GLOSSARY

Autonomous Guided Vehicle (AGV)

A robotic device that is capable of navigating by the assistance of static guidance, such as magnetic lines, tags, beacons, etc.

Autonomous Mobile Robot (AMR)

A mobile robot that has a higher degree of navigation than AGVs, which can localize and navigate via the usage of sensors and without the assistance of static guides

Data Distribution System (DDS)

A middleware protocol that is recommended for high-quality data communication in manufacturing.

Firmware

A type of software that accomplishes basic machine instructions that enable hardware to work and connect with other affiliated software on a device.

Framework

A structure that functions as a base, on which a software could be developed. In other words, the software is not built from scratch.

Inertial Measurement Unit (IMU)

A sensory device that combines multi-axes accelerometers and gyroscopes to produce an orientation estimation of an object in space.

Light Detection and Ranging (LiDAR)

A sensing component that functions by utilizing a form of pulsed laser that imitates the principle operation of a radar, with the objective to measure distance.

Localization

In robotics, localization is a method of establishing the position of a mobile robot is in relation to its surroundings

Micro-ROS (μ-ROS)

A microcontroller library that simplifies data transfer between microcontrollers and ROS2 in main processors by having the programs within the microcontrollers to be compatible with ROS2.

Robot Odometry

A form of data generated by motion-based sensors which are systematically utilized to estimate changes in position over time.

Robot Operating System 2 (ROS2)

The successor of Robot Operating System (ROS), which includes almost all libraries from the predecessor with a specialized design approach for commercial robotics development.

Real Time Kinematics (RTK) / Global Navigation Satellite System (GNSS)

A method for increasing the accuracy of GNSS signals by using a stationary base station that sends correction messages to a moving receiver.

RQt

A software framework in ROS2 that provides a variety of plugins to simplify system troubleshooting and analysis in ROS2, as an alternative for CLI-based monitoring.

Simultaneous Localization and Mapping (SLAM)

A proposed method in the world of robotics that enables mobile robots to map the surrounding environment and establish its position at the same time.

Visual Inertial Odometry (VIO)

A category of the SLAM approach that uses visual-based sensors to observe the environment and distinguish its features, which are then utilized as a source of points to localize a mobile robot in a particular scenario.

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APPENDIX A - DATASHEETS

1. Intel Realsense T265 Tracking Camera

3.3 Intel® RealSense™ Tracking Camera T265 Device

Figure 3-3. Intel® RealSense™ Tracking Camera T265

3.3.1 Intel® RealSense™ Tracking Camera T265 Mechanical Dimensions

Table 3-13. Intel® RealSense™ Tracking Camera T265 Mechanical Dimensions

Dimension	Min	Nominal	Max	Unit
Width	107.85	108.00	108.15	mm
Height	24.35	24.50	24.65	mm
Depth	12.35	12.50	12.65	mm
Flatness Tolerance	-	0.15	-	mm
Weight	57	60	63	gr

3.3.2 Intel® RealSense™ Tracking Camera T265 Thermals

Table 3-14. Max Skin Temperature

Tracking Camera	Max Skin Temperature (25°C Ambient in Open Environment)
T265	40°C

Figure A-1 T265 Tracking Camera - Datasheet 1

3.3.3 Intel® RealSense™ Tracking Camera T265 Storage and Operating Conditions

Table 3-15. Storage and Operating Conditions

Condition	Description	Min	Max	Unit
Storage (Still Air), Not Operating	Temperature (Sustained, Controlled)[1]	0	40	°C
	Temperature (Short Exposure)[2]	-30	65	°C
	Humidity, Non-Condensing	90% RH, 30°C		
Operating(3) (Still Air)	Temperature	0	35	°C

NOTES:

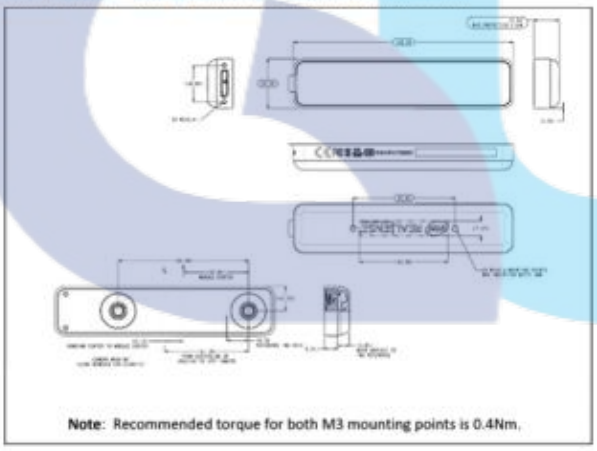
1. Controlled conditions should be used for long term storage of product.
2. Short exposure represents temporary max limits acceptable for transportation conditions.
3. Component case temperature limits must be met for all operating temperatures.

3.3.4 Product Identifier and Material Code

Table 3-16. Product Identifier and Material Code

Production	Product Material Code
Intel® RealSense™ Tracking Camera T265	999AXU

Figure 6-8. Intel® RealSense™ Tracking Camera T265 Center of Tracking Location



Note: Recommended torque for both M3 mounting points is 0.4Nm.

