



SWD[®] Starter Kit

For AGV & AMR

Instruction manual
Preliminary version

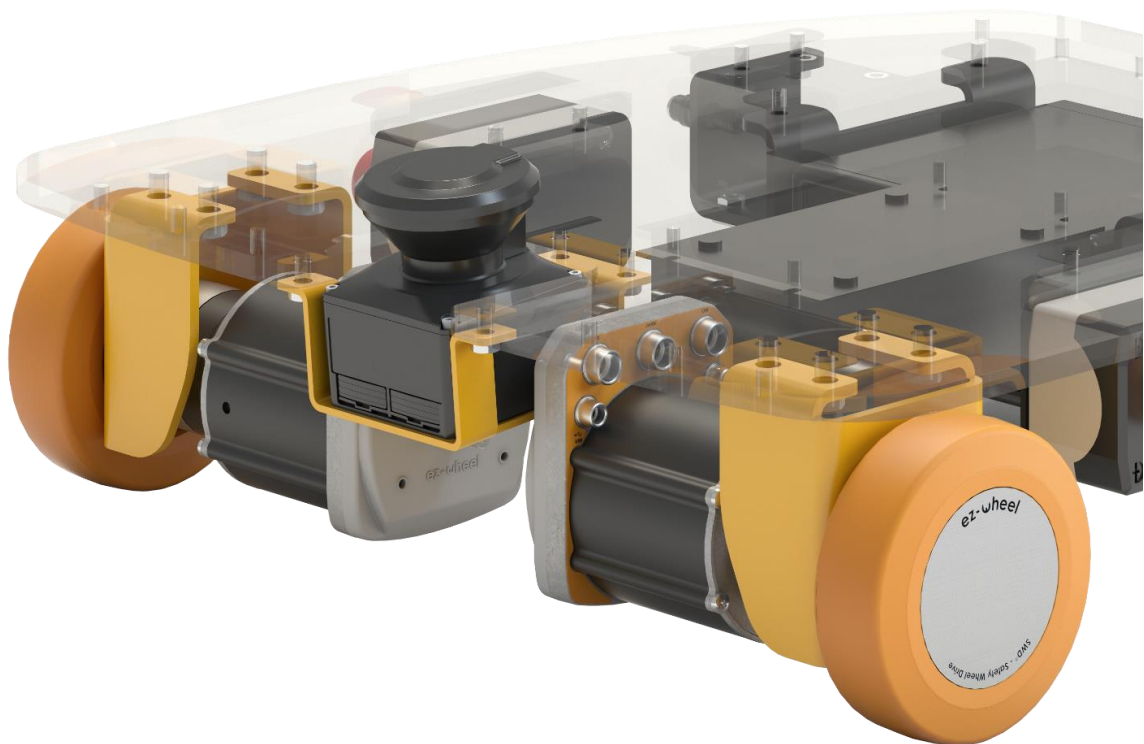


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 **This document should be read carefully before the first use of the product.**

1. Preamble

1.1. Who is this manual for?

This manual is intended for skilled robotics integrators.

The SWD Starter Kit saves a lot of development time, but needs some core competencies in:

- Automation, functional safety, and robotics
- Embedded Linux, Python and C++
- ROS development environment

1.2. Terminology

The terms used in this manual are related to the technical field of industrial machinery and more particularly to driverless industrial trucks and drive systems controlled by fieldbus.

For a precise reading of the manual, a good knowledge of the following standards is recommended:

- Machinery Directive (2006/42/EC)
- Safety requirements for driverless industrial trucks and their systems (ISO 3691-4)
- Variable speed power electric drives (EN 61800-5)
- CANopen Application Profile for Motor Drives (CiA 402)

1.3. Additional resources

The SWD Starter Kit uses SWD Core safety drives, the following **SWD® Core** documents are available from ez-Wheel:




- **SWD® Core** datasheet
- **SWD® Full Range Brochure** Safety Wheel Drive Series Overview
- 2D and 3D mechanical plans of the **SWD® Core**

1.4. Declarations of conformity

The **SWD® Core** product is developed in accordance with legal requirements applicable in the European Union.

The **SWD® Core** declarations of conformity (DoC) are being established by ez-Wheel.

1.5. Important information about the manual

	Important information – Read carefully
	Parameterizable value
	Additional information

1.6. Disclaimer

The technical information included in this manual is subject to change without prior notice. No responsibility is assumed for the completeness, up-to-date or accuracy of the data and illustrations provided.


The textual and visual data included in this manual are the property of ez-Wheel SAS. The trademarks ez-Wheel and SWD Safety Wheel Drive are registered.

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16400 LA COURONNE - FRANCE

2. Safety Instructions – SWD® Starter Kit Precautions

	<p>Do not open.</p> <p>Do not expose to a heat source.</p> <p>Do not expose to fire.</p> <p>Do not insert metal parts into the connectors.</p> <p>Under no circumstances should the product receive any modifications not authorized by ez-Wheel.</p> <p>Do not attempt to modify the technical performance of the product.</p> <p>The product must not be used for use beyond the technical performance specified by ez-Wheel.</p> <p>Inappropriate use results in the cancellation of the warranty.</p> <p>Opening the product results in the cancellation of the warranty.</p>
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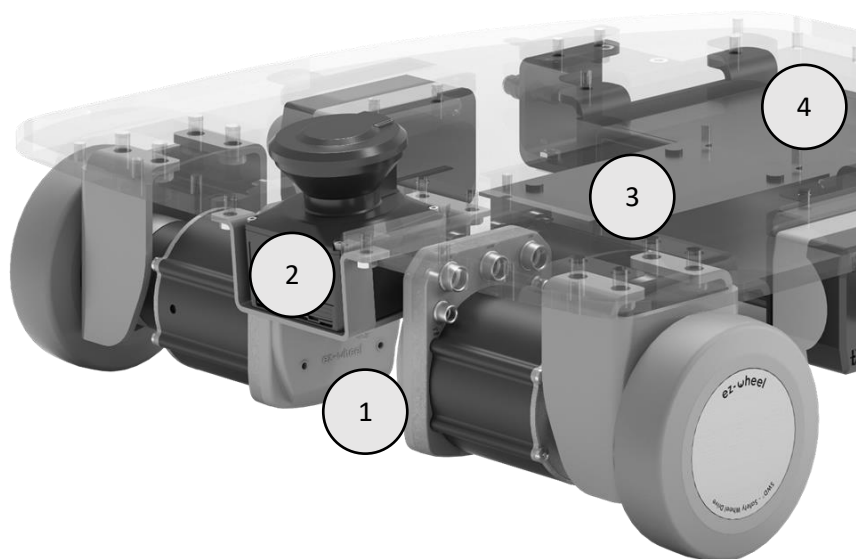
3. Description

3.1. A toolkit for robot developers

The SWD Starter Kit is made of combinable, modular devices for mobile robotics.

