APICOO ROBOTICS

SusGrip Smart Gripper

USER MANUAL

revision SG.2.1
apicoorobotics.com

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REVISIONS

REVISION	DATE	CHANGES
rev_2f.1.1	17 Aug 2024	First release
rev_2f.2.1	21 Oct 2024	- Added ModbusRTU registers information; - Added examples for ModbusRTU interfacing.
rev_2f.3.1	12 Jan 2025	- Added Universal Robots compatibility information; - Added detailed information for each register; - Adjusted graphics for Electrical Setup; - Added manual for URCap installation and programming. - Added ModbusRTU framing guide; - Added ModbusRTU register mapping; - Adjusted graphics for Product Ratings.
rev_SG.1.1	04 Mar 2025	- Changed UR compatibility information: UR16 non “e” removed from compatibility table; - Changed GPIO type: GPIO input pin 4 supports native PNP Outputs; - Added remark: PNP-to-NPN adapter for pin 4 supported. - Changed GPIO logic: GPIO input pin 4 is now pulled down by default, and activates when HIGH (Previously: Pulled up by default, activated LOW); - Improved typos, grammatical errors, general diction. - Overhauled entire manual; - Merged manuals for SusGrip 2F and SusGrip 3F; - Added TL;DR section for quick starting; - Renamed GPIO mode to Normal mode; - Renamed Modbus RTU mode to Advanced mode;
rev_SG.2.1	05 May 2026	- Deprecated legacy SusGrip and manuals; - Deprecated legacy GUI Application (SG GUI); - First release for SusGrip Gen 2;

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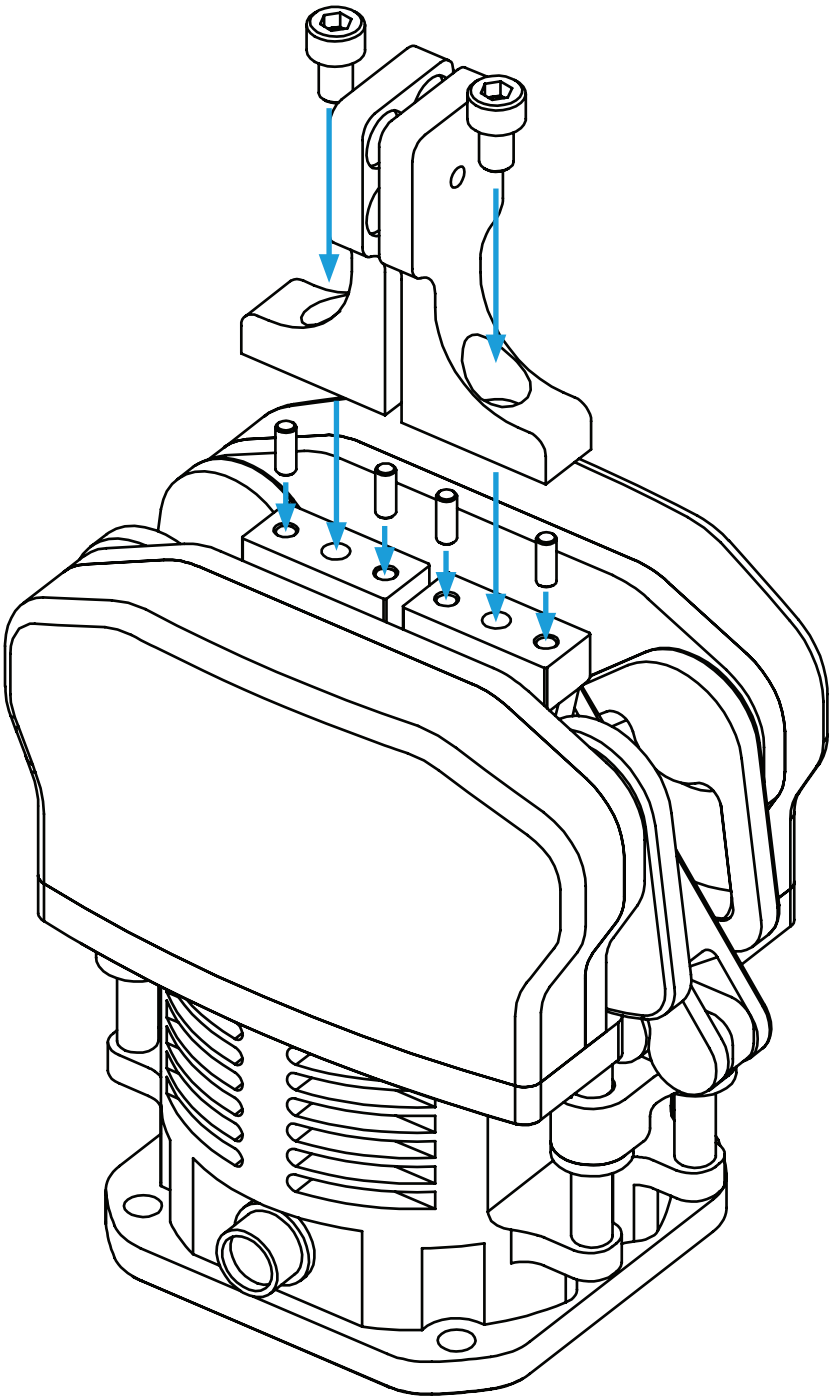
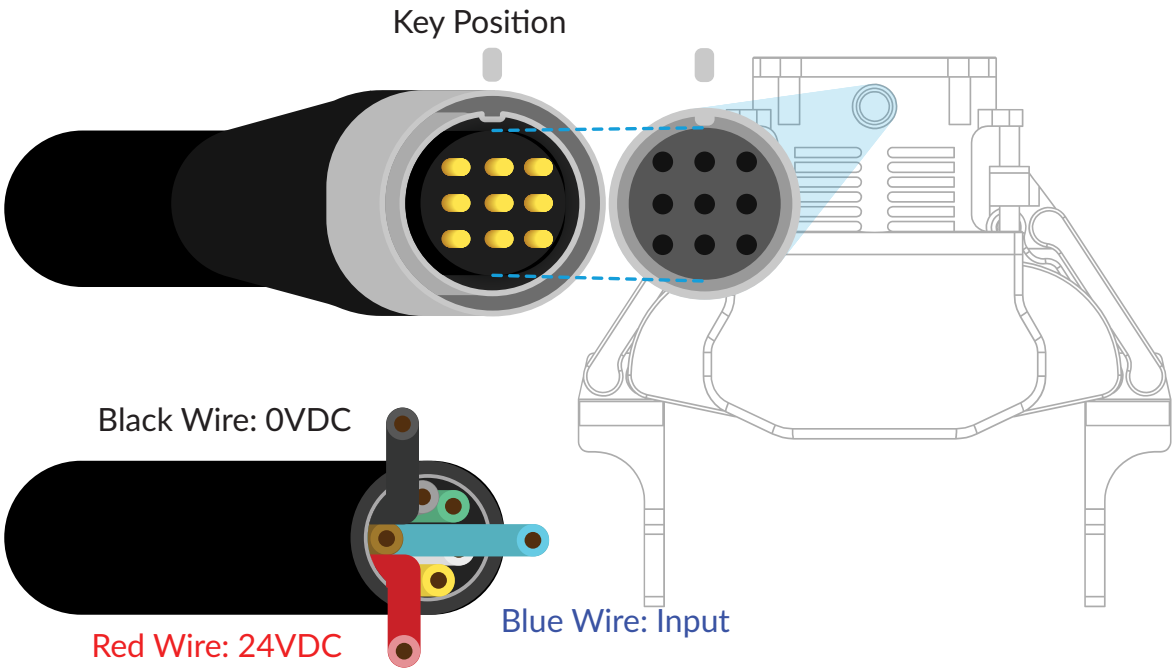
QUICK START GUIDE

1. Installation



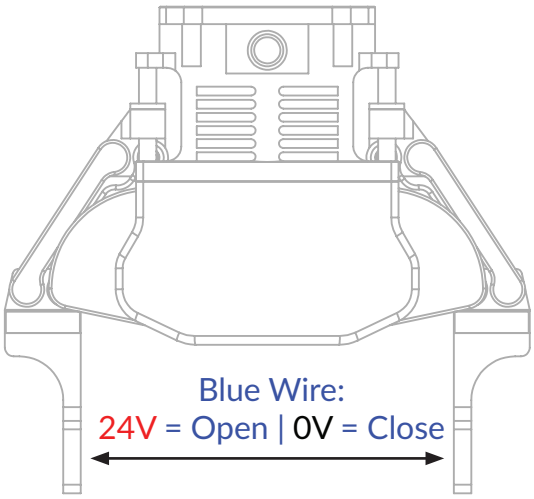
2. Connectivity



3. Control

Blue Wire: 24V = Open | 0V = Close

Blue Wire Logic Level	Gripper State
0	--> Close <--
1	<-- Open -->
Floating	--> Close <--



CONTENTS

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1 - GENERAL INTRODUCTION

1.1. SusGrip Overview

The SusGrip series features cutting-edge grippers with a sophisticated mechanical design that ensures precise parallel motion of the fingers. Powered by high-performance BLDC motors, these grippers deliver efficient and robust operation across a diverse range of applications.

Each gripper in the SusGrip lineup is equipped with a high-precision absolute encoder, enabling continuous monitoring of finger positions. This eliminates the need for pre-operation calibration, significantly enhancing convenience and efficiency. Additionally, SusGrip offers an array of intelligent features, including Object Detection, Gripper Status Notifications, Anti-Backdriving, and Anti-Pinching capabilities.

With a modular design, SusGrip fingers can be easily swapped and exchanged using common bolts, providing users with the flexibility to customize their gripper to meet specific application needs and personal preferences.

1.2. Key Features

The SusGrip lineup is equipped with a comprehensive suite of intelligent features, designed to ensure seamless integration and exceptional versatility across a wide range of applications and industries. Whether users are working in robotics, research, automation, or prototyping, SusGrip adapts effortlessly to users' workflow—minimizing development time while maximizing performance and reliability.

- **Long Stroke**: Up to 132-millimeter grasp in a compact package;
- **Parallel Motion**: Height compensation is not in SusGrip's dictionary;
- **Fingers Encoder**: No calibration, wake up and go;
- **Prominent Strength**: Guaranteed 100N grasp force;
- **Ecosystems Infiltrator**: Present in and supports various co-bot ecosystems;
- **Object Detection**: No delay, SusGrip tells you when an object is grasped;
- **Familiar Commission**: Open and close using a single signal line;
- **Deep Manipulation**: Total control of the gripper with Modbus RTU;
- **Any-how Grasping**: Handles objects in both ways, internally or externally;
- **Safety-Oriented Design**: No injuries-causing pinch points whatsoever;
- **Intuitive GUI**: Specific application for easy one-time configuration;
- **Customizable Fingertip**: Effortless finger types swapping and modding.

1.3. Applications

This section outlines the recommended use cases for SusGrip, guiding users in leveraging its full potential while ensuring optimal performance and compatibility with their specific operational requirements:

- Palletizing;
- Pick & Place;
- Handling;
- Assembly;
- Feeding;
- Sorting.

1.4. About this manual

This manual is meant for any devices that are a part of the SusGrip gripper family such as:

- SusGrip-2F Gripper (linear parallel);
- SusGrip-3F Gripper (concentric parallel);
- SusGrip Variants.

This manual is only meant for the SusGrip family and its variants running firmware version 2.4.x where x is from 5 to 255.

2 - SAFETY

2.1. Safety Guidelines

Read This Manual Thoroughly – Before installing, operating, calibrating, programming, decommissioning, inspecting, or maintaining the SusGrip 2F or 3F, ensure you have read and understood this manual in full. Familiarity with the gripper's functions, limitations, and safety protocols is essential for safe and effective use.

Trained and Qualified Personnel Only – Installation, operation, and servicing of the SusGrip should be performed exclusively by trained personnel. Operators must be knowledgeable in collaborative robot safety standards, including but not limited to ISO/TS 15066.

Use as Intended – The SusGrip 2F and 3F are designed solely for gripping tasks within their specified payload capacities. Do not exceed these limits, and do not use the gripper to handle hazardous, flammable, corrosive, or radioactive materials unless explicitly authorized by the manufacturer.

2.2. Warnings and Precautions

ATTENTION:
Any use of the SusGrip Gripper in noncompliance of these warnings is inappropriate and may cause injury or damage.

WARNING:
- When commissioned with a robot, the gripper needs to be properly secure before operation;
- Do not supply the gripper with electrical sources that are above the specified ratings;
- Key position on the cable must align correctly with the gripper's connector;
- Cable must be secured on both ends before operation;
- Do not install or turn on a gripper that is damaged beyond operation or lacking vital parts;
- Attempt not to exceed the gripper's payload for a prolonged period of time;
- Do not use the gripper directly on people or living animals;
- Refer to the mechanical dimensions when customizing fingers.

2.3. Intended Use

SusGrip gripper is designed for grasping and temporarily holding objects. The gripper is intended for installation on a robot, machinery, or special-purpose jig.

ATTENTION:
SusGrip gripper is NOT intended for applying force against objects or surfaces.
SusGrip gripper is NOT intended for actively hold objects for an extended period of time.

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3 - PRODUCT SPECIFICATIONS

3.1. Mechanical Dimensions

The figures below demonstrate the mechanical dimensions of the standard variant of the SusGrip 2F gripper, each dimension is given in millimeters (mm):

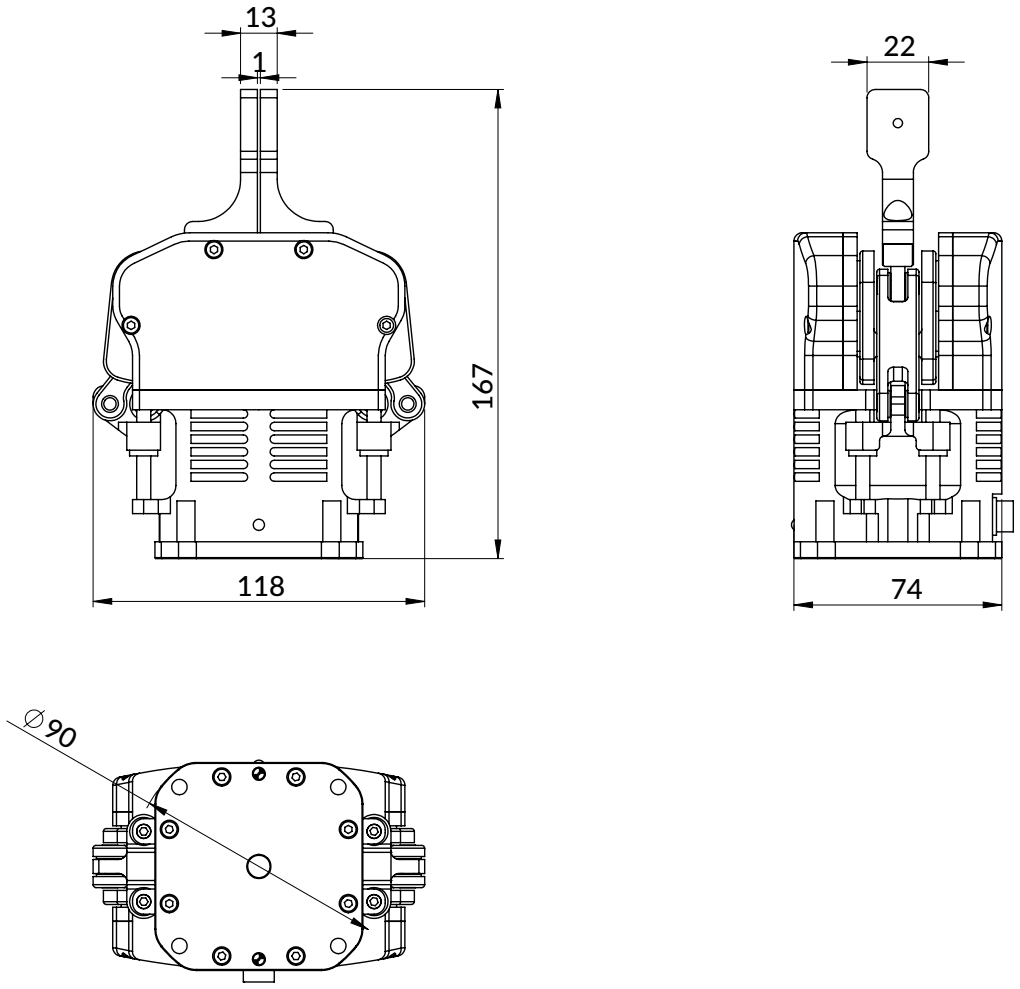


Figure 3.1 - SusGrip 2F Mechanical Dimensions (Closing)

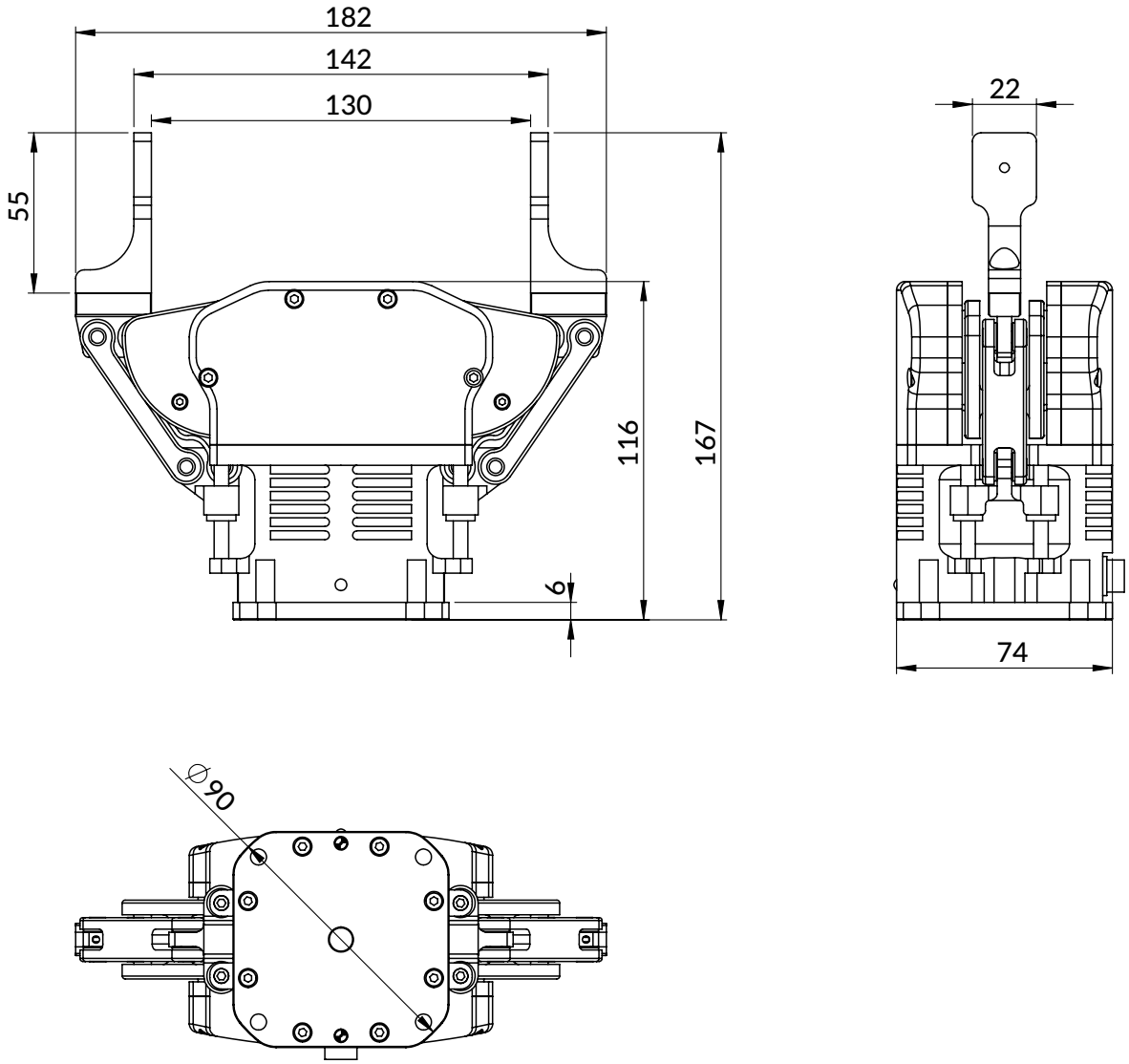


Figure 3.2 - SusGrip 2F Mechanical Dimensions (Opening)

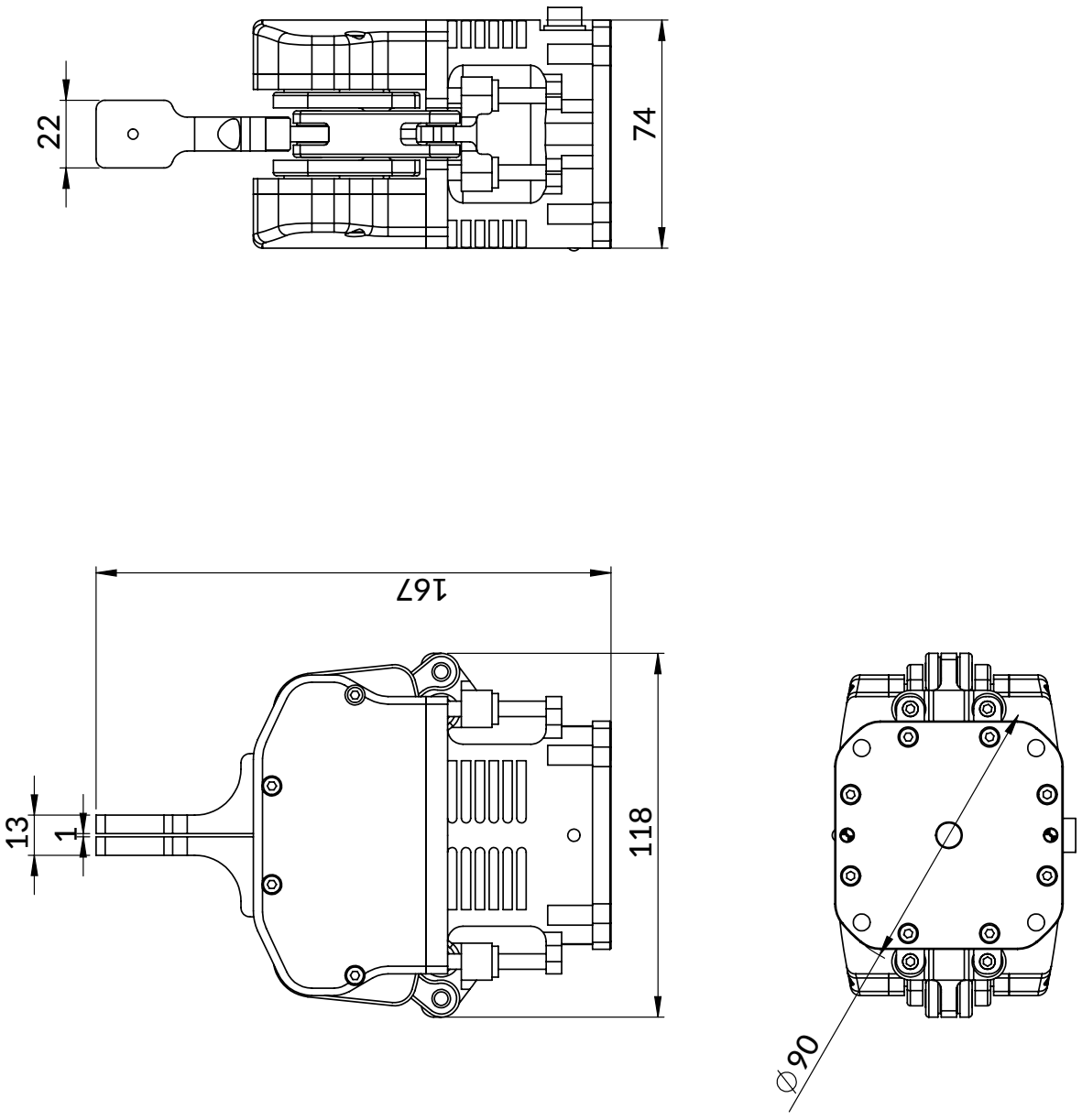


Figure 3.3 - SusGrip 2F Mechanical Dimensions (Closing, Rotated)

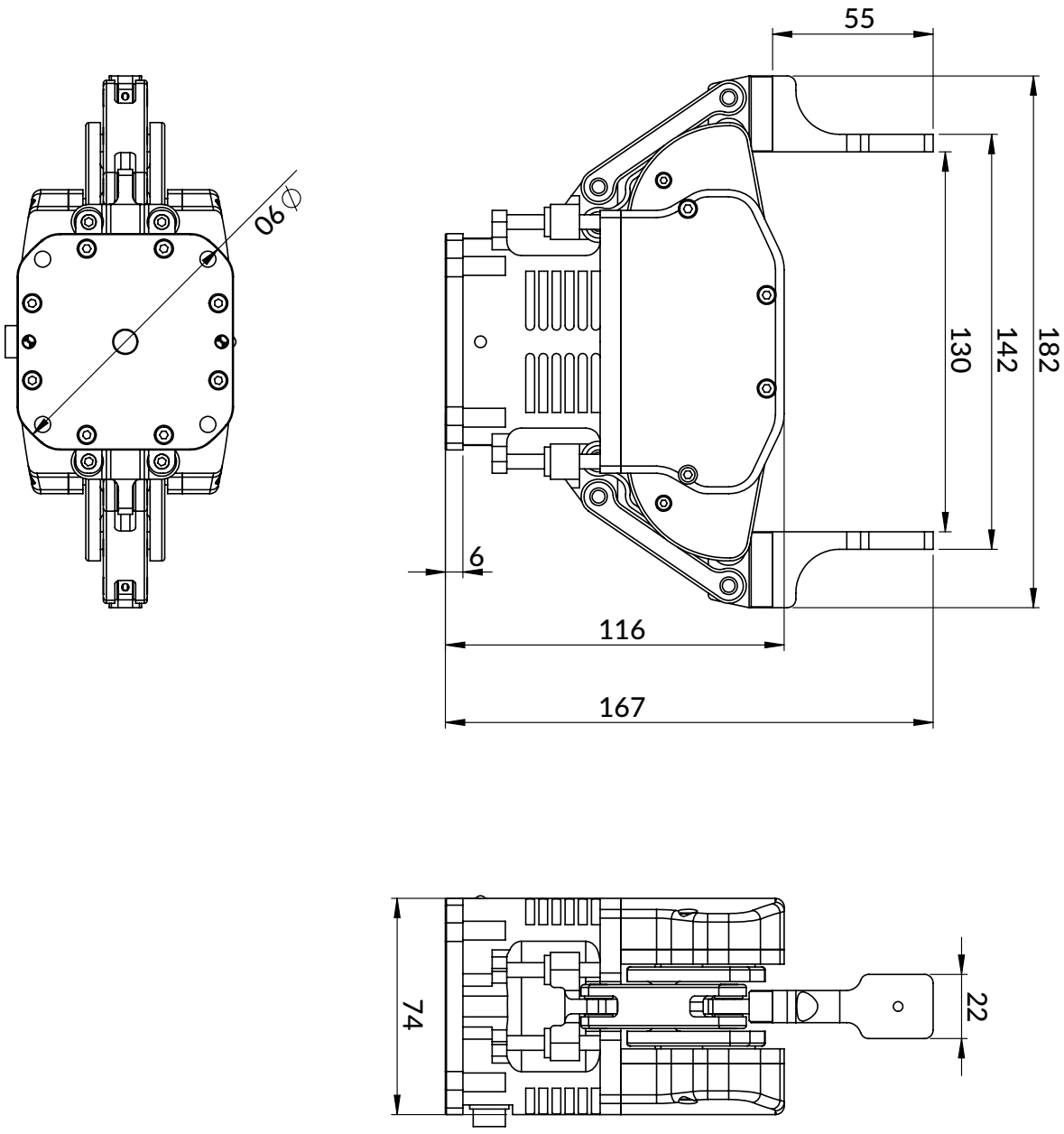


Figure 3.4 - SusGrip 2F Mechanical Dimensions (Opening, Rotated)

The figures below demonstrate the mechanical dimensions of the standard variant of the SusGrip 3F gripper, each dimension is given in millimeters (mm):