6.8 Tracking System Coordinate System

Figure 6-9. Tracking System Coordinate System

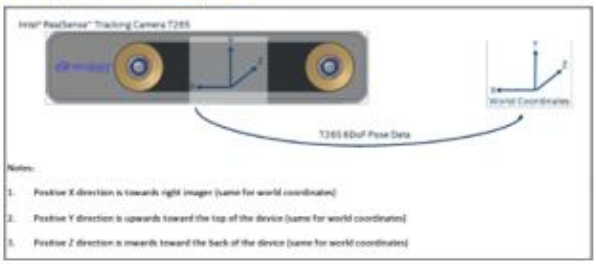


Figure A-2 T265 Tracking Camera - Datasheet 2

2. Intel Realsense D415 Tracking Camera

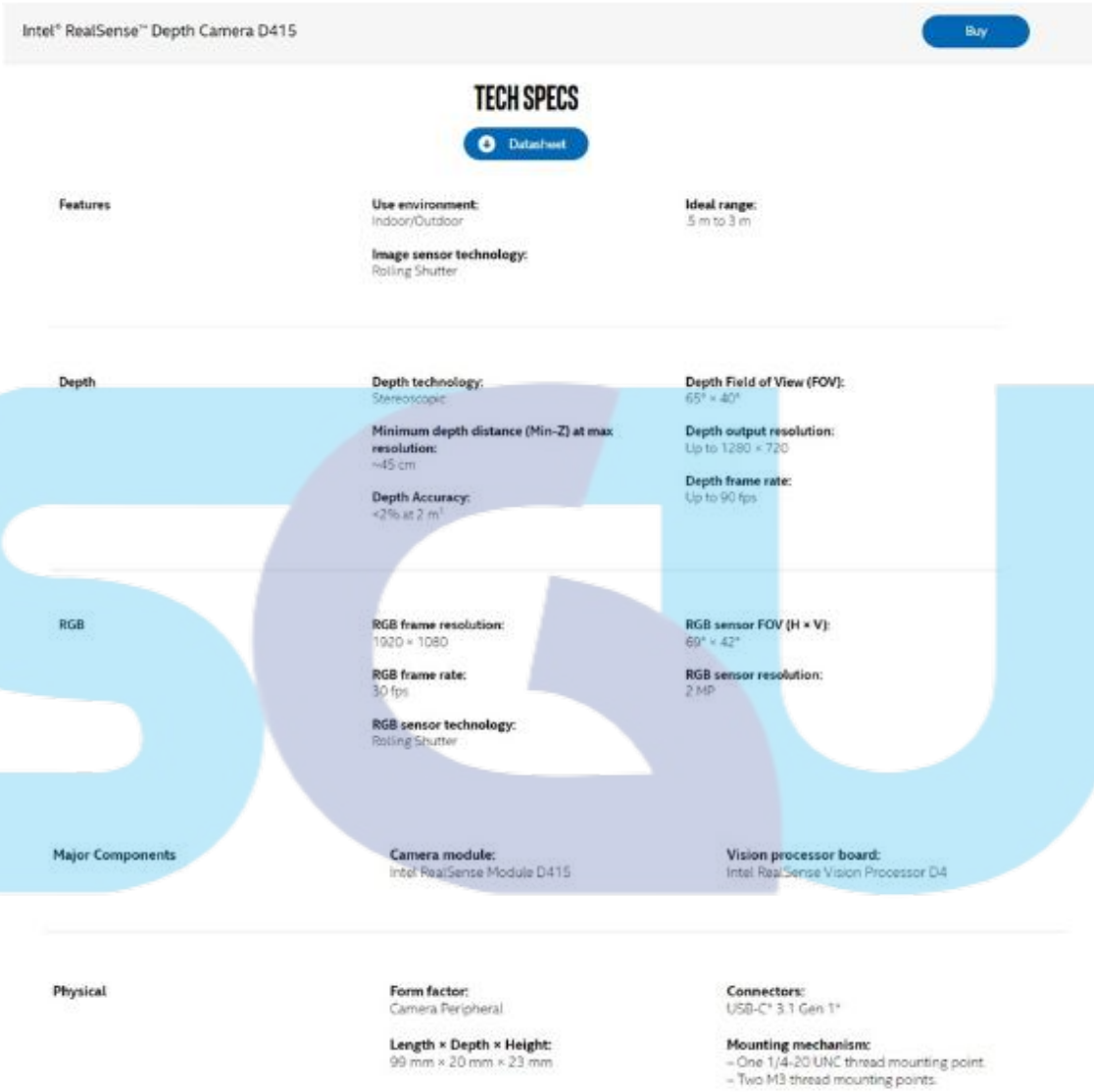


Figure A-3 D415 Depth Camera Datasheet

3. ZED F9P RTK/GNSS Module

1.2 Performance

Parameter	Specification	
Receiver type	Multi-band GNSS high precision receiver	
Accuracy of time pulse signal	RMS 99%	30 ns 60 ns
Frequency of time pulse signal		0.25 Hz to 10 MHz (configurable)
Operational limits[2]	Dynamics Altitude Velocity	≤ 4 g 80,000 m 500 m/s
Velocity accuracy[3]		0.05 m/s
Dynamic heading accuracy[3]		0.3 deg

Table 1: ZED-F9P-04B specifications

GNSS[4]		GPS+GLO+GAL+BDS	GPS+GLO+GAL	GPS+GAL	GPS+GLO	GPS+BDS	GPS
Acquisition[5]	Cold start	25 s	25 s	30 s	25 s	30 s	30 s
	Hot start	2 s	2 s	2 s	2 s	2 s	2 s
	Aided start[6]	2 s	2 s	2 s	2 s	2 s	2 s
Max navigation update rate[7]	RTK	7 Hz	10 Hz	15 Hz	14 Hz	13 Hz	20 Hz
	PVT	9 Hz	10 Hz	20 Hz	20 Hz	16 Hz	25 Hz
	RAW	15 Hz	18 Hz	25 Hz	25 Hz	25 Hz	25 Hz

1 PPP-RTK position accuracy depends on the quality of the SSR service used, high-quality SSR services can perform similarly to RTK
2 Assuming Airborne 4 g platform
3 50% at 30 m/s for dynamic operation
4 GPS used in combination with QZSS and SBAS
5 Commanded starts. All satellites at -130 dBm. Measured at room temperature.
6 Dependent on the speed and latency of the aiding data connection, commanded starts
7 Measured with primary output only, secondary output disabled (default)

GNSS[4]		GPS+GLO+GAL+BDS	GPS+GLO+GAL	GPS+GAL	GPS+GLO	GPS+BDS	GPS
Convergence time[8]	RTK	< 10 s	< 10 s	< 10 s	< 10 s	< 10 s	< 30 s