The SWD Starter Kit introduces key technologies for mobile robots' development

- SWD Safety Wheel Drive: the world's first drive with embedded safe motion control
- SE2L Safety Laser Scanner: the world's smallest laser scanner for safety critical applications
- ROS Robot Operating System: the reference Open-Source OS for robots

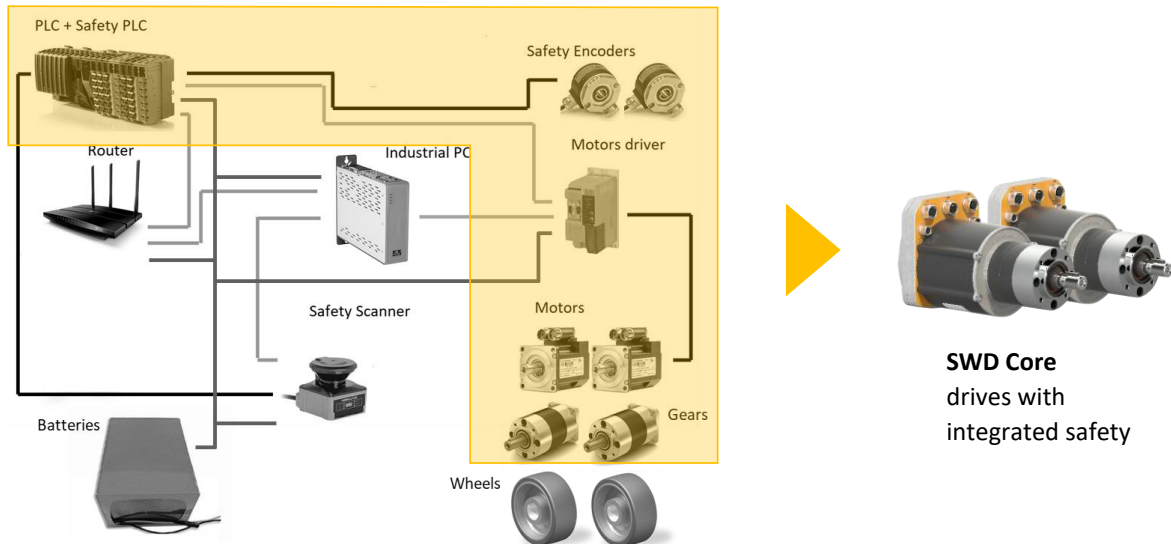


1	SWD Core safety drives
2	SE2L safety scanner
3	Embedded PC with ROS
4	Battery

3.2. Integrated Safety

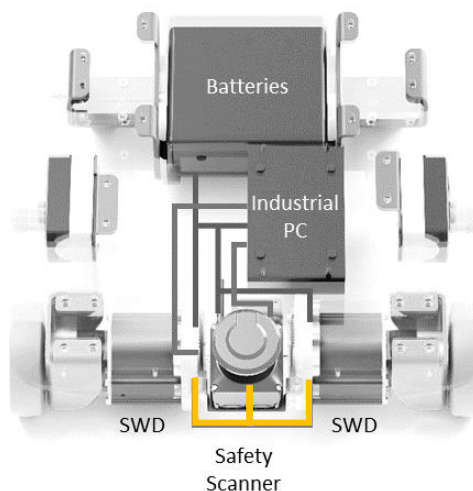
The SWD Starter Kit provides the simplest AGV/AMR safety architecture ever:

- SWD integrates motor drivers
- Unique, fully certified safe motion features
- Safety encoder integrated into SWD



The robot architecture is therefore extremely simplified compared to conventional AGVs or AMRs:

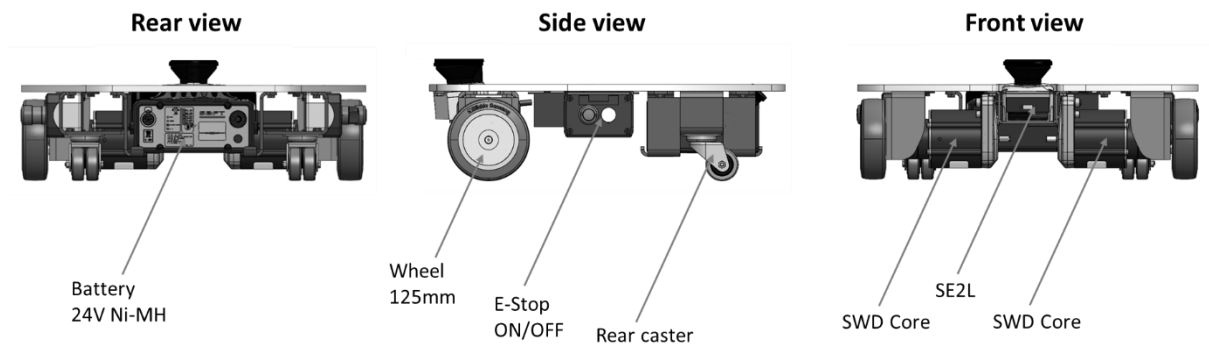
- ✓ Drives interfaced directly with safety laser scanners
- ✓ Replaces safety encoders, PLCs and motor drivers



3.3. Specificities of the SWD® Starter Kit

The SWD Starter Kit is a demonstration platform based on AMR use case, including:

- One SE2L safety laser scanner in front/center position
- Two SWD Core safety drives with 125mm wheels
- An ARM iMX6 PC controller with Linux Ubuntu 20.04 OS and ROS Noetic metasytem
- A 24 VDC 9 Ah Ni-MH rechargeable battery
- A chassis and complete wiring with two E-Stops



The SWD Starter Kit is not a complete, functional AMR:

- Navigation has to be done
- No fleet management software

3.4. Safety features¹

Motor disconnection	STO SIL2/PLd with E-Stops buttons
Motion control	SLS, SDI SIL2/PLd with SE2L detection zones
Braking	SBC SIL2/PLd, configurable with STO