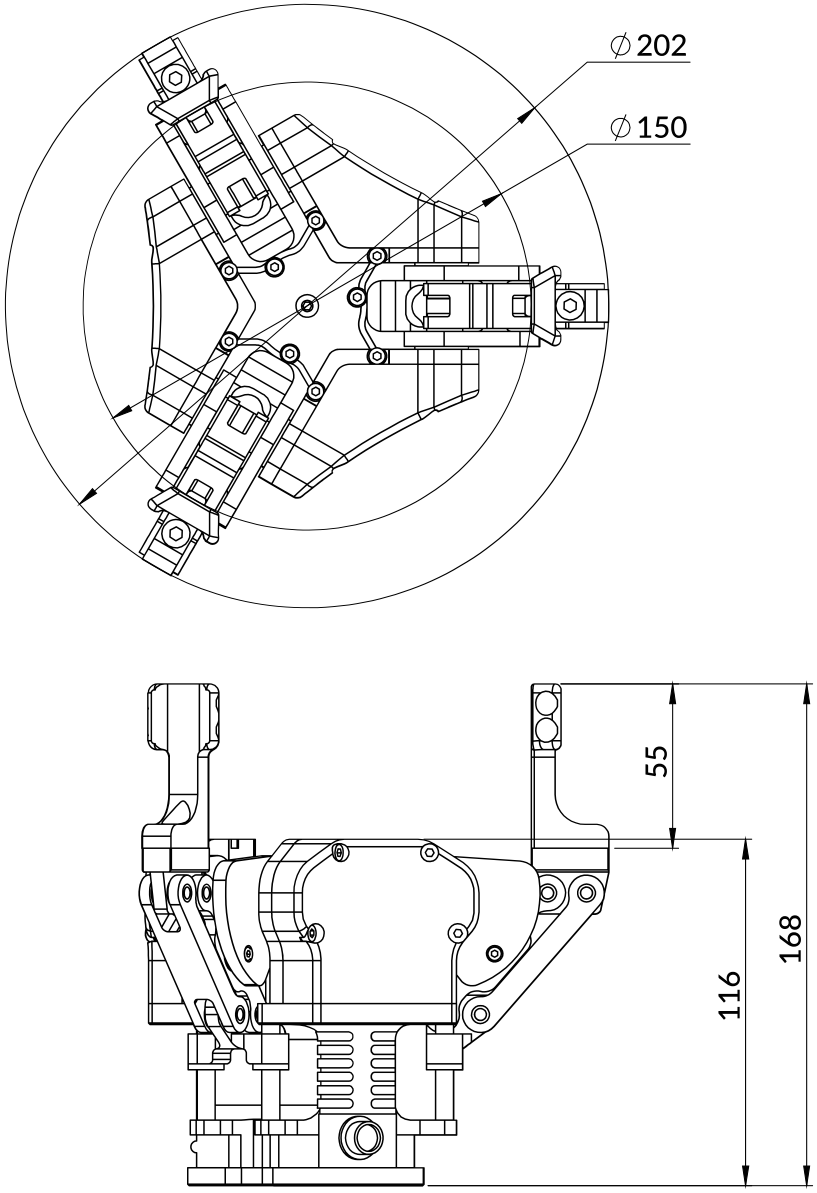


Figure 3.5 - SusGrip 3F Mechanical Dimensions (Opening)

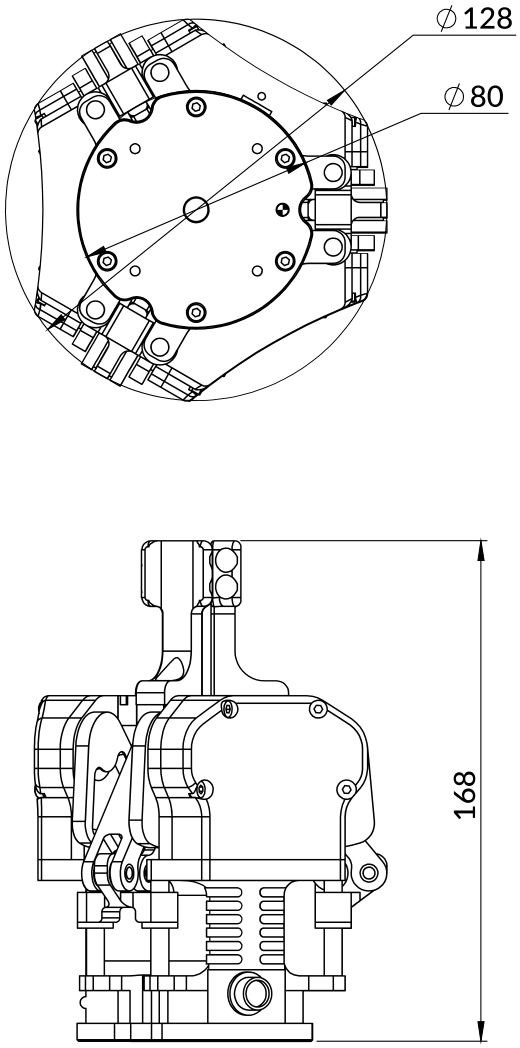


Figure 3.6 - SusGrip 3F Mechanical Dimensions (Closing)

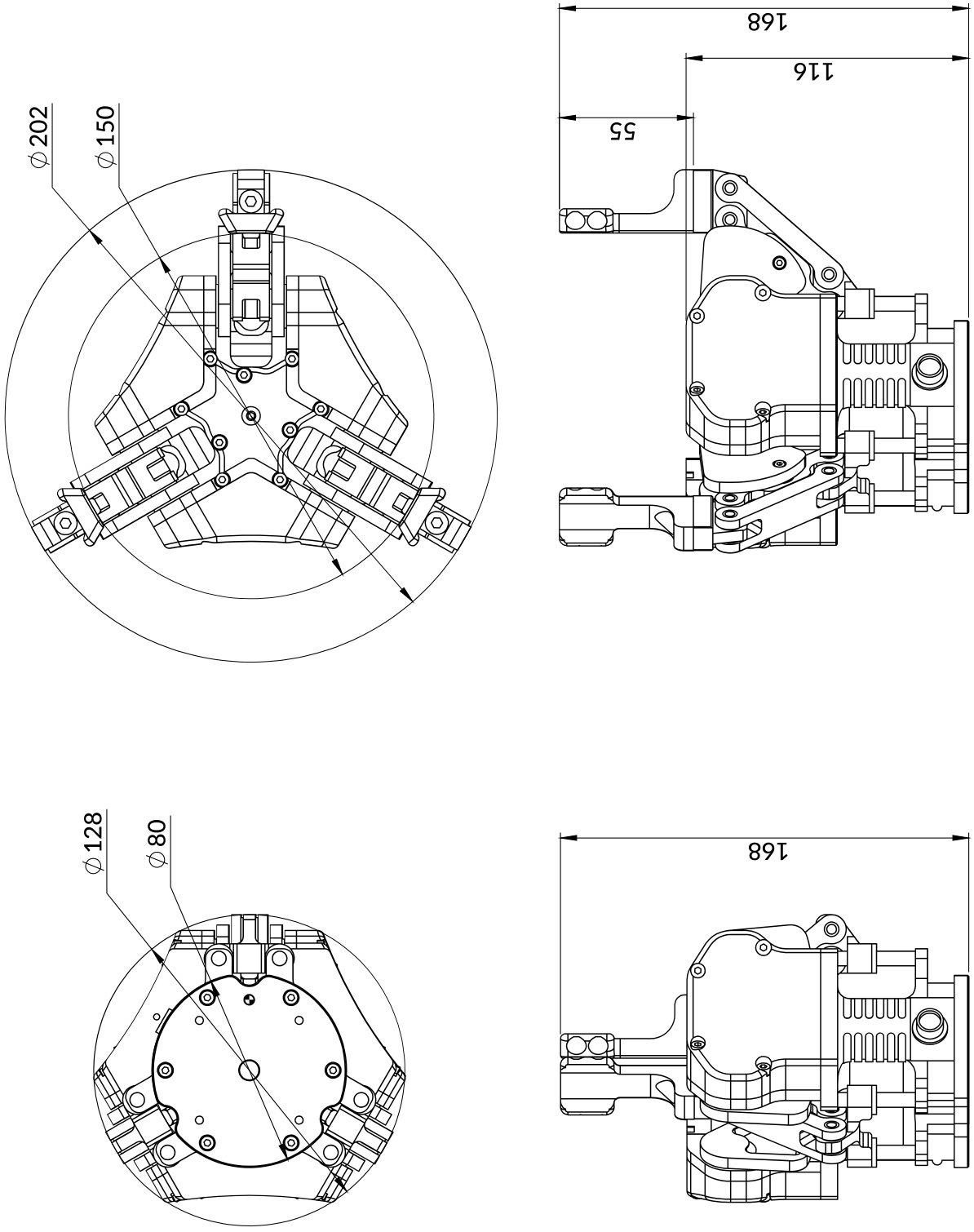


Figure 3.7 - SusGrip 3F Mechanical Dimensions (All, Rotated)

3.2. CoM, TCP, and Moment of Inertia

The table below elaborates the parameters for Center of Mass (CoM) and Tool Centre Point (TCP) of the standard variant of the SusGrip-2F and SusGrip-3F grippers:

Table 3.1 - SusGrip 2F & 3F CoM, TCP (Standard)

TYPE	CENTER OF MASS (mm)			TCP (mm)			MASS (g)
	X	Y	Z	X	Y	Z	
SUSGRIP-2F	0.00	2.00	61.50	0.00	0.00	167.00	1250.00
SUSGRIP-3F	1.00	-2.00	66.00	0.00	0.00	168.00	1540.00

Parameters computed with SusGrip standard fingertips installed.

The Moment of Inertia of the SusGrip-2F gripper when fully opens is as follow:

$$I = \begin{pmatrix} I_{xx} & I_{xy} & I_{xz} \\ I_{yx} & I_{yy} & I_{yz} \\ I_{zx} & I_{zy} & I_{zz} \end{pmatrix} = \begin{pmatrix} 6304 & -5 & 18 \\ -5 & 7313 & 199 \\ 18 & 199 & 1895 \end{pmatrix}$$

The Moment of Inertia of the SusGrip-3F gripper when fully opens is as follow:

$$I = \begin{pmatrix} I_{xx} & I_{xy} & I_{xz} \\ I_{yx} & I_{yy} & I_{yz} \\ I_{zx} & I_{zy} & I_{zz} \end{pmatrix} = \begin{pmatrix} 10313 & 12 & 132 \\ 12 & 10299 & -286 \\ 132 & -286 & 3442 \end{pmatrix}$$

3.3. I/O Interface

The SusGrip 2F and SusGrip 3F grippers offer a 9-pin port for power, signals, and Modbus RTU communication via RS485+ and RS485- pins. The figure below demonstrates the pin mapping of the I/O port:

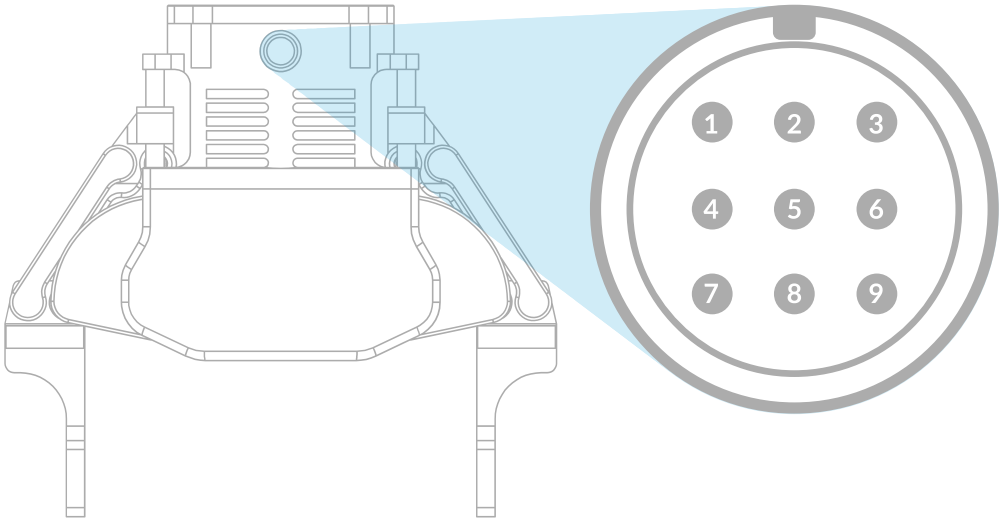


Figure 3.8 - SusGrip 2F & 3F I/O Port Pin Map

Table 3.2 - SusGrip 2F & 3F I/O Port Pin Map

PIN	TYPE	FUNCTIONALITY	NOTE
1	PWR	POWER SUPPLY 0VDC	
2	RS485	RS485 B-	
3	DO	OBJECT DETECTION SIGNAL OUTPUT	PNP 24V Output
4	RS485	RS485 GND	
5	DO	MOTION STATUS SIGNAL OUTPUT	PNP 24V Output
6	DI	GRIPPER OPEN/CLOSE SIGNAL INPUT	PNP 24V Input
7	RS485	RS485 A+	
8		NOT CONNECTED	
9	PWR	POWER SUPPLY 24VDC	

- PWR: Power supply;
- RS485: RS485 data bus;
- DO: Digital output;
- DI: Digital input;

3.4. Product Ratings

The specifications of the standard variant of SusGrip-2F and SusGrip-3F are listed in the table below:

Table 3.3 - SusGrip-2F and SusGrip-3F Ratings

PARAMETER	VALUE	UNIT
STROKE [1]	(2F) 1~130 | 0.04~5.04	mm | inches
	(3F)10~150 | 0.4~5.90	
HOLDING FORCE [2]	(normal) up to 100	N
	(uncaged) up to 180	
FORM-FIT PAYLOAD	5.0	Kg
	11.0	Lbs
WEIGHT	(2F) 1.25 | 2.75	Kg | Lbs
	(3F) 1.54 | 3.39	Kg | Lbs
OPERATIONAL VOLTAGE	20-25	Volts (DC)
ABSOLUTE LIMIT VOLTAGE	15-30	Volts (DC)
MAXIMUM CURRENT DRAW [3]	(normal) < 2.0	Amperes (DC)
	(uncaged) up to 10.0	
OPERATIONAL TEMPERATURE	-5.0~55.0	°C
FINGER POSITION RESOLUTION	0.1	mm
FINGER CONTROL RESOLUTION	1.0	mm
FINGER MAXIMUM SPEED [4]	(2F) 240.0	mm/s
	(3F) 300.0	

(1) Stroke (fingers position) is computed differently between 2F and 3F. On SusGrip-2F, stroke is the distance between the 2 fingers, whereas on SusGrip-3F, stroke is the diameter of concentric grasping.

(2) Uncaged mode is a feature that allows the gripper to bypass most constraints and operate with much greater strength and power.

(3) Under normal operation (Uncaged mode disabled), current draw by the gripper is affected by the force setting set by users. Normally this value is < 2.0A but can spike above this level for a brief moment when collision with the objects first occurs.

(4) Similar to stroke, fingers speed is computed differently on SusGrip-2F and SusGrip-3F. As a rule of thumb, using the same speed value, the 3F is approximately 2 times faster than the 2F.

3.5. Compatibility with Universal Robots (UR)

The SusGrip family and its variants are compatible with Universal Robots (UR). The table below shows detailed information:

Table 3.4 - SusGrip Gripper Compatibility with UR Arms

SUSGRIP	CB3.1	POLY-SCOPE 5	POLY-SCOPE X
GRIPPER IO	Compatible	Compatible	Compatible
GRIPPER RS485 (TOOL IO)	Deprecated	Compatible	Not yet
GRIPPER RS485 (CONTROL BOX)	Deprecated	Compatible	Not yet
URCAP PACKAGES	Deprecated	Available	Not yet

SusGrip grippers can draw more than 1.5A of power supply current, depending on users' settings. The Tool IO power supply from UR arms is rated for 1.5A using single pin, or 2.0A using dual-pin power. Users should configure the settings for force and over-current protection (OCP) on SusGrip to prevent triggering emergency stop of the robot.

If more power is needed, it is recommended to connect SusGrip to the robot's control box and use an external 24VDC power supply unit.

The URCap for SusGrip supports controlling of multiple grippers at the same time.

4 - INSTALLATION GUIDE

4.1. Setup Overview

This section discusses the components in the SusGrip package and ways of setting up the gripper for various use cases.

The SusGrip gripper physical package arrives at users with the following components:

- 01 SusGrip gripper;
- 02 default SusGrip fingers for 2F, or 03 fingers for 3F;
- 02 dowel pins + 01 M5 bolts for each finger;
- 04 M5 bolts for robot end-effector;
- 01 4-meter SusGrip cable;
- 01 USB-to-RS485 device.

Addtionally, if requested by users at purchase, the following components can be included:

- Customized fingers for specific applications;
- Customized tool flanges for specific robot models;
- Customized cables for specific I/O ports;
- USB drive for documents and softwares.

Mechanical setup guidance is elaborated next.

4.2. Mechanical Setup

4.2.1. Fingertips Installation

The required tools to install fingertips onto SusGrip grippers:

- An M4 hex screw (or Allen key);
- Low strength threadlocker (such as Loctite 243).

The required parts (provided in the package) to install fingertips:

- 02x M5x8 bolts for SusGrip-2F | 03x M5x8 bolts for SusGrip-2F;
- 02x Fingertips for SusGrip-2F | 03x Fingertips for SusGrip-3F;
- 04x Dowel pins Ø3x8 for SusGrip-2F | 06x Dowel pins Ø3x8 for SusGrip-3F;

To install the fingertips onto the gripper base:

- Align the Fingertip indexing pins with the finger dowel holes;
- Insert the dowel pins and mount the fingertips on top;
- Apply low strength threadlocker onto the bolts;
- Insert the M5x8 SHCS bolts;
- Use up to 3N.m of torque to tighten the M5x8 bolts.

The figure below demonstrates the fingertips installation process:

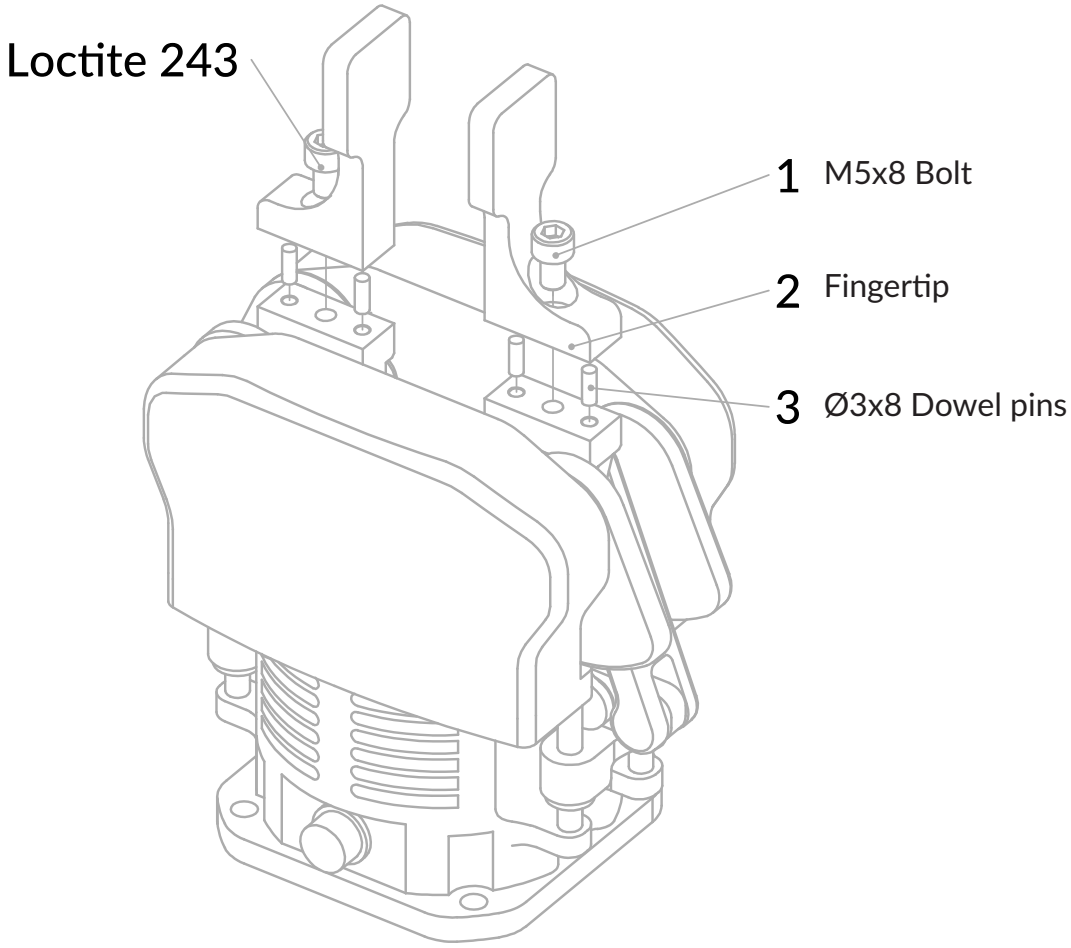


Figure 4.1 - Fingertips Installation onto SusGrip Grippers

4.2.2. Gripper Installation onto Robot

The required tools to install SusGip grippers onto robot arm:

- An M5 hex screw (or Allen key);

Depending on the gripper type, and robot endtool dimensions and specifications, a special adaptive flange with suitable bolts might be provided. The figure below demonstrates an example installation process:

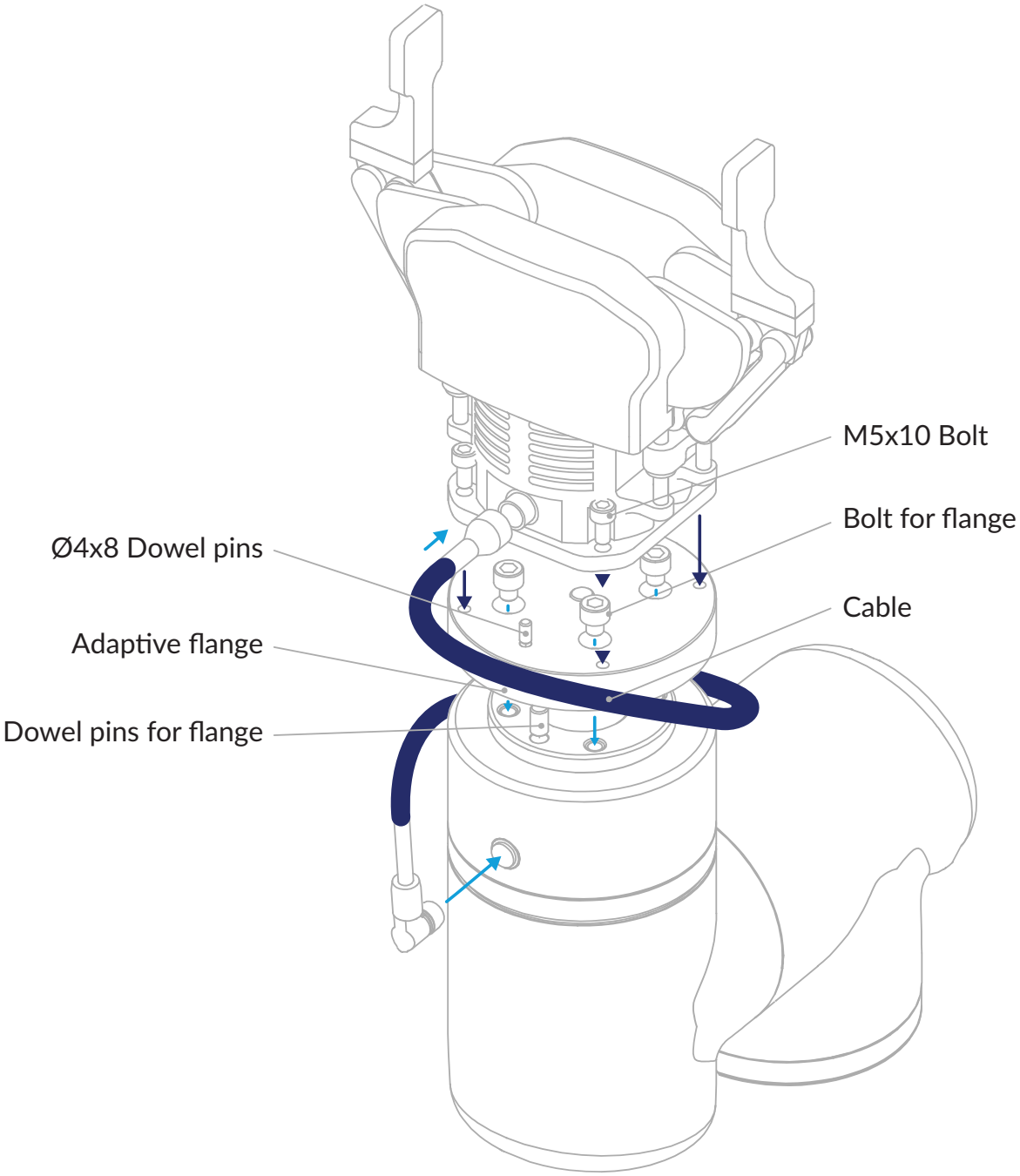


Figure 4.2 - SusGrip Gripper Installation on Robot Arm

Certain robots might require additional layers of flange, for example:

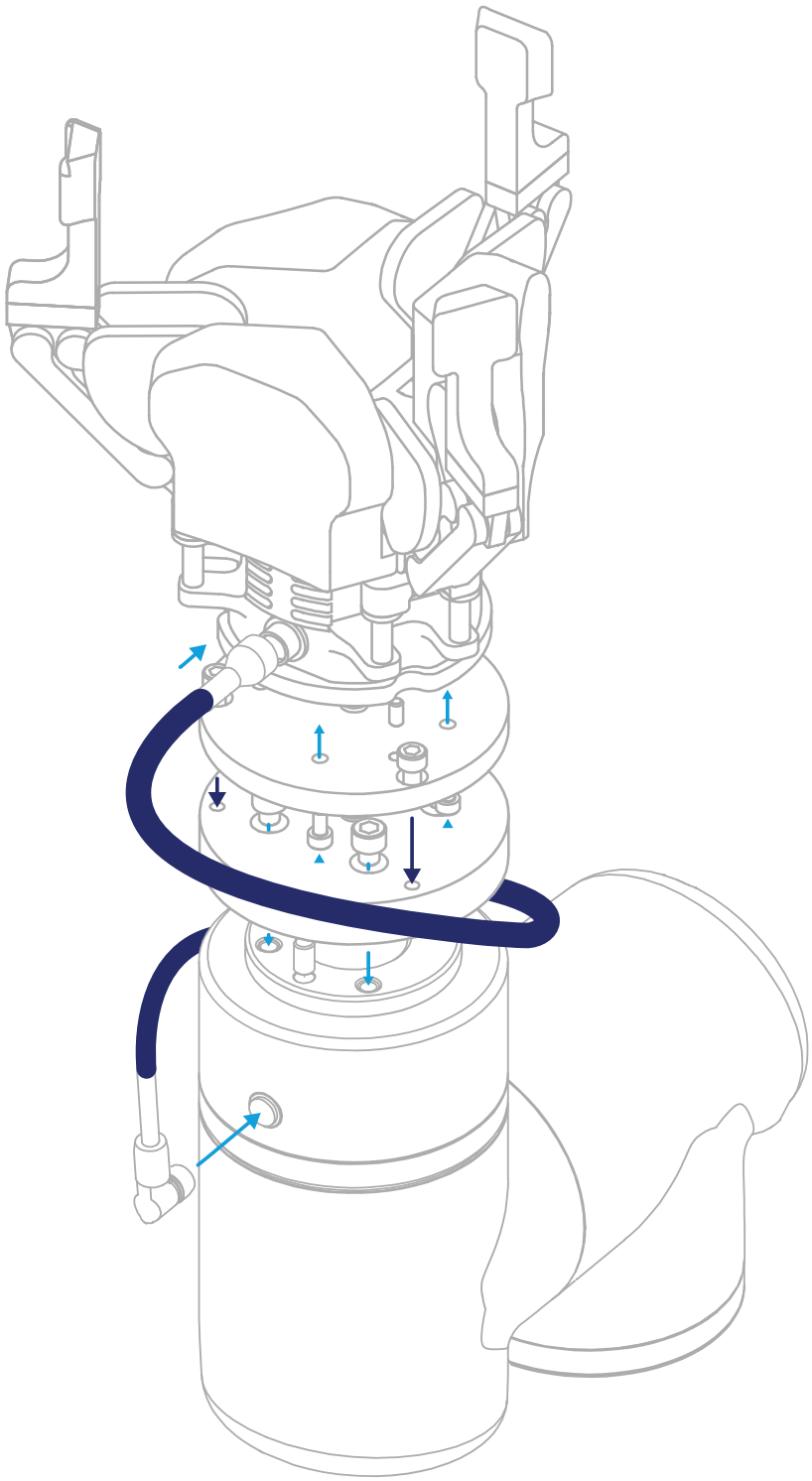


Figure 4.3 - SusGrip Gripper Installation on Robot Arm with Additional Flanges

4.3. Flange Dimensions

Refer to this section if users wish to self-fabricate customized adaptive flange for SusGrip grippers.

