SUBINITIAL LLC

General Description

The Relay Deck provides a number of relays for user control. Its mechanical relays allow switching high power loads and its solid-state relays provide an alternative for lower-power loads. When connected to the Core, the Relay Deck is a seamless expansion of the Core's functionality. Just like the Core, it can be controlled using Python.

The Relay Deck contains four mechanical relays, two solid-state relays, and two opto-isolated inputs. Two of the mechanical relays are SPDT rated at 250VAC with an internal 8A fuse, and the other two are DPDT relays rated at 250VAC with internal 4A fuses on each pole. All relays have the Normally Open (NO), Normally Closed (NC), and Common (COM) terminals accessible. The SPDT relays have transient overvoltage protection across all contacts for extended contact life with inductive loads. Each SPDT relay and DPDT has true RMS current readings through DC and AC current sensing to ±50A.

Two solid-state relays are provided along with two opto-isolated inputs. One solid-state relay is rated at 250VAC with internal 1A fuse. It is for AC only, as it is triac-based. The other solid-state relay is rated at 48VDC with internal 750mA fuse. It can be used for AC or DC, as it is MOSFET-based. Both solid-state relays have overtemperature protection. The opto-isolated inputs act as discrete inputs and can measure ±3VDC up to 250VAC directly. These inputs can easily be programmed to automate triggering, such as turning on relays 1 and 3 when AC power is detected.

A full bodied hard anodized aluminum enclosure provides physical protection for the Relay Deck. Electrically, the Relay Deck I/O are designed with industry-standard protection, and all I/O are galvanically isolated from the Stacks Core and all other Decks.

Applications

- Automated Test Systems
- Design Verification
- Rapid Prototyping

Features

- 2 SPDT Relays, 7.5A 250VAC with Current Meters
- 2 DPDT Relays, 3.5A 250VAC Relays with Current Meters
- True RMS current readings
- Fusing with auto-detect of blown fuse on mechanical relays
- AC Solid-state Relay, 0.9A 250VAC
- DC Solid-state Relay, 0.7A 48VDC
- Opto-isolated inputs, 3-250V, for easy automation

Related Products

Description	Part Number
Relay Deck Breakout Board	SA13710
Stacks Core	SA13729

Rear Panel Connection
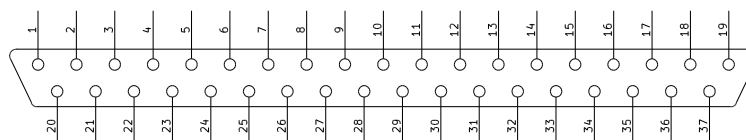
Figure 1: Connector Diagram

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Pin Functionality Table

Please refer to Figure 1.

Relay Deck DC-37 Connector Pin Functionality Chart:

Pin #	Function Name	Functionality
ALL		All lines are 250VAC tolerant and isolated with at least functional isolation from Stacks GND, unless otherwise specified. There is no Basic or Reinforced insulation.
1	RELAY3B_COMMON	Relay contact common connection.
2	RELAY3A_NC	Relay contact - Normally Closed connection. Connects to common when relay is not energized.
3	RELAY3A_NO	Relay contact - Normally Open connection. Connects to common when relay is energized.
4	RELAY3A_COMMON	Relay contact common connection.
5	RELAY2B_NC	Relay contact - Normally Closed connection. Connects to common when relay is not energized.
6	RELAY2B_NO	Relay contact - Normally Open connection. Connects to common when relay is energized.
7	RELAY2B_COMMON	Relay contact common connection.
8	RELAY2A_NC	Relay contact - Normally Closed connection. Connects to common when relay is not energized.
9	RELAY2A_NO	Relay contact - Normally Open connection. Connects to common when relay is energized.
10	RELAY2A_COMMON	Relay contact common connection.
11, 29	RELAY1_NC	Relay contact - Normally Closed connection. Connects to common when relay is not energized.
12, 30	RELAY1_NO	Relay contact - Normally Open connection. Connects to common when relay is energized.
13, 31	RELAY1_COMMON	Relay contact common connection.
14, 32	RELAY0_NC	Relay contact - Normally Closed connection. Connects to common when relay is not energized.
15, 33	RELAY0_NO	Relay contact - Normally Open connection. Connects to common when relay is energized.
16, 34	RELAY0_COMMON	Relay contact common connection.
17	RELAY4_NO	AC solid-state relay Normally Open connection. Connects to common when relay is active. This solid-state relay requires a voltage zero-crossing to turn off after commanded to turn off. Suggested to only use with AC waveforms.