3.5. Conditions of Use

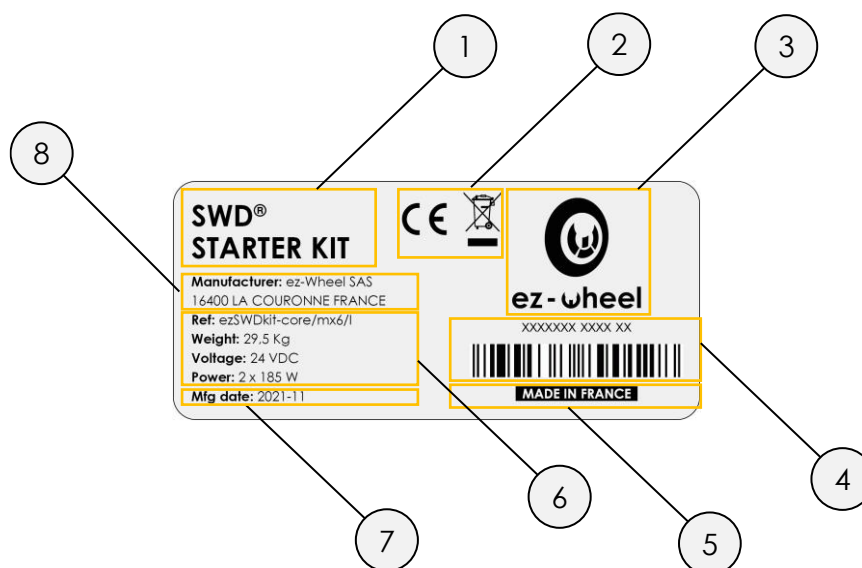
Temperatures	0 to +40°C
IP index	IP66 for SWD Core, IP65 for SE2L, IP54 for battery, NC for others
Maintenance period	5 years

3.6. Weight

Total weight	29,5 Kg
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¹ Certification in progress

3.7. Product Label

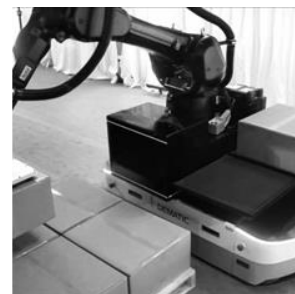


1	Commercial identification of the product
2	Legal pictograms
3	Identification of the manufacturer
4	Serial Number
5	Geographical origin of the product
6	Product information Product performance
7	Manufacturing date
8	Address of manufacturer

3.8. Applications

The **SWD® Starter Kit** is intended for development of mobile robotics applications such as:

- Industrial AGVs, AGCs and AMRs
- Logistics AGVs, AGCs and AMRs
- Cobots and mobile robot arms
- Mobile platforms



4. Synoptic

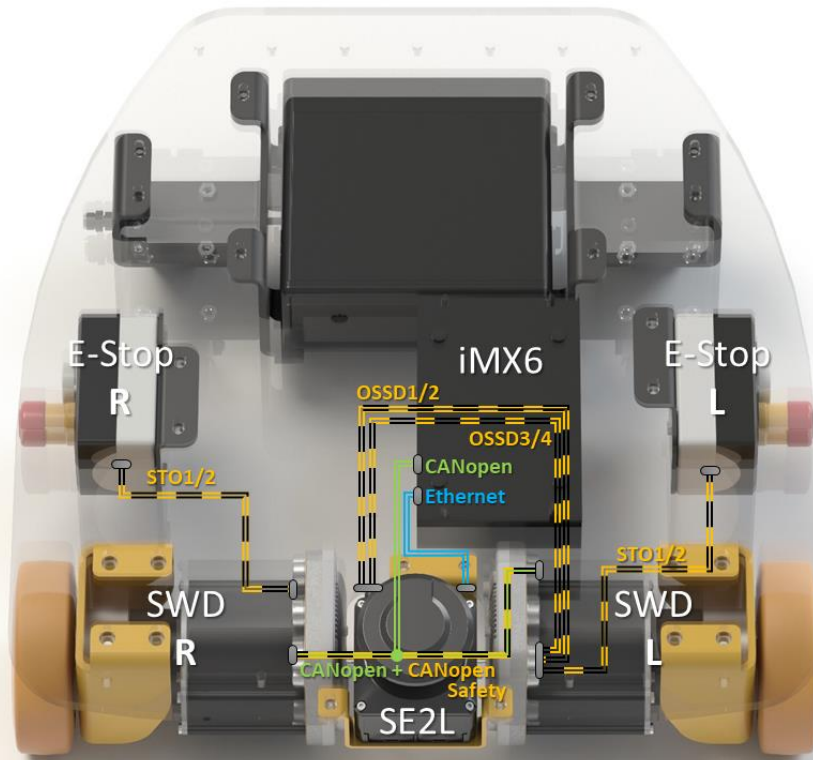


Figure 1 – Safety and Control synoptic of the product

Safety

Direct connection of safety sensors and switches to SWD safe inputs

Emergency Stop L → SWD L - STO inputs

Emergency Stop R → SWD R - STO inputs

SE2L OSSD outputs → SWD R - programmable inputs

CANopen Safety between SWD L and R, to replicate the safety inputs from one drive to the other one

Control

CANopen from iMX6 to SWD L and R, using CiA 402 velocity control mode for speed and direction control

Ethernet from SE2L to iMX6, to get data for SLAM and ROS-based algorithms

Note: CANopen and CANopen Safety frames are transmitted on the same physical CAN bus

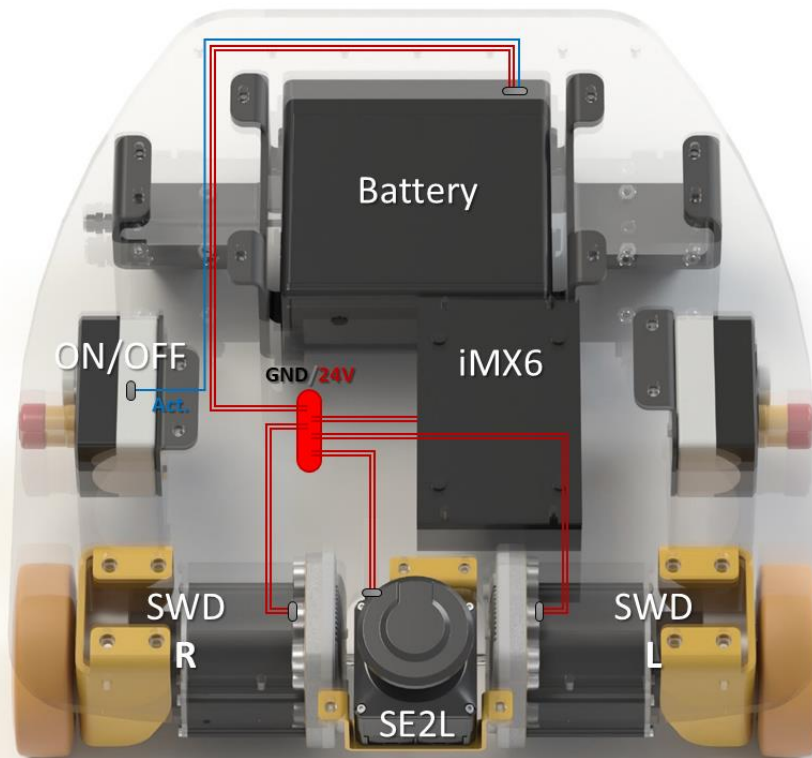


Figure 2 – Power Supply synoptic of the product

Power supply

All devices powered by Ni-MH 24V / 9Ah battery

Battery to junction box

Junction box to SWD L, SWD R, SE2L and iMX6

Activation signal, from the ON/OFF button to the activation input of the battery

Charging

The external charger can be directly connected on the battery panel connector:



5. Interfaces

5.1. Overview

The SWD Starter Kit is using the SWD safety hub interface to centralize the connections of all devices and facilitate the overall wiring.