The figure below shows the flange cap dimensions of the standard variant of the SusGrip-2F gripper:

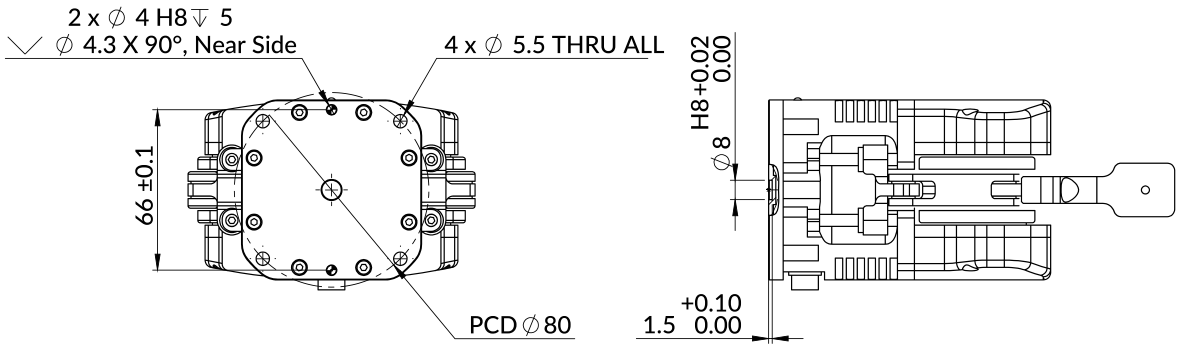


Figure 4.4 - Standard SusGrip-2F Gripper Flange Cap

The figure below shows the flange cap dimensions of the standard variant of the SusGrip-3F gripper:

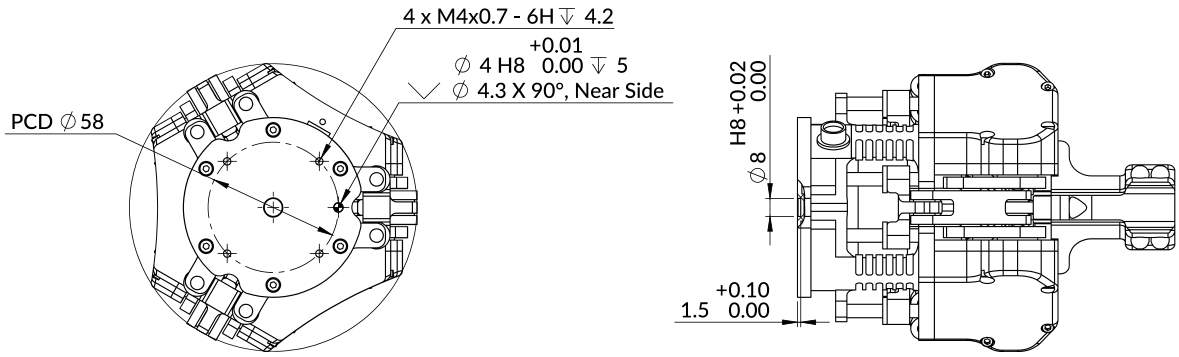


Figure 4.5 - Standard SusGrip-3F Gripper Flange Cap

Next, fingerbase dimensions are described.

4.4. Fingers Customization

The SusGrip 2F and SusGrip 3F grippers offer effortless swapping of a wide variety of finger designs. Users can create customized finger types that are best suited to their specific applications and install onto SusGrip's finger base following the dimensions specified:

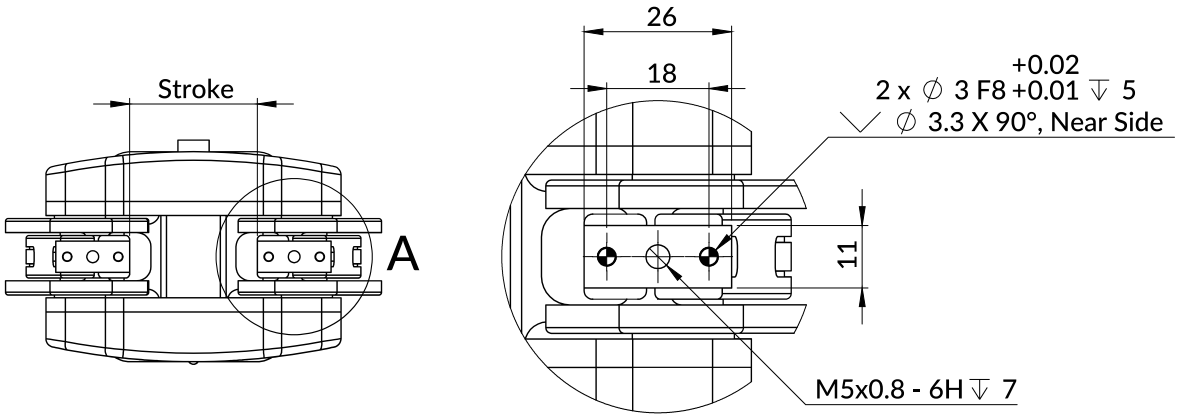


Figure 4.6 - Standard SusGrip Finger Base

The standard variant of SusGrip-2F and SusGrip-3F grippers has the same finger base design.

For design reference, the following figures shows the standard finger design of SusGrip-2F and SusGrip-3F grippers:

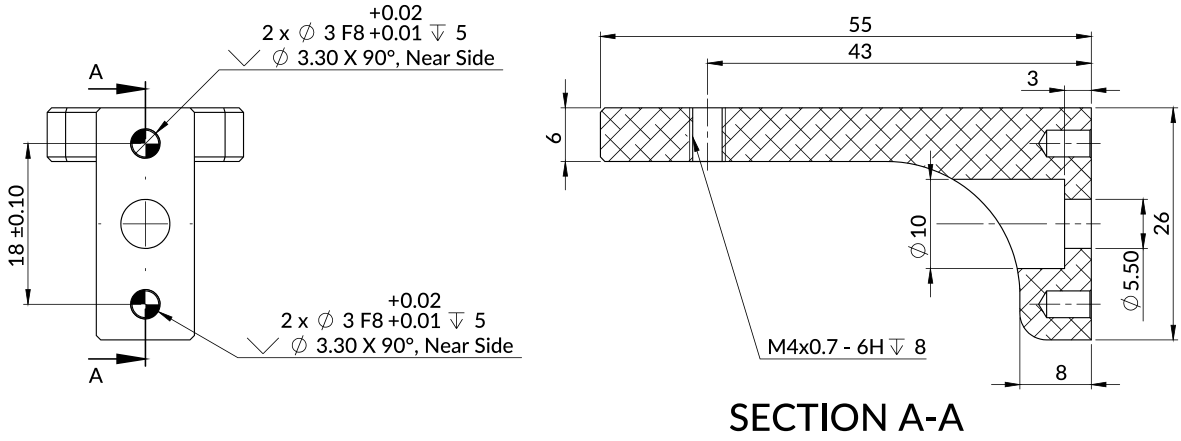


Figure 4.7 - Standard SusGrip-2F Finger Design

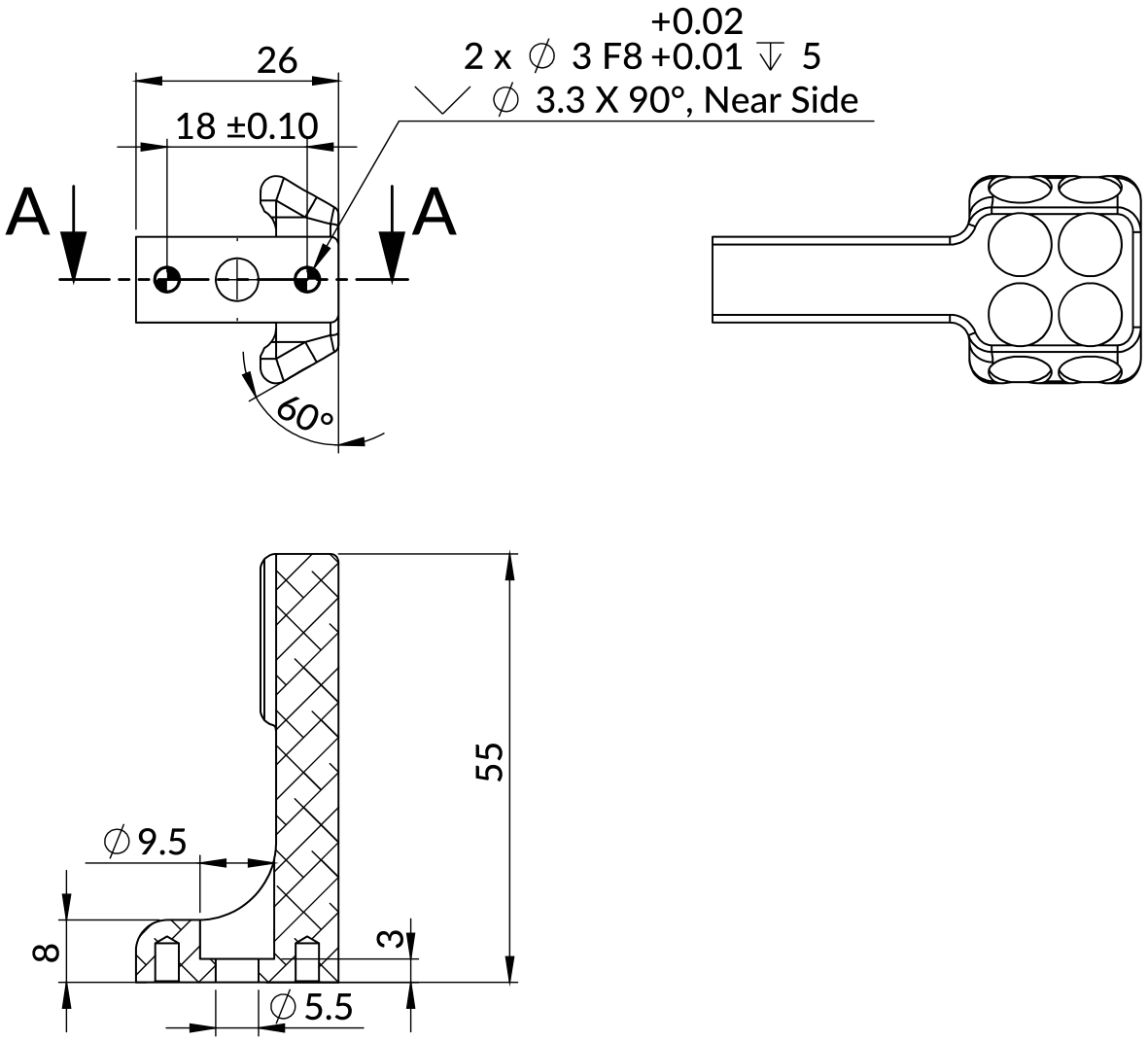


Figure 4.8 - Standard SusGrip-3F Finger Design

4.5. Electrical Setup

First, connect the gripper with the provided SusGrip cable with the key properly aligned:

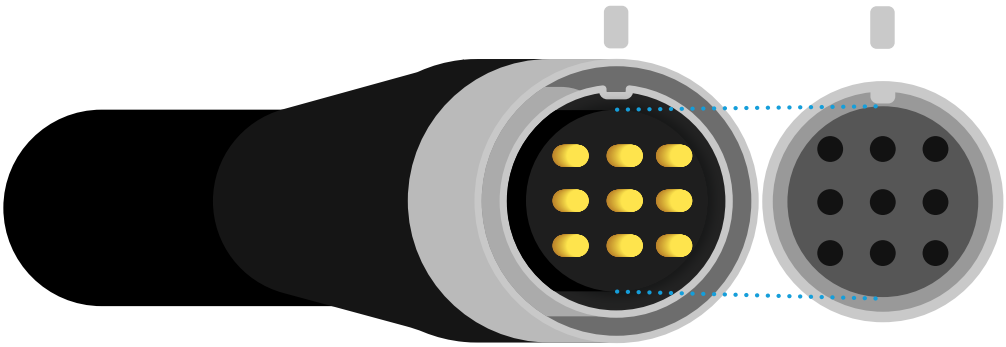


Figure 4.9 - Connect SusGrip Cable to the Gripper

4.5.1. RS485 Connection

SusGrip grippers can be operated via Modbus RTU over RS485. On the open end of the provided SusGrip cable, connect as follow:

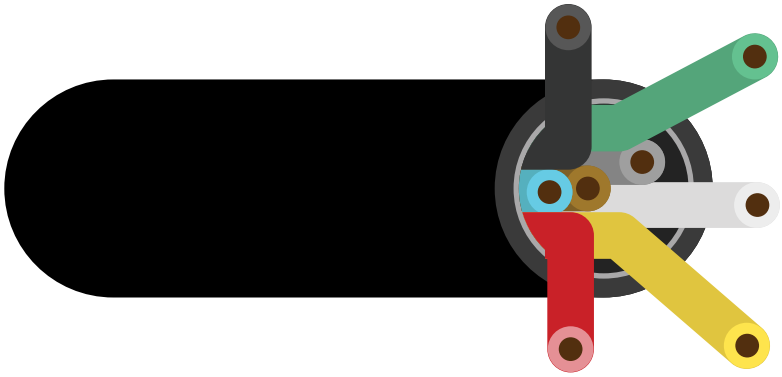


Figure 4.10 - SusGrip Cable Connection with RS485

Table 4.1 - SusGrip Cable Connection Guide with RS485

WIRE	TYPE	ON GRIPPER	CONNECT TO
RED	PWR	POWER SUPPLY 24VDC	24VDC POWER SUPPLY
BLACK	PWR	POWER SUPPLY 0VDC	0VDC POWER SUPPLY
YELLOW	RS485	RS485 A+	RS485 BUS A+
GREEN	RS485	RS485 B-	RS485 BUS B-
WHITE	RS485	RS485 GND (shorted with 0VDC)	(OPTIONAL) RS485 BUS GND REF

4.5.2. Digital Input/Output (DIO) Connection

If users wish to control using robot's or PLC's digital inputs and outputs, on the open end of the provided SusGrip cable, connect as follow:

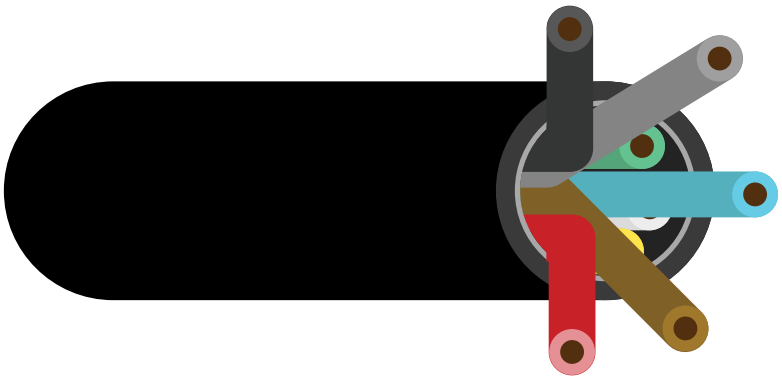


Figure 4.11 - SusGrip Cable Connection with Digital IO

Table 4.2 - SusGrip Cable Connection Guide with Digital IO

WIRE	TYPE	ON GRIPPER	CONNECT TO
RED	PWR	POWER SUPPLY 24VDC	24VDC POWER SUPPLY
BLACK	PWR	POWER SUPPLY 0VDC	0VDC POWER SUPPLY
BLUE	DI	OPEN/CLOSE INPUT	24V PNP (SOURCING) OUTPUT
BROWN	DO	MOTION STATUS OUTPUT	24V PNP (SOURCING) INPUT
GREY/ ORANGE	DO	OBJECT STATUS OUTPUT	24V PNP (SOURCING) INPUT

If the gripper is already powered on but cannot be controlled with 24V input signals, it is likely because the gripper is configured to operate in Normal mode, in which all signals on the input pin are ignored.

To switch to IO mode, either send command via Modbus RTU over RS485 or use the Quick Shift feature: send 5 consecutive pulses to the input pin to quickly shift to IO mode.

Continued on the next page.

4.5.3. Example Connection to Computer via RS485-to-USB Converter

Connecting SusGrip grippers to a personal computer requires an RS485-to-USB converter device, which is provided in the package at purchase.

Follow the RS485 Connection sub-section above:

- Connect the gripper using the standard SusGrip cable;
- On the open end of the cable, connect the RS485 wires to the USB device;
- Plug the USB device into the computer;
- Provide SusGrip gripper with the appropriate power supply.

The figure below demonstrates such connection:

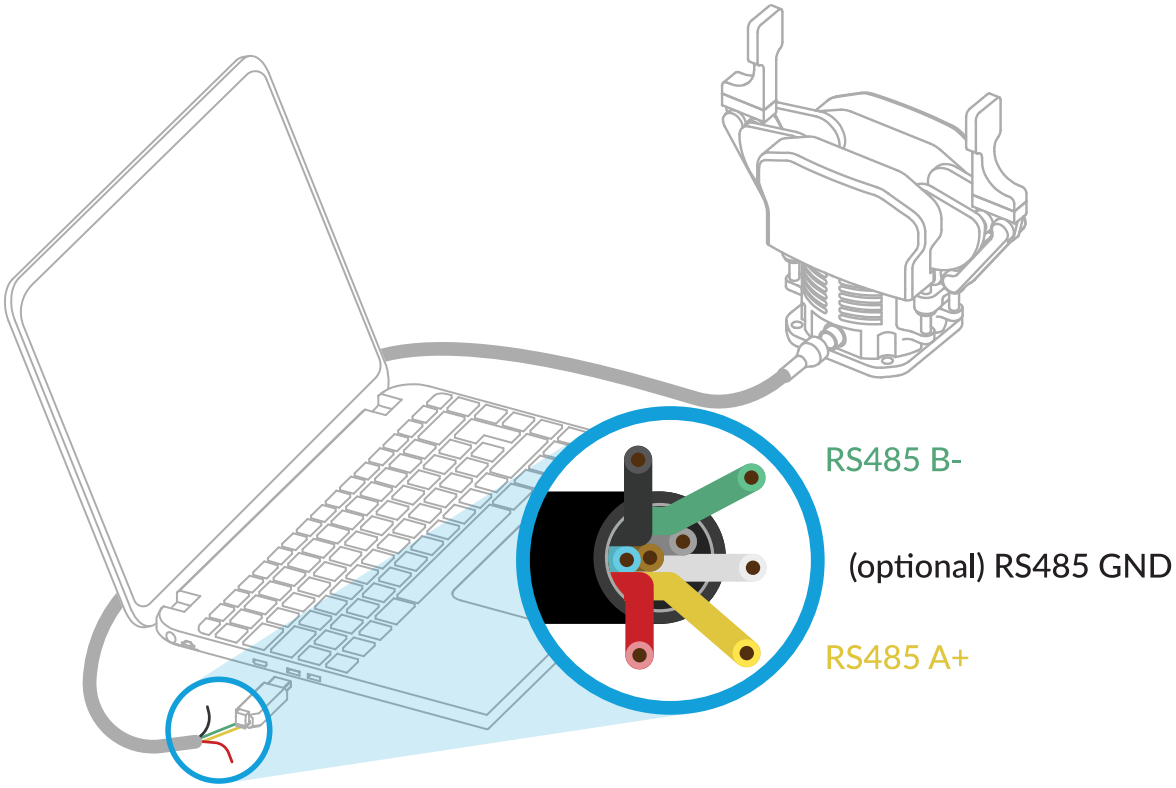


Figure 4.12 - Example Connection to Computer

Continued on the next page.

4.5.4. Example Connection to Robot RS485 Port

If a robot offers RS485 ports, simply connect using the standard SusGrip cable with the gripper and the RS485 wires on the open end to the appropriate pins of the robot's port.

Follow the RS485 Connection sub-section above:

- Connect the gripper using the standard SusGrip cable;
- On the open end of the cable, connect the RS485 wires to the robot pins;
- RS485 ports on robots are typically offered in DB9 style;
- Provide SusGrip gripper with the appropriate power supply.

The figure below demonstrates such connection:

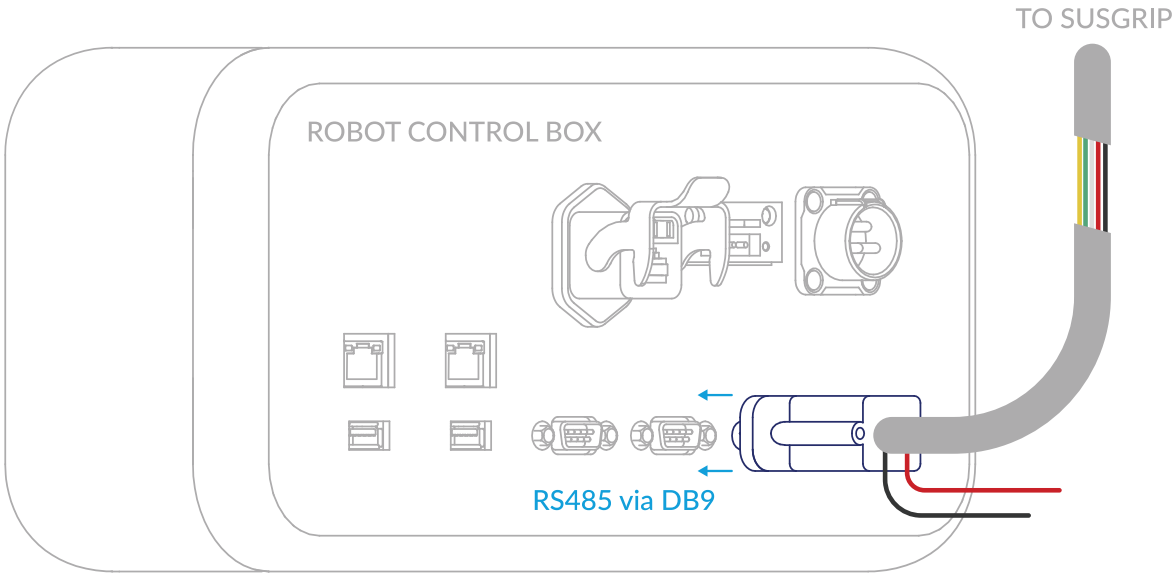


Figure 4.13 - Example Connection to Robot's RS485 via DB9 Port

4.5.5. Example Connection to Robot Serial USB Port

RS485 connection can be established if the robot offers serial communication over USB ports. In this case, connection is made similar to connecting SusGrip with a computer.

Please check the supported USB serial chip. The provided converter device is based on the chip CH34x. Some robots support only devices based on the chip FT232x (such as UR arms).

Next, software setup is discussed.

4.6. Software Setup: Apicoo Universal Console

To facilitate a seamless setup process for users, Apicoo provides the Apicoo Universal Console (AUC) application that is compatible with Microsoft Windows. Users can download the application files from the official website or contact Apicoo Robotics Customers Support for assistance.

AUC is a light-weight application that can run directly without the need for any installation procedure. To run the application, simply run the executable file and wait for the program to launch:

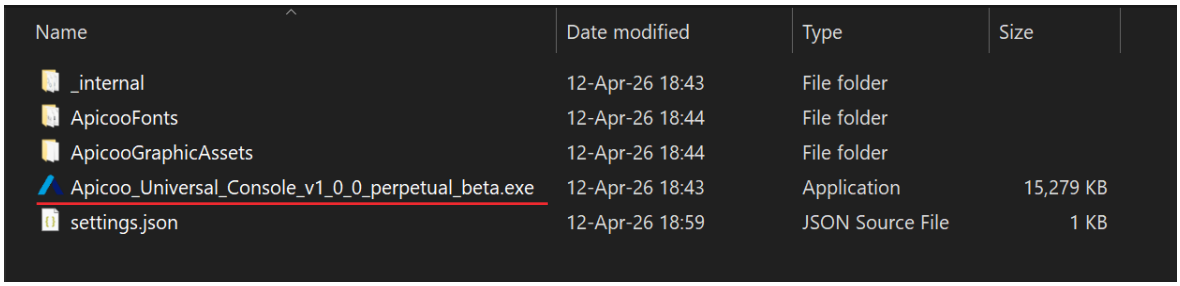


Figure 4.14 - Apicoo Universal Console (Windows PC) Files

Users may be prompted with a warning screen due to unidentified publisher. In this case, click on *More info* and choose **Run anyway**.

On successful launch, the application screen should look like this:

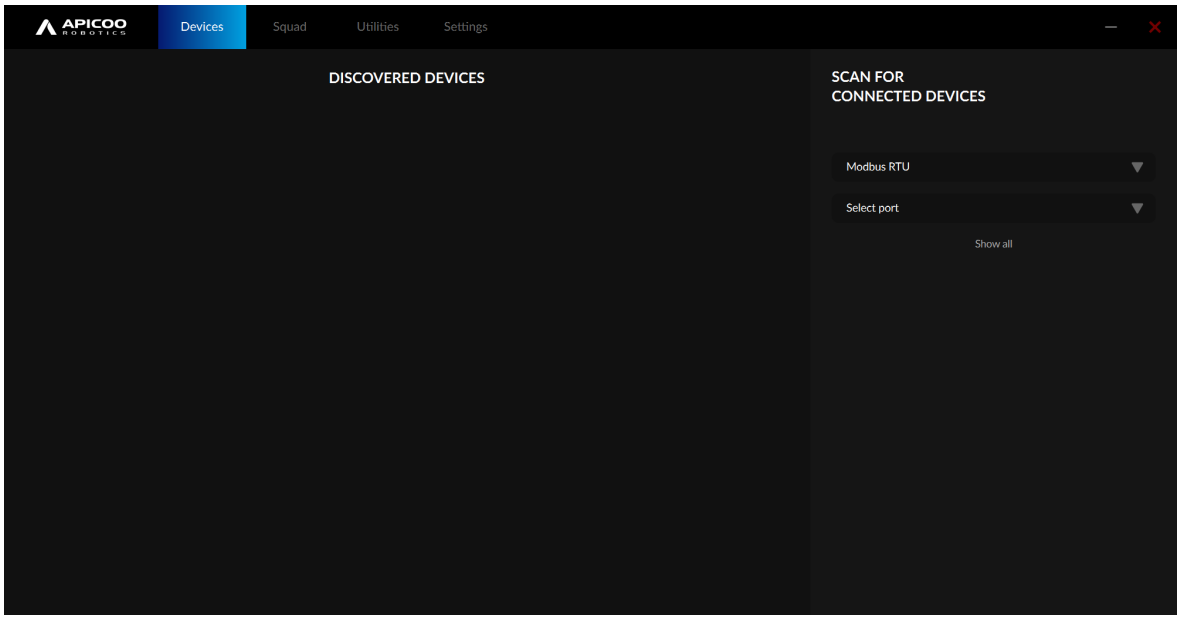


Figure 4.15 - AUC On Opened Screen

Apicoo is NOT responsible for any security issues arising from third-party hardware or software. This includes situations where users obtain software from sources other than the official Apicoo website.

5 - OPERATION GUIDE

SusGrip grippers offer two control modes: Normal mode and IO-only mode. In Normal mode, commands are sent to the gripper by accessing its Modbus registers over RS485, and signals on the input pin are ignored except for the Quick Shift signal. In IO Only mode, commands can still be received over RS485, but will be overriden by signal on the input pin.

