SURGE ROBOTIC HAND

Interface Control Document

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Revision	A
Date	January 1, 2026
Status	Initial Release

— REVISION HISTORY

Rev	Date	Author	Description of Change
A	January 1, 2026	Jackson Heinz	Initial Release

1 SYSTEM OVERVIEW

Rev	Date
Product Name	Surge
Document Rev	A
Date	January 1, 2026
Prepared By	Jackson Heinz
Reviewed By	Ryan Saavedra, Jason Beens, Samuel Woolfolk
Integration Platform	Multiple platforms; compatible with multi-axis robotic arms and humanoid platforms
Intended Use	General-purpose dexterous manipulation: applications include industrial automation, research, prosthetics, and broad human-environment interaction

System Description

Surge is a 6-DoF robotic hand designed for humanoid and robotic arm platforms, combining human-inspired dexterity with robust engineering to give robots reliable, practical interaction in real-world environments

Interface Summary

Power: 48V DC via M8 4-pin circular connector (Pin 1: Vcc, Pin 2: GND). Communication: RS-485 half-duplex (Pin 3: RS485_B, Pin 4: RS485_A). Single cable carries both power and communication

Assumptions & Constraints

The RS-485 serial interface used for communication with the host will be a direct connection between the Surge and the host. There will be no other nodes on the RS-485 bus. Host processor type, OS, and cable harness configuration are determined by the integrating platform.

2 ELECTRICAL INTERFACE

Parameter	Value / Specification
Operating Voltage Range	28 – 58 VDC
Nominal Input Voltage	48 VDC
Typical Current Draw	~79.6 mA at 48.15 V (idle)
Peak Current Draw	~3.5 A (48.15 V, Fine Pinch pose) No hardware current limit. Actual peak may exceed this value depending on supply impedance and cable gauge.
Startup / Inrush Current	~19 A peak, ~20 µs duration (60 V, worst-case input). Actual peak value is dependent upon power supply output impedance and cable gauge.
Power Connector Type	M8 circular, 4-pin, A-coding, right-angle female (IEC 61076-2-104); M8x1.0 locking thread
Power Sequencing Notes	Not applicable. Single power source; no sequencing required.

Connector Pinout

The following pinout applies to the Surge wrist connector (M8, 4-pin) and the mating cable (FTDI USB-RS485-WE or equivalent).

Pin #	Signal Name	Wire Color (Cable) / Notes
Pin 1	Vcc	Blue — Power Supply Positive
Pin 2	GND	Brown — Power supply ground
Pin 3	RS485_B	Black — RS-485 Data B (−)
Pin 4	RS485_A	White — RS-485 Data A (+)

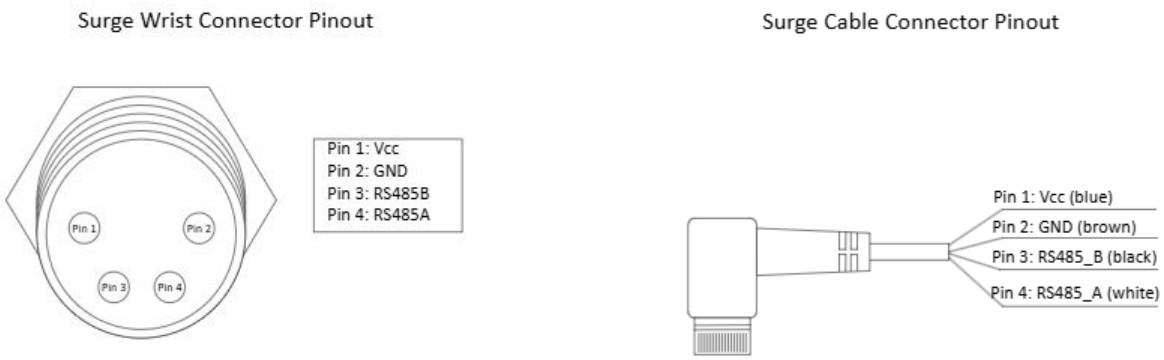

Figure 2.1 — Surge Wrist Connector Pinout (Surge side, M8 4-pin)