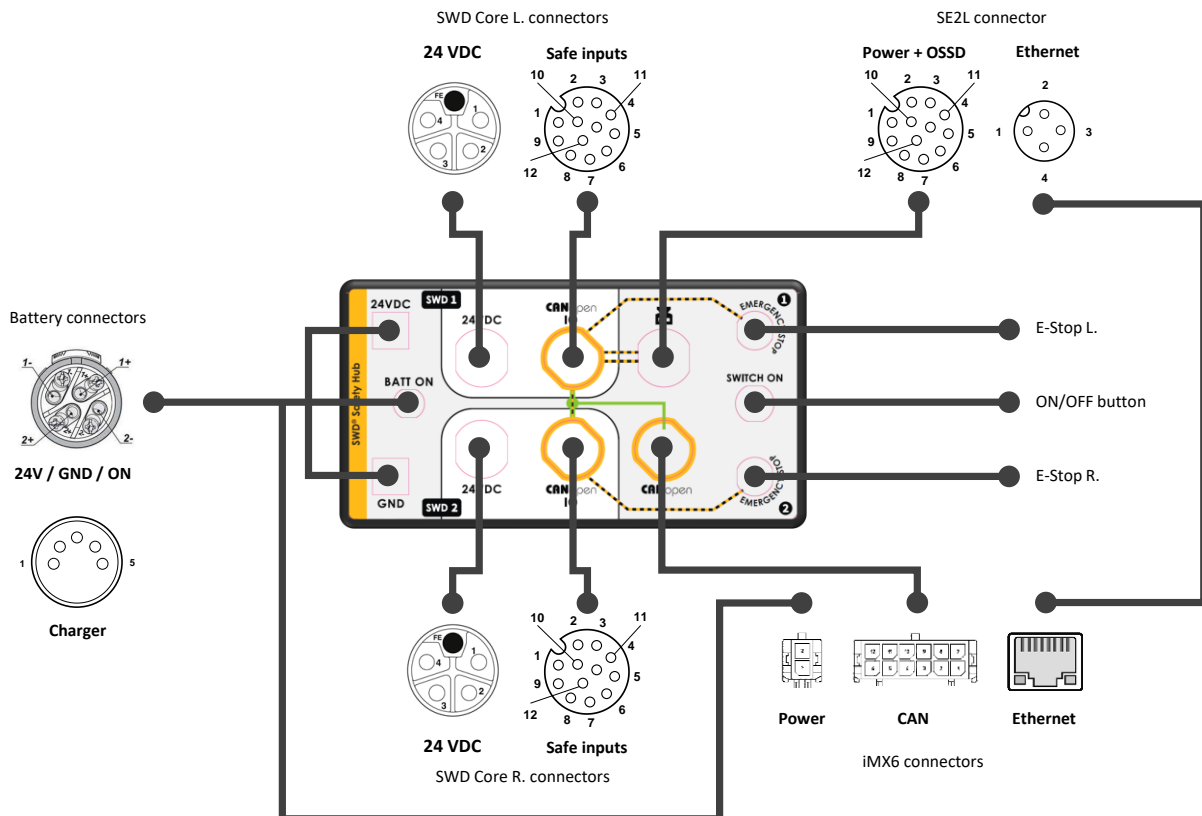


Figure 3 – Overview of interfaces

5.2. SWD Core connectors

The I/O connector and 24 VDC connector of the SWD Core are used in the SWD Starter Kit.

The other connectors (CAN, USB, Ethernet and Brake) are not used, please refer to the Instruction Manual of the SWD Core for details on the complete connections of the product.

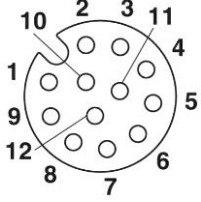


The same connector types and pin numbers are used in the SWD Core and the associated connection featured on the SWD safety hub. The following pinout description is therefore valid for both.

I/O connector

The I/O connector is type M12 - 12 pin A-coded.

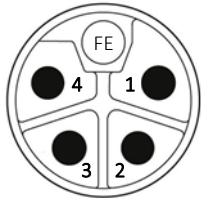
It is used for the CAN interface between the drives and the iMX6, and for the safety loops coming from the SE2L safety scanner and E-Stops.

Pin #	Designation	
1	CAN H - used for CANopen Safety	
2	INSafe_3 - used for SLS	
3	CAN L - used for CANopen Safety	
4	Power supply 24 VDC (2A) - disabled	
5	STO_1 - used for E-Stop	
6	GND Power Supply (2A) - unused	
7	INSafe_1 - used for SDI	
8	STO_2 - used for E-Stop	
9	INSafe_4 - used for SLS	
10	INSafe_2 - used for SDI	
11	GND - unused	
12	ON - unused	

24 VDC connector

The 24 VDC power connector is of type M12 Power - L-coded 5 (4 pin + FE).

It is used to distribute the battery power on the drives.

Pin #	Designation	
1	+ Power supply 24 VDC (16A)	
2	+ Power supply 24 VDC (16A)	
3	GND Power Supply (16A)	
4	GND Power Supply (16A)	
FE	Mechanical earth connected to the chassis	

5.3. SE2L connectors

The Power+OSSD connector and Ethernet connector of the SE2L are used in the SWD Starter Kit.

Please refer to the SE2L User Manual for details on the complete connections of the product.



The original connector of the SE2L has been replaced by a M12 Power+OSSD connector to get homogeneous connections with the SWD products.



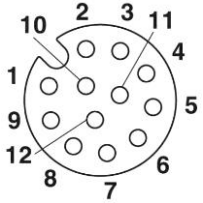
The same connector types and pin numbers are used in the SE2L and the associated connection featured on the SWD safety hub. The following pinout description is therefore valid for both.

Power+OSSD connector

The Power+OSSD connector is type M12 - **TBC**

It is used to power the SE2L and for the safety loops going to the SWD Core safety drives.

Pin #	Designation
1	24 VDC
2	GND
3	OSSD1
4	OSSD2
5	OSSD3
6	OSSD4
7	NC
8	NC
9	NC
10	NC
11	NC
12	NC

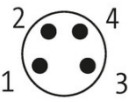


Ethernet connector

The Ethernet connector is a M8 4-pin A-coded.

It is used to exchange non-safe data between the SE2L and the iMX6 PC.

Pin #	Designation
1	TD+
2	RD+
3	RD-
4	TD-



5.4. iMX6 connectors

The Power connector, CAN connector and Ethernet connector of the iMX6 embedded PC are used in the SWD Starter Kit.