The figure below demonstrates the internal operational structure of SusGrip-2F and SusGrip-3F grippers:

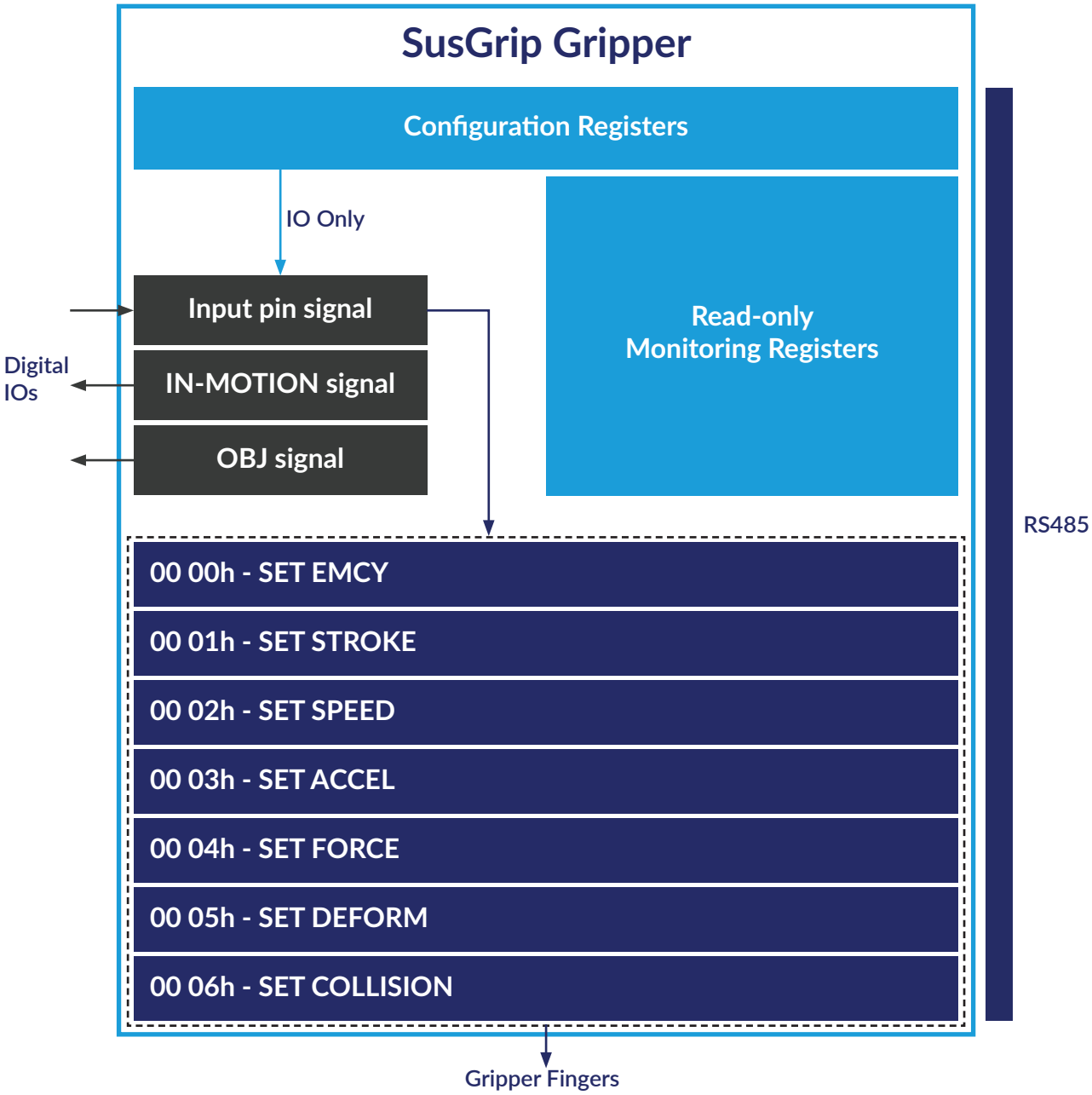


Figure 5.1 - SusGrip Gripper's Internal Commanding Structure

5.1. Features Description

SusGrip-2F and SusGrip-3F offer various operational features and customization options. This section provides a detailed description of each function of the gripper.

5.1.1. Commissioning Methods

SusGrip grippers offer two commissioning modes: Normal mode and IO-only mode. At startup, the gripper enters the mode last saved in memory.

In Normal mode, motion commands are sent to the gripper by accessing its Modbus registers over RS485, and signals on the input pin are ignored. Switching from IO-only to Normal mode can be done via Modbus RTU communication over RS485.

In IO-only mode, motion commands can still be received over RS485, but are overridden by signals on the input pin. Switching from Normal to IO-only mode can be done via Modbus RTU communication over RS485 or the Quick Shift feature.

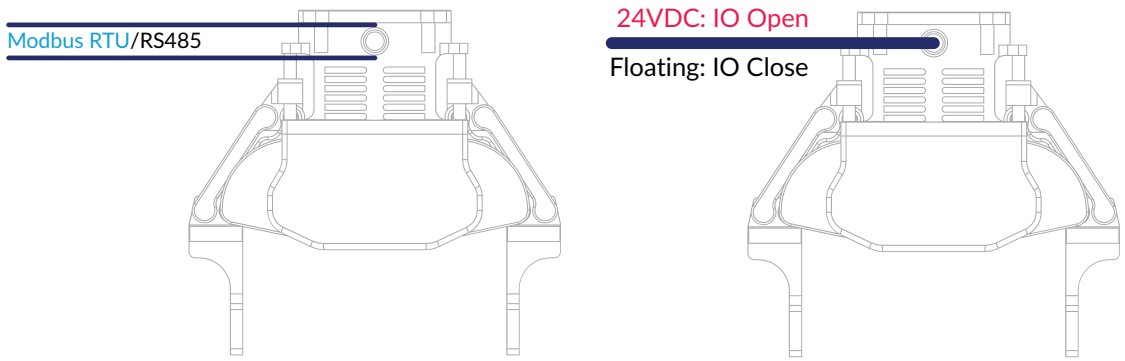


Figure 5.2 - SusGrip Gripper Modes of Commissioning: Normal mode (left) and IO Only mode (right)

5.1.2. Quick Shift of Commissioning Method

Switching from Normal to IO-only mode can be done via Modbus RTU communication over RS485. However, if communication is not possible—for example, if RS485 is inaccessible—IO-only mode can still be entered using the Quick Shift feature.

While in Normal commissioning mode, swiftly send five 24-volt pulses to the input pin of the gripper to activate Quick Shift and switch to IO-only mode without Modbus communication. This is similar to pressing a button five times in a row.

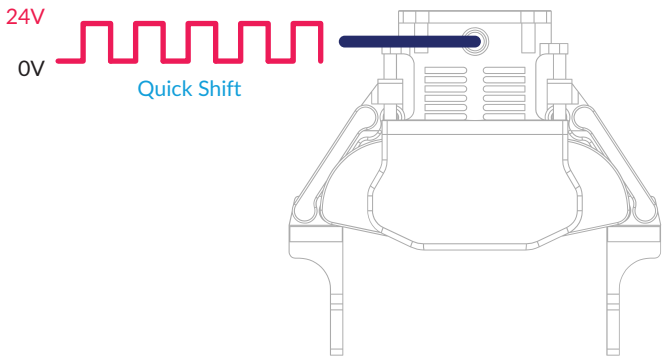


Figure 5.3 - Activate Quick Shift by swiftly tapping input 5 times with 24V

5.1.3. Customized IO Open and Close Motion

In IO Only mode, motion commands are received by sending 24V digital signal to the gripper's input pin, with 24V for opening, and 0V for closing the gripper.

The open and close stroke (fingers position), as well as the swiftness can be configured independently for opening and closing motion.

Configuration parameters are sent to the gripper via Modbus RTU communication over RS485. The configuration parameters for motion in IO Only mode are:

Table 5.1 - SusGrip Motion Parameters in IO Only mode

PARAMETER	DESCRIPTION
OPEN POSITION	Fingers position when input pin receives 24VDC.
OPEN SPEED	Fingers speed when input pin receives 24VDC.
OPEN ACCELERATION	Fingers acceleration when input pin receives 24VDC.
CLOSE POSITION	Fingers position when input pin receives 0VDC or left floating.
CLOSE SPEED	Fingers speed when input pin receives 0VDC or left floating.
CLOSE ACCELERATION	Fingers acceleration when input pin receives 0VDC or left floating.

5.1.4. Object Detection and Holding Behavior

When obstacles are detected on the travel path of the fingers, the gripper signifies object detection status and switches to exerting constant holding force. The following parameters dictate object detection and holding behavior of the gripper:

Table 5.2 - SusGrip Object Detection and Holding Parameters

PARAMETER	DESCRIPTION
HOLDING FORCE	Magnitude of holding force.
ALLOWABLE DEFORM	Maximum amount of displacement before holding force is stopped.
COLLISION THRESHOLD	Threshold for object detection.

The parameter "HOLDING FORCE" decides the magnitude of force applied for holding an object after successful detection. This parameter can be set from 0% to 100% and extended up to 160% when Uncaged feature is activated.

While applying holding force, the gripper continuously monitors object displacement by checking its finger position and comparing it to the original position at which the object was detected. When the difference exceeds the "ALLOWABLE DEFORM" value, the gripper immediately cuts off all holding force to prevent further motion..

The sensitivity for detecting objects is decided by the "COLLISION THRESHOLD" parameter. Its value is the maximum amount of effort to push the fingers toward the target position before switching to applying holding force.

Under the circumstances where the gripper fingers get stuck mechanically, raise the threshold to help them move to the target position without triggering object detection. When grasping fragile objects such as thin glass or soft organic bodies, however, lower the threshold to prevent exerting too much force during motion execution.

The figure below demonstrates the affect of these parameters on the gripper motion and object holding behavior:

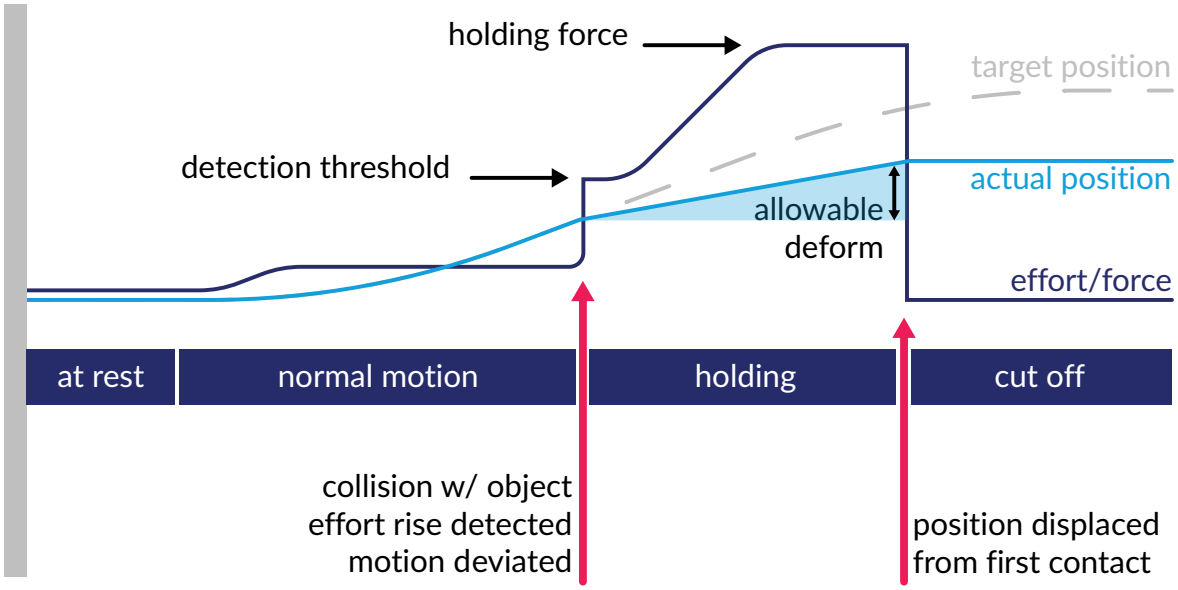


Figure 5.4 - SusGrip Motion and Object Holding Behavior

In this hypothetical scenario, the fingers start from rest and move toward the target position. During motion, a collision with an object is detected by a rise in effort and a deviation in trajectory. The gripper then applies a gradual holding force until the target holding force is reached. After a certain period, the finger position appears to drift beyond the allowable deform value. At this point, the gripper cuts off all holding force, and the fingers remain stationary.

Continued on the next page.

5.1.5. Offset for Customized Finger Designs

The position of gripper's fingers is measured at the inner surface of their base.

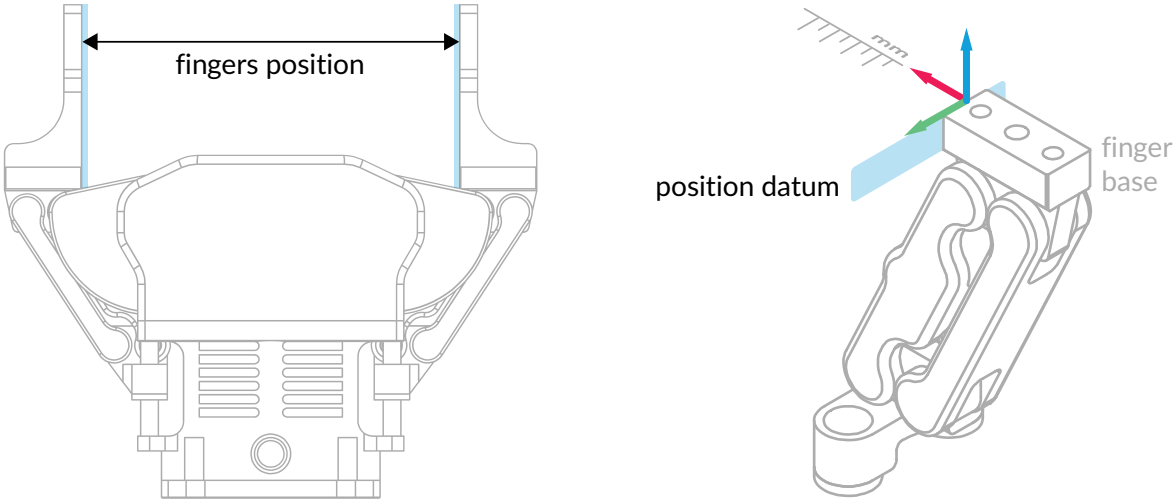


Figure 5.5 - Fingers Position Datum

For linear parallel grippers, such as the SusGrip-2F and its variants, the finger position is defined as the distance between the inner surfaces of the finger bases. For concentric parallel grippers, such as the SusGrip-3F and its variants, the position is defined as the diameter of the concentric circle formed by the inner faces of the fingers.

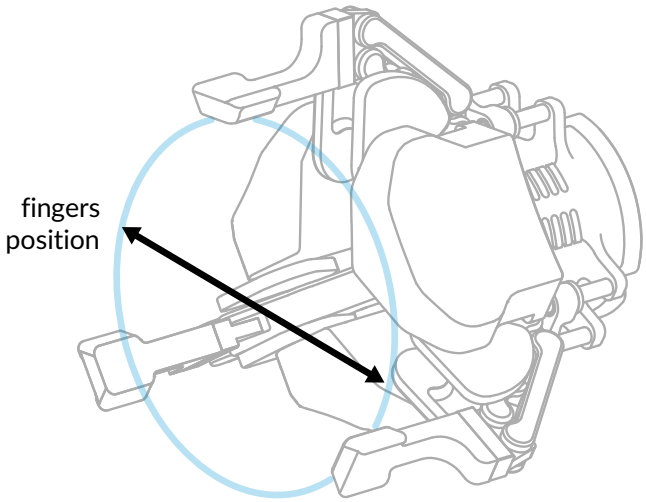
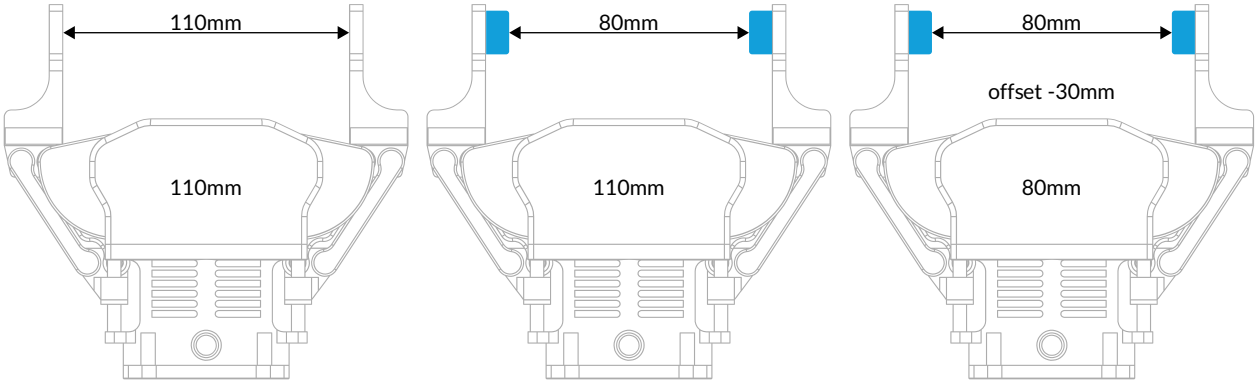


Figure 5.6 - Fingers Position on Concentric Parallel SusGrip-3F

When using customized finger designs with contact points that differ from the default position datum—for example, a design with a thick cushion attached to the fingertip—an offset value can be used to normalize the new position.

Continued on the next page.

Position offset affects both the reporting value and the motion target value. Use this fingers position offset feature on customized designs for correct motion commands and reporting, as well as to avoid false object detection due to fingers colliding with one another.



Original design:
Gap between contact points is 110mm

Customized design:
Gap between contact points is 80mm but is being treated as 110mm

With position offset:
Setting an offset value of -30mm to correct for the position of the new design

Figure 5.7 - Fingers Position Offset for Customized Finger Designs

5.1.6. Protection Features

SusGrip gripper offers operational protection, featuring Over-Current Protection (OCP), Under-Voltage Lockout (UVLO), and Over-Voltage Protection (OVP).

The OCP trip threshold can be adjusted by writing to the configuration parameters via Modbus RTU communication over RS485. This feature prevents the gripper from drawing excessive current, which may trigger errors on certain robots. For example, UR robots typically have a maximum tool I/O output current of 2.0A, in which case the OCP threshold should be set no higher than 2.0A.

The UVLO threshold is fixed at 20VDC, and the OVP threshold is fixed at 26VDC. Operating at any value outside of the 20-26VDC range will trigger emergency of the gripper. When Uncaged is enabled, however, the UVLO feature is turned off, and power supply voltage might drop to below 20VDC with intense holding force target.

Table 5.3 - Protection Threshold Values

PARAMETER	VALUE	UNIT
OVER-CURRENT PROTECTION (OCP)	(normal) 1.0~6.0	ADC
	(uncaged) 1.0~uncapped	
UNDER-VOLTAGE LOCKOUT (UVLO)	(normal) 20.0	VDC
	(uncaged) disabled	
OVER-VOLTAGE PROTECTION (OVP)	26.0	VDC

5.1.7. Uncaged Mode

For safety reasons, the gripper's performance is constrained by certain limits to ensure safe, universal commissioning. The voltage drop (UVLO feature) and maximum current (OCP feature) constraints result in lower force output than what SusGrip is capable of.

When more force is required and power supply constraints are no longer the limiting factor—for example, when using a dedicated external high-wattage power supply—Uncaged mode can be enabled to bypass these limitations and allow the gripper to draw more power for higher force output.

When Uncaged is enabled, the OCP range is not capped, and users can set the threshdhold to any value greater than 1.0A. The holding force target command limit is extended from 0-100% to 0-160%.

Extreme holding force commands will result in excessive current draw, which raises temperature, damages internal electronics and the motor, increases EMI, and may cause electrical system failure leading to fire hazards.

Uncaged mode is NOT RECOMMENDED for non-expert users. Please consult system engineers and carefully consider the risks before enabling this feature or modifying the limit threshold values.

5.1.8. Extended Object Holding Behavior

In addition to the three parameters that affect object detection and holding, the following parameters are extended features that further influence the gripper's grasping behavior:

Table 5.4 - SusGrip Extended Object Grasping Parameters

PARAMETER	DESCRIPTION
HOLD TIME	The amount of time during which target force is applied.
DECAY LEVEL	The magnitude of force decayed to after HOLD TIME elapsed.
FORCE RISE SPEED	The speed at which force rises (collision->target and target->decay).
OBJ DO NOTIFICATION	The meaning of digital output signal of the OBJ DO pin.

Continued on the next page.

When grasping objects, after the target holding force is reached, SusGrip continues exerting this force for a set period before reducing it to a lower value. This period is defined by the "HOLD TIME" parameter. This behavior is possible because SusGrip grippers feature a self-locking mechanism, allowing the holding force to be maintained at a reasonable level without continuous active effort.

HOLD TIME is typically set to between 1 to 5 seconds. Longer HOLD TIME at high force raises the temperature, while short HOLD TIME might result in insufficient grip.

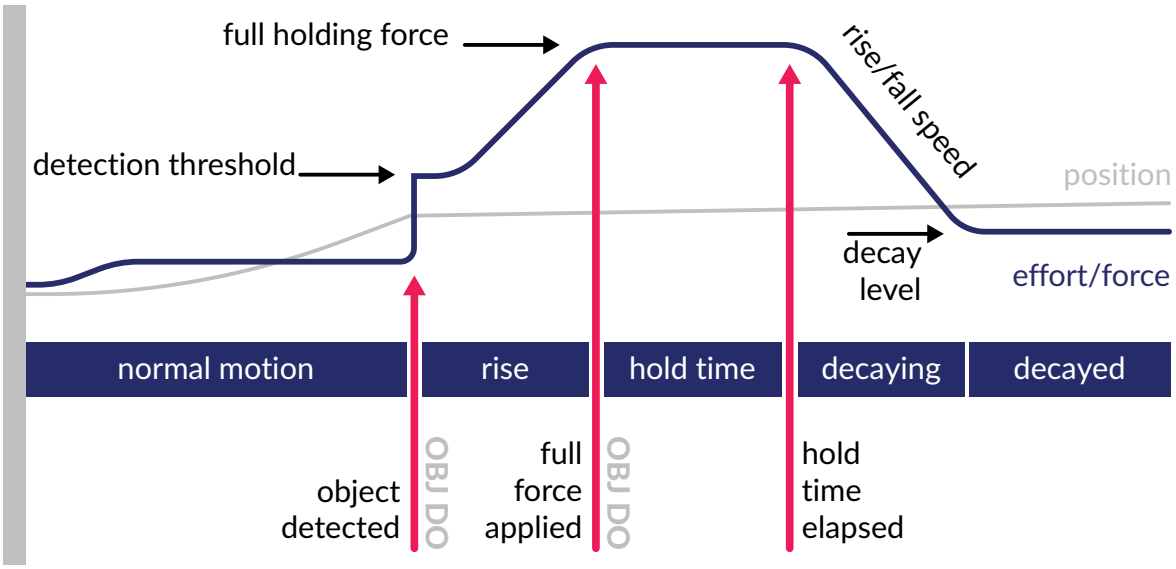


Figure 5.8 - SusGrip Extended Object Grasping Behavior

After the HOLD TIME period has elapsed, force is lowered to the value of the "DECAY LEVEL" parameter.

The speed at which force is raised or lowered is determined by the "FORCE RISE SPEED" parameter. This is a four-level setting, with level 3 being the fastest and level 0 the slowest. A lower rise speed is gentler and better for fragile objects but takes longer to reach full force, while a higher rise speed reduces this delay but may cause force overshoot.

The OBJ DO (Object Digital Output) is a digital output pin on SusGrip that provides notification of object events. There are two possible events to report:

when an object is first detected and when the holding force is fully applied.

The "OBJ DO NOTIFICATION" parameter selects which event is reported. The DO reporting logic is as follows:

No OBJ event = 0VDC | 24VDC = OBJ event occured.

Use these extended parameters to refine and balance between force requirement, process time, and temperature.

If HOLD TIME is set to 0s, force decay never happens, and full force is applied indefinitely until the next motion command.

5.1.9. Events Reporting Digital Outputs and LED

SusGrip grippers offer 02 digital output pins that are of type PNP (Sourcing) that report fingers motion status and object events.

The Object Event Digitial Output (OBJ DO) pin reports the events related to object detection and grasping behavior, as elaborated in the previous sub-section. The diagram below shows the output state of this pin in such an event:

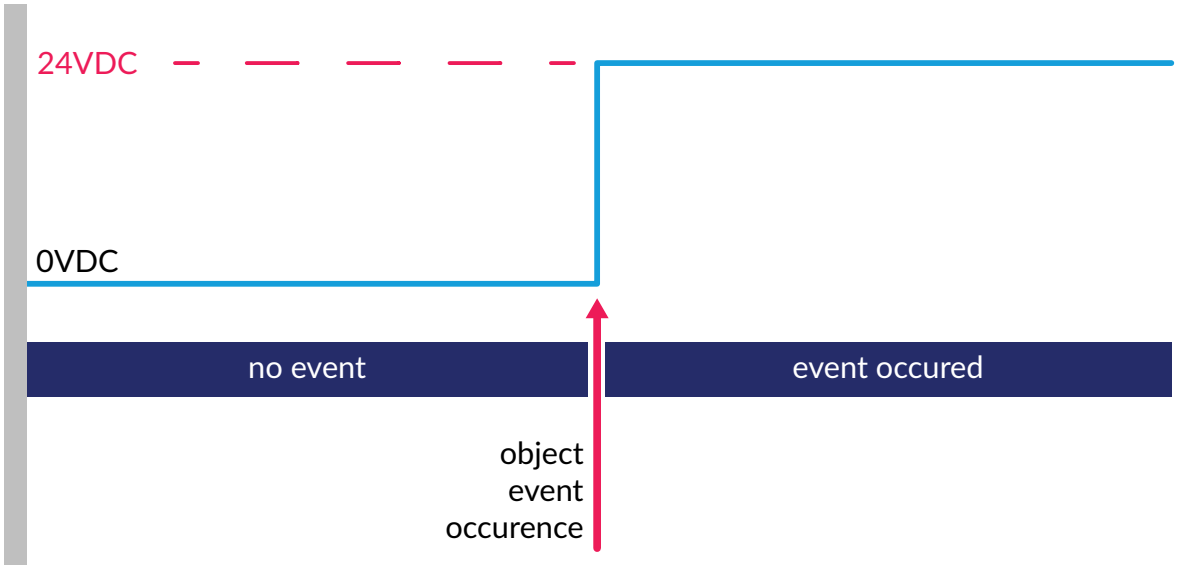


Figure 5.9 - Timing Diagram of OBJ DO Pin

When an object-related event occurs, OBJ DO pin voltage is raised to 24VDC and remained at this level until the object status changes. Using processors with digital inputs (DI) PNP for 24V, users can read from this pin to get notified about object events by polling for logic HIGH or via RISING EDGE detection.

Continued on the next page.

The Motion Event Digitial Output (MOV DO) pin reports the event of fingers finishing motion, whether they reached the target destination or are prevented from further motion due to abrupt stop on object collision or emergency. The diagram below shows the output state of this pin in such an event:

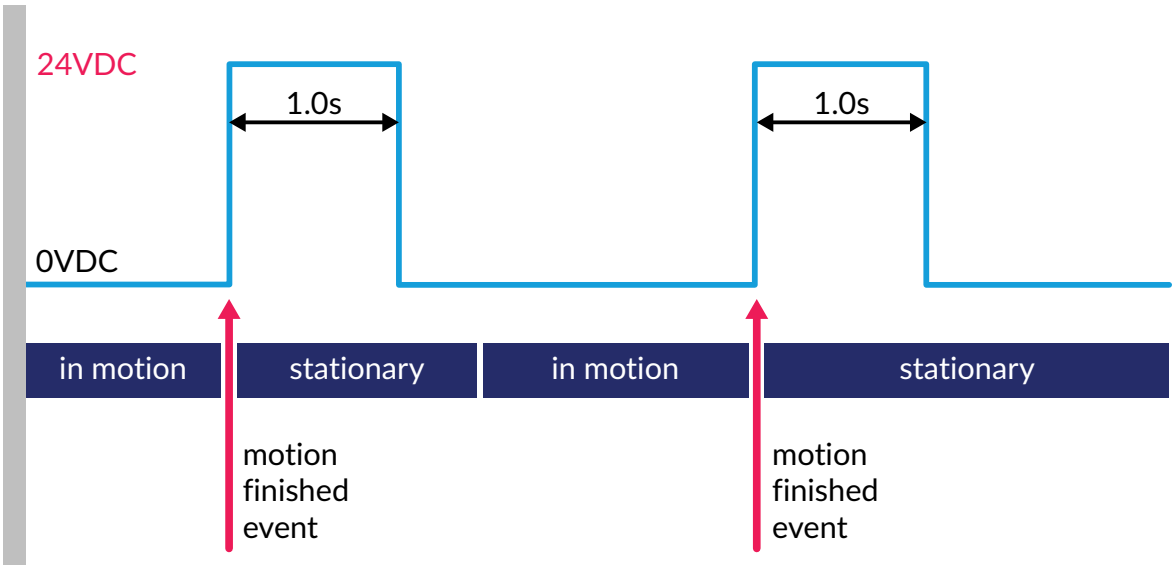


Figure 5.10 - Timing Diagram of MOV DO Pin

When gripper's fingers motion stops, MOV DO pin voltage is raised to 24VDC and remained at this level for exactly 1.0 second before it is dropped. Using processors with digital inputs (DI) PNP for 24V, users can read from this pin to get notified about the motion status of the fingers. Polling for logic HIGH and RISING EDGE detection give information about the exact moment motion finishes, while FALLING EDGE detection gives information that 1.0 second has passed since fingers stopped.

Modbus RTU communication over RS485 gives even more detailed status and monitoring of every parameter. In case the 2 DO pins are not used, they can be disabled in the configurations. When disabled, the DO pins remain at 0VDC always.

The blue LED reports partial information of gripper's object status and error:

- IDLE BLUE: No errors, no events;
- DOUBLE BLINKS -> ON: Object events occurred;
- TRIPLE BLINKS -> OFF: Errors occurred;
- SINGLE BLINKS: Special event - Memory Save in progress.

LED blinking may cause discomfort. In such cases, it can be disabled in the configuration parameters.

5.1.10. Modbus RTU Server Modification

Modbus RTU (MBRTU) is canonically known with the Master-Slave convention. In this document, however, the terminologies Client and Server are going to be used instead, where MBRTU Client refers to the conventional MBRTU Master, and MBRTU Server refers to the conventional MBRTU Slave.

SusGrip gripper's MBRTU Server parameters such as Server ID, Serial Baud Rate, Serial Parity, and Serial Stop Bits can be modified by writing to the configurations.

