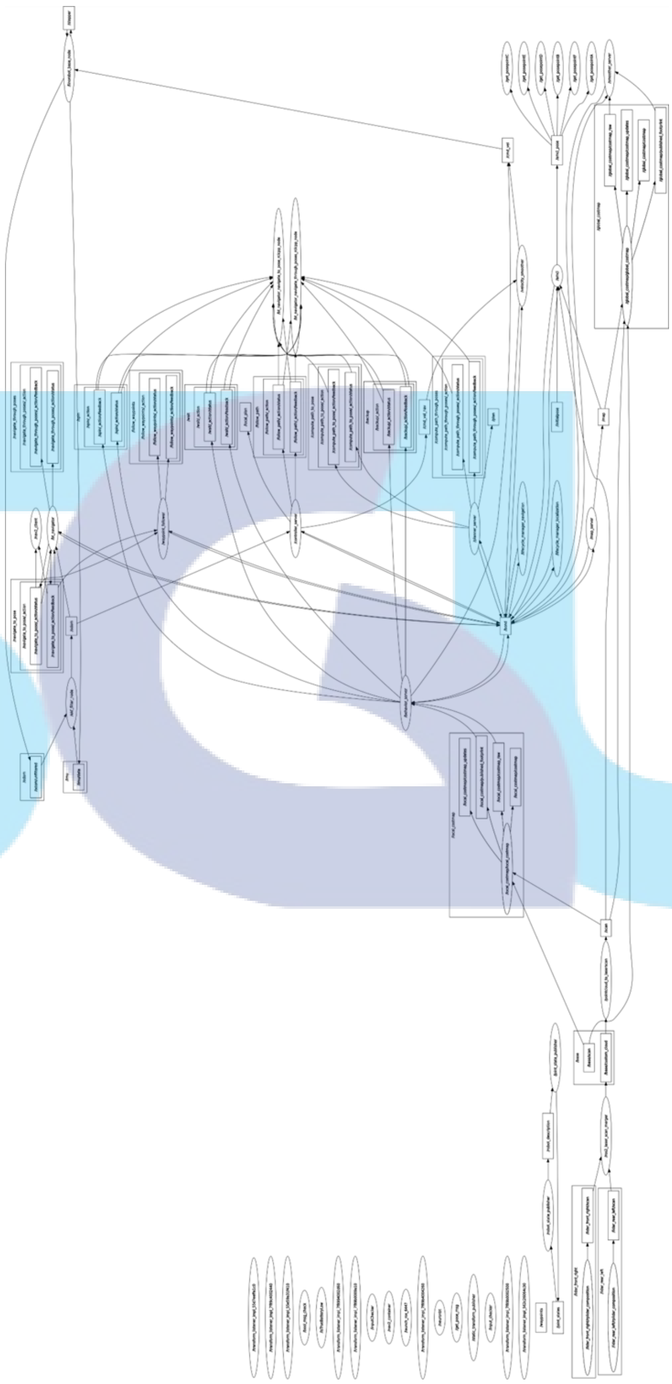


Figure B-1 ROS2 RQT Graph of the Robot During Operation

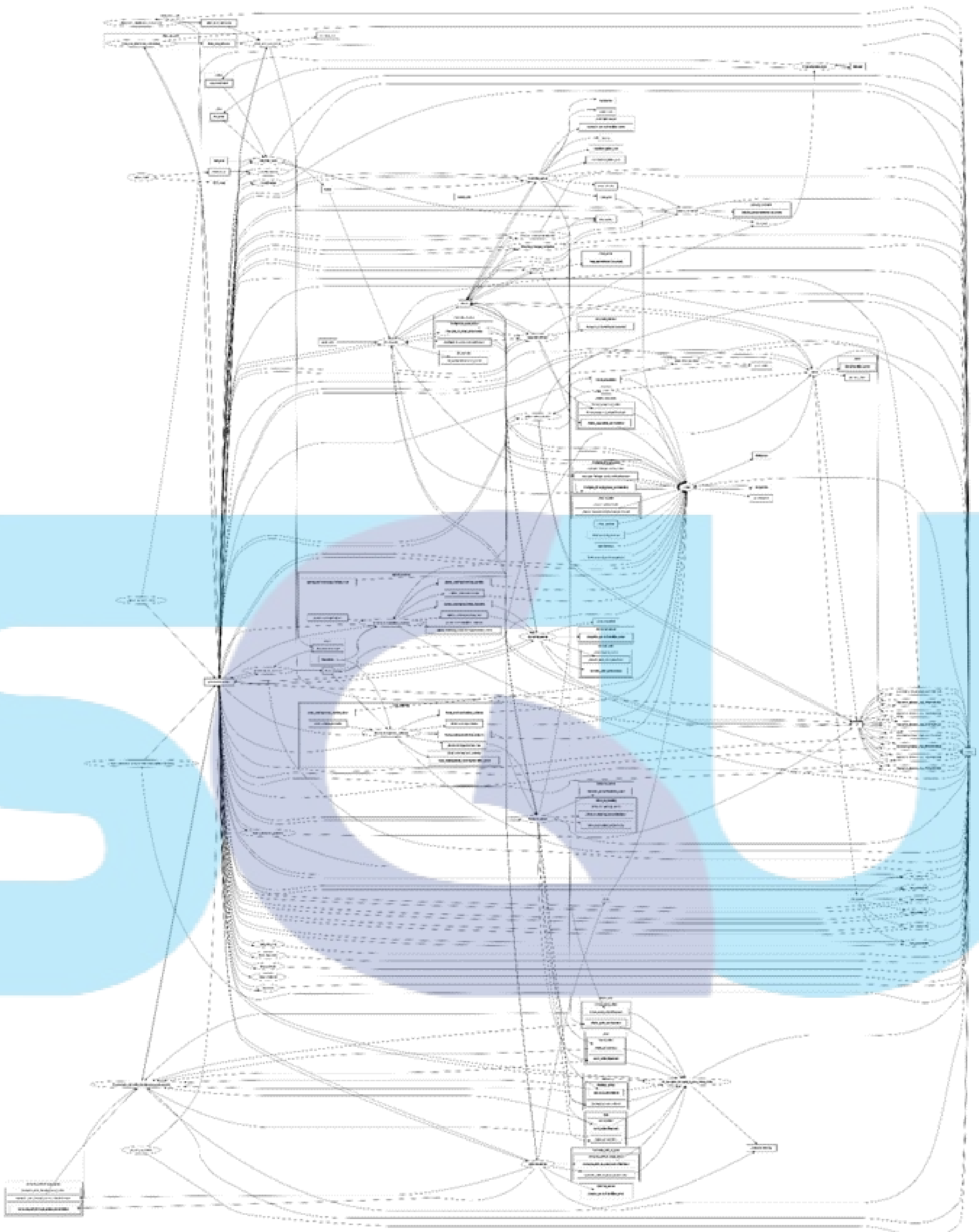


Figure B-2 Full RQT ROS2 Graph of the AMR

APPENDIX C – BILL OF MATERIALS

Table C-1 Bill of Materials

No.	Item	Quantity	Cost/Item	Total Cost
1	ESP32 DevKitC V4 WROOM-32D	1	Rp79,000.00	Rp79,000.00
2	Shield IO ESP32 DevkitC V4	1	Rp85,000.00	Rp85,000.00
3	Control Box Push Button 22mm 3 Hole	2	Rp19,000.00	Rp38,000.00
4	Push Button Fort 22mm XB7-EA NO	3	Rp7,280.00	Rp21,840.00
5	Push Button Fort 22mm XB7-EA NO	3	Rp7,280.00	Rp21,840.00
			Total	Rp245,680.00

CURRICULUM VITAE

HANZEN CLEMENTIUS HARTANTO

Undergraduate Student

DETAILS

ADDRESS
Tangerang
Indonesia

PHONE
+6282110149280

EMAIL
hanzenclementius28@gmail.com

SKILLS

ROS2

C++

Python

LANGUAGES

Indonesian

English

German

HOBBIES

Custom Keyboard Building
Guitar
Violin
Table Tennis

EDUCATION

Mechanical Engineering with Mechatronics Concentration, Swiss German University — Tangerang
Sep 2019 — Present

Basic Electrical Engineering and Electric Drive, Fachhochschule Südwestfalen — Soest
Feb 2022

High School (Science), IPEKA Puri — Jakarta
2019

INTERNSHIPS

Intern, SMS group GmbH — Mönchengladbach
Mar 2022 — Aug 2023

Assigned to the Comprehensive Service Products division. Created a database for customer and product management, helped reformat SMS TECademy teaching materials, and did hydraulic system simulations.

Intern, Swiss German University — Tangerang
Sep 2020 — Nov 2023

Helped with a project, with a concentration in ROS. Wrote a manual for the installation of Linorobot as well as the utilization of the follow_waypoints ROS package.

Trainee, Akademi Teknik Mesin Industri (ATMI) — Cikarang
Jul 2020 — Jan 2023

Training in lathe machines, milling machines, bench work, welding, assembly, reverse engineering, electrical bench work, safety techniques, and PCB design in 2 months over the course of 2020-2023.