Table 2: ZED-F9P-04B performance in different GNSS modes

GNSS		GPS+GLO+GAL+BDS	GPS+GLO+GAL	GPS+GAL	GPS+GLO	GPS+BDS	GPS
Horizontal pos. accuracy	PVT[9]	1.5 m CEP	1.5 m CEP	1.5 m CEP	1.5 m CEP	1.5 m CEP	1.5 m CEP
	SBAS[9]	1.0 m CEP	1.0 m CEP	1.0 m CEP	1.0 m CEP	1.0 m CEP	1.0 m CEP
	RTK[10]	0.01 m + 1 ppm CEP	0.01 m + 1 ppm CEP	0.01 m + 1 ppm CEP	0.01 m + 1 ppm CEP	0.01 m + 1 ppm CEP	0.01 m + 1 ppm CEP
Vertical pos. accuracy	PVT[9]	2.0 m R50	2.0 m R50	2.0 m R50	2.0 m R50	2.0 m R50	2.0 m R50
	SBAS[9]	1.5 m R50	1.5 m R50	1.5 m R50	1.5 m R50	1.5 m R50	1.5 m R50
	RTK[10]	0.01 m + 1 ppm R50	0.01 m + 1 ppm R50	0.01 m + 1 ppm R50	0.01 m + 1 ppm R50	0.01 m + 1 ppm R50	0.01 m + 1 ppm R50

Figure A-4 ZED F9P RTK/GNSS Module - Datasheet 1

5.5 Default interface settings

Interface	Settings
UART1 output	38400 baud, 8 bits, no parity bit, 1 stop bit. NMEA protocol with **GGA, GLL, GSA, GSV, RMC, VTG, TXT** messages are output by default. UBX and RTCM 3.3 protocols are enabled by default but no output messages are enabled by default.
UART1 input	38400 baud, 8 bits, no parity bit, 1 stop bit. UBX, NMEA and RTCM 3.3 input protocols are enabled by default. SPARTN input protocol is enabled by default.
UART2 output	38400 baud, 8 bits, no parity bit, 1 stop bit. UBX protocol is disabled by default. RTCM 3.3 protocol is enabled by default but no output messages are enabled by default. NMEA protocol is disabled by default.
UART2 input	38400 baud, 8 bits, no parity bit, 1 stop bit. UBX protocol is enabled by default. RTCM 3.3 protocol is enabled by default. SPARTN protocol is enabled by default. NMEA protocol is disabled by default.
USB	Default messages activated as in UART1. Input/output protocols available as in UART1.
I2C	Available for communication in the Fast-mode with an external host CPU in slave mode only. Default messages activated as in UART1. Input/output protocols available as in UART1. Maximum bit rate 400 kb/s.
SPI	Allow communication to a host CPU, operated in slave mode only. Default messages activated as in UART1. Input/output protocols available as in UART1. SPI is not available unless D_SEL pin is set to low (see section D_SEL interface in Integration manual [1]).

Figure A-5 ZED F9P RTK/GNSS Module - Datasheet 2

4. Power Supply Unit (PSU)

Switching Power Supply PSU 24V 30A High Quality, 24 Volt 30 Ampera Fan

Terjual 100+ • 4.9 (61 rating) • Diskusi (2)

Rp185.000

Detail

Kondisi: Baru
Min. Pemesanan: 1 Buah
Etalase: **POWER SUPLAY 24V**

SAAT TERIMA BARANG ADA KERUSAKAN BISA CHAT KITA YA BOS

POWER SUPPLY 24V DC OUTPUT 30A (720 WATT) + FAN

- AC Input : 220V +/- 15%
- DC Output : 24V ~ 30A (720 Watt max)
- Ukuran : 22x11,5x5 cm

- Merubah tegangan AC 220Volt menjadi DC 24Volt
- Digunakan untuk bermacam macam piranti elektronik yg menggunakan tegangan 24 Volt DC
- Dipastikan sudah dilakukan test sebelum dikirim ke customer
- No Warranty

CARA PEMAKAIANNYA :
- Kabel listrik di hubungkan ke lambang Input AC
- Lambang -V (-) di hubungkan 24 V- (min)
- Lambang +V (+) di hubungkan 24 + (plus)
- Lambang V ADJ untuk mengatur tegangan DC supaya tepat menjadi 24V DC