Changes to Server ID take effects immediately as long as emergency is activated to prevent accidental uncontrolled motions.

Changes to serial properties like Baud Rate, Parity, and Stop Bits require being saved to memory and will take effect on a new power cycle.

If users forget the modified serial properties, a special "RESET-TO-DEFAULTS" firmware can be used to bring all parameters to factory defaults.

5.1.11. Firmware Updates

SusGrip grippers support easy firmware updates via serial communication over RS485. To perform a firmware update (FWU), users must have access to the target SusGrip gripper, a 24 VDC power supply, the SusGrip cable, an RS485-to-USB converter, and a personal computer.

FWU is performed using Apicoo Universal Console. When the gripper first receives power, a 5-second window is allotted during which the software attempts to enter FWU. Upon successful FWU, the gripper requires a power cycle to resume normal operation.

The FWU procedure is typically:

1. Power off the gripper;
2. Connect the RS485-to-USB device to the RS485 pins of the gripper;
3. Connect the RS485-to-USB device to the computer via a USB port;
4. Open AUC on the computer and go to Device firmware update utility;
5. Select the firmware file to be uploaded and connect to communication port;
6. Power on the gripper with 24VDC;
7. Within 5 seconds, start the FWU process in the software;
8. Wait for FWU completion then power down;
9. Power up again to start normal operation again.

If errors occurred during the FWU process, the gripper might not function. Users may re-attempt the FWU procedure again until success. If the errors persist, please contact Apicoo Robotics for further support.

5.2. Modbus RTU Communication

Motion commands and configuration parameters are sent to the SusGrip gripper via Modbus RTU (MBRTU) communication over RS485. In this protocol, the SusGrip gripper acts as an MBRTU server (conventionally referred to as a slave) that executes incoming requests from an MBRTU client (conventionally referred to as a master).

5.2.1. Modbus RTU Server Properties

The table below shows the properties of SusGrip MBRTU Server:

Table 5.5 - SusGrip Modbus RTU Properties

PARAMETER	VALUE				UNIT
MODBUS SERVER ID	1~247				
SUPPORTED MODBUS FUNCTIONS	FC03	FC04	FC06	FC16	
THROWABLE EXCEPTIONS	01 - Illegal Function	02 - Illegal Data Address			
INTERFACE	RS485 half-duplex				
SUPPORTED SERIAL BAUD RATES	2400	4800	9600	19200	bits/s
	38400	57600	115200		
SERIAL DATA BITS	8				bits
SUPPORTED SERIAL PARITIES	None	Odd	Even		
SUPPORTED SERIAL STOP BITS	1	2			bits
EXPECTED RESPONSE INTERVAL	< 200 @115200bps				ms
MAXIMUM FRAME SIZE	30 (server responds)	30 (server receives)			bytes

The SusGrip RTU server's registers are classified into the following types:

- Motion Command Registers;
- Configuration Registers;
- Monitoring Registers.

Motion Command Registers are Modbus Holding Registers (Analog Output Holding Registers) used to directly control the gripper's fingers. These registers can be read and written at any time, regardless of the operating mode. In IO-only mode, however, they are overridden by signals on the input pin.

Configuration Registers are Modbus Holding Registers (Analog Output Holding Registers) used to send configuration settings such as the operating mode, server (slave) ID, baud rate, and safety protections. These registers can be read and written at any time, regardless of the operating mode.

Monitoring Registers are Modbus Input Registers (Analog Input Registers) used to read data from the gripper for monitoring purposes. These registers can be read at any time, regardless of the operating mode.

5.2.2. Modbus RTU Registers Map

Register addresses are given in hex-decimal format, unless specified otherwise.

Motion Command Registers and Configuration Registers are Holding Registers and have read-write access type (RW).

Monitoring Registers are Input Registers that have read-only access type (RO).

The table below shows the list of all Modbus registers of SusGrip gripper:

Table 5.6 - SusGrip RTU Server Register Map

No	ADDRESS	NAME	DESCRIPTION	TYPE
MOTION COMMAND REGISTERS				
1	00 00	SET EMCY	Set emergency state	RW
2	00 01	SET POSITION	Set target fingers position in mm	RW
3	00 02	SET SPEED	Set target fingers speed in mm/s	RW
4	00 03	SET ACCEL	Set target fingers acceleration in mm/s/s	RW
5	00 04	SET FORCE	Set target holding force	RW
6	00 05	SET DEFORM	Set allowable object deformation in mm	RW
7	00 06	SET COLLISION	Set object detection sensitivity	RW
CONFIGURATION REGISTERS				
8	01 00	CONFIG SAVE	Save all configurations to memory	RW
9	01 01	CONFIG MODE	Change mode of operation	RW
10	01 02	CONFIG POSITION H	Target position when input is HIGH in IO Only mode	RW
11	01 03	CONFIG SPEED H	Target speed when input is HIGH in IO Only mode	RW
12	01 04	CONFIG ACCEL H	Target acceleration when input is HIGH in IO Only mode	RW
13	01 05	CONFIG POSITION L	Target position when input is LOW in IO Only mode	RW
14	01 06	CONFIG SPEED L	Target speed when input is LOW in IO Only mode	RW
15	01 07	CONFIG ACCEL L	Target acceleration when input is LOW in IO Only mode	RW
16	01 08	CONFIG FORCE	Magnitude of object holding force in IO Only mode	RW

No	ADDRESS	NAME	DESCRIPTION	TYPE
CONFIGURATION REGISTERS (continued)				
17	01 09	CONFIG DEFORM	Allowable object deformation in mm in IO Only mode	RW
18	01 0A	CONFIG OFFSET	Fingers position offset in mm	RW
19	01 0B	CONFIG COLLISION	Set object detection sensitivity in IO Only	RW
20	01 0C	Reserved	Reserved	Rs
21	01 0D	Reserved	Reserved	Rs
22	01 0E	Reserved	Reserved	Rs
23	01 0F	Reserved	Reserved	Rs
24	01 10	CONFIG OCP	Over-current protection threshold in mA	RW
25	01 11	CONFIG UNCAGED	Enable/Disable UNCAGED mode	RW
26	01 12	CONFIG HOLD	Set hold time in ms	RW
27	01 13	CONFIG DECAY	Set the current level decayed to after hold time elapsed in mA	RW
28	01 14	CONFIG CURRISE	Set the rise speed of current when grasping an object	RW
29	01 15	CONFIG OBJEVENT	Select which OBJ event to be reported by the OBJ DO pin	RW
30	02 00	CONFIG MBRTUID	Set Modbus server (slave) ID	RW
31	02 01	CONFIG BAUD	Set serial baudrate (power cycle required)	RW
32	02 02	CONFIG PARITY	Set serial parity (power cycle required)	RW
33	02 03	CONFIG STOPS	Set serial stop bits (power cycle required)	RW
34	02 04	CONFIG LEDDIS	Disable/enable LED blinking	RW
35	02 05	CONFIG OUTDIS	Disable/enable signal on DO pins	RW
MONITORING REGISTERS				
36	00 00	INFO	Gripper type (2F or 3F)	RO
37	00 01	POSITION	Instantaneous fingers position in mm	RO
38	00 02	SPEED	Instantaneous fingers velocity in mm/s	RO
39	00 03	RMS	Instantaenous motor RMS current in mA	RO

No	ADDRESS	NAME	DESCRIPTION	TYPE
MONITORING REGISTERS (continued)				
40	00 04	ERROR	Latest error code	RO
41	00 05	MOTION	Fingers movement status	RO
42	00 06	OBJ	Object detection status	RO
43	00 07	EMCY	Emergency status	RO
44	00 08	VBUS	Instantaneous supply bus voltage in mV	RO
45	00 09	IBUS	Instantaneous bus current draw in mA	RO
SPECIAL REGISTERS				
46	01 00	VER HW MAJOR	Hardware major version	RO
47	01 01	VER HW REV	Hardware revision	RO
48	01 02	VER FW	Corresponding firmware version	RO
49	01 03	YEAR FW	Firmware release year	RO
50	01 04	MONTH FW	Firmware release month	RO

The register addresses in this table are given as offset value in hex-decimal format. To obtain the PLC address, Holding Register (RW) addresses are added with 40001 (decimal), whereas Input Register (RO) addresses are added with 30001 (decimal).

For example:

RW Register SET ACCEL with address 00 03 (= 3 dec) in this table has the equivalent PLC address of: 40001 + 3 = 40004 (decimal);

For example:

RW Register CONFIG MODE with address 01 01 (= 257 dec) in this table has the equivalent PLC address of: 40001 + 257 = 40258 (decimal);

For example:

RO Register POSITION with address 00 01 (= 1 dec) in this table has the equivalent PLC address of: 30001 + 1 = 30002 (decimal);

Registers marked as Reserved (Rs) are to be released in future updates and have no effects when read or written to. Every register is of 16-bit data size.

Attempts to read from or write to register addresses not defined in this register map will result in exception 02. Attempts to use unsupported function codes will result in exception 01.

5.2.3. Motion Command Register: SET EMCY

The SET EMCY register in the Motion Command Registers group sets the emergency state for the gripper. When emergency (EMCY) is enaged, the gripper stops all on-going fingers motion and drops all holding force. Fingers then remain stationary until EMCY is disengaged:

ADDR	Data	15-0
00 00	RW	EMCY disengage = 00 00 | FF FF = EMCY engage

Bits 15~0:

All set to engage EMCY;
All reset to disengage EMCY;
Disengaging EMCY will also clear all errors.

In IO Only mode, EMCY is automatically released (disengaged) on new input signals.

5.2.4. Motion Command Register: SET POSITION

The SET POSITION register in the Motion Command Registers group sets the target fingers position to be executed by the gripper in millimeters:

ADDR	Data	15-0
00 01	RW	Target fingers position in mm

Bits 15~0:

Target stroke (fingers position) in mm;
On linear parallel grippers, this is set as the distance between 2 fingers;
On concentric parallel grippers, this is set as diameter of concentricity:

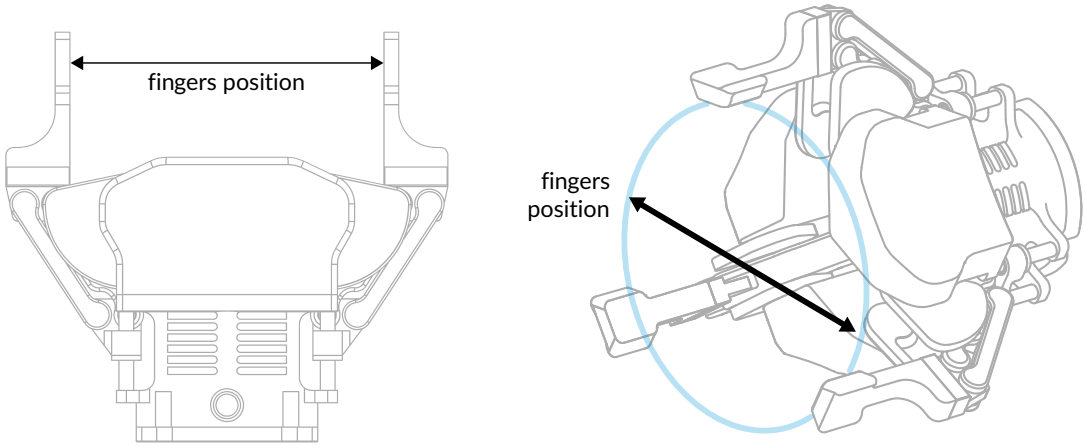


Figure 5.11 - SusGrip Finger Position Computation

At boot up, this register is set automatically to the instantaneous position.

Any values set to this register will be executed immediately and must be in the valid range, otherwise it will cause EMCY to engage automatically and raise the Invalid-Command error. This is also affected by Finger offset configuration.

5.2.5. Motion Command Register: SET SPEED

The SET SPEED register in the Motion Command Registers group sets the target fingers speed to be executed by the gripper in mm/s:

ADDR	Data	15-0
00 02	RW	Target fingers speed in mm/s

Bits 15~0:

Target fingers speed in mm/s.

This register's value is set as the maximum velocity (Vmax) for the position motion trajectory of the fingers. Whether or not the fingers can reach this set value is influenced by the maximum acceleration set (Amax) and the total distance they have to travel;

At boot up, this register copies the value of the CONFIG SPEED H (01 03) configuration register. During commissioning, this can be modified or left unchanged.

The value set should be in the valid range for the respective device, and is automatically constrained by the gripper upon successful receive.

If the target stroke is set to be within 10mm of the instantaneous stroke (e.g. 50mm now -> target 60mm), the target is treated as step target and motion trajectory is ignored. In such cases, this value plays no role in affecting the motion of the fingers.

Example: If register CONFIG SPEED H (01 03) is configured with a value of 60mm/s, this register would take 60 as the default value.

5.2.6. Motion Command Register: SET ACCEL

The SET ACCEL register in the Motion Command Registers group sets the target fingers acceleration to be executed by the gripper in mm/s/s:

ADDR	Data	15-0
00 03	RW	Target fingers acceleration in mm/s/s

Bits 15~0:

Target fingers acceleration in mm/s/s.

This value is set as the maximum acceleration (Amax) for the position motion trajectory of the fingers. This parameter influences whether the fingers can reach the set target speed.

At boot up, this register copies the value of the CONFIG ACCEL H (01 04) configuration register. During commissioning, this can be modified or left unchanged.

Continued on the next page.

This register's value is set as the maximum velocity (Vmax) for the position motion trajectory of the fingers. Whether or not the fingers can reach this set value is influenced by the maximum acceleration set (Amax) and the total distance they have to travel;

The value set should be in the valid range for the respective device, and is automatically constrained by the gripper upon successful receive.

If the target stroke is set to be within 10mm of the instantaneous stroke (e.g. 50mm now -> target 60mm), the target is treated as step target and motion trajectory is ignored. In such cases, this value plays no role in affecting the motion of the fingers.

Example: If register CONFIG ACCEL H (01 04) is configured with a value of 120mm/s/s, this register would take 120 as the default value.

5.2.7. Motion Command Register: SET FORCE

The SET FORCE register in the Motion Command Registers group sets the target force magnitude applied for holding objects:

ADDR	Data	15-0
00 04	RW	Target magnitude of holding force

Bits 15~0:

Magnitude of holding force;
When Uncaged is disabled, the magnitude is set from 0% to 100%;
When Uncaged is enabled, the magnitude is set from 0% to 160%.

At boot up, this register copies the value of the CONFIG FORCE (01 08) configuration register. During commissioning, this can be modified or left unchanged.

When Uncaged is disabled, this register's value is constrained from 0 to 100, and the unit is in percent. When Uncaged is enabled, all constraints are removed, and the unit is in mArms of the RMS current of the gripper's motor.

When this register is set to 0, the gripper does not apply holding force, and grasping is achieved solely by the residual collision force from finger motion. Note that without applied force, the gripper cannot detect if the grasped object is dropped or deformed.

Continued on the next page.

The figure below gives clues about force settings for the general apllications:

Figure 5.12 - Force Range For General Cases

Example: If register CONFIG FORCE (01 08) is set to 130% mArms, but Uncaged is disabled, this register will constrain back to the value of 100%.

5.2.8. Motion Command Register: SET DEFORM

The SET DEFORM register in the Motion Command Registers group sets the max allowable deformation/displacement of the grasped object in millimeters:

ADDR	Data	15-0
00 05	RW	Allowable object deformation in mm

Bits 15-0:

Allowable object deformation in mm (Non-zero).

At boot up, this register copies the value of the CONFIG DEFORM (01 09) configuration register. During commissioning, this can be modified or left unchanged.

Continued on the next page.

The figure below gives clues about deform settings for the general applications:

Figure 5.13 - Force Range for General Cases

Example: For fragile object, lower this value to around 1~3mm.

Example: For high elasticity objects that must be squeezed for secured grasping, increase this value to allow larger holding window (7~10mm).

Example: When using custom finger designs that allow high mechanical flex, consider increasing this value to prevent false deform detection.

5.2.9. Motion Command Register: SET COLLISION

The SET COLLISION register in the Motion Command Registers group sets the effort threshold for collision detection, hence object detection in the unit of mArms (milli-Ampere root mean square):

ADDR	Data	15-0
00 06	RW	Effort threshold for collision (object) detection in mArms

Bits 15~0:
Effort threshold for collision (object) detection in mArms.

At boot up, this register copies the value of the CONFIG COLLISION (01 0B) configuration register. During commissioning, this can be modified or left unchanged.

Under circumstances where the gripper fingers become mechanically stuck, increase the threshold to help them reach the target position without triggering object detection. When grasping fragile objects such as thin glass or soft organic materials, however, lower the threshold to prevent excessive force during motion.

A higher value ensures reliable object detection but results in higher impact force, while a lower value reduces impact force but may be insufficient for proper motion execution.

The figure below gives clues about collision settings for the general applications:

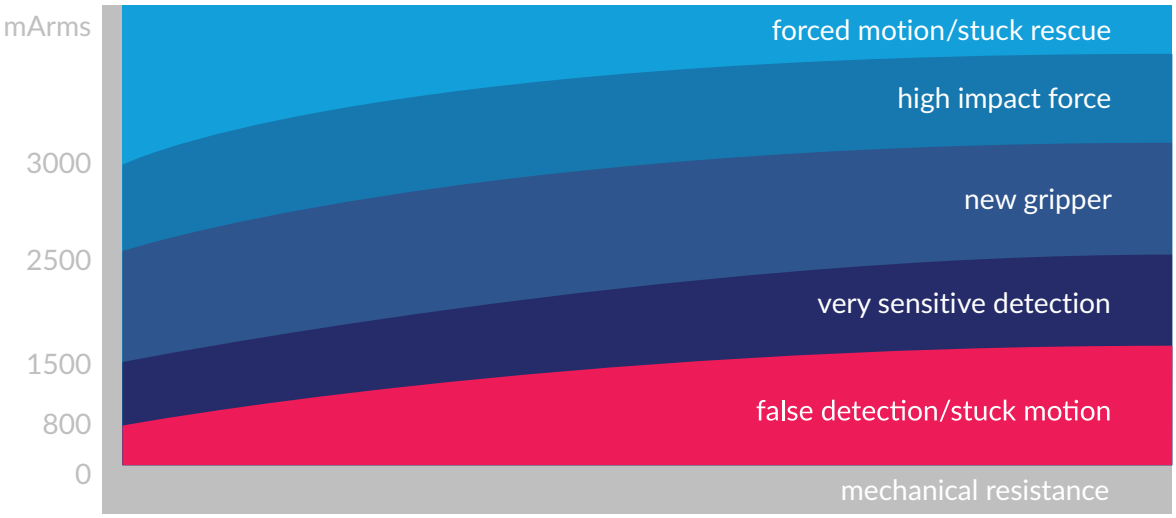


Figure 5.14 - Collision Effort Threshold Range for General Cases

Example: For new devices with less mechanical wear, the ideal range is between 1500 and 2500.

Example: The ideal value in general is ~1200.

Example: When the fingers are mechanically stuck, set this to ~3000 to ~4000 for forced motion.

Next, the Configuration Registers Group is elaborated.

5.2.10. Configuration Register: CONFIG SAVE

The CONFIG SAVE register in the Configuration Registers group triggers the memory save action that writes all parameters to SusGrip's non volatile memory:

ADDR	Data	15-0
01 00	RW	Write AA F5 to trigger save action, auto reset to 00 00

Bits 15~0:

AA F5 (hex) = trigger save action, auto reset to 00 00.

If the exact value of AA F5 (hex) is written to this register, the gripper engages EMCY and starts the process of saving all configuration parameters to non-volatile memory.

During this time, the gripper enters a stasis and responds to neither commands from IO nor from Modbus RTU. The saving process should take no longer than 10 seconds to complete, after which, normal operation is returned, and this register is automatically set to 00 00.

While memory save is in action, the gripper MUST NOT be powered down.

Any changes made to the gripper by modifying the configuration registers are only valid until powered down, unless they are saved to nonvolatile memory by writing AA F5 (hex) to this register.

The save action SHOULD NOT be triggered multiple times in a short period. It is recommended that an interval of at least 30 seconds is allotted after each save action before triggering another save.

Some configuration parameters such as Serial line properties modification requires new power cycle to take effect, while others such as Mode of Commissioning apply immediately.

After the process completes and no errors occur, the EMCY status is returned to the original state before stasis was entered.

Registers description continues on the next page.

5.2.11. Configuration Register: CONFIG MODE

The CONFIG MODE register in the Configuration Registers group dictates the mode of commissioning for the gripper:

ADDR	Data	15-0
01 01	RW	Select mode of commissioning

Bits 15~0:

Mode of commissioning selection:
- 00 00: Normal mode, motion commands via MBRTU;
- 00 01: IO Only mode, motion commands via Digital Input Signals;
- Otherwise: Reserved.

In Normal mode, motion commands are sent over MBRTU communication with the gripper over RS485, and signals on Input pin are ignored. In IO Only mode, motion commands are overridden by signals on the Input pin.

Mode of commissioning can be modified by writing to this register and will take effect immediately requiring neither EMCY engaged nor power cycle.

Saving this register to non-volatile memory decides the default mode of operation the gripper enters on boot.

5.2.12. Configuration Register: CONFIG POSITION H

The CONFIG POSITION H register in the Configuration Registers group sets the target fingers position in mm in IO Only mode when the Input pin is in logic HIGH:

ADDR	Data	15-0
01 02	RW	Target IO position in mm when input is in logic HIGH

Bits 15~0:

Target fingers position in mm when input is HIGH in IO Only mode.

Refer to the description of the SET POSITION (00 01) register for further explanation of fingers position computation.

Changes are immediate and requires neither engaging EMCY nor reboot. Saving must be done for the modification to this register to persist after powering down.

Registers description continues on the next page.

5.2.13. Configuration Register: CONFIG SPEED H

The CONFIG SPEED H register in the Configuration Registers group sets the target fingers speed in mm/s in IO Only mode when the Input pin is in logic HIGH:

ADDR	Data	15-0
01 03	RW	Target IO speed in mm/s when input is in logic HIGH

Bits 15~0:

Target fingers speed in mm/s when input is HIGH in IO Only mode.

Refer to the description of the SET SPEED (00 02) register for further semantic explanation.

At boot up, this register's value is copied by the SET SPEED (00 02) register.

Changes are immediate and requires neither engaging EMCY nor reboot. Saving must be done for the modification to this register to persist after powering down.

5.2.14. Configuration Register: CONFIG ACCEL H

The CONFIG ACCEL H register in the Configuration Registers group sets the target

ADDR	Data	15-0
01 04	RW	Target IO accleration in mm/s/s when input is in logic HIGH

fingers accleration in mm/s/s in IO Only mode when the Input pin is in logic HIGH:

Bits 15~0:

Target fingers accleration in mm/s/s when input is HIGH in IO Only mode.

Refer to the description of the SET ACCEL (00 03) register for further semantic explanation.

At boot up, this register's value is copied by the SET ACCEL (00 03) register.

Changes are immediate and requires neither engaging EMCY nor reboot. Saving must be done for the modification to this register to persist after powering down.

Registers description continues on the next page.

5.2.15. Configuration Register: CONFIG POSITION L

The CONFIG POSITION L register in the Configuration Registers group sets the target fingers position in mm in IO Only mode when the Input pin is in logic LOW:

ADDR	Data	15-0
01 05	RW	Target IO position in mm when input is in logic LOW

Bits 15~0:

Target fingers position in mm when input is LOW in IO Only mode.

Changes are immediate and requires neither engaging EMCY nor reboot. Saving must be done for the modification to this register to persist after powering down.

5.2.16. Configuration Register: CONFIG SPEED L

The CONFIG SPEED L register in the Configuration Registers group sets the target fingers speed in mm/s in IO Only mode when the Input pin is in logic LOW:

ADDR	Data	15-0
01 06	RW	Target IO speed in mm/s when input is in logic LOW

Bits 15~0:

Target fingers speed in mm/s when input is LOW in IO Only mode.

Changes are immediate and requires neither engaging EMCY nor reboot. Saving must be done for the modification to this register to persist after powering down.

5.2.17. Configuration Register: CONFIG ACCEL H

The CONFIG ACCEL L register in the Configuration Registers group sets the target fingers accleration in mm/s/s in IO Only mode when the Input pin is in logic LOW:

ADDR	Data	15-0
01 07	RW	Target IO accleration in mm/s/s when input is in logic LOW

Bits 15~0:

Target fingers accleration in mm/s/s when input is LOW in IO Only mode.

Changes are immediate and requires neither engaging EMCY nor reboot. Saving must be done for the modification to this register to persist after powering down.

Registers description continues on the next page.

5.2.18. Configuration Register: CONFIG FORCE

The CONFIG FORCE register in the Configuration Registers group sets the target magnitude of holding force used in IO Only mode:

ADDR	Data	15-0
01 08	RW	Target IO holding force in %

Bits 15~0:

Target magnitude of holding force in %, in IO Only mode.

Refer to the description of the SET FORCE (00 04) register for further explanation and force range selection guide.

At boot up, this register's value is copied by the SET FORCE (00 04) register.

Changes are immediate and requires neither engaging EMCY nor reboot. Saving must be done for the modification to this register to persist after powering down.

5.2.19. Configuration Register: CONFIG DEFORM

The CONFIG DEFORM register in the Configuration Registers group sets the max allowable deformation/displacement of the grasped object in millimeters:

ADDR	Data	15-0
01 09	RW	Allowable object deformation in mm in IO Only mode

Bits 15~0:

Allowable object deformation in mm in IO Only mode.

Refer to the description of the SET DEFORM (00 05) register for further explanation and deform range selection guide.

At boot up, this register's value is copied by the SET DEFORM (00 05) register.

Changes are immediate and requires neither engaging EMCY nor reboot. Saving must be done for the modification to this register to persist after powering down.

Registers description continues on the next page.

5.2.20. Configuration Register: CONFIG OFFSET

The CONFIG OFFSET register in the Configuration Registers group sets the fingers position offset in mm for every mode of commissioning:

ADDR	Data	15-0
01 0A	RW	Fingers position offset in mm

Bits 15~0:

Fingers position offset in mm, which can be negative.

Refer to the feature description Offset for Customized Finger Designs sub-section for further explanation. When offset is configured, position can be negative.

It is recommended that EMCY is engaged before making changes to the fingers position offset value.

Changes are immediate and requires neither engaging EMCY nor reboot. Saving must be done for the modification to this register to persist after powering down.

5.2.21. Configuration Register: CONFIG COLLISION

The CONFIG COLLISION register in the Configuration Registers group sets the effort threshold for collision detection, hence object detection in IO Only mode:

ADDR	Data	15-0
01 0B	RW	IO Effort threshold for collision (object) detection in mArms

Bits 15~0:

Effort threshold for collision (object) detection in IO Only mode.

Refer to the description of the SET COLLISION (00 06) register for further explanation and threshold value selection guide.

At boot up, this register's value is copied by the SET COLLISION (00 06) register.

Changes are immediate and requires neither engaging EMCY nor reboot. Saving must be done for the modification to this register to persist after powering down.

Registers description continues on the next page.

5.2.22. Configuration Register: CONFIG OCP

The CONFIG OCP register in the Configuration Registers group sets the threshold for the Over-Current Protection feature in milli-Amperes:

ADDR	Data	15-0
01 10	RW	Threshold for OCP in mA

Bits 15~0:

Threshold for Over-Current Protection feature in milli-Amperes.

This feature prevents the gripper from drawing excessive current, which may trigger errors on certain robots. For example, UR robots typically have a maximum tool I/O output current of 2 A, in which case this register should be set to no more than 2000 (dec) mA (2.0 A).

When Uncaged is disabled, this register's value is constrained from 1000 (dec) to 6000 (dec). When Uncaged is enabled, however, the upper limit is removed, and this register can be set to any value greater than 1000 (dec).

If a value greater than 6000 (dec), for example 10 000 (dec), is saved to memory, but Uncaged is disabled, it is automatically constrained down to 6000 (dec) on boot up.

The recommended absolute maximum value for safe commissioning is no greater than 5000 (dec) (mA) (= 5.0A). High current draw will damage internal electronics and reduce product lifetime.

The OCP threshold unit is milli-Amperes (mA) and is the threshold for the DC current consumption from Power Supply Unit. It is not to be mistaken with the unit of collision effort threshold, which is in RMS milli-Amperes (mArms) of the current generated by the internal motor of the gripper.

Changes are immediate and requires neither engaging EMCY nor reboot. Saving must be done for the modification to this register to persist after powering down.

Registers description continues on the next page.

5.2.23. Configuration Register: CONFIG UNCAGED

The CONFIG UNCAGED register in the Configuration Registers group enables or disables the Uncaged feature:

ADDR	Data	15-0
01 11	RW	Uncaged disabled = 00 00 | FF FF = Uncaged enabled

Bits 15~0:

All set to enable Uncaged;
All reset to disable Uncaged.

When Uncaged is enabled:

- Holding force is extended from 0 to 160%;
- UVLO is disabled;
- OCP upper limit is removed;

Uncaged mode is NOT RECOMMENDED for non-expert users. Please consult system engineers and carefully consider the risks before enabling this feature or modifying the limit threshold values.