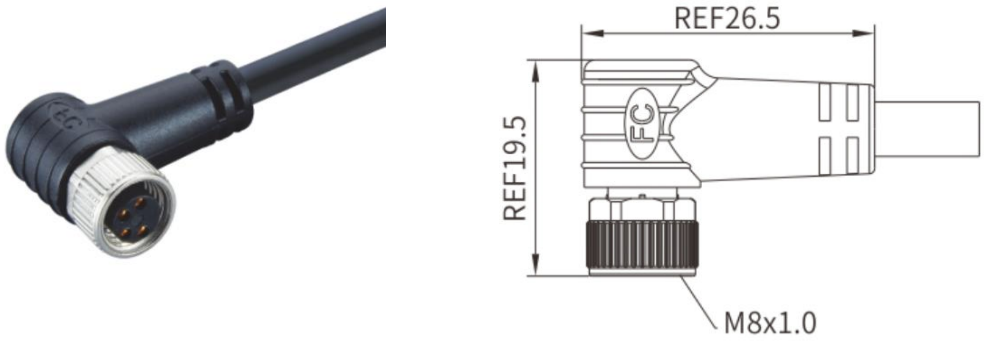

Figure 2.2 — Mating Cable Connector (M8 right-angle female, 90°)

3 COMMUNICATION INTERFACE

Parameter	Rev
Interface Type	RS-485 (TIA-485 B) half-duplex
Bit Rate	115200 bits per second
Data Bits	8 bits
Stop Bits	1 bit
Parity	None
Bus Termination	Termination provided on Surge PCBA. This termination is always present.
Max Cable Length	3 meters
Connector / Cable Type	Surge side: M8 4-pin circular, A-coding, right-angle female (IEC 61076-2-104). PC/host side: FTDI USB-RS485-WE-1800-BT or equivalent RS-485 adapter.
Notes	1. Only the host node and the Surge node are allowed on the RS-485 bus. Additional nodes can be supported but must not transmit. 2. A delay of 1.5 ms must be allowed between a query and its response. During this delay, further transmission is not allowed, or data corruption will occur. This applies even when command response is enabled via AT+SEF=1.

4 AT COMMAND SET

Commands follow AT-command convention. Set commands write a value; query commands read a value. Terminate every command with \n\r. Command feedback is disabled by default (AT+SEF=0).

All commands are 7-bit ASCII encoded strings. Each command must be terminated with \n\r. Non-ASCII characters (including Unicode) are not supported and will cause undefined behavior.

Startup Banner & Self-Test Sequence

On power-up, the Surge transmits an unstructured ASCII banner over RS-485 before the command interface becomes active. Parsers must be designed to tolerate and discard this unstructured data before issuing commands. The complete startup sequence is shown below.

```
*********************************************************************************
---------------------------------------------------------------------------------
---------------------------------Welcome to Surge---------------------------------
---------------------------------------------------------------------------------

Hand Version: Surge v1
Firmware Version: v1.4

---------------------------------------------------------------------------------
---------------------------------Performing Idle Current Test----------------------
---------------------------------------------------------------------------------

PCB No Error: Idle current test passed

---------------------------------------------------------------------------------
---------------------------------Performing Hand Calibration-----------------------
---------------------------------------------------------------------------------

---------------------------------------------------------------------------------
---------------------------------Finger Min/Max Results----------------------------
---------------------------------------------------------------------------------

Index Min: 4
Index Max: 107
Middle Min: 4
Middle Max: 109
Ring Min: 4
Ring Max: 106
Pinky Min: 4
Pinky Max: 106
Thumb Flextion Min: 4
Thumb Flextion Max: 102
Thumb Rotation Min: 10
Thumb Rotation Max: 100

---------------------------------------------------------------------------------
---------------------------------Encoder Error Results-----------------------------
---------------------------------------------------------------------------------

Pinky error: 0xDD - No error
Ring error: 0xDD - No error
Middle error: 0xDD - No error
Index error: 0xDD - No error
Thumb Flextion error: 0xDD - No error
Thumb Rotation error: 0xDD - No error
Encoder: Encoder range test passed
Encoder: Encoder drift test passed

Calibration Passed

---------------------------------------------------------------------------------
Startup Sequence Complete
---------------------------------------------------------------------------------
```

Note: Finger min/max values shown above are example calibration results and will vary per unit. The 0xDD encoder error code indicates no error. Startup Sequence Complete signals that the command interface is ready.

Query Commands

Command	Syntax	Description	Parameters	Example	Response
AT+GJA	AT+GJA?<finger>	Get current joint angle	finger: finger identifier	AT+GJA?I	<angle>\n\r
AT+GJE	AT+GJE?<finger>	Get joint error state	finger: finger identifier	AT+GJE?T	0x0001\n\r