Lihat Lebih Sedikit

Figure A-6 PSU Datasheet

5. 12V Battery

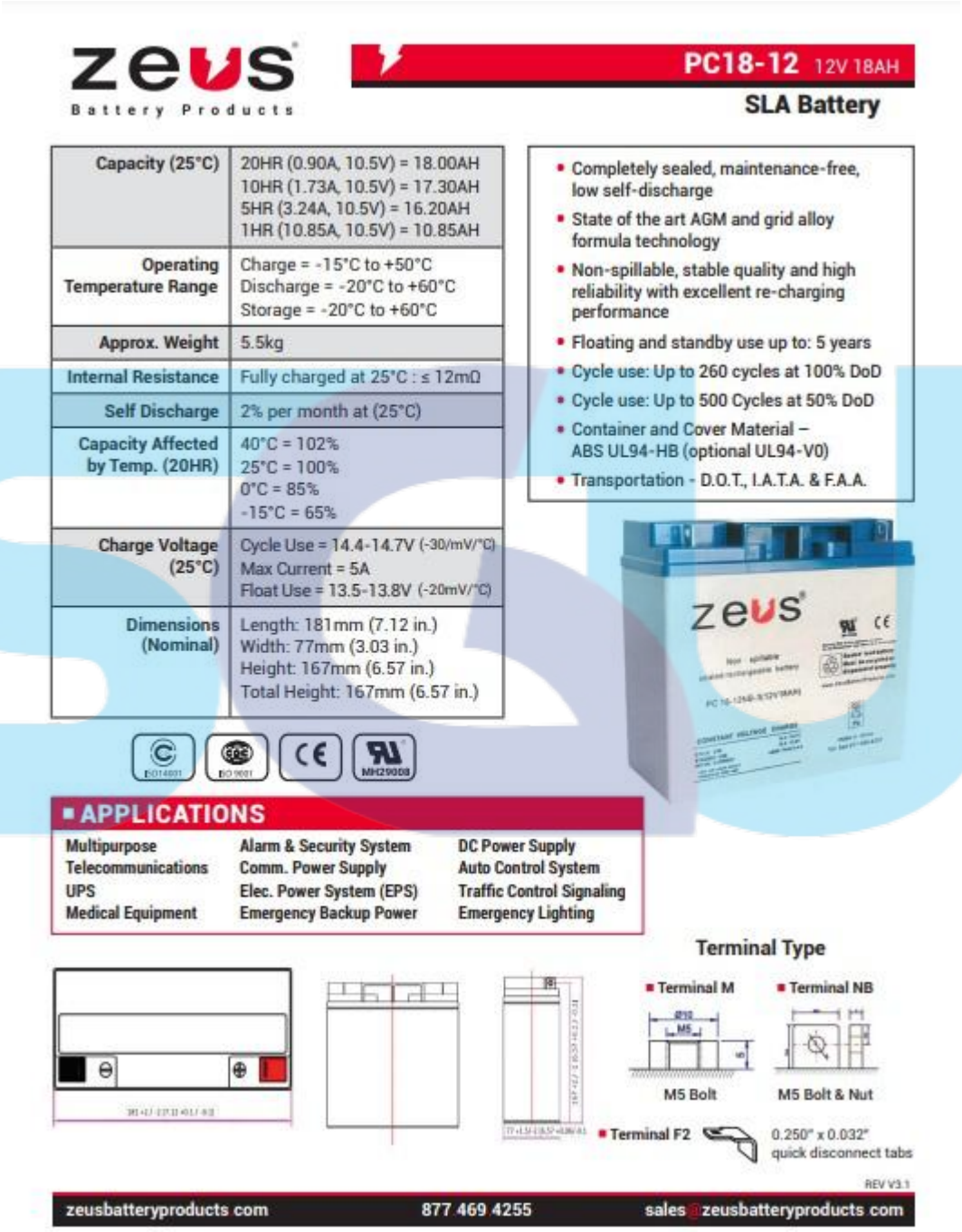
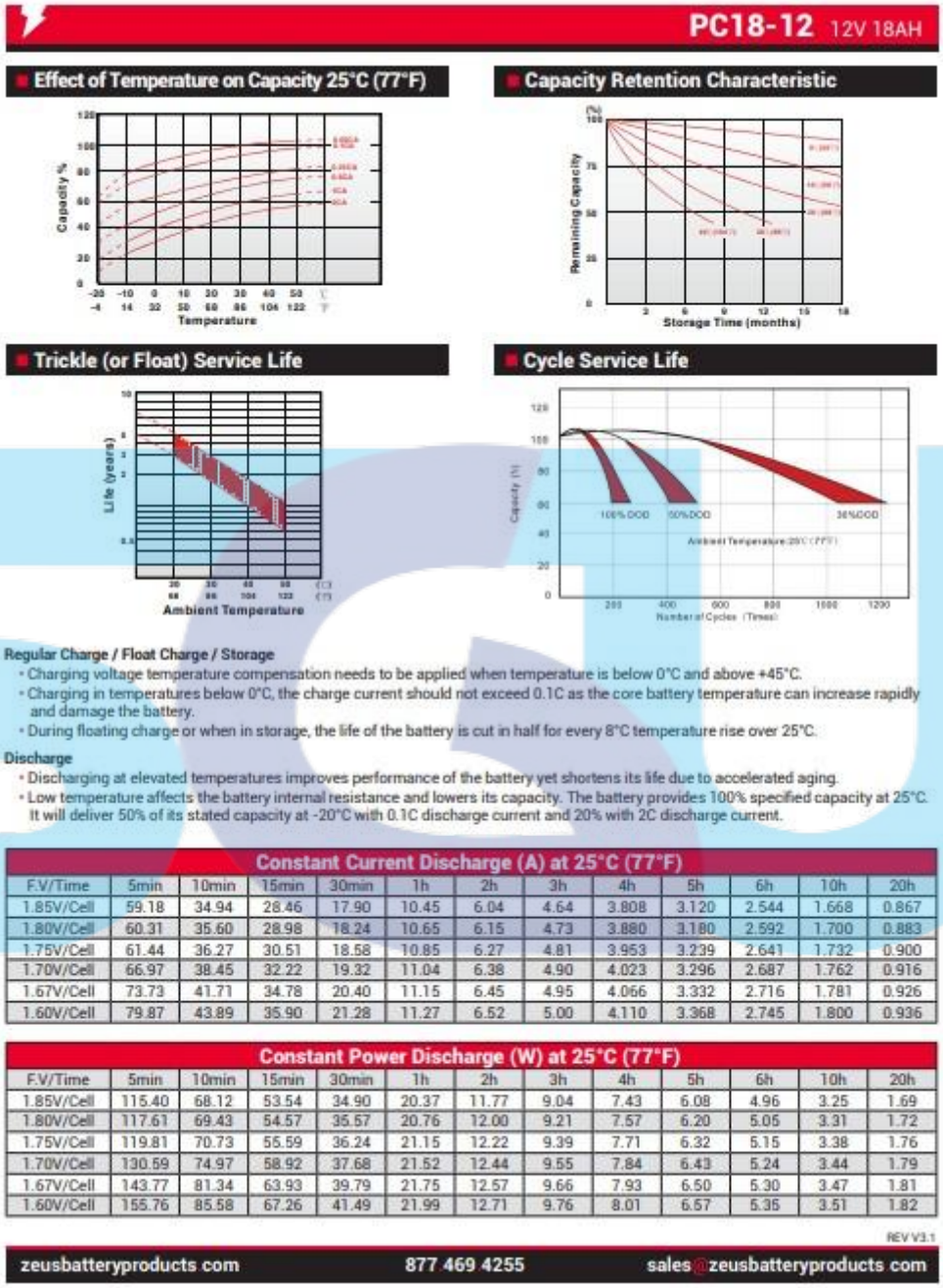


Figure A-7 12V Battery - Datasheet 1



PC18-12 12V 18AH

Effect of Temperature on Capacity 25°C (77°F)

Capacity Retention Characteristic

Trickle (or Float) Service Life

Cycle Service Life

Regular Charge / Float Charge / Storage

- Charging voltage temperature compensation needs to be applied when temperature is below 0°C and above +45°C.
- Charging in temperatures below 0°C, the charge current should not exceed 0.1C as the core battery temperature can increase rapidly and damage the battery.
- During floating charge or when in storage, the life of the battery is cut in half for every 8°C temperature rise over 25°C.