Refer to the feature description Uncaged Mode sub-section for further explanation.

Changes are immediate and requires neither engaging EMCY nor reboot. Saving must be done for the modification to this register to persist after powering down.

5.2.24. Configuration Register: CONFIG HOLD

The CONFIG HOLD register in the Configuration Registers group sets the duration in milliseconds (ms) to maintain target holding force before falling to a lower value:

ADDR	Data	15-0
01 12	RW	How long in ms to maintain target holding force before decreasing

Bits 15~0:

Duration in ms to maintain target holding force:

- 500~1000ms: Low holding time;
- 1000~3000ms: Typical;
- 3000~5000ms: Secured holding;
- >5000ms: Not recommended, increased heat.

If this register is set to 00 00, holding force never decays but remains at the target value indefinitely until the next motion command.

Refer to the feature description Extended Object Holding Behavior sub-section for further explanation.

5.2.25. Configuration Register: CONFIG DECAY

The CONFIG DECAY register in the Configuration Registers group sets the level of holding force in percent decayed to after the holding period elapsed:

ADDR	Data	15-0
01 13	RW	Holding force level in % after holding period elapsed

Bits 15~0:

Holding force level in % after holding period elapsed.

Note that if this register is set to 0%, force decays completely after the holding period elapsed, and the gripper will not be able to detect object deformation.

Refer to the feature description Extended Object Holding Behavior sub-section for further explanation.

Changes are immediate and requires neither engaging EMCY nor reboot. Saving must be done for the modification to this register to persist after powering down.

5.2.26. Configuration Register: CONFIG CURRISE

The CONFIG CURRISE register in the Configuration Registers group sets the level of swiftness at which force rises and decays:

ADDR	Data	15-0
01 14	RW	Force rise/decay speed: 0-1-2-3

Bits 15~0:

Level of force rise/decay: 0-1-2-3.

This register's value is automatically constrained from 0 to 3:

- 0: Force rises/decays slowly;
- 1: Force rises/decays at medium rate;
- 2: Force rises/decays at fast rate;
- 3: Force rises/decays at very fast rate;

Refer to the feature description Extended Object Holding Behavior sub-section for further explanation.

Changes are immediate and requires neither engaging EMCY nor reboot. Saving must be done for the modification to this register to persist after powering down.

5.2.27. Configuration Register: CONFIG OBJEVENT

The CONFIG OBJEVENT register in the Configuration Registers group decides which object-related event to be reported by the OBJ DO pin:

ADDR	Data	15-0
01 15	RW	Object-related event report selection

Bits 15~0:

Select which object-related event to be reported by the OBJ DO pin:
- 00 00: Report event when an object was first detected;
- 00 01: Report event when full force is applied to hold the object;

Refer to the feature description Extended Object Holding Behavior sub-section for further explanation.

Changes are immediate and requires neither engaging EMCY nor reboot. Saving must be done for the modification to this register to persist after powering down.

5.2.28. Configuration Register: CONFIG MBRTUID

The CONFIG MBRTUID register in the Configuration Registers group sets the Modbus Server ID for the gripper:

ADDR	Data	15-0
02 00	RW	Modbus Server (Slave) ID from 1 to 247

Bits 15~0:

Modbus Server ID of the gripper from 1 to 247.

This register's value is automatically constrained from 1 to 247.

Changes are immediate but requires engaging EMCY. Saving must be done for the modification to this register to persist after powering down.

Example procedure to change gripper's Modbus ID immediately:

1. Engage EMCY to prevent uncontrolled motion;
2. Write new desired ID to this register (immediate effect);
3. Re-establish connection with the new Modbus ID;
4. (Optional) Trigger memory save to keep this new ID after powering down;
5. Release EMCY and return to normal operation with the new ID.

Example procedure to change gripper's Modbus ID for the next power cycle:

1. Write new desired ID to this register (no effect on current communication);
2. Trigger memory save to keep this new ID;
3. Wait for memory save completion then power down the gripper;
4. Power the gripper back on, establish connection with the new ID.

5.2.29. Configuration Register: CONFIG BAUD

The CONFIG BAUD register in the Configuration Registers group sets the Serial Baud Rate for Modbus RTU communication:

ADDR	Data	15-0
02 01	RW	Serial Baud Rate: 24-48-96-192-384-576-1152

Bits 15~0:

Serial Baud Rate for Modbus RTU communication divided by 100.

To set the desired Serial Baud Rate, divide the Baud Rate by 100 and write to this register.

Writing any values outside the specified ones will trigger an InvalidCommand error, and this register is set to the default value of 1152 (= 115200 bits/s).

Changes require memory save and reboot. New Baud Rate will take effect on new power cycle.

For example, to set a Baud Rate of 9600 bits/s:

1. Write 96 (dec) to this register;
2. Trigger memory save by writing AA F5 (hex) to the CONFIG SAVE register;
3. Wait for memory save completion then power cycle the gripper;
4. Establish new serial connection with the new Baud Rate of 9600 bits/s.

5.2.30. Configuration Register: CONFIG PARITY

The CONFIG PARITY register in the Configuration Registers group sets the Serial Parity type for Modbus RTU communication:

ADDR	Data	15-2	1-0
02 02	RW	Reserved	Serial Parity type: N-O-E

Bits 15~2:

Reserved, must be 0;

Bits 1~0:

Serial Parity type:

- 0 (dec): Parity NONE;
- 1 (dec): Parity ODD;
- 2 (dec): Parity EVEN.

Writing any values outside the specified ones will trigger an InvalidCommand error.

Changes require memory save and reboot. New Serial Parity type will take effect on new power cycle.

5.2.31. Configuration Register: CONFIG STOPS

The CONFIG STOPS register in the Configuration Registers group sets the Serial Stop Bits count for Modbus RTU communication:

ADDR	Data	15-2	1-0
02 03	RW	Reserved	Serial Stop Bits count: 1-2

Bits 15~2:
Reserved, must be 0;
Bits 1~0:
Serial Stop Bits count for Modbus RTU communication: 1 or 2.

Writing any values outside the specified ones will trigger an InvalidCommand error.

Changes require memory save and reboot. New Stop Bits will take effect on new power cycle.

5.2.32. Configuration Register: CONFIG LEDDIS

The CONFIG LEDDIS register in the Configuration Registers group disables/enables LED blinking behavior of the gripper:

ADDR	Data	15-0
02 04	RW	FF FF = disable LED blinking

Bits 15~0:
All set to disable LED blinking;
Otherwise enable LED blinking.

Changes are immediate and requires neither engaging EMCY nor reboot. Saving must be done for the modification to this register to persist after powering down.

5.2.33. Configuration Register: CONFIG OUTDIS

The CONFIG OUTDIS register in the Configuration Registers group disables/enables Digital Output (DO) pins:

ADDR	Data	15-0
02 05	RW	FF FF = disable DO pins 24VDC level

Bits 15~0:
All set to disable DO pins rise to 24VDC, voltage level remains at 0VDC;
Otherwise enable DO pins rise to 24VDC.

Changes are immediate and requires neither engaging EMCY nor reboot. Saving must be done for the modification to this register to persist after powering down.

5.2.34. Monitoring Register: INFO

The INFO register in the Monitoring Registers group holds the information about SusGrip gripper type:

ADDR	Data	15-0
00 00	RO	SusGrip gripper type

Bits 15~0:

SusGrip gripper type of the device:
- 56 2F (hex): SusGrip-2F gripper;
- 56 3F (hex): SusGrip-3F gripper.

In a system where both SusGrip-2F and SusGrip-3F are being commissioned at the same time, this information allows identification of each device.

5.2.35. Monitoring Register: POSITION

The POSITION register in the Monitoring Registers group shows the instantaneous fingers position of the gripper in mm:

ADDR	Data	15-0
00 01	RO	Instantaneous fingers position in mm

Bits 15~0:

Instantaneous fingers position in mm, unsigned value.

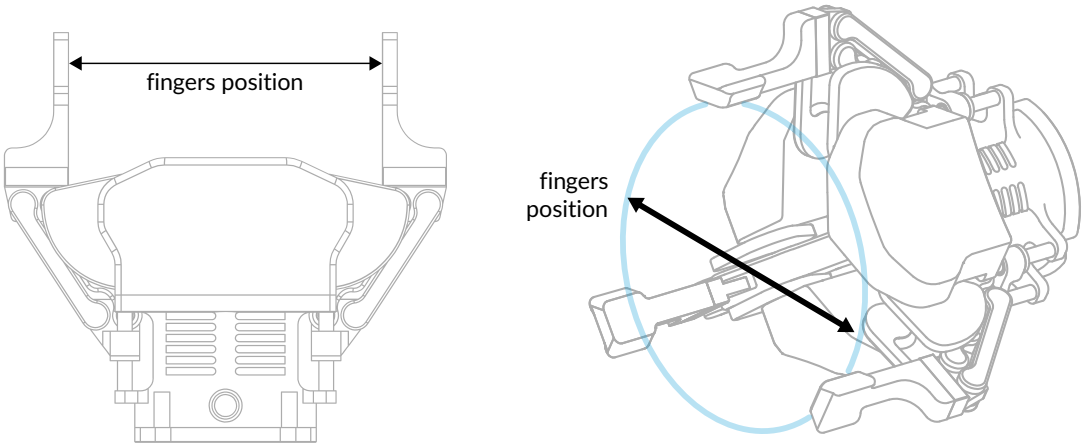


Figure 5.11 (repeated) - SusGrip Finger Position Computation

Example:

[00 01]: 00 0B (hex) = 11 (dec) = 11mm.

Registers description continues on the next page.

5.2.36. Monitoring Register: SPEED

The SPEED register in the Monitoring Registers group shows the instantaneous fingers velocity of the gripper in mm/s:

ADDR	Data	15-0
00 02	RO	Instantaneous fingers velocity in mm/s

Bits 15~0:

Instantaneous fingers velocity in mm/s, signed value;
Converted using 2's complement.

Example:

[00 02]: FE 6A (hex) = -406 (2's comp) = -406 mm/s.

Example:

[00 02]: 00 C2 (hex) = 194 (dec) = 194 mm/s.

5.2.37. Monitoring Register: RMS

The RMS register in the Monitoring Registers group shows the RMS current of the gripper's internal motor in milli-Amperes:

ADDR	Data	15-0
00 03	RO	RMS current in mA

Bits 15~0:

RMS current of the gripper's internal motor in milli-Amperes, signed value;
Converted using 2's complement.

The sign of the RMS value shows the direction of acting of motor torque, hence the fingers' force. When closing, the sign is typically negative. When opening, the sign is typically positive.

Example:

[00 03]: F5 CC (hex) = -2612 (2's comp) = 2612 mArms closing.

Example:

[00 03]: 02 07 (hex) = 519 (dec) = 519 mArms opening.

Registers description continues on the next page.

5.2.38. Monitoring Register: ERROR

The ERROR register in the Monitoring Registers group shows the latest operational error code of the gripper:

ADDR	Data	15-8	7-0
00 04	RO	Reserved, always 0	Operational error code

Bits 15~8:

Reserved, don't-cares, always 0;

Bits 7~0:

Latest operational error code:

- 0000 0000 (bin): No errors, normal operation;
- 0000 0001 (bin): Invalid command requested error (invalid position, ...);
- 0000 0010 (bin): Object lost (dropped/max allowed deform exceeded);
- 0000 0011 (bin): Supply power under-voltage, locked out;
- 0000 0100 (bin): Supply power over-voltage;
- 0000 0101 (bin): Supply power over-current;

- 0001 0001 (bin): Internal hardware error;
- 0001 0010 (bin): Memory error;
- 0001 0011 (bin): Invalid finger data;
- 0001 0100 (bin): Fingers are mechanically blocked from motion.

EMCY is engaged automatically by the gripper if error code is not 00 00. Disengaging EMCY will also clear all non-persistive errors.

5.2.39. Monitoring Register: MOTION

The MOTION register in the Monitoring Registers group shows the instantaneous motion status of the fingers:

ADDR	Data	15-1	0
00 05	RO	Reserved, always 0	Fingers motion status

Bits 15~1:

Reserved, don't-cares, always 0;

Bit 0:

Instantaneous fingers motion status:

- 0: Fingers stationary, not moving;
- 1: Fingers moving, in motion.

Registers description continues on the next page.

5.2.40. Monitoring Register: OBJ

The OBJ register in the Monitoring Registers group shows the instantaneous object detection and holding status:

ADDR	Data	15-8	7-0
00 06	RO	Reserved, always 0	Object status

Bits 15~8:

Reserved, don't-cares, always 0;

Bits 7~0:

Instantaneous object detection and holding status:

- 0000 0000 (bin): No object detected/Object lost;

- 0000 0001 (bin): Object/collision detected while fingers closing;
- 1111 0001 (bin): Holding force fully applied while closing;

- 0000 0010 (bin): Object/collision detected while fingers opening;
- 1111 0010 (bin): Holding force fully applied while opening;

Example:

1. [00 06]: 00 00 (hex) -> No object detected;
2. [00 06]: 00 01 (hex) -> Object first detected while closing;
3. [00 06]: 00 F1 (hex) -> Full holding force reached, object secured.

5.2.41. Monitoring Register: EMCY

The EMCY register in the Monitoring Registers group mirrors the value of the SET EMCY register for better convenience of monitoring:

ADDR	Data	15-0
00 07	RO	EMCY status (mirrors SET EMCY)

Bits 15~0:

Mirror SET EMCY value:

- 00 00 (hex): EMCY disengaged;
- FF FF (hex): EMCY engaged.

Registers description continues on the next page.

5.2.42. Monitoring Register: VBUS

The VBUS register in the Monitoring Registers group shows the instantaneous supply bus voltage in milli-Volts:

ADDR	Data	15-0
00 08	RO	Instantaneous supply bus voltage in mV

Bits 15~0:

Instantaneous supply bus voltage in milli-Volts, unsigned value.

Example:

[00 08]: 5D 42 (hex) = 23 874 (dec) = 23.874 VDC.

5.2.43. Monitoring Register: IBUS

The IBUS register in the Monitoring Registers group shows the instantaneous supply bus current draw in milli-Amperes:

ADDR	Data	15-0
00 09	RO	Instantaneous supply bus current draw in mA

Bits 15~0:

Instantaneous supply bus current draw in milli-Amperes, unsigned value.

Example:

[00 09]: 04 EE (hex) = 1 262 (dec) = 1.262 ADC.

5.2.44. Special Registers: Version

To obtain version of the gripper, these special input registers can be read:

ADDR	Data	15-0
01 00	RO	Hardware major version

ADDR	Data	15-0
01 01	RO	Hardware revision

ADDR	Data	15-0
01 02	RO	Corresponding firmware version

ADDR	Data	15-0
01 03	RO	Firmware release year

ADDR	Data	15-0
01 04	RO	Firmware release month

For example:

[01 00]: 00 02 (hex) = 2 (dec);
[01 01]: 00 04 (hex) = 4 (dec);
[01 02]: 00 06 (hex) = 6 (dec);
[01 03]: 07 EA (hex) = 2026 (dec);
[01 04]: 00 05 (hex) = 5 (dec);

gives the firmware version of 2.4.5, with the release date of May 2026.

This is the end of registers description.

Next, guidance for Apicoo Universal Console (AUC) is elaborated.

5.3. Operation with Apicoo Universal Console

Apicoo Universal Console (AUC) is a portable software provided by Apicoo Robotics that can be run on MS Windows machines. AUC can be used to communicate, control, configure, and perform various utility tasks with every Apicoo Robotics' product.

The interface of AUC contains 3 main parts, please note the terminologies:

- The upper-most horizontal bar (red) is called the **Title Bar**;
- The large area on (green) is called the **Content Region** (or **Content**);
- The narrow area (blue) is called the **Action Panel** (or **Panel**):

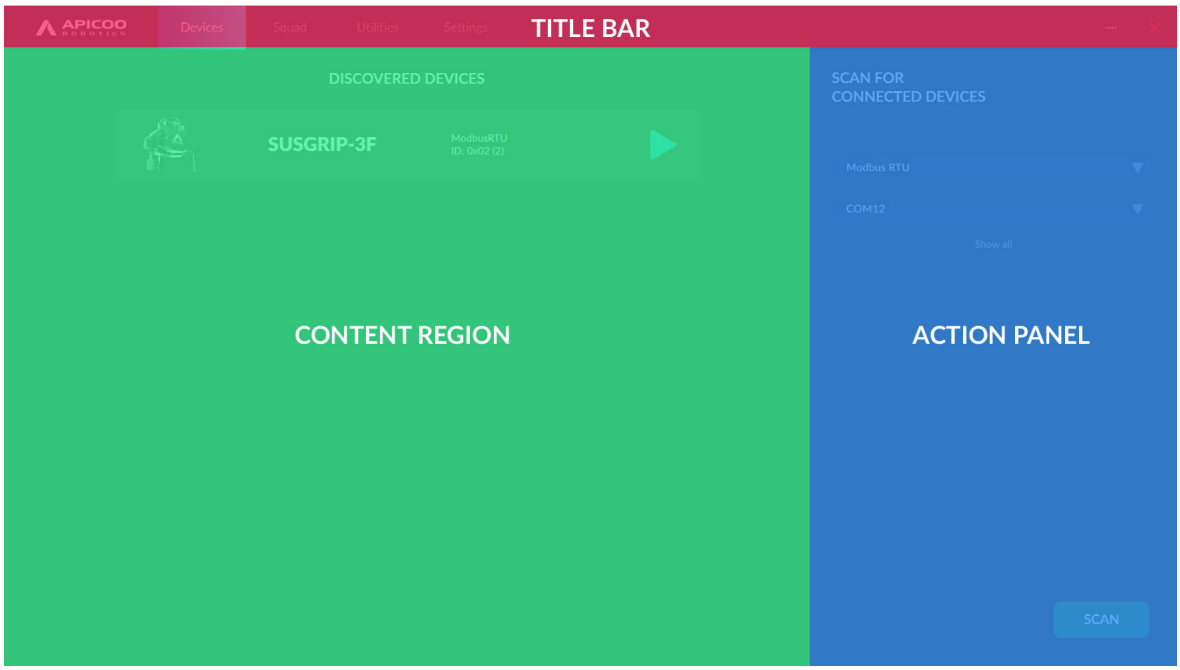


Figure 5.15 - AUC Layout

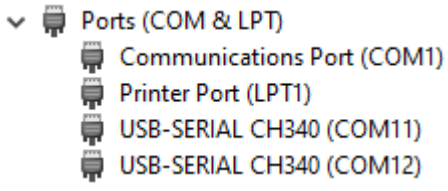
5.3.1. Connect SusGrip to AUC

To control SusGrip grippers with AUC, connect using the provided SusGrip cable and the RS485-to-USB (485USB) converter device. Provide the gripper with appropriate power supply (24VDC) and make sure the gripper is on with the blue LED idling.

Connect the 485USB to the computer. The device should be recognized as a COMx port, where x is a number, for example: COM12.

Refer to the previous chapter for further elaboration on how to connect SusGrip grippers to the computer via 485USB converter device.

The COMx number can be checked by going to Device Manager, under Ports (COM & LPT):



If the 485USB device cannot be recognized (not listed as a COM port), install the appropriate driver for the corresponding chip. These can be driver for: CH340, CH340N, FT232R, FT232RQ, ...

When everything is ready, open AUC, select **Devices** on the **Title Bar** to open the Device Scanner Lobby. Open the port drop-down and select the correct port, for example COM12:

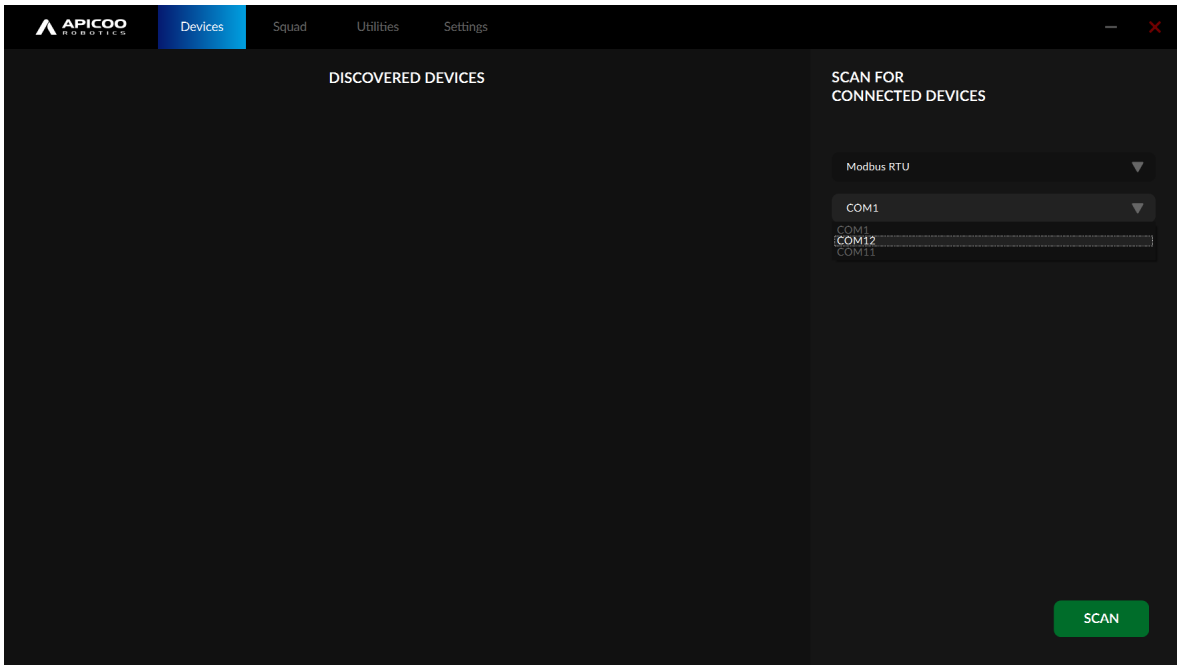


Figure 5.16 - AUC Device Scanner Lobby

Click on SCAN to start looking for connected SusGrip grippers. Detected devices are listed in the Content Region:

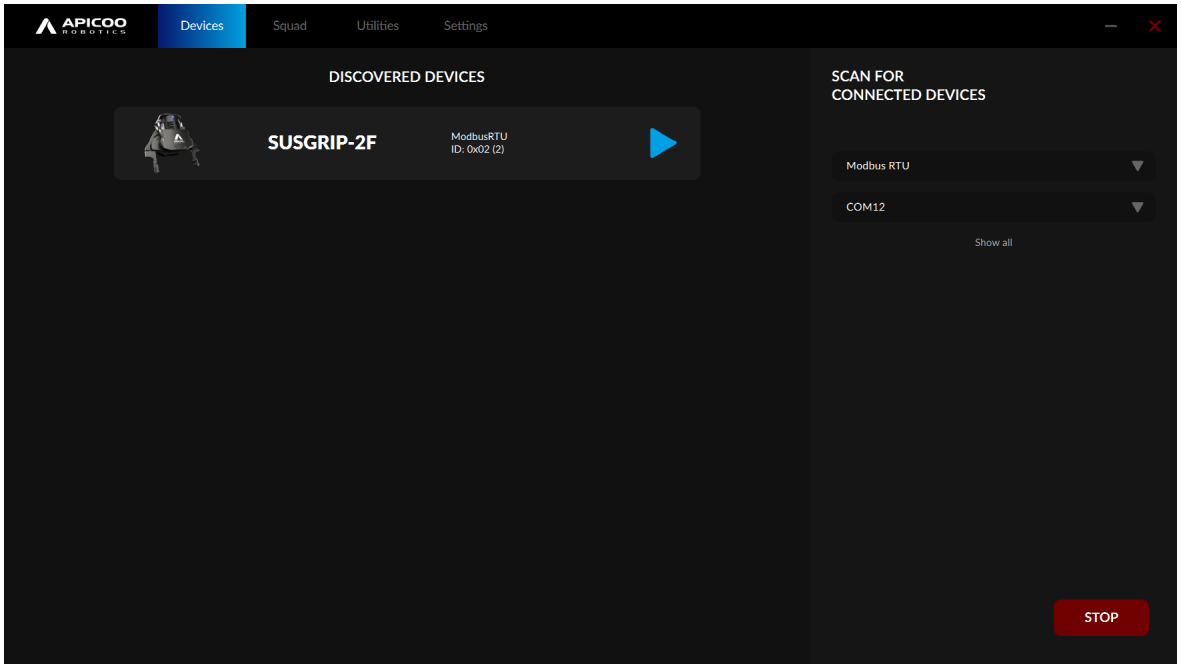


Figure 5.17 - Detected SusGrip Gripper Listed in Lobby

Users can expand the scanning options by clicking **Show more** to expose advanced parameters:

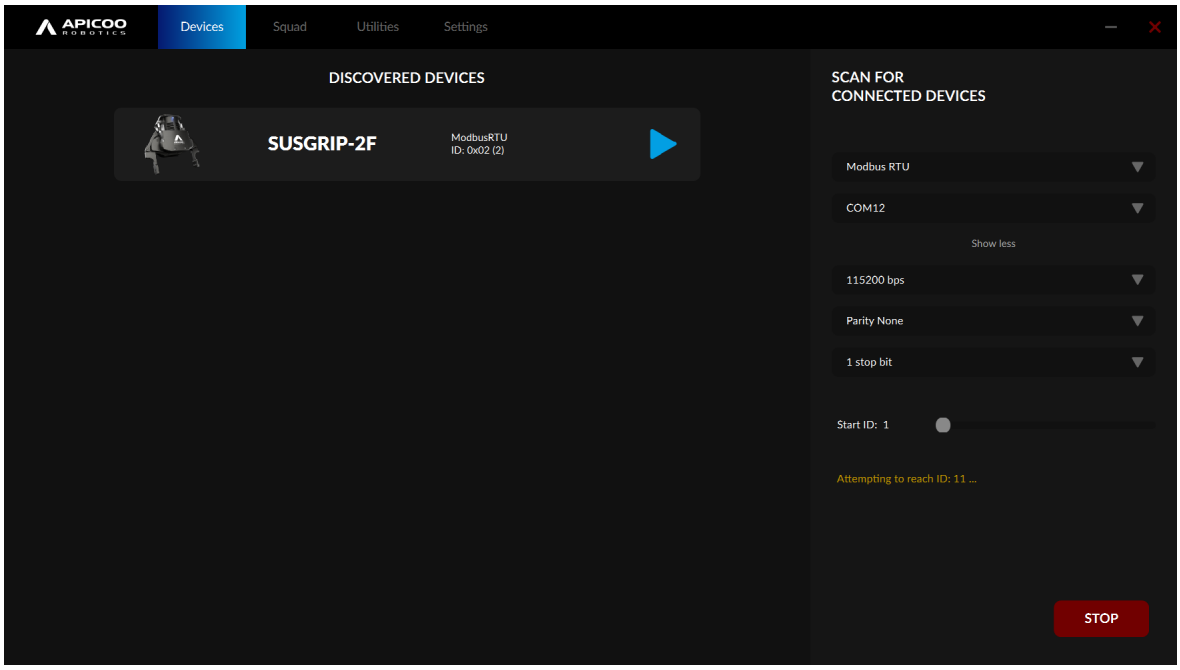


Figure 5.18 - Expanded Device Scanner Parameters

Users can click the blue "Play" button on each device card to start controlling.

5.3.2. Control SusGrip with AUC in Simple Mode

The control screen for SusGrip grippers is as follow:

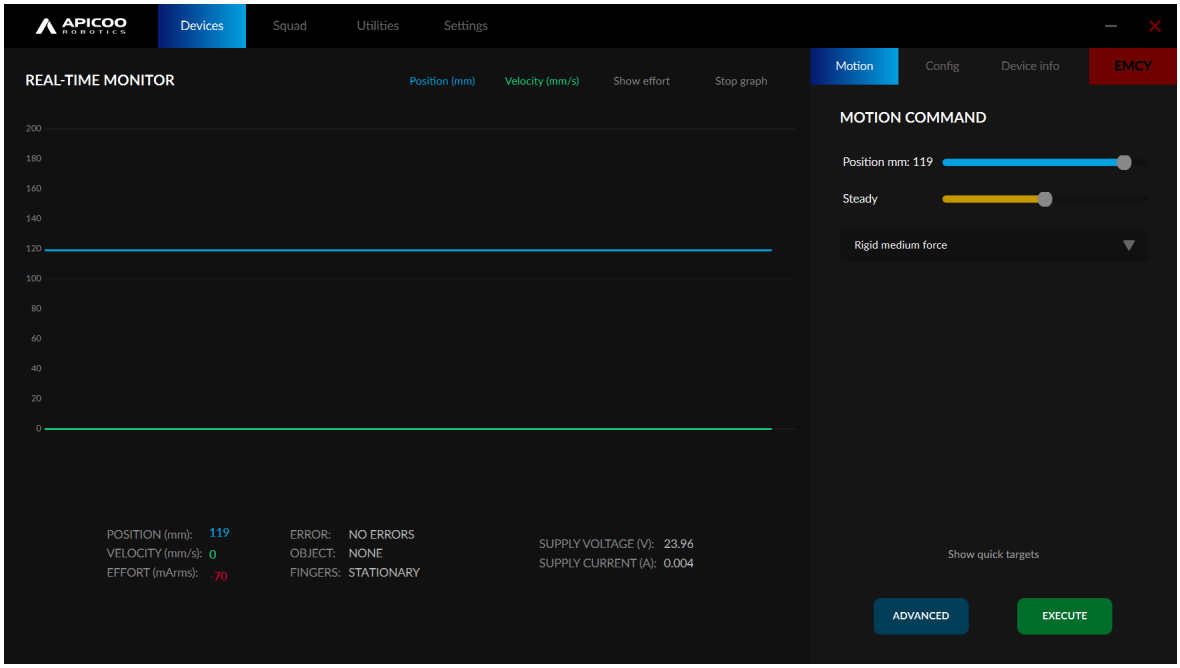


Figure 5.19 - AUC Control Screen for SusGrip Grippers (Simple)

The **Content Region** contains a graph that plots real-time data read from the device about finger position (position in mm), finger velocity (velocity in mm), and effort (RMS current in mA), and a text area that displays the parameters. The **Action Panel** contains control parameters for the device. By defaults, the **Motion** tab of the **Action Panel** is selected.

A red EMCY button is used for sending emergency stop signal to the device. When this button is pressed, it behaves as a blinking light indicating that emergency brake on the device has been engaged. Any error during device operation that triggers emergency stop will also make the button blink. Press it again to release emergency brake and clear all non-persisting errors.

On this screen, the blue slider sets the position target for the device. Motion is automatically executed when the slider knob is released. If motion is not executed, click on the green EXECUTE button at the bottom.

On this screen, the yellow slider sets the speed target for the execution of motion.

On this screen, the drop-down sets the target object grasp types. Each sets empirical force, deform, and collision threshold values that are considered most suitable for that object type.

5.3.3. Control SusGrip with AUC in Advanced Mode

Click on the blue ADVANCED/SIMPLE button at the bottom to switch between Simple and Advanced control modes:

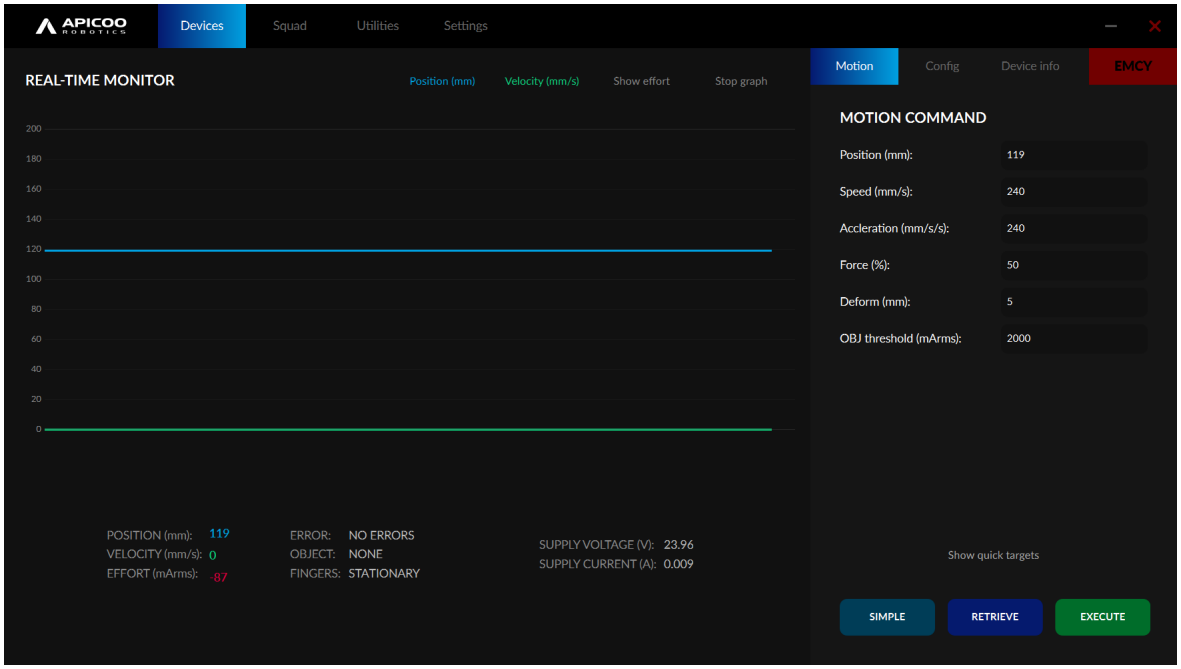


Figure 5.20 - AUC Control Screen for SusGrip Grippers (Advanced)

In advanced control mode, users can set each parameter directly. The new dark blue **RETRIEVE** button is used to read what's being set to the device.

5.3.4. Configure SusGrip with AUC

Switch to the **Config** tab of the **Action Panel**:

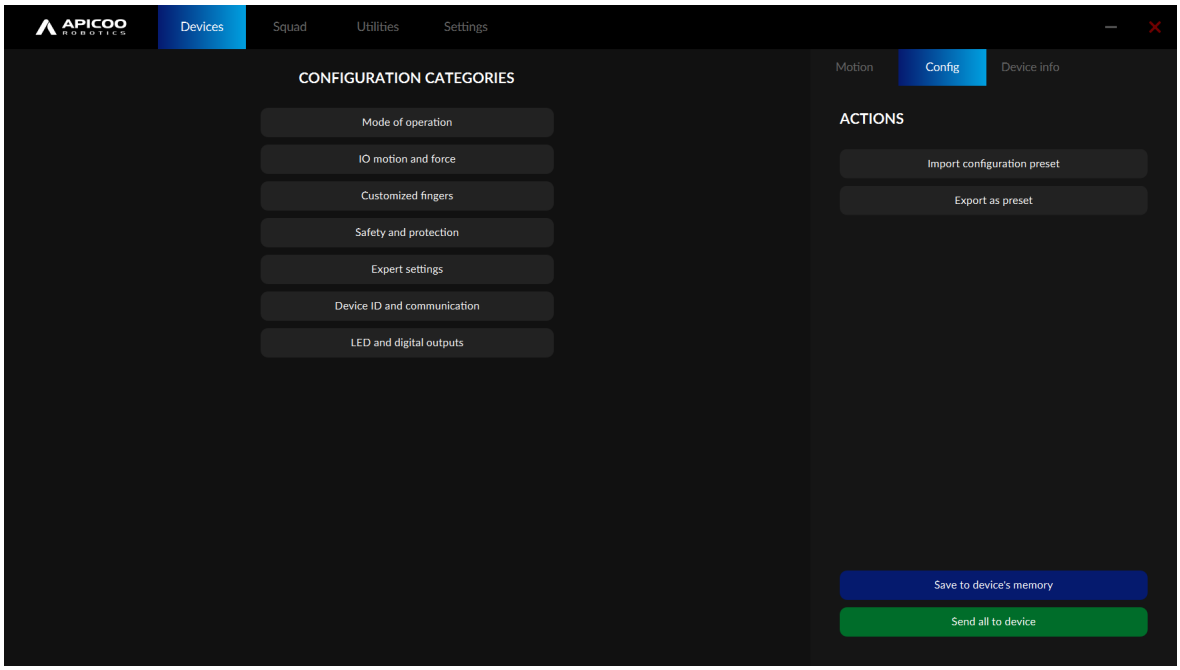


Figure 5.21 - AUC Config Screen for SusGrip Grippers

The **Content Region** shows the categories of parameters. Select each category to expose the configuration, for example select IO motion and force to set the open/close position, speed, and force magnitude when grasping in IO mode:

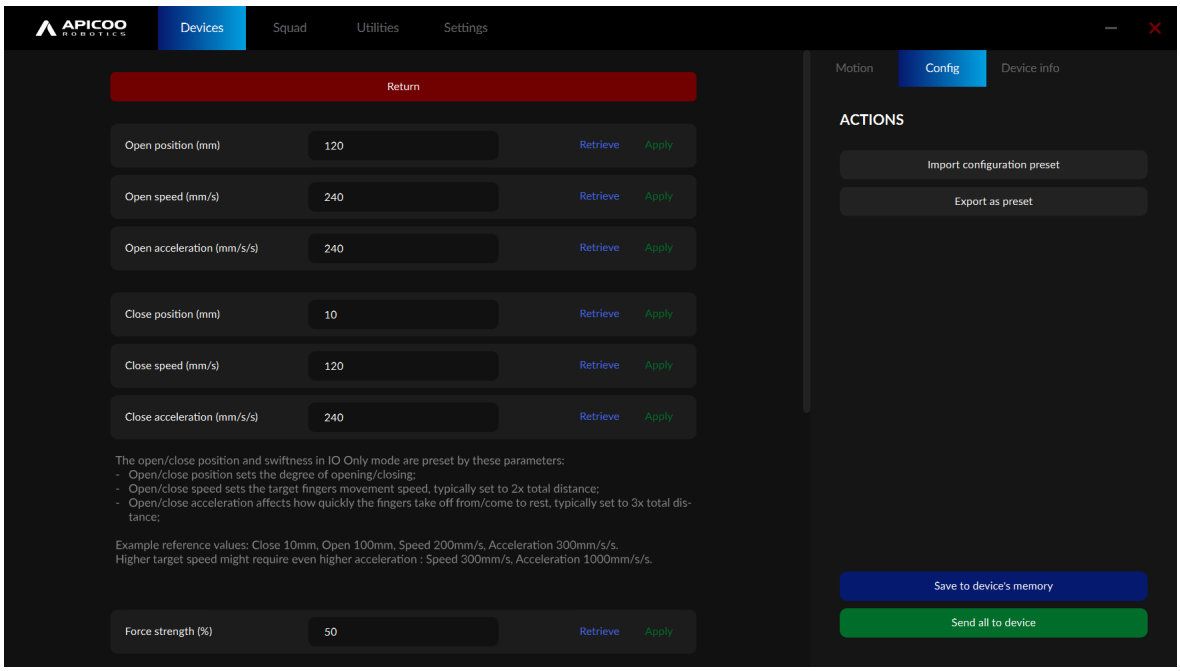


Figure 5.22 - AUC Config Screen for IO motion and force

Each category corresponds to a feature of SusGrip grippers. Refer to the Features Description section for further information.

The **Import configuration preset** button on the **Action Panel** imports and applies a configuration profile to the device. This is helpful when users have multiple configuration profiles and wish to quickly apply to the gripper, or when there are multiple grippers that need to receive the same set of parameters.

To create configuration profiles (presets), click on the **Export as preset** button on the **Action Panel** to export every configuration parameter currently set to a file that can be saved and then later imported.

The green **Send all to device** button sends all configuration parameters to the device. This is equivalent to clicking the **Apply** button for each parameter.

The dark blue **Save to device's memory** button triggers the save feature on SusGrip. Memory save must be triggered after changes were made for them to persist after power cycles. When memory save is in progress, DO NOT disconnect or power down the device.

5.3.5. Obtain SusGrip Information with AUC

SusGrip information can be attained by switching to the **Device info** tab of the **Action Panel**. Click on the green Retrieve device information button, the **Content Region** displays the attained data:

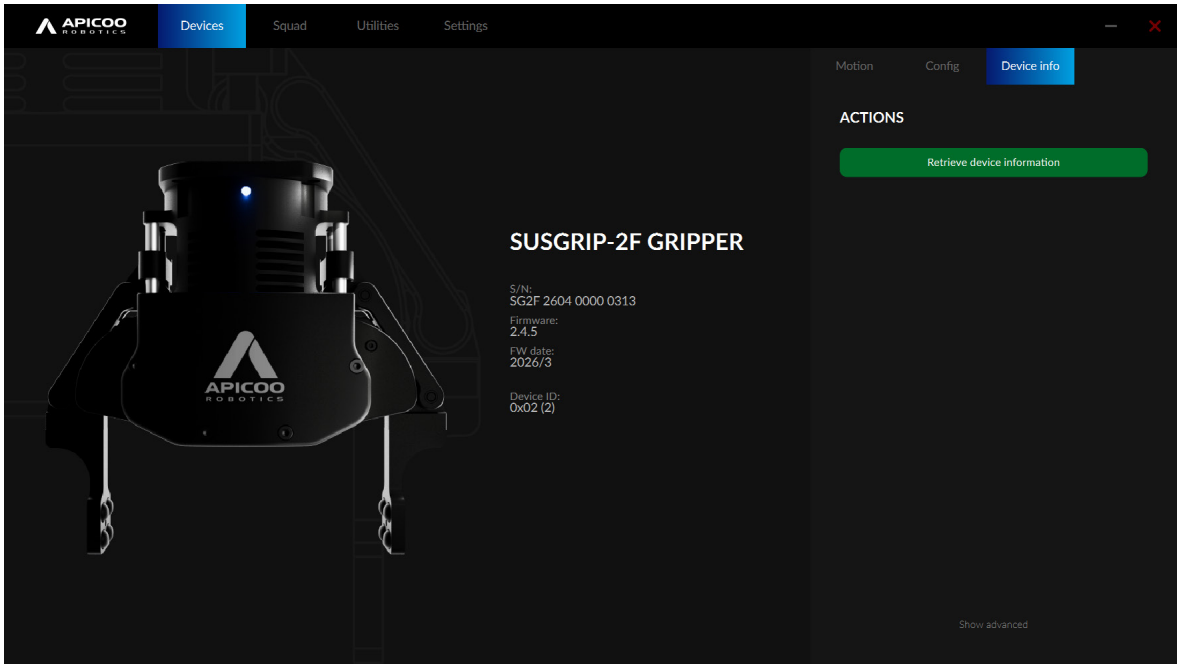


Figure 5.23 - AUC Device Information Screen

5.3.6. Control Multiple Devices with Squad

Users can control multiple SusGrip grippers if they are all detected by the Device Scanner. To connect multiple devices to AUC, the RS485 wires of each device should be joined together and then connected to the RS485-to-USB device. The Device Scanner will then be able to scan and list all grippers present on the RS485 line:

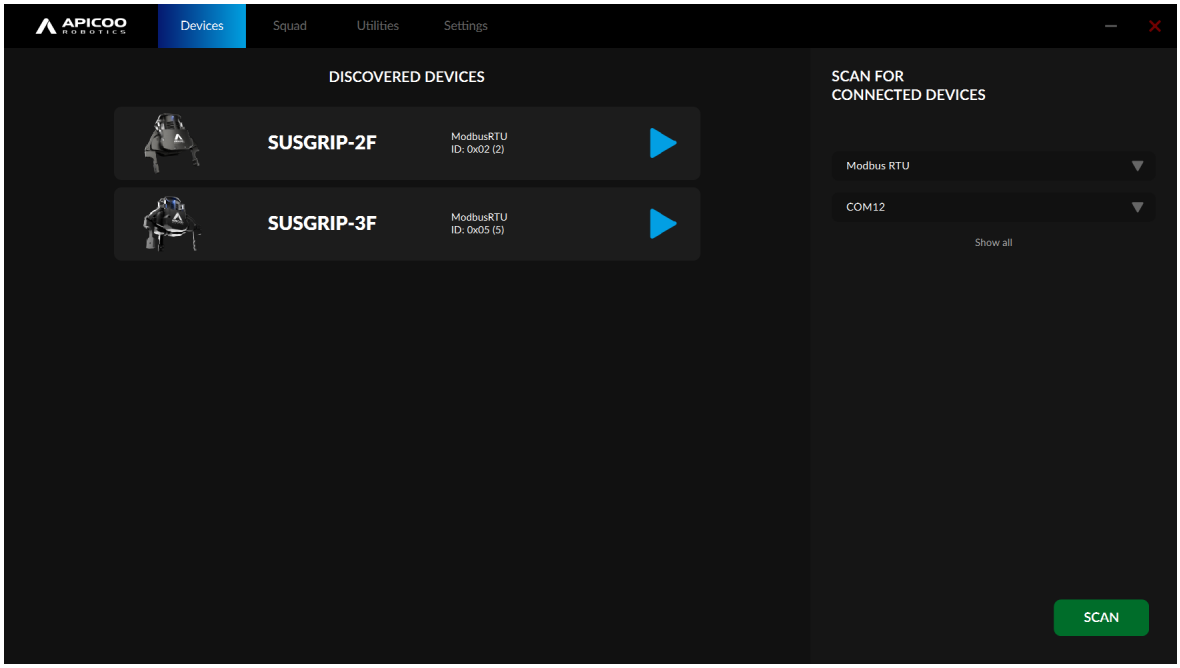


Figure 5.24 - Multiple Devices Detected in Devices Lobby

Switch to **Squad** screen on the **Title Bar**. All grippers discovered by the Device scanner and listed in the Devices lobby will also be listed in the Squad lobby:

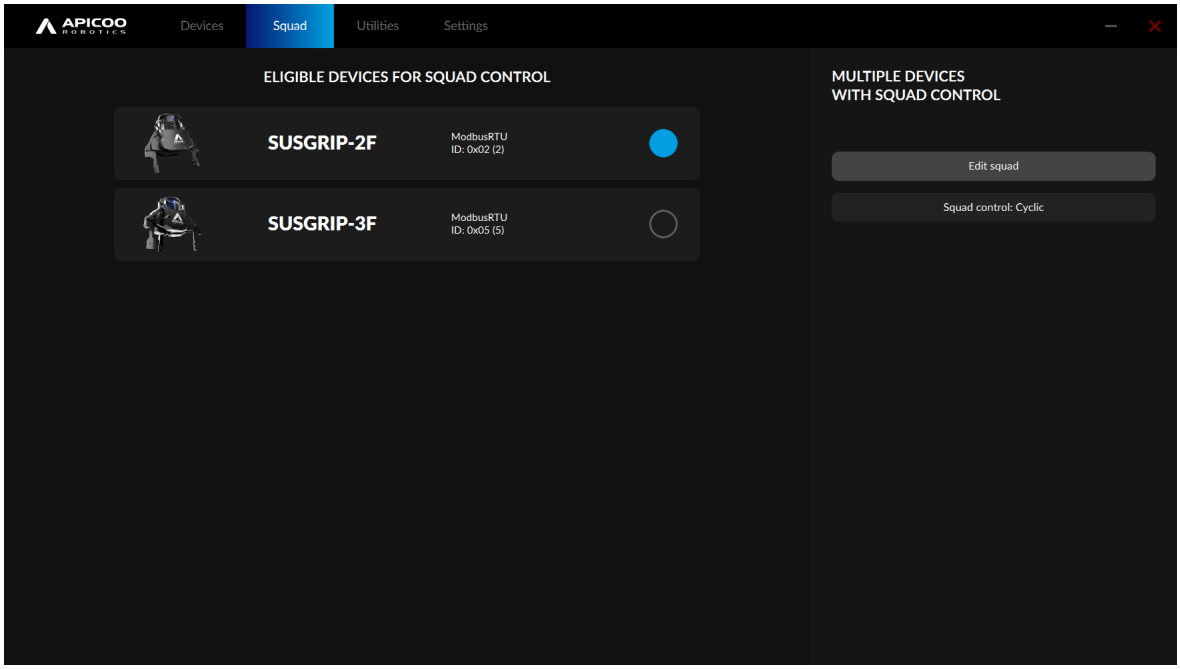


Figure 5.25 - Multiple Devices Detected in Squad Lobby

Click the "Circle" button on each device card to add or remove the device from the active squad. When the device is selected and added to the active squad, the circle is displayed in blue. When the device is deselected and removed from the active squad, the circle is displayed in grey.

At least 01 member (device) must be selected to establish a valid active squad. When a valid active squad is ready, go to **Squad control: Cyclic** on the **Action Panel** to perfrom motion control for all members (devices) of the squad:

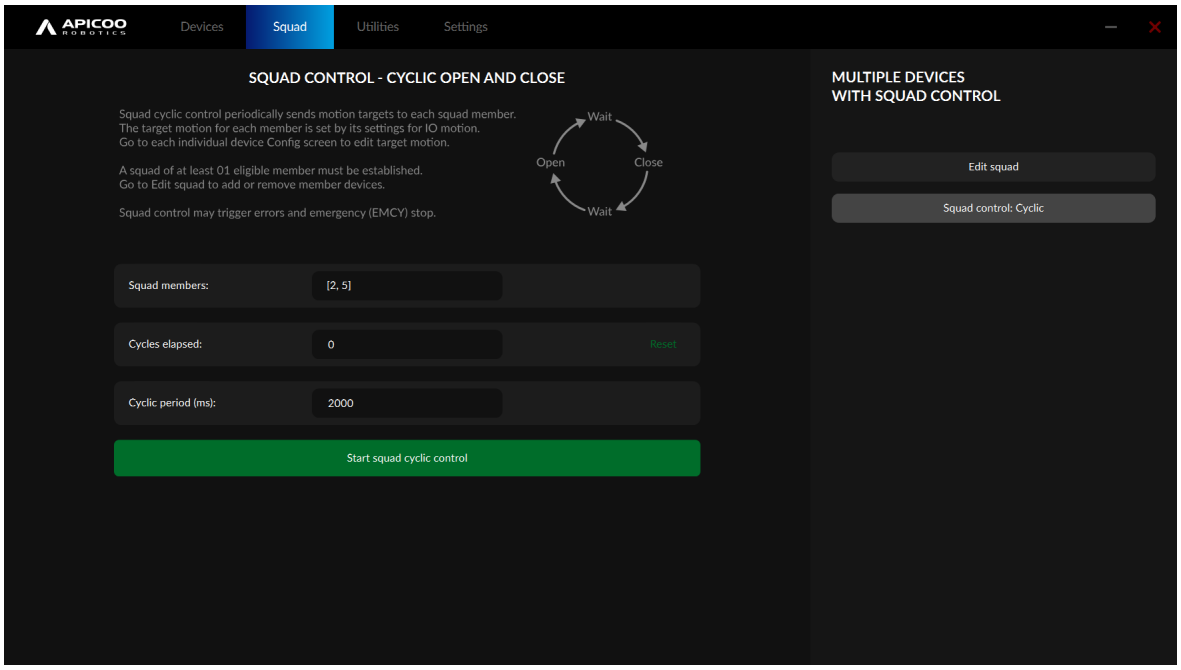


Figure 5.26 - Squad Cyclic Control Screen

Enter the cyclic period, for example 2000ms (2s) and click on **Start squad cyclic control** button. Then every 2s each member of the squad will execute motion commands.

Squad cyclic control periodically sends motion targets to each squad member. The target motion for each member is read from its configured settings for **IO motion and force**. These can be changed by going back to the Devices lobby, selecting the target device, going to **Config** tab of the **Action Panel**, and clicking on **IO motion and force**:

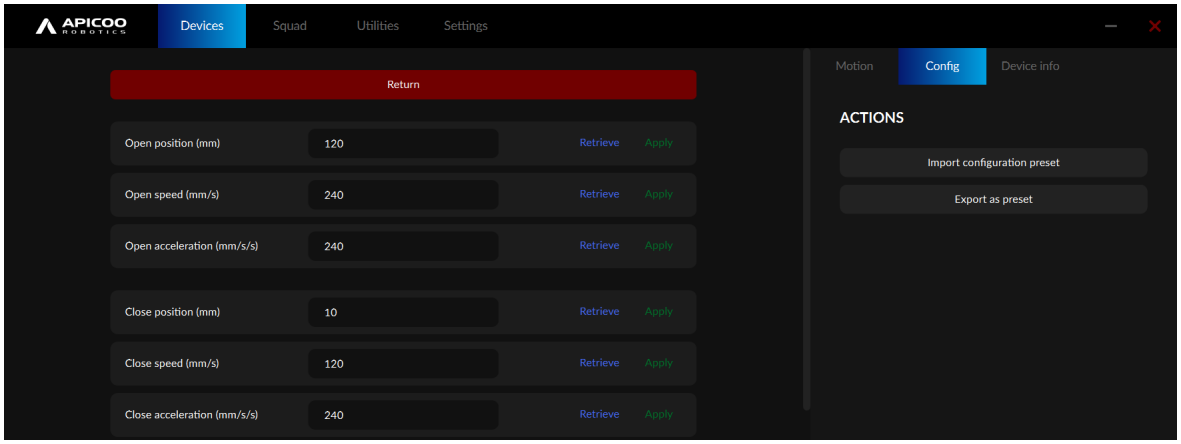


Figure 5.27 - Changing IO Open/Close Settings Affects Squad Control

5.3.7. Firmware Update Utility

When new features and bug fixes are released, the firmware of SusGrip can be updated using AUC Device firmware updater. Go to Utilities screen on the Title Bar, select Device firmware update on the Action Panel:

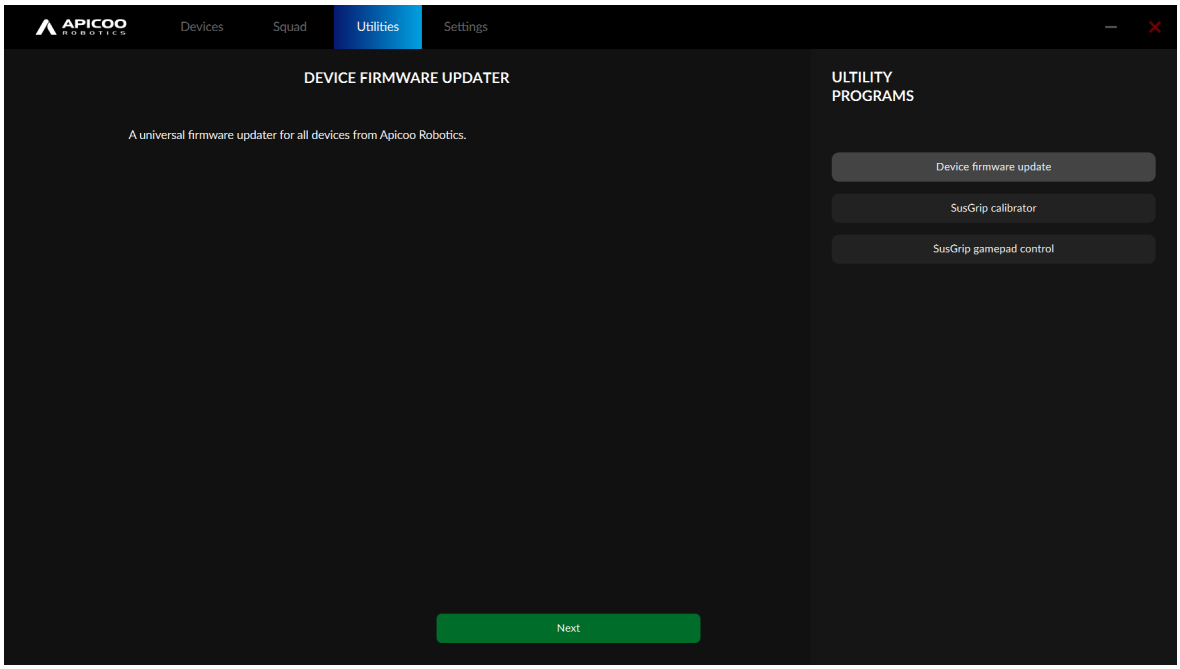


Figure 5.28 - AUC Device Update Utitlity Screen

Select the correct device type, for example **SusGrip grippers version 2.4.x**, and follow the instructions:

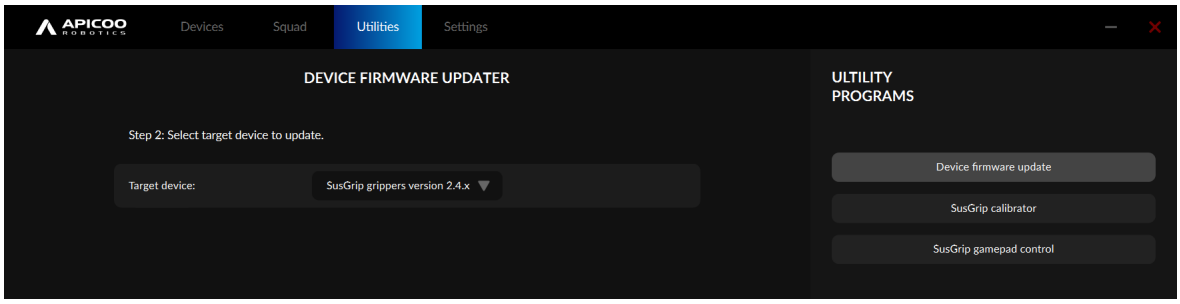


Figure 5.29 - Select the Correct Target Device Type

Select the firmware file. Device updater will verify to check if the file is appropriate:

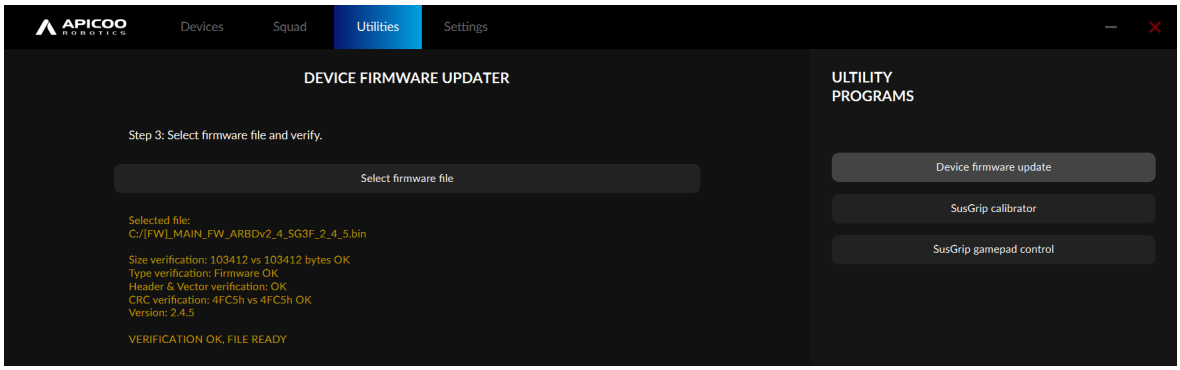


Figure 5.30 - Device Updater Checks and Verifies File

Continue to select and connect to communication port, for example COM12:

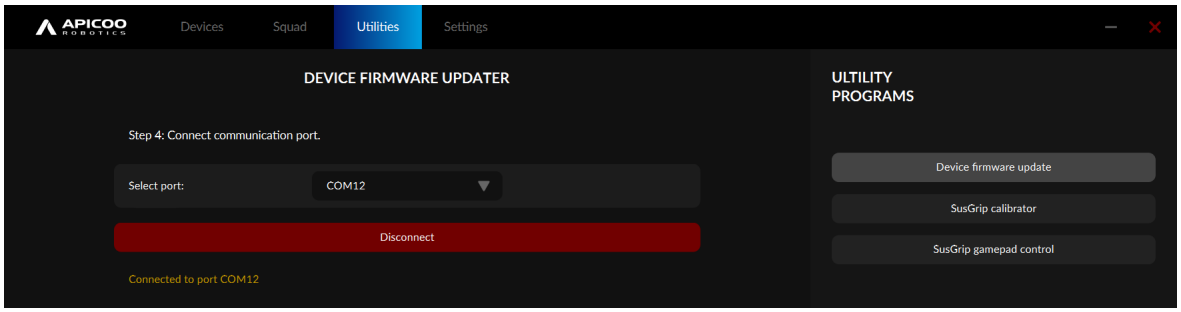


Figure 5.31 - Select and Connect to Gripper's Port

Note that if the selected port is the same port used by the Device Scanner or Squad Controller, they will be released from that port. Users must stop all ongoing Squad control routines before continuing.