Set Commands

Command	Syntax	Description	Parameters	Example	Response
AT+SJA	AT+SJA=<angle>,<finger>	Set target joint angle	angle: float (1 dp); finger: identifier	AT+SJA=45.5,I	OK\n\r
AT+SPP	AT+SPP=<pose>	Execute predefined grip/pose	pose: pose index (0–6)	AT+SPP=1	OK\n\r
AT+SSM	AT+SSM=<stop>,<finger>	Stop / run motor. A stops all	stop: 0=Run 1=Stop; finger or A	AT+SSM=1,A	OK\n\r
AT+SCE	AT+SCE=<finger>	Clear motor error / release joint	finger: finger identifier	AT+SCE=T	OK\n\r
AT+SMC	AT+SMC=<mode>	Enable / disable Manus control	mode: 0=Disabled 1=Enabled	AT+SMC=1	OK\n\r
AT+SEF	AT+SEF=<mode>	Enable OK/ERROR feedback	mode: 0=Disabled 1=Enabled	AT+SEF=1	OK\n\r
AT+RCH	AT+RCH=1	Trigger full hand recalibration	None	AT+RCH=1	None

PID Gain & Current Threshold Commands

⚠ **WARNING** Surge ships with a stable PID and current threshold configuration. Modify these values at your own risk. Incorrect settings may cause unpredictable motor behavior or hardware damage.

Command	Syntax	Description	Parameters	Example	Response
AT+SCG	AT+SCG=<gain>,<finger>	Enable/disable user-defined PID gains	gain: 0=Disabled 1=Enabled; finger	AT+SCG=1,I	OK\n\r
AT+SCP	AT+SCP=<p>,<finger>	Set P gain (SCG=1 required first)	p: int; finger	AT+SCP=5,M	OK\n\r
AT+SCI	AT+SCI=<i>,<finger>	Set I gain (SCG=1 required first)	i: int; finger	AT+SCI=5,M	OK\n\r
AT+SCD	AT+SCD=<d>,<finger>	Set D gain (SCG=1 required first)	d: int; finger	AT+SCD=5,R	OK\n\r
AT+SCT	AT+SCT=<thresh>,<finger>	Set current threshold (% of max)	thresh: int 0–100; finger	AT+SCT=50,I	OK\n\r

Finger Identifier Codes

Index	Code	Finger	Notes
0	X	Thumb – Rotation	
1	T	Thumb – Flex	
2	I	Index	
3	M	Middle	
4	R	Ring	
5	P	Pinky	
6	A	All Joints	SSM command only

Pose Index Codes

Index	Pose Name	Notes
0	Open	All fingers fully extended with the thumb abducted. Neutral starting position.
1	Power Grip	Fingers wrap around object while thumb secures grip for forceful holding.
2	Chuck Grip	Thumb, index, and middle finger pinch medium objects with stable control.
3	Fine Pinch	Thumb and index fingertip pinch small objects requiring precise control.
4	Key Grip	Thumb presses object against side of index finger for lateral holding.
5	Hook Grip	Fingers flex without thumb to carry handles, bags, or straps.
6	Tool Grip	Cylindrical grasp optimized for holding elongated tools like pens or utensils.

5 STATUS & TELEMETRY

Query commands (Section 4) are the primary telemetry interface. Cross-references are provided below.

Parameter	Query Command	Format / Notes
Position Feedback (per joint)	AT+GJA?<finger>	Float, degrees (1 dp)
Joint Error State	AT+GJE?<finger>	Hex error code, e.g. 0x0001

6 FAULT HANDLING

Fault codes are returned by AT+GJE?<finger>. If a joint enters a locked state due to an error condition (e.g., collision event), it will automatically clear when motion returns to a collision-free direction. To manually clear the error and immediately release a locked joint, use AT+SCE=<finger>.

Fault Code	Cause / Trigger	Reported Via	Clear Procedure
0x0001	Stall resulting in overcurrent	AT+GJE?<finger>	AT+SCE=<finger>

7 STARTUP / INITIALIZATION

Parameter	Details
Boot Time	~5 seconds
Default State on Power-Up	Uncalibrated. Previous hand state is not retained.
Required Init Commands	None.
Ready Signal / Message	Startup Sequence Complete
Additional Notes	The interface is designed for compatibility with a terminal.

Safe Shutdown Behavior

Place hand into open pose (AT+SPP=0) and remove power.

8 MECHANICAL INTERFACE

Parameter	Details
Mounting Interface / Pattern	EN ISO 9409-1-50-4-M6 (industry standard); custom mounting adapters also available
Connector Location	Wrist adapter, dorsal side. 90° right-angle M8 connector.
Cable Strain Relief Required?	Suggested
Min Bend Radius (Cable)	35 mm
Integration Notes	Please ensure M8 cable is fully tightened when removing and attaching.

9 ENVIRONMENTAL LIMITS

Parameter	Specification
Operating Temperature	-20°C to +60°C (not formally characterized; standard industrial range)
Storage Temperature	+15°C to +35°C (room temperature)
Humidity (Operating)	5% to 95% RH, non-condensing
IP Rating	IP54 (not formally certified)

END OF DOCUMENT