Discharge

- Discharging at elevated temperatures improves performance of the battery yet shortens its life due to accelerated aging.
- Low temperature affects the battery internal resistance and lowers its capacity. The battery provides 100% specified capacity at 25°C. It will deliver 50% of its stated capacity at -20°C with 0.1C discharge current and 20% with 2C discharge current.

Constant Current Discharge (A) at 25°C (77°F)

F.V/Time	5min	10min	15min	30min	1h	2h	3h	4h	5h	6h	10h	20h
1.85V/Cell	59.18	34.94	28.46	17.90	10.45	6.04	4.64	3.808	3.120	2.544	1.668	0.867
1.80V/Cell	60.31	35.60	28.98	18.24	10.65	6.15	4.73	3.880	3.180	2.592	1.700	0.883
1.75V/Cell	61.44	36.27	30.51	18.58	10.85	6.27	4.81	3.953	3.239	2.641	1.732	0.900
1.70V/Cell	66.97	38.45	32.22	19.32	11.04	6.38	4.90	4.023	3.296	2.687	1.762	0.916
1.67V/Cell	73.73	41.71	34.78	20.40	11.15	6.45	4.95	4.066	3.332	2.716	1.781	0.926
1.60V/Cell	79.87	43.89	35.90	21.28	11.27	6.52	5.00	4.110	3.368	2.745	1.800	0.936

Constant Power Discharge (W) at 25°C (77°F)

F.V/Time	5min	10min	15min	30min	1h	2h	3h	4h	5h	6h	10h	20h
1.85V/Cell	115.40	68.12	53.54	34.90	20.37	11.77	9.04	7.43	6.08	4.96	3.25	1.69
1.80V/Cell	117.61	69.43	54.57	35.57	20.76	12.00	9.21	7.57	6.20	5.05	3.31	1.72
1.75V/Cell	119.81	70.73	55.59	36.24	21.15	12.22	9.39	7.71	6.32	5.15	3.38	1.76
1.70V/Cell	130.59	74.97	58.92	37.68	21.52	12.44	9.55	7.84	6.43	5.24	3.44	1.79
1.67V/Cell	143.77	81.34	63.93	39.79	21.75	12.57	9.66	7.93	6.50	5.30	3.47	1.81
1.60V/Cell	155.76	85.58	67.26	41.49	21.99	12.71	9.76	8.01	6.57	5.35	3.51	1.82