Please refer to the TEK3-IMX6 BOX PC Product Manual for details on the complete connections of the product.

Power connector

The Power connector is a Molex 43025-0200 (2-pin Micro-Fit 3.0)

It is used to bring the battery power on the PC.

Pin #	Designation
1	GND
2	DC Voltage input (8-36 VDC)

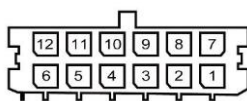


CAN connector

The CAN connector is a Molex 43025-1200 (12-pin Micro-Fit 3.0)

It is used for the CANopen interface between the drives and the iMX6.

Pin #	Designation
1	Ground for CAN
2	NC
3	CAN Bus 1A high
4	CAN Bus 1A low
5	NC
6	NC
7	NC

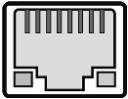


8	NC	
9	NC	
10	NC	
11	NC	
12	NC	

Ethernet connector

The Ethernet connector is a standard RJ45 for 10/100 Mbps transmission.

It is used to exchange non-safe data between the SE2L and the iMX6 PC.

Pin #	Designation	
1	TD+	
2	TD-	
3	RD+	
4	NC	
5	NC	
6	RD-	
7	NC	
8	NC	

5.5. Battery connectors

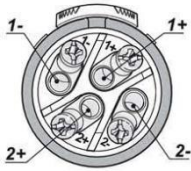
The Power connector and Charger connector of the Mobility Module battery are used in the SWD Starter Kit.

Please refer to the Mobility Module User Manual for details on the complete connections of the product.

Power connector

The Power connector is a Neutrik Speakon 4-pin.

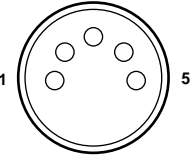
It is used to power the kit and to turn ON and OFF the battery.

Pin #	Designation	
1+	24 VDC	
2+	GND	
1-	RD+	
2-	ON signal	

Charger connector

The Charger connector is a Neutrik XLR 5-pin.

It is used to connect the charger to the battery.

Pin #	Designation	
1	Charger+	
2	NC	
3	NC	
4	NC	
5	GND	


5.6. SWD safety hub connectors

The SWD and Scanner connectors of the SWD safety hub follow the pinouts of the above-described connectors.

Emergency stop connector

The Emergency stop connectors are of type M8 4-pin A coded.


They are used to connect the two normally closed switches of an E-Stop button (2NC type).

Pin #	Designation	
1	SW1 NC1	
2	SW1 NC2	
3	SW2 NC1	
4	SW2 NC2	

Switch ON and Batt ON connectors

The Switch ON and Batt ON connectors are of type M8 3-pin A coded.

They are used to forward the ON button signal to the activation signal of the battery.

Pin #	Designation	
1	SW	
3	GND	
4	NC	

6. Mechanical assembly

6.1. Dimensions of the packaging and contents of the pack



⚠ For all engine logistics operations alone, preferably use the original packaging.