Then, power down the target device and remove all other grippers from the RS485-to-USB device (if multiple grippers are connected). If two or more devices are present on the RS485 line when the updater begins, the firmware may become corrupted on all grippers.

Follow the instruction and start the updater:

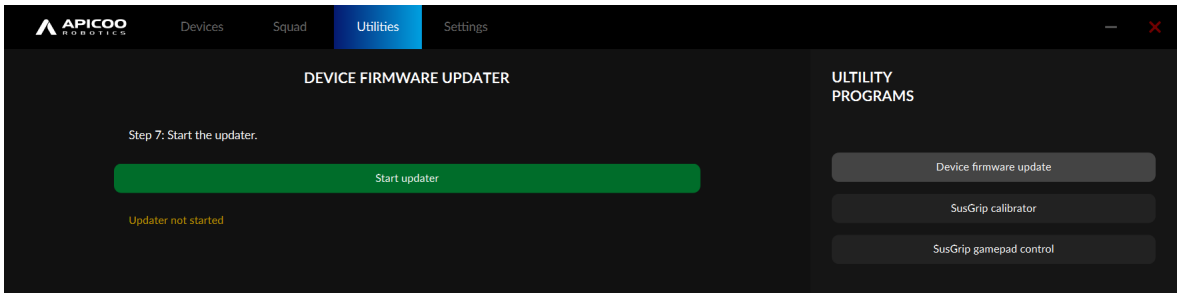


Figure 5.32 - No Return Once Device Updater Is Started

Once the updater is started, a 20-second interval is allotted during which users must power on the device. When DFU is successfully entered, the update progress begins. During this time, users MUST NOT power off the device, disconnect the RS485-to-USB device, or close the application:

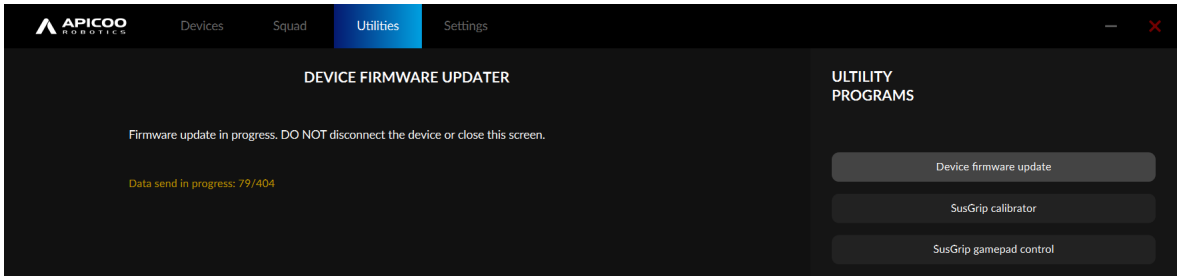


Figure 5.33 - Device Firmware Update In Progress

Once done, exit the updater and power cycle the device to resume normal operation:

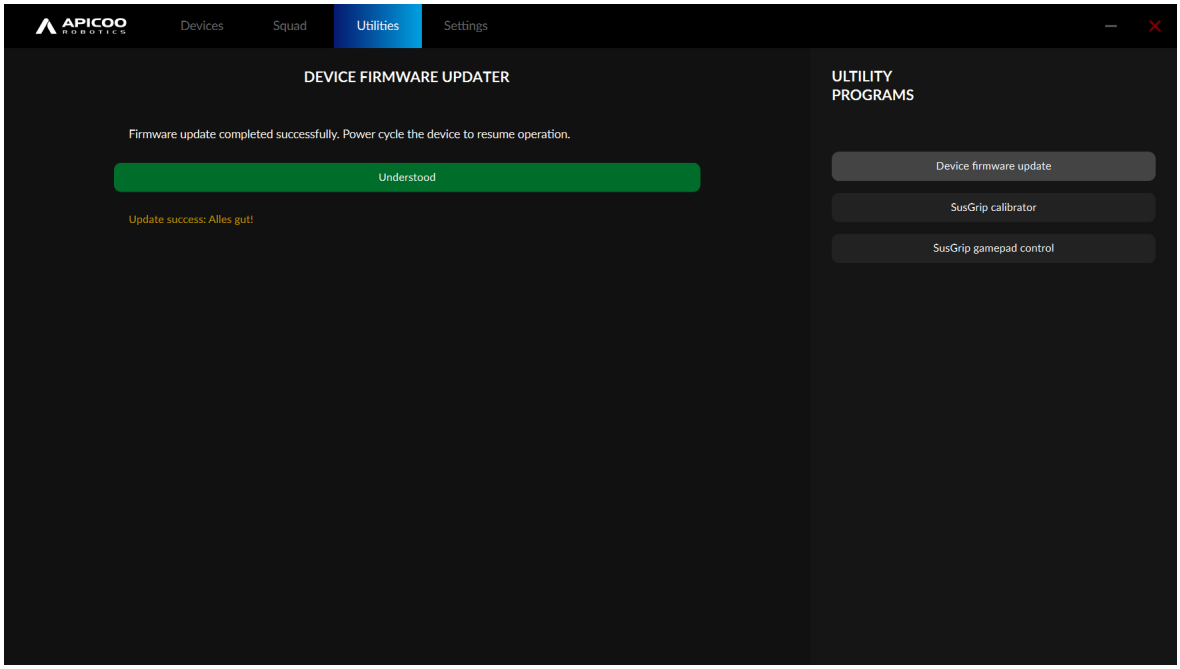


Figure 5.34 - Device Firmware Update Complete with Success

It is recommended to use the provided USB-to-RS485 converter device to perform firmware update. If it is lost or no longer operates properly, users should use any USB-to-RS485 converter devices that are based on the CH340 chip.

If firmware update fails, users power down the device and re-try the entire process. If failure persists, contact Apicoo Robotics for further support.

When performing updates, ensure that the firmware file is correct for the target device. For example uploading the firmware file of a SusGrip-2F gripper to a target SusGrip-3F will cause operational errors. In such cases, simply re-upload the correct firmware file.

Further AUC functionalities can be discovered by users on their own.

This manual is meant for AUC version 1.0.0 - perpetual beta.

This is the end of AUC guidance.

6 - MAINTENANCE AND TROUBLESHOOTING

6.1. Maintenance Guide

To ensure optimal performance and extend the service life of SusGrip grippers, regular maintenance is recommended. Users are advised to return the gripper for servicing after one year of continuous operation or upon reaching 2,000,000 open-and-close cycles, whichever comes first.

Contact Apicoo Robotics for further support.

Next, troubleshooting and error handling during operation are discussed.

6.2. Status LED Indicator

The LED indicator on every SusGrip gripper indicates the instantaneous (current) operational status of the device, regardless of operation mode (IO Only or Normal).

6.2.1. On SusGrip Versions with Single Blue LED

On SusGrip grippers with a single round blue LED indicator, the status is reported by the blinking patterns:

Table 6.1 - Single Blue LED Blinking Patterns

PATTERN	MEANING	SOLUTION
OFF	Device is not powered on.	
	Device was just powered on and is initializing.	Wait up to 7 seconds for device initialization.
	LED indicator broken.	Contact Apicoo Robotics support.
	Device failed to power on.	
IDLE ON	Device is powered on and ready for operation.	No errors.
DOUBLE BLINKS THEN ON	An object is detected and being grasped, held.	
TRIPLE BLINKS THEN OFF	Emergency (EMCY) brake was engaged per requested by users.	
	Emergency (EMCY) brake was engaged because 1 or more errors occurred during operation.	- Obtain and handle error code then release EMCY to clear all errors; - If the error persists, contact Apicoo Robotics support.
CONSTANT SINGLE BLINKS	Memory save in progress.	Allow up to 5 seconds for memory save to complete.

6.2.2. On SusGrip Versions with Single RGB LED

Is to be released in future versions.

6.3. Error Codes and Handling

The Input Register 00 04 (hex) - ERROR in the Monitoring Registers group holds the latest error code of the device:

ADDR	Data	15-8	7-0
00 04	RO	Reserved, always 0	Operational error code

This is an Input Register (IR) with access type Read-only (RO) that can be accessed with Modbus FC04 - Read Input Registers. The equivalent PLC address in decimal format is 40005. Example poll frame to read from this register:

[TX] 01 04 00 04 00 01 70 0B

Refer to register description sub-section for this register or the table below for error codes description. The error code can also be obtained semantically by using Apicoo Universal Console (AUC):

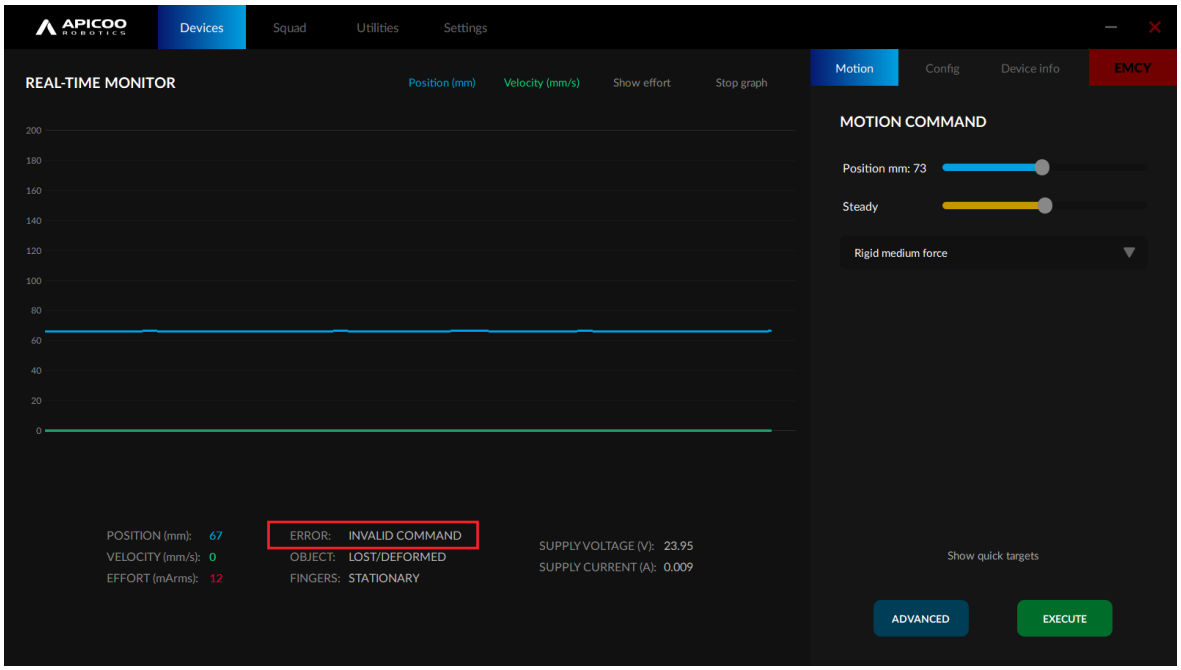


Figure 6.1 - AUC Device Screen Showing Error

To attempt to clear errors, release EMCY brake by toggling the red blinking EMCY button on the top right corner of AUC or by sending to the Holding Register 00 00 (hex) - SET EMCY in the Motion Command Register group. Example frame to release EMCY brake and clear errors:

[TX] 01 06 00 00 00 00 89 CA (using FC06)

[TX] 01 10 00 00 00 01 02 00 00 A6 50 (using FC16)

Table 6.2 - SusGrip Operational Error Codes

ERROR CODE (BINARY)	ERROR NAME	DESCRIPTION
0000 0000	NO ERRORS	Alles gut, no worries!
0000 0001	INVALID COMMAND	The requested command was sent successfully to the device, but is rejected. It must be cleared manually. This could be due to sending a position request that is outside of the posible range for that device, or sending a configuration parameter that is not in the allowable range. Example: Sending position command of 9999mm, or configure device ID to 300. Solution: Verify the commanded value and release EMCY to clear this error.
0000 0010	GRASP FAILURE	This error occurs when an object was detected, grasped, but then fell out of grasp or was distorted beyond set limit. This could be that the Deform command was too low (for example <=2mm), or due to the object being pulled out by its weight or external force. Another reason would be when using elastic fingers that could bend during grasping, making the gripper mistake it for object distortion. Solution: - Slightly increasing the Deform command (>= 5) usually works. Refer to Feature Description and Register Description sub-sections for further detail; - If using flexible or elastic fingers, measure the degree of distortion and use a Deform value that is slightly higher (+1 or +2mm); - If this error is triggered when the object falls out of grasped (heavy, slippery), increase the force gradually and experiment with each value; - If this error is triggered when a person tries to pull the object out of grasp, simply clear it by releasing EMCY; - If the person tries to pull the object out of grasp without consent, tell them to stop.

ERROR CODE (BINARY)	ERROR NAME	DESCRIPTION
0000 0011	UNDER-VOLTAGE	This error occurs when the input voltage supplied to the device is below the minimum threshold. This could happen when SusGrip is powered by an unstable or bad power supply unit. It could also happen when performing grasp with intensive force, which draws high current and makes the voltage drop across the power terminals. Solution: - Verify power supply unit, make sure it can handle the rated specifications; - Lower SusGrip performance (lower speed, lower force); - Under-voltage lockout (UVLO) is disabled in Uncaged mode, but it is NOT RECOMMENDED for non-expert users.
0000 0100	OVER-VOLTAGE	This error occurs when the input voltage supplied to the device is above the maximum threshold. Note that the device can still turn on and display this error if and only if the internal electronics are not damaged permanently by applying too high voltage. Solution: Verify power supply unit and use a step-down converter if necessary.
0000 0101	OVER-CURRENT	This error occurs when the gripper draws more current than the set protection threshold from the power supply unit. The Over-current protection (OCP) feature activates automatically, and EMCY is engaged. Current drawn is proportional to the force and speed settings. Higher speed typically requires slightly more current, and force request directly affects current draw. Solution: - If the OCP threshold cannot be lifted, try reducing speed and force; - Else raise the OCP threshold, example 5000mA, if power supply is not a constraint.

ERROR CODE (BINARY)	ERROR NAME	DESCRIPTION
0001 0001	INTERNAL FAILURE	This error occurs when the internal circuitry of the device was struck with an unrecoverable error. Solution: Contact Apicoo Robotics for a replacement, repair, or refund.
0001 0010	CALIB DATA FAILURE	This error occurs when the data read from device memory failed. Solution: Contact Apicoo Robotics for support.
0001 0011	ENCODER FAILURE	This error occurs when the absolute encoder for the detection of gripper's fingers fails or returns garbage values. This could be due to the encoder device degrading after certain time or being damaged by collision and fluid liquid. Another less critical cause would be loose internal connection or incorrect calibration data. Solution: - Contact Apicoo Robotics support; - Users might need to perform manual cable re-connection; - Users might need to perform manual re-calibration for the gripper's fingers.
0001 0100	MOTION OBSTRUCTED	This error occurs when a motion command was successfully received and accepted, but the fingers are prevented from executing motion. This typically happens when releasing a grasped object, especially from high force. Another cause would be the failure of the device's mechanical parts. Solution: - Clear the error, then raise the OBJ Detection Threshold value and try again. Note that this will cause the gripper to draw more current from power supply; - If raising the Threshold does not work, contact Apicoo Robotics support.

6.4. Other Known Issues

Aside from the mentioned errors that raise codes during SusGrip operation, the device may, under rare conditions, exhibit undesired and unexpected behavior. This section provides a quick troubleshooting guide for common known issues; however, users are strongly encouraged to contact Apicoo Robotics for feedback and support.

6.4.1. The Gripper Turns On but Is Not Moving

If users attempt to command gripper motion using 24VDC Digital Input pin but the fingers do not move, it is likely that the gripper is configured to run in Normal mode.

In Normal mode, all signals on the DI pin are ignored.

Solution:
Simply send 5 consecutive 24VDC pulses to the DIN pin. This is equivalent to pressing a button 5 times rapidly.

6.4.2. The Gripper Does Not Turn On

This happens when the LED on SusGrip gripper does not turn on after more than 10 seconds from receiving power.

This could be due to an under-performing power supply unit, broken LED indicator, or faulty SusGrip device.

Solution:
- Verify the rating of power supply unit and make sure it meets the required specifications;
- Send 5 consecutive 24VDC pulses to the DIN pin to see if the fingers move. If they do move, only the LED indicator is malfunctioning. If they do not move at all, the device is faulty, and users are recommended to contact Apicoo Robotics for support;
- Check the power supply monitor output. If the current spikes up to extremely high when providing for SusGrip, the internal electronics are likely damaged. In this case, users are recommended to contact Apicoo Robotics for support.

6.4.3. The Gripper Cannot Be Connected Via Modbus RTU

This happens when using AUC or other methods to communicate with the device but no response is recieved.

This could be due to improper wiring, faulty USB-to-RS485 converter device, faulty SusGrip cable, or faulty SusGrip device.

Solution:
- Check whether the fingers move by sending 5 consecutive 24VDC pulses to the DIN pin. If they do move, only the communication is problematic. If they do not

move, the device might be faulty, in which case users should contact Apicoo Robotics for support;
- Verify wiring order: RS485 A+ to RS485 A+, RS485 B- to RS485 B-;
- Verify SusGrip cable by using a multimeter to check for continuity;
- If the problem involves using a USB-to-RS485 device, try with a different one;
- If multiple Modbus devices (slaves) are present on the same RS485 line, verify that the ID of each individual device is unique.

6.4.4. The Gripper's Fingers Jerk, then Object Loss/Deform Error

The gripper executes motion but ends with a sudden jerk, then the notifies Grasp Failure error with Object Lost/Deformed. This is especially likely at the 2 ends of the fingers travel path.

This is likely due to obstruction to the mechanical parts, like grains, dirt, metal chips, and other debris stuck on the travel path of the fingers and the parts. Another probable cause would be high friction due to lack of lubrication for the moving parts.

Solution:
- Increasing the OBJ Detection Threshold usually helps, refer to Feature Description and Registers Description for further detail;
- Clean the exterior of the device and apply proper lubrication.

6.4.5. The Gripper's Fingers Get Stuck at Certain Positions

This similar to the issue discussed above, but with the fingers not being able to execute motion even after releasing EMCY. This is usually accompanied with the Motion Obstructed error.

Solution: As discussed above.

6.4.6. The Gripper Keeps Disconnecting From AUC

The Apicoo Universal Console (AUC) application can scan and recognize the device, but it keeps being disconnected and returned to lobby.

This could be due to improper wiring between the SusGrip cable's RS485 wires (typically Yellow for A+, Green for B-, White for GND), loose connection of the wires, a faulty USB-to-RS485 converter device, a faulty SusGrip calbe, or a faulty SusGrip gripper.

Solution:
- Verify that the wiring from SusGrip cable to the USB-to-RS485 converter is correct and properly secured;
- Try with another USB-to-RS485 converter device to see if the problem resolves;
- Verify SusGrip cable by using a multimeter to check for continuity;
- If the problem persists after all the above steps, contact Apicoo Robotics support.

6.4.7. AUC Laggy When Connecting Multiple SusGrip

When entering the control screen on AUC with more than 1 gripper connected, the application gets laggy and unresponsive and can sometimes return to lobby with disconnected device notification.

This is likely because the grippers on the RS485 line have the same ID.

Solution:
Remove all devices from the RS485 line, connect each one by one and assign them with unique ID from 1 to 247.

6.4.8. AUC Scan Misses Devices with Consecutive ID

When multiple devices are connected to the same RS485-to-USB converter device with guaranteed unique ID for each, yet sometimes they are not listed in the AUC devices lobby when scanning. Restarting the scanning process usually works but devices are still missed.

This likely happens when the ID of the devices are configured to be consecutive or adjacent to one another, example: ID 01, ID 02, ID 03, ID 04.

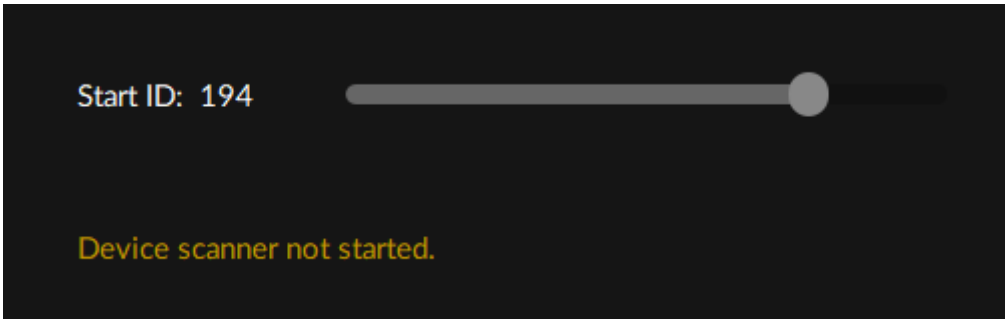
Solution:
Re-configure each device at least 01 value apart, for example ID 01, ID 03, ID 05, ID 08, ID 12.

6.4.9. AUC Takes Too Long to Scan and Find My Device

This is when AUC takes a long time, likely > 5s to scan and recognize the connected SusGrip gripper(s).

This likely happens when the ID of the device(s) is/are configured with a larger value, example: ID 50+, ID 100+, ID 200+. By defaults, AUC starts scanning from ID 01 to ID 247, and an interval of 100ms is added between each ID for the RS485 line to settle. This makes devices with higher ID wait longer to be scanned.

Solution:
On the scanning screen of AUC, expand the scanner options and drag the "Start ID" slider to select which ID to start scanning from:



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7 - CERTIFICATES

See on the next page.

방송통신기자재등(전자파적합성) 시험성적서

1. 발 급 번 호	:	F690501-RF-EMC002514_1
2. 접 수 일	:	2024년 01월 22일
3. 시 험 기 간	:	2024년 06월 17일 ~ 2024년 06월 26일
4. 신청인(상호명)	:	주식회사 아피쿠로보틱스코리아 (Apicoo Robotics Korea Co., Ltd.)
사업자등록번호	:	526-87-03058
대표자 성명	:	VO GIA LOC(보지아록)
주 소	:	경기도 성남시 분당구 판교로 289번길 20, 3동 1층 (삼평동, 판교테크노밸리 스타트업 캠퍼스)
5. 기자재 명칭 / 모 델 명	:	서스그립 스마트 그리퍼 / 서스그립
6. 제 조 자 / 제조국가	:	주식회사 아피쿠로보틱스코리아(Apicoo Robotics Korea Co., Ltd.) / 베트남
7. 시 험 결 과	:	적합

방송통신기자재등 시험기관의 지정 및 관리에 관한 고시
제13조의 규정에 의하여 시험성적서를 발급합니다.

2024년 07월 24일

한국에스지에스㈜ 대표이사 (인)

주소 : 경기도 군포시 엘에스로 182번길 4 (산본동)
전화번호 : 031-428-5700
팩스번호 : 031-427-2370

※ 인증 받은 방송통신기자재는 반드시 "적합성평가표시"를 부착하여 유통하여야 합니다.
위반 시 과태료 처분 및 인증이 취소될 수 있습니다.

본 시험성적서의 시험결과는 신청인이 제출한 시료에 한합니다.

본 시험성적서는 전파법에 따른 적합성평가 시험성적서이므로 "KOLAS 인정"과 관련이 없음.

345C-6088-BA5F-6018

방송통신기자재등의 적합등록 필증

Registration of Broadcasting and Communication Equipments

상호 또는 성명 Trade Name or Registrant	주식회사 아피쿠로보틱스코리아 (Apicoo Robotics Korea Co., Ltd.)
기자재명칭(제품명칭) Equipment Name	서스그립 스마트 그리퍼
기기부호/추가 기기부호 Equipment code /Additional Equipment code	ROB11
기본모델명 Basic Model Number	서스그립
파생모델명 Series Model Number	
등록번호 Registration No.	R-R-26a-SusGrip
제조자/제조국가 Manufacturer/Country of Origin	주식회사 아피쿠로보틱스코리아 (Apicoo Robotics Korea Co., Ltd.)/베트남
등록연월일 Date of Registration	2024-07-24
기타 Others	

위 기자재는「전파법」제58조의2 제3항에 따라 등록되었음을 증명합니다.

It is verified that foregoing equipment has been registered under the Clause 3, Article 58-2 of Radio Waves Act.

2024년(Year) 07월(Month) 24일(Day)

국립전파연구원장 국립전파연구원장인

Director General of National Radio Research Agency

※ 적합등록 방송통신기자재는 반드시 **"적합성평가표시"** 를 부착하여 유통하여야 합니다.

위반시 과태료 처분 및 등록이 취소될 수 있습니다.

TEST REPORT

Job No.	:	**GPEM2401000077EC**
Test Report No.	:	**F690501-RF-EMC002516**
Applicant	:	**Apicoo Robotics Korea**
Product Name	:	**Susgrip Smart Gripper**
Model Name	:	**SusGrip**
Standards	:	**FCC Part 15 Subpart B**
Date of Receipt	:	**January 22, 2024**
Date of Test	:	**June 17, 2024**
Date of Issue	:	**July 18, 2024**
Test Result	:	**Complied**

1) This test report does not assure KOLAS accreditation.
2) The results of this test report are effective only to the items tested.
3) The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received.

	Tested by (Name, signature)	Approved by (Name, signature)
Affirmation	*Luther Choi*	*Julia Choi*

SGS Korea Co., Ltd. Gunpo Laboratory
4, LS-ro 182beon-gil, Gunpo-si, Gyeonggi-do, 15807, KOREA

TEST REPORT

Job No.	:	**GPEM2401000076EC**
Test Report No.	:	**F690501-RF-EMC002515**
Applicant	:	**Apicoo Robotics Korea**
Product Name	:	**Susgrip Smart Gripper**
Model Name	:	**SusGrip**
Standards	:	**EN IEC 61000-6-2:2019**
		EN IEC 61000-6-4:2019
Date of Receipt	:	**January 22, 2024**
Date of Test	:	**June 17, 2024 ~ June 26, 2024**
Date of Issue	:	**July 24, 2024**
Test Result	:	**Complied**

1) This test report does not assure KOLAS accreditation.
2) The results of this test report are effective only to the items tested.
3) The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received.

	Tested by (Name, signature)	Approved by (Name, signature)
Affirmation	*Luther Choi*	*Julia Choi*

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