REV V3.1

zeusbatteryproducts com 877 469 4255 sales@zeusbatteryproducts com

Figure A-8 12V Battery - Datasheet 2

APPENDIX B - ROS2 TERMINAL LOG RESULTS

1. Combinatory launch file terminal log for tracking camera, depth camera, and depth to laser scan conversion.

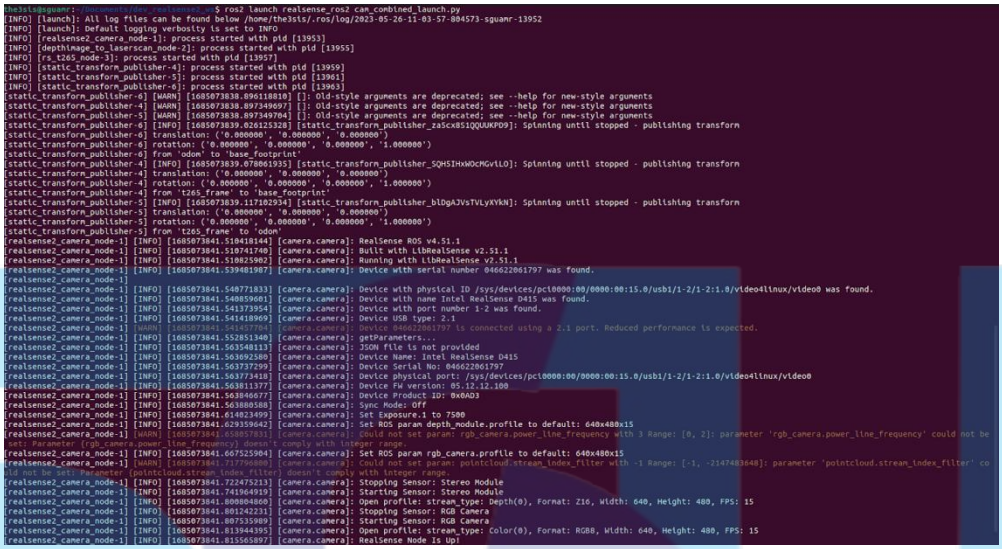


Figure B-1 Combined Camera Launch File Terminal Log

2. Linorobot2 Bringup launch file terminal log.

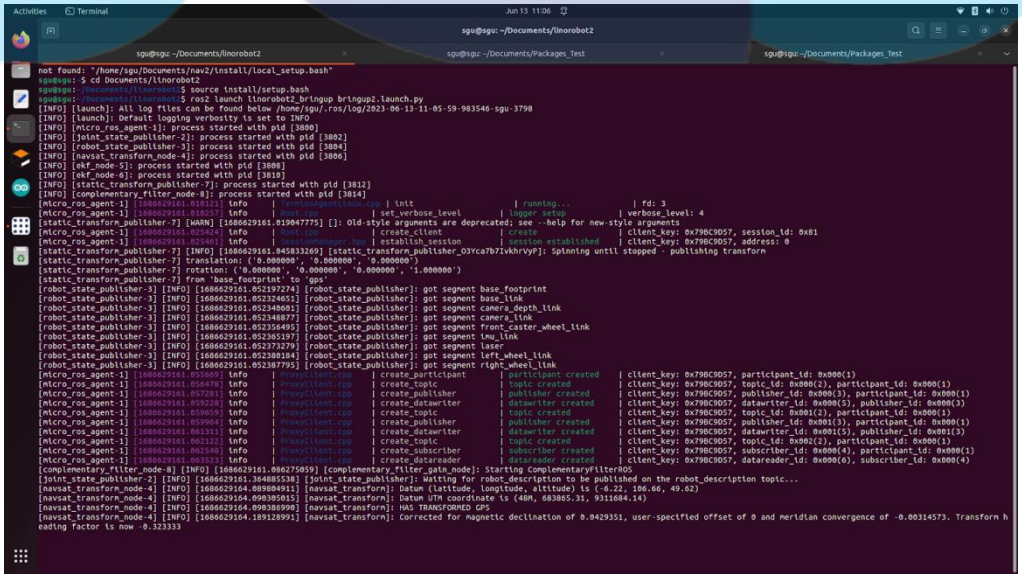


Figure B-2 Linorobot2 Bringup Launch File Terminal Log

3. Nav2 launch file terminal log.

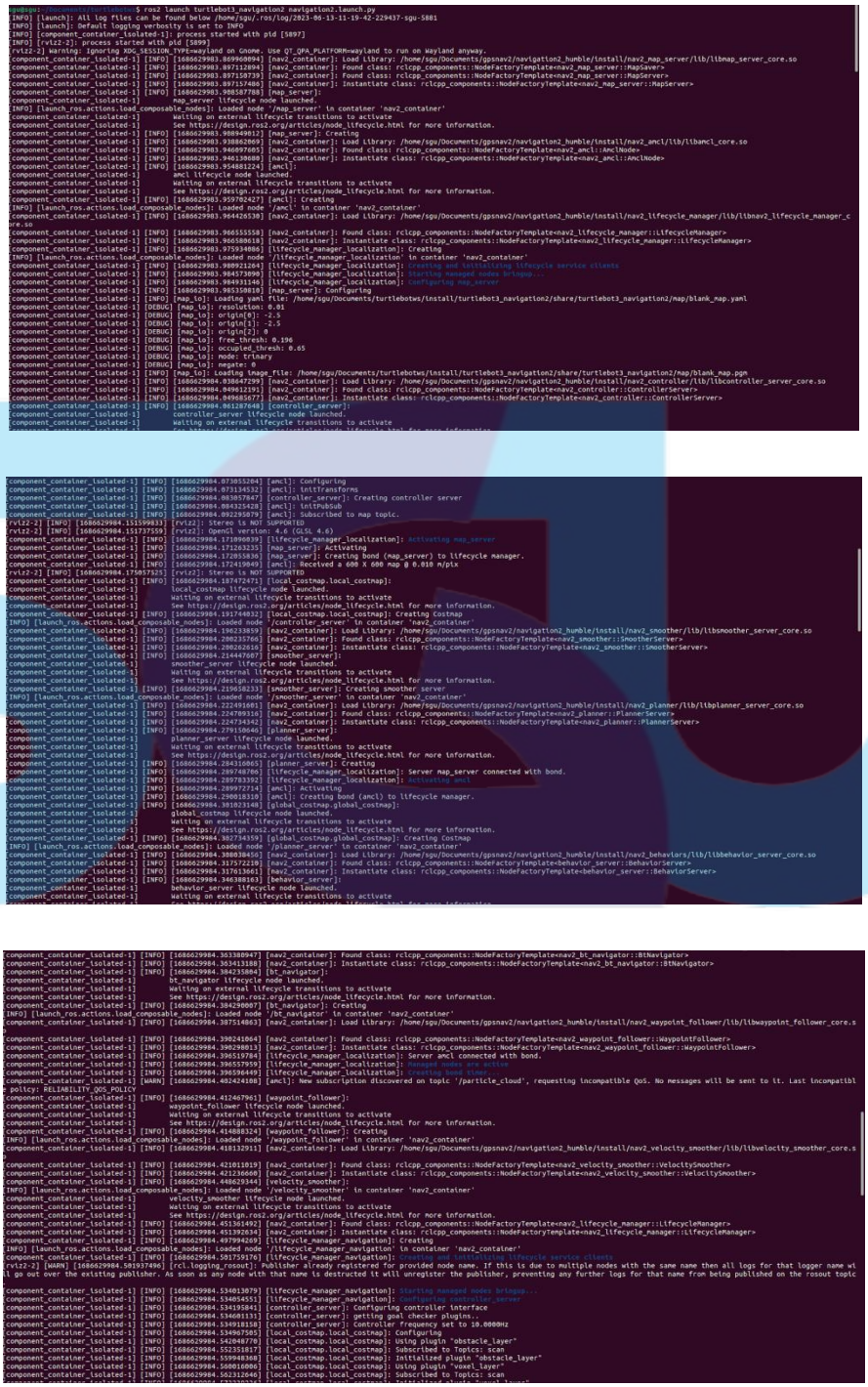


Figure B-3 Nav2 Launch File Terminal Log

4. Turtlebot3 teleop.

```
sgu@sgu:~/Documents/turtlebotws$ ros2 run turtlebot3_teleop teleop_keyboard

Control Your TurtleBot3!
---------------------------
Moving around:
        w
   a    s    d
        x

w/x : increase/decrease linear velocity (Burger : ~ 0.22, Waffle and Waffle Pi : ~ 0.26)
a/d : increase/decrease angular velocity (Burger : ~ 2.84, Waffle and Waffle Pi : ~ 1.82)

space key, s : force stop

CTRL-C to quit
```