6.2. Overall dimensions

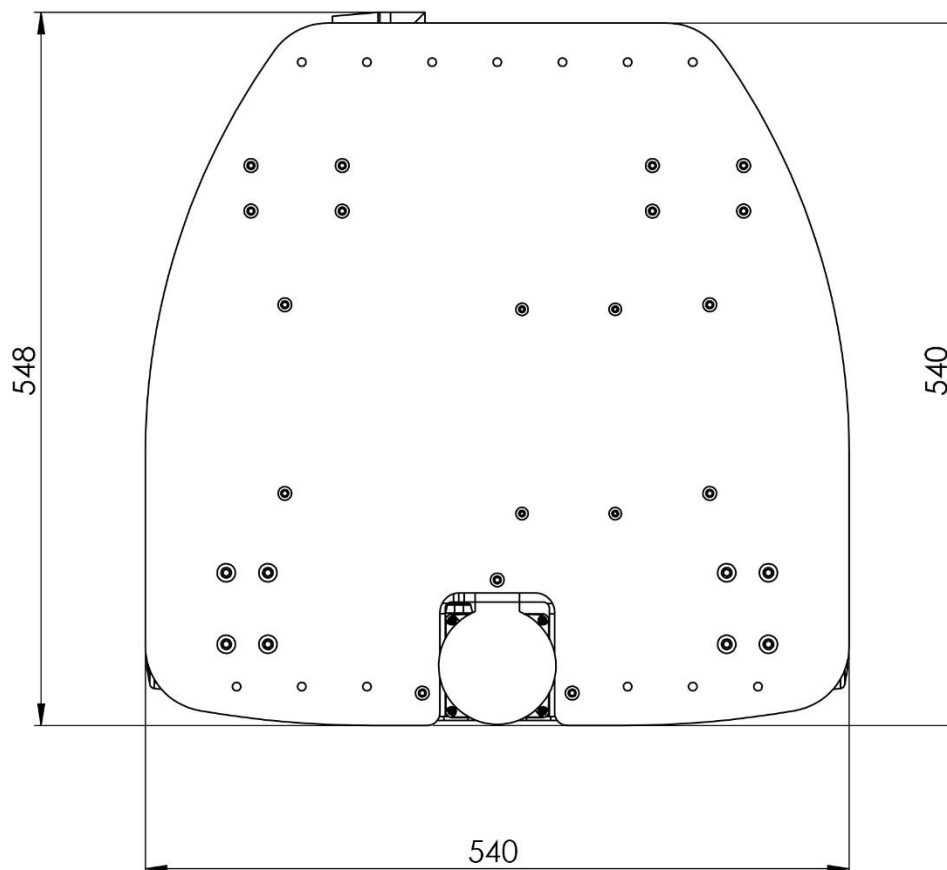


Figure 4 - Overall dimensions, top view

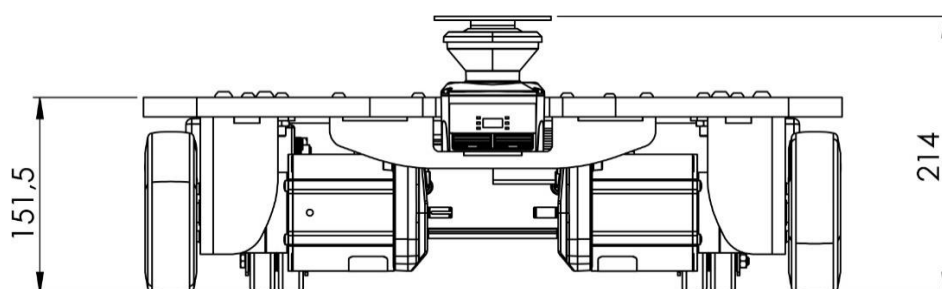
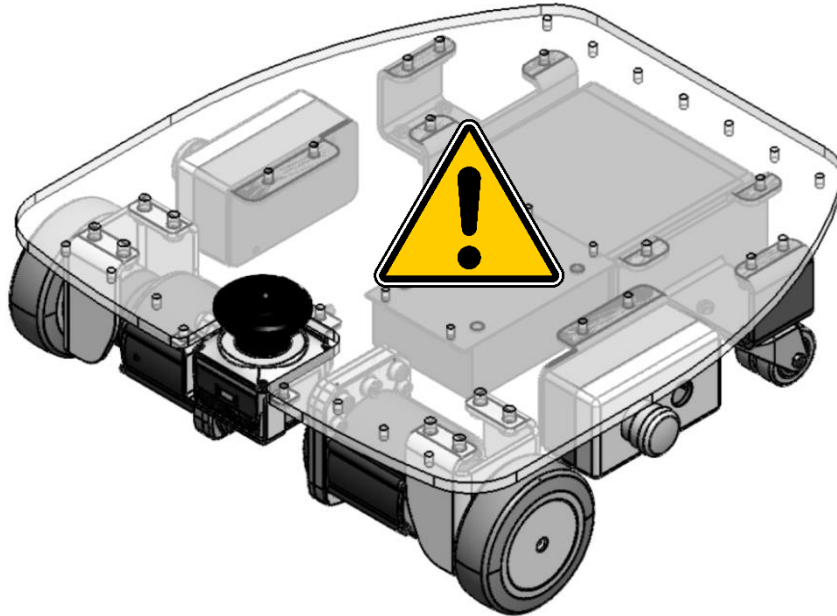


Figure 5 - Overall dimensions, front view

6.3. Mechanical specifications

The casters are designed to support a maximum load of 40 kg per caster, but the plastic chassis, for demonstration purpose only, is not designed to carry load.



Do not step or put loads on the chassis of the Starter Kit!

7. Safety features

7.1. Overview of safety features

Safety features available from the SWD® Core safety drives

The **SWD® Core** includes safe engine shutdown features, as well as advanced safe speed monitoring features. This exclusive integrated solution developed by ez-Wheel simplifies the machine architecture by avoiding the need for external supervisory bodies and safety logics.

The engine shutdown functions include:

- STO (Safe Torque Off): safe disconnection of motor torque
- SBC (Safe Brake Control): safe braking engagement







Speed monitoring functions are based on a safety encoder integrated into the product and include:

- SDI (Safe Direction): safe control of the direction of rotation
- SLS (Safely Limited Speed): safe rotational speed limitation



These safety functions are implemented in accordance with IEC 61800-5-2 (functional safety requirements for the development of safety drives) and according to the CiA/DS 402-4 profile for the safety functions of motor controllers.

	Safety features	Possible settings
	Safe disconnection of engine torque	Rearmament: <ul style="list-style-type: none"> ▪ automatic ▪ by request for acquittal Braking configuration associated with the STO (Cf. SBC)
	Safe braking engagement	Joint activation of the STO: <ul style="list-style-type: none"> ▪ from internal braking to SWD® Core ▪ an external electromechanical brake ▪ of both brakes simultaneously
	Safe control of the direction of rotation	Prohibition of the direction of rotation: <ul style="list-style-type: none"> ▪ positive or negative ▪ with two tolerance thresholds levels
	Safe rotational speed limitation	Prohibition of speeding: <ul style="list-style-type: none"> ▪ eight switchable throttling thresholds ▪ an adjustable trigger time



Refer to the Instruction Manual of the SWD Core to get all details on the operation and configuration of available safety features.

7.2. Use of safety features in the SWD Starter Kit

Emergency Stops

E-Stops on each side of the kit, stopping the motors (STO safe torque off function)

When one SWD reads the STO signal from an E-Stop button, it sends the STO message to the other drive through the CANopen Safety

In the default configuration, the SBC function is not used with the engagement of the STO.



Safety fields and Safe Motion

Close obstacle: when the SE2L scanner detects an obstacle in the close range (<1m forward), the speed limit (SLS safely limited speed function) is engaged on the SWD motors, set at 0.3 m/s

Collision risk: when the SE2L scanner detects an immediate risk of collision (<50cm forward), the forward direction (SDI safe direction function) is engaged on the SWD motors



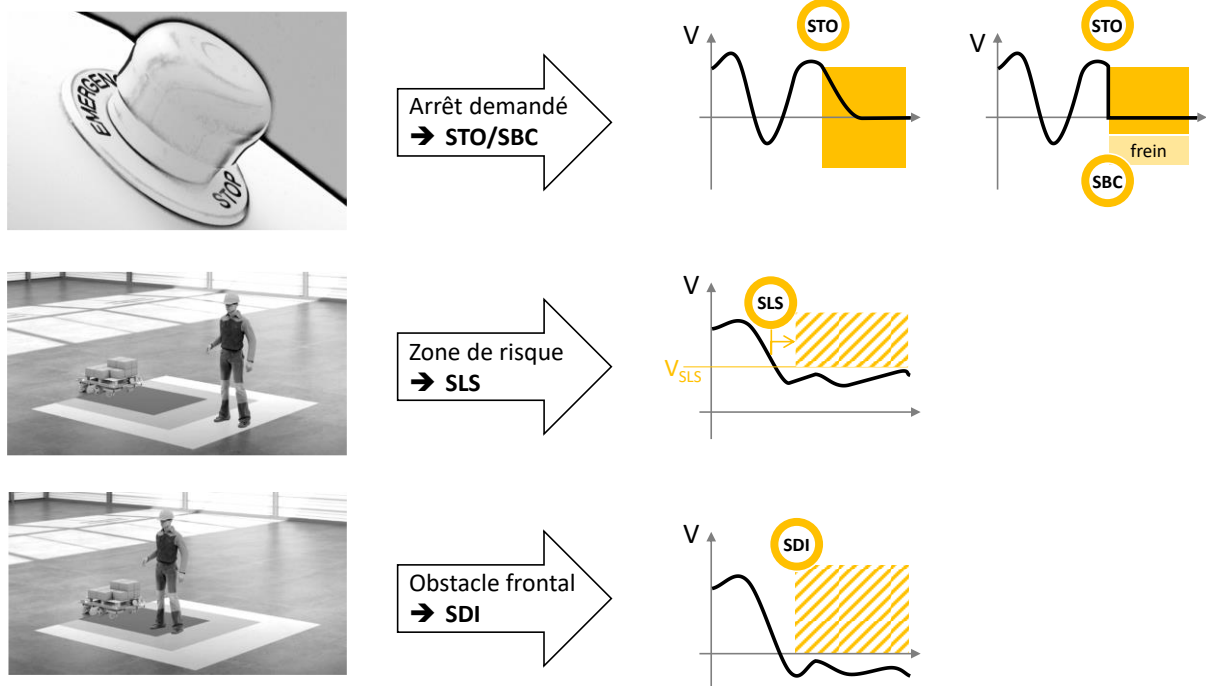


Figure 6 - Use of Safety Features

7.3. Safety fields configuration

The default configuration of safety fields in the SE2L scanner is set as follows:

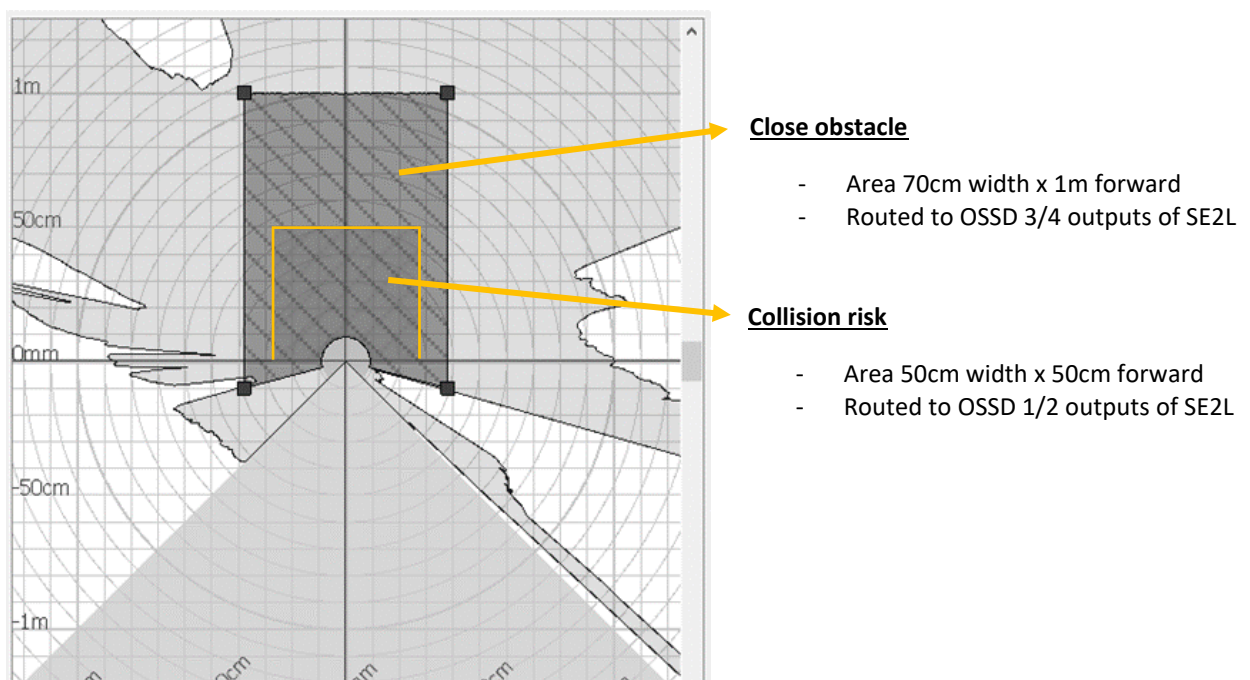


Figure 7 - Safety fields of the SE2L



To edit and customize the safety fields, use the SLS Project Designer software

7.4. Safety loops configuration

The safety loops of the SWD Starter Kit are set up as follows:

- Emergency Stop L → SWD L - STO inputs
- Emergency Stop R → SWD R - STO inputs
- SE2L OSSD outputs → SWD L - programmable inputs
- CANopen Safety between SWD L and R, to replicate the safety inputs from one drive to the other one

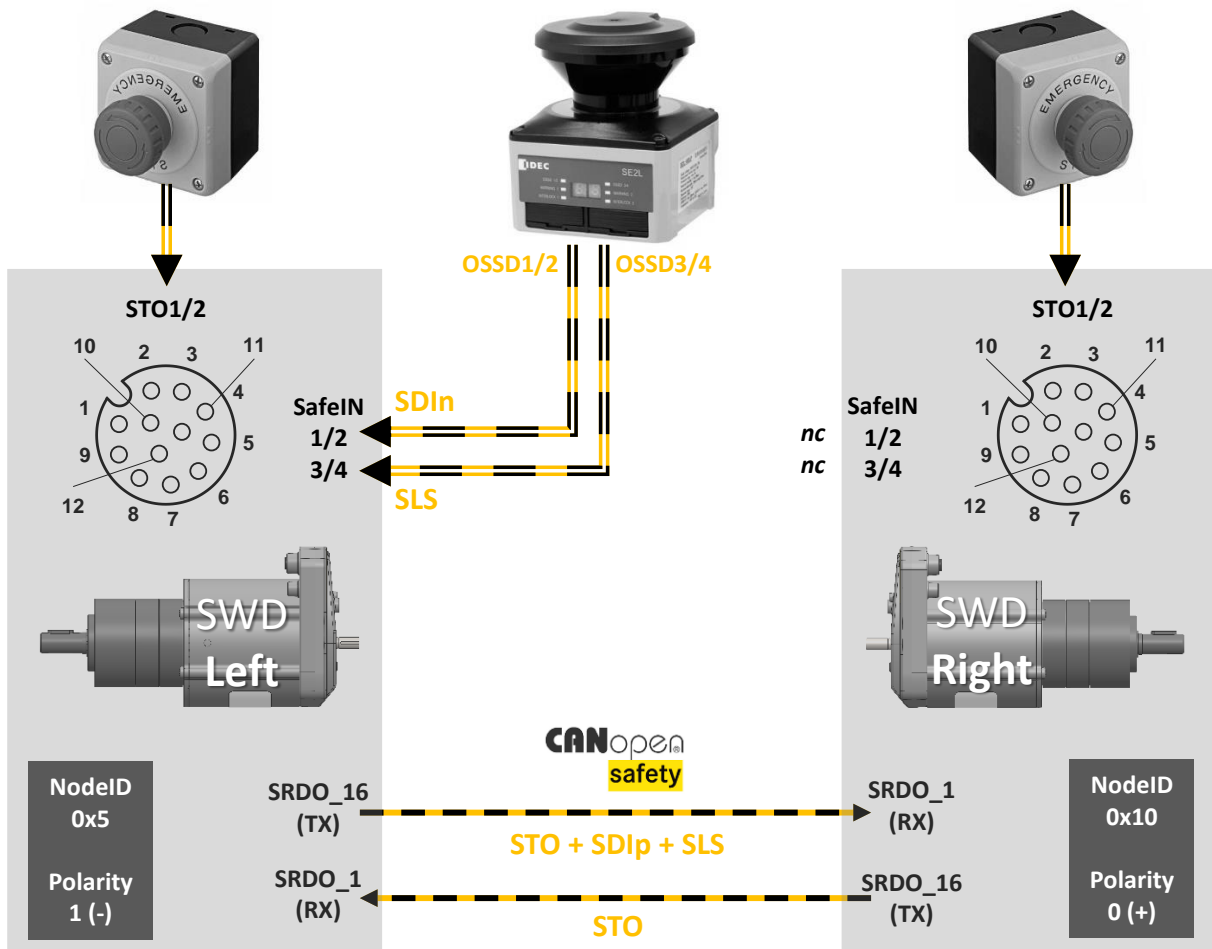


Figure 8 - Configuration of safety loops in SWD Core



The drives configuration is done by CANopen messages. Scripts are available to configure the drives on the ez-Wheel GitHub.