18	RELAY4_COMMON	AC solid-state relay common connection. Connects to Normally Open connection when relay is active. This solid-state relay requires a voltage zero-crossing to turn off after commanded to turn off. Suggested to only use with AC waveforms.
19	RELAY5_COMMON	DC solid-state relay common connection. Connects to Normally Open connection when relay is active. This solid-state relay turns on or off on command. May be used for AC or DC. Tolerant to ±48VDC from contact A to contact B. Tolerant to ±100V from Stack GND.
20	INPUT_RTN	Return line for INPUT_A and INPUT_B.
21	RELAY3B_NO	Relay contact - Normally Open connection. Connects to common when relay is energized.
22	RELAY3B_NC	Relay contact - Normally Closed connection. Connects to common when relay is not energized.
23	RELAY2B_NC	Relay contact - Normally Closed connection. Connects to common when relay is not energized.
24	RELAY2B_NO	Relay contact - Normally Open connection. Connects to common when relay is energized.
25	RELAY2B_COMMON	Relay contact common connection.
26	RELAY2A_NC	Relay contact - Normally Closed connection. Connects to common when relay is not energized.
27	RELAY2A_NO	Relay contact - Normally Open connection. Connects to common when relay is energized.
28	RELAY2A_COMMON	Relay contact common connection.
29	RELAY1_NC	See pin 11
30	RELAY1_NO	See pin 12
31	RELAY1_COMMON	See pin 13
32	RELAY0_NC	See pin 14
33	RELAY0_NO	See pin 15
34	RELAY0_COMMON	See pin 16
35	INPUT_A	Optoisolated input that can be programmed to control relays. Turns on with a ±3V input with respect to INPUT_RTN. Can accept up to 250VAC. Directly controls rear LED 7.
36	INPUT_B	Optoisolated input that can be programmed to control relays. Turns on with a ±3V input with respect to INPUT_RTN. Can accept up to 250VAC. Directly controls rear LED 8.
37	RELAY5_NO	DC solid-state relay Normally Open connection. Connects to common when relay is active. This solid-state relay turns on or off on command. May be used for AC or DC. Tolerant to ±48VDC from contact A to contact B. Tolerant to ±100V from Stack GND.
SHD	SHIELD	Connector shield is connected to chassis, and is capacitively coupled to GND though 1000V capacitors.

General Characteristics

Measurement Category:
> CAT I

Recommended Female 37-pin D-sub (DC-37) Mating Connector:
> Norcomp 171-037-203L001

Software Interface

The Relay Deck's features are controlled by software running on a host machine. Software documentation, the Stacks Python API Reference, and example code can be found at http://subinitial.com/documentation/software.

SPDT Relay

There are two single pole double throw (SPDT) relays, Relay 0 and Relay 1. These relays are mechanical relays, have current sense and fusing with blown fuse detection, and have transient overvoltage protection across all contacts for extended contact life with inductive loads.

Current sense is achieved using a galvanically isolated differential hall effect sensor in line with the COM terminal. This provides ability to measure both DC and AC current, as well as true RMS current.

The fuses are standard replaceable cartridge fuses (with leads) in line with the COM terminal. The devices providing the transient overvoltage protection are Metal Oxide Varistors (MOV's) across the relay's terminals from COM to NC and COM to NO.

Note: The MOV's may allow AC currents to pass through their internal capacitance regardless of relay position. See MOV CHARACTERISTICS electrical characteristics section for details.
Note: The fuse detection circuit will allow current to pass through its internal structure when fuse is blown. See FUSE DETECT electrical characteristics section for details.

Replaceable Fuse: Littelfuse PN 0216008.MXESPP or equivalent (8A 250V, fast-acting, ceramic fuse), leads bent and clipped to fit in the socket.

Applicable Pins: DC-37 pins 11, 12, 13, 14, 15, 16, 29, 30, 31, 32, 33, 34.

Absolute Maximum Ratings[(1)(2)(3)]

T_A = 25C, unless otherwise specified.