Figure B-4 Turtlebot3 teleop Terminal Log

APPENDIX C - AMR RQt GRAPH

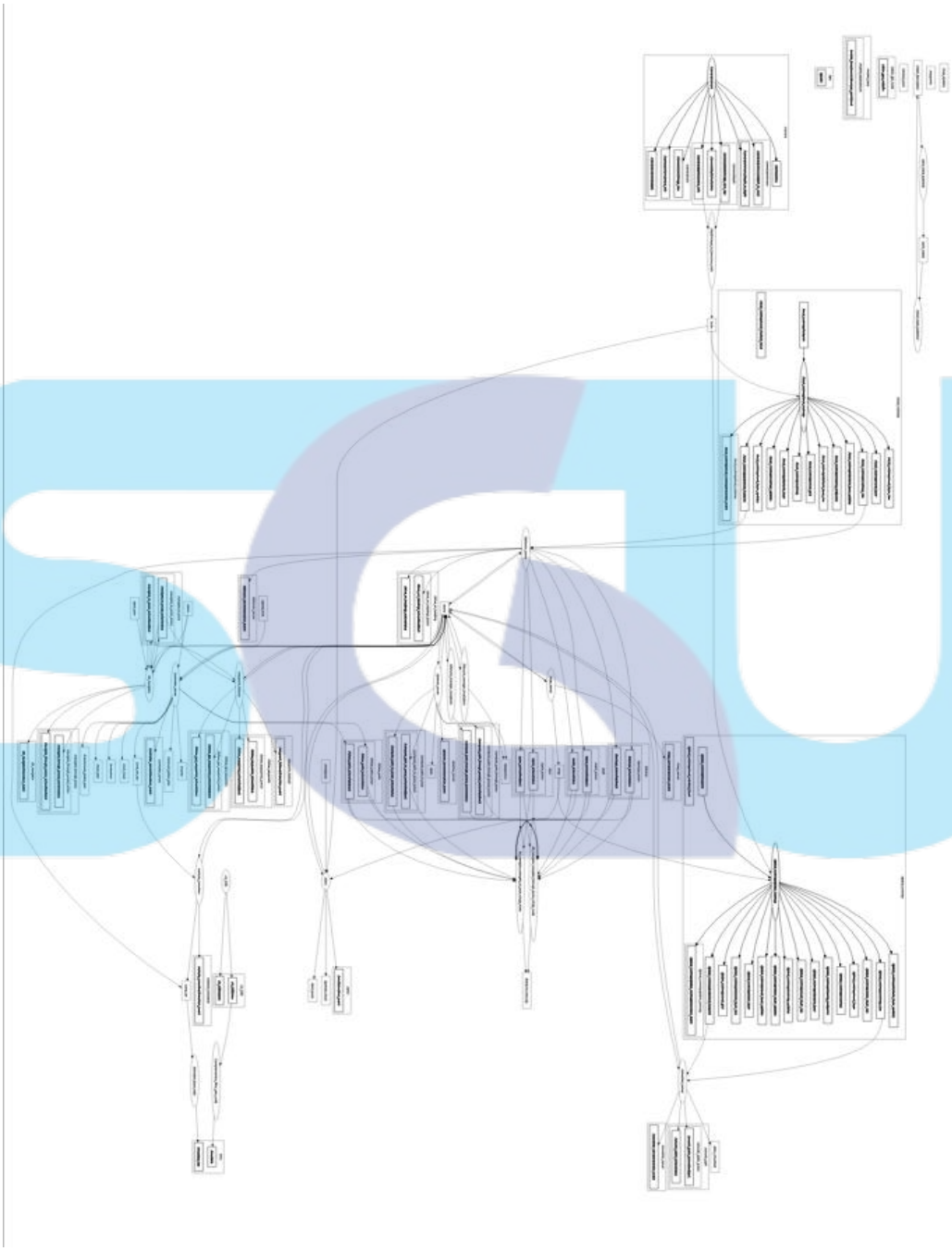


Figure C-1 Full RQt Graph of The AMR

APPENDIX D - BILL OF MATERIAL

Table D-1 Outdoor AMR Bill of Material

No	Item Name	Price/ Qty	Qty	Total Price	Notes
1	Roller Chain 35-1 with Connector CL35-1	Rp119,000.00	2	Rp238,000.00	Passed down
2	Sprocket RS35-30T	Rp49,000.00	2	Rp98,000.00	Passed down
3	Pillow Block UCP 204	Rp28,500.00	8	Rp228,000.00	Passed down
4	Pillow Block UCFL 204	Rp30,500.00	2	Rp61,000.00	Passed down
5	AS S45C 35mm	Rp195.00	900	Rp175,500.00	Passed down
6	AS S45C 25mm	Rp112.00	800	Rp89,600.00	Passed down
7	Aluminium Profile 3030	Rp820.00	512	Rp419,840.00	Passed down
8	Aluminium Plate 2mm 59x46x2mm with Laser Cut Fee	Rp325,000.00	1	Rp325,000.00	Passed down
9	T Hammer Nut M53030	Rp1,950.00	104	Rp202,800.00	Passed down
10	L/ Socket Head Cap Screw M5x15 (10 pcs/ pack)	Rp7,000.00	11	Rp77,000.00	Passed down
11	Gusset 3030 Aluminium Profile Bracket	Rp5,700.00	32	Rp182,400.00	Passed down
12	Steel Screw HTB Grade 10.9	Rp2,600.00	16	Rp41,600.00	Passed down
13	13in Wheel	Rp85,000.00	4	Rp340,000.00	Passed down
14	DKM Motor 24V 90W	Rp300,000.00	2	Rp600,000.00	Passed down
15	1:50 DKM Gearbox	Rp1,500,000.00	2	Rp3,000,000.00	Passed down
16	Rotaray Encoder Hanyoung NUX HE50B-8-360-3N-24	Rp687,500.00	1	Rp687,500.00	Passed down
17	Gland PG13.5 Cable	Rp11,600.00	1	Rp11,600.00	Passed down
18	Electronic Case Enclosure Plastic Box with Clear Cover	Rp74,500.00	1	Rp74,500.00	Passed down
19	PCB Printing	Rp10,000.00	1	Rp10,000.00	Passed down
20	AWG12 Cable	Rp2,000.00	12	Rp24,000.00	Passed down
21	3D Printing	Rp140,000.00	1	Rp140,000.00	Passed down
22	Acrylic Lasercut	Rp70,000.00	1	Rp70,000.00	Passed down

23	Resistors, Capacitors, Jumpers, Terminal Blocks, and Conn-Sill	Rp20,000.00	1	Rp20,000.00	Passed down
24	Teensy 4.1 Board	Rp635,000.00	1	Rp635,000.00	Passed down
25	10cm Pigtail Cable SMA Female to U.FL/UFL	Rp25,000.00	1	Rp25,000.00	Passed down
26	IBT-2 Motor Driver	Rp62,500.00	2	Rp125,000.00	Passed down
27	Optocoupler	Rp9,000.00	2	Rp18,000.00	Passed down
28	Heatshrink	Rp15,000.00	1	Rp15,000.00	Passed down
29	Cable Jumper Male to Male (20 pcs/ pack)	Rp5,400.00	3	Rp16,200.00	Passed down
30	IMU MPU9250	Rp65,500.00	1	Rp65,500.00	Passed down
31	SparkFun GPSRTK2 Board (ZED-F9P)	Rp3,911,600.00	1	Rp3,911,600.00	Passed down
32	ANN-MB-00-00 Antenna	Rp913,548.00	1	Rp913,548.00	Passed down
33	Battery PC18-12 12V 18Ah	Rp478,900.00	1	Rp478,900.00	Bought
34	Switching Power Supply Unit 24V 30A	Rp185,000.00	1	Rp185,000.00	Bought
35	Intel NUC7I7BNH-16S480 Mini-PC	Rp6,000,000.00	1	Rp6,000,000.00	Passed down
36	Intel NUC6CAYH Mini-PC	Rp2,200,000.00	1	Rp2,200,000.00	Passed down
37	Intel T265 Tracking Camera	Rp6,000,000.00	1	Rp6,000,000.00	Passed down
38	Intel D415 Depth Camera	Rp4,000,000.00	1	Rp4,000,000.00	Passed down
			Total Price	**Rp31,705,088.00**	

CURRICULUM VITAE

DYLAN LOUIS

+6281283899980
dylanlouislau@gmail.com
linkedin.com/in/dylan-louis/

SKILLS

Languages

Indonesian	Native proficiency
English	Professional working proficiency
Deutsch	Limited working proficiency

Programmable Logic Controllers

- PLC Programming
- Ladder Logic
- SIEMENS TIA Portal
- SIMATIC STEP 7
- WinCC

Software

Microsoft Office	Arduino IDE
SOLIDWORKS 2016	Proteus 8
Autodesk Fusion	NI Multisim

INTERESTS

- Automotives
- Motorsport
- Technology
- Automation

WORK EXPERIENCE

Landpack GmbH
Intern Engineering Department — March – August 2022

- Developed and optimized algorithm processes with S7-1200 which results a more stable and higher production output and more intuitive features
- Optimized programming codes and structure on the TIA Portal V16 Professional
- Worked with WinCC Professional and WinCC Advanced
- Integrated SENTRON energy monitor into the SCADA system, processing and visualizing its data
- Worked with quality control processes on the production line

Industrial Polytechnic Akademi Teknik Mesin Industri Cikarang
Trainee Practical Training — November – December 2021

- Mechanical Engineering: Mechanical Benchwork, Turning, Milling, Welding, Technical Drawing, Reverse Engineering
- Electrical Engineering: Electrical Benchwork, Safety Technique/ Electrical Installation

PT Bastler Indonesia
Student Intern Mechatronics Department — September – November 2020

- Programming with Arduino IDE and Raspberry Pi
- Designed PCB for external Third-Party order with Proteus
- Created technical drawings and 3D designs for Automatic Hand Sanitizer Project with SOLIDWORKS

EDUCATION

Swiss German University
Bachelor's Degree Mechatronics Engineering — Expected graduation: 2023

Fachhochschule Südwestfalen
Bachelor's Degree Mechatronics Engineering — Expected graduation: 2023
Double degree program and exchange student for Winter 2021 and Summer 2022 semesters

ACTIVITIES & ORGANIZATIONAL EXPERIENCE

Swiss German University
Head of Mechatronics Student Association — March - December 2021

- Established a myriad of newly official organizational division of the Mechatronics Student Association
- Co-advised the establishment of a tutoring program with the aim to assist fellow mechatronic student in their studies, especially in online classes during the pandemic COVID-19 era.

Mechatronics Day 2021
Program Division Member January – October 2021

Mechatronics Day is an annual innovation-based event held by the Mechatronics Student Association of Swiss German University. Established to introduce, educate and increase the participation of Indonesian youth in the fields of Mechatronics and Robotics by conducting an online Workshop and Competition

- Assisted and gave guidance to 10 finalist groups with their competition projects through a Hotline system via WhatsApp.
- Supervised colleagues in the process of revising and updating the presentation (content and quality) for the workshop prior to the main event of Mechatronics Day 2021.
- Delivered a workshop prior to the main event of Mechatronics Day 2021, with the aim to provide participants with basic knowledge regarding programming and IoT (The combination of Google Firebase, Thunkable/App Inventor, and Arduino IDE).

Swiss German University
Robotics Club 2019 – 2021

Extracurricular Mentor

- Mentored a selection IPEKA BSD senior high school students to construct robotics and mechatronics-related projects (Bluetooth controlled car and Automated Sensing Lifting Lever System utilizing LEGO and Arduino)

Workshop Speaker

- Delivered several workshops as a part of Swiss German University's robotics club program.
- The workshops were undertaken at several schools across Indonesia with the topic of IoT, Firebase Platform, and the objective of introducing the world of robotics and technology to a total approximated audience of around 150+ high school students from each school.