8. Starting the SWD Starter Kit

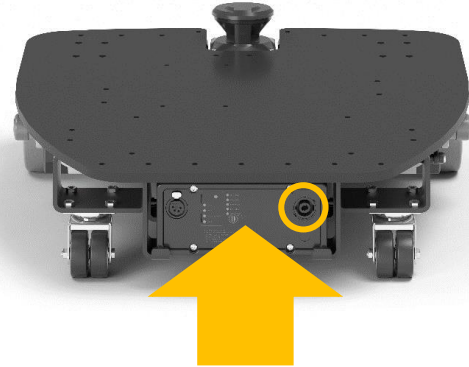
8.1. Power on

Setting up the kit

Put the kit on the floor on a stable and flat surface.

Battery

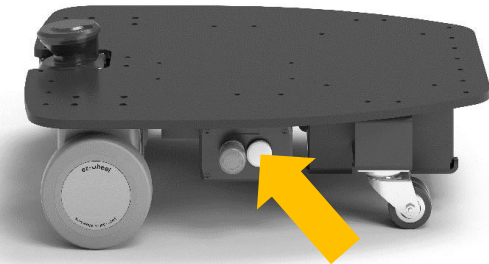
Install and plug the battery power connector on the rear side of the robot.



Start button

Press the white ON/OFF button on the right side of the robot, nearby the Emergency Stop.

The PC and SE2L lights turn on, and the kit starts booting for a few tens of seconds.



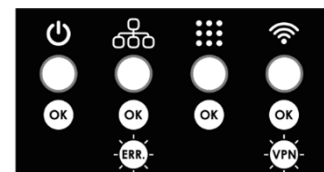
Emergency Stops

To start safely, you can engage one of the Emergency Stops while the robot is powering on.

8.2. Display and status

When powered, the embedded PC shows the status of each service started on the side 4-LED display.

- Power LED: green when the battery power is available.
- Devices LED: green when the connection to the SWD Core and to the SE2L is active, flashing if the connection cannot be established.
- ROS LED: green when the ROS environment is active.
- Wi-Fi LED: green when the Wi-Fi connection is established, flashing when the VPN connection is activated (only for support).



8.3. Connection to Control Page

Once started, the SWD Starter Kit generates its own Wi-Fi access point to connect third-party devices. Any device with a navigator can be connected to the SWD Starter Kit to access the web Control Page hosted on the embedded iMX6 PC.

To connect to the Wi-Fi hotspot, the SSID and initial password are indicated on the front plate beside the SE2L safety scanner.



SSID: SWD-StarterKit-880756
Password: swd_starterkit

Upon MAC address
of each hardware kit



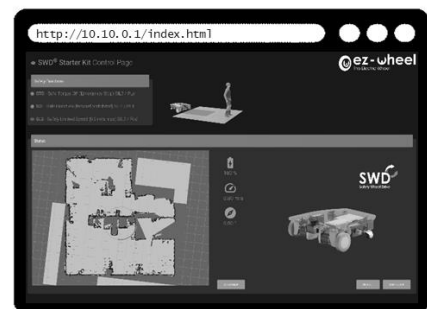
Once a PC or tablet connected to the SWD Starter Kit Wi-Fi access point, a web page is accessible with any navigator by typing the page's address.



<http://10.10.0.1>

The SWD Starter Kit generates a web Control Page for the user to monitor the real time activity.

The page is used to check the status of the safety features set up with the SWD Core safety drives and the SE2L safety laser scanner and shows an example of map built thanks to a ROS open-source SLAM algorithm using the data from the SE2L scanner.

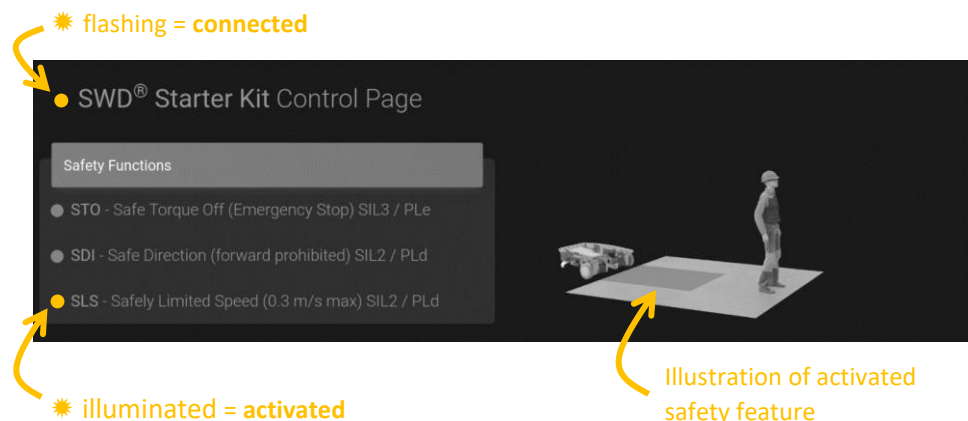


The SLAM algorithm used by default is Hector Slam available under ROS Noetic, but other algorithms such as LaMa or Gmapping could be used.

8.4. Safety features monitoring

Once the control page of the connected Starter Kit is active and displayed the status of the safety features can be monitored:

- **STO** status is RED when one of the two Emergency Stops is engaged, the motors are stopped (Safe Torque Off)
- **SDI** status is RED when the SE2L detects an obstacle in the short perimeter (<50cm), the motors cannot go forward (Safe Direction)
- **SLS** status is RED when the SE2L detects an obstacle in the nearby perimeter (<2m), the motors cannot exceed 50 RPM i.e. 0,32 m/s (Safely Limited Speed)



8.5. Hand control for teleoperation

The SWD Starter Kit is delivered with a consumer type console joystick, for demonstration purpose only. The wireless joystick is directly connected to the embedded iMX6 PC and allows a manual teleoperation of the machine.



The SWD Starter Kit uses standard ROS Noetic packages (using *joy* and *teleop_twist_joy*) providing interfaces with a standard console joystick.



To activate the hand control, the ROS packages must be started. The status of the ROS LED can be checked to confirm that ROS is active.