Description	Rating
Applied Voltage, $V_{PIN-TO-PIN}$ [(4)]	265VAC or ±145VDC
Applied Voltage, $V_{PIN-TO-GND}$	±400V
Applied Voltage, $V_{PIN-TO-CHASSIS}$ [(5)]	±400V
Peak Current	±50A

(1) Stresses beyond those listed may cause permanent device damage. Functional operation range of the device is defined in Recommended Operating Ratings or Electrical Characteristics. Exposure to absolute max ratings for extended periods may reduce device reliability.
(2) As designed and characterized, not fully tested in production.
(3) Voltages are relative to Stacks GND, as connected to the Core or other Decks.
(4) Voltage between any pins of the same relay pole.
(5) Relative to chassis, as defined as the DC-37 (D-sub) metal shell.

Recommended Operating Ratings

T_A = 25C, unless otherwise specified.

Parameter	Conditions		Min	Typ	Max	Unit
AC Voltage			-	-	250	VAC
Peak Voltage			-	-	±350	V
DC Voltage			-	-	±120	VDC
AC Current			-	-	7.8	A
DC Current	Continuous (Non-switching)		-	-	±7.8	A
	Switching Voltage	≤ 24V	-	-	±7.8	A
	24V < Switching Voltage	≤ 30V	-	-	±5	A
	30V < Switching Voltage	≤ 35V	-	-	±2	A
	35V < Switching Voltage	≤ 50V	-	-	±1	A
	50V < Switching Voltage	≤ 100V	-	-	±0.4	A
	100V < Switching Voltage		-	-	±0.3	A

Electrical Characteristics[2]

$T_A = 25C$, unless otherwise specified.

Parameter	Symbol	Conditions	Ratings
RELAY			
Operate time			15ms max
Release time			5ms max
Max Operating Frequency		Mechanical	5 Hz
		Electrical, 12A load	0.5 Hz
Endurance (Mechanical)		At 18,000 operations/hr	20,000,000 operations
Electrical Life		8A at 250VAC (cos ϕ=1)	50,000 operations min.
		8A at 24VDC	30,000 operations min.
		5A at 250VAC (cos ϕ=0.4), normally open contacts	150,000 operations min
		5A at 30VDC (L/R=7ms) normally open contacts	20,000 operations min
Shock Resistance		Malfunction	$100 \ m/s^2$ (approx. 10 G)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
FUSE CHARACTERISTICS						
Type				Fast		
Current Rating				8		A
Voltage Rating				250		V
Interrupt Rating		250VAC	-	-	1500	A
Nominal Melting I^2t			-	64.3	-	A^2 sec
Opening Time		210% Current Rating	-	-	30	min
		275% Current Rating	0.04	-	20	sec
		400% Current Rating	0.01	-	1.0	sec
		1000% Current Rating	-	-	0.03	sec
CURRENT SENSE MEASUREMENT						
Gain Error [1] [3]		RMS measurement	-	-	±2.5	%
Offset Error [1] [3]		RMS measurement	-	-	±50	mA
RMS Bandwidth			-	1.1	-	kHz
FUSE DETECT						
Voltage for Fuse Detect [1]			±3.0	-	-	V
Impedance Across Fuse Terminals		Fuse Blown, Input voltage < 25V	1	1.2	-	kΩ
		Fuse Blown, Input voltage > 25V	-	-	1	MΩ
MOV CHARACTERISTICS						
Voltage at Leakage		1mA DC	351	390	429	V
Clamping Voltage		10A, 8/20 µs waveform	-	-	650	V
Energy Absorption		8/20 µs waveform	-	-	25	J
Capacitance		1kHz	-	-	130	pF
Response Time			-	10	25	ns

(1) Parameter 100% production tested at $T_A = 25C$
(2) As designed and characterized, not fully tested in production unless otherwise specified.

DPDT Relay

There are two double pole double throw (DPDT) relays, Relay 2 and Relay 3. These relays are mechanical relays, have current sense on pole A, and have fusing on each pole with blown fuse detection.

Current sense is achieved using a galvanically isolated differential hall effect sensor in line with the COM terminal on pole A. This provides ability to measure both DC and AC current, as well as true RMS current.

The fuses are standard replaceable cartridge fuses (with leads) in line with the COM terminal.

Note: The fuse detection circuit will allow current to pass through its internal structure when fuse is blown. See FUSE DETECT electrical characteristics section for details.

Replaceable Fuse: Littelfuse PN 0216004.MXESPP or equivalent (4A 250V, fast-acting, ceramic fuse), leads bent and clipped to fit in the socket.

Applicable Pins: DC-37 pins 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 21, 22, 23, 24, 25, 26, 27, 28.

Absolute Maximum Ratings[1][2][3]

T_A = 25C, unless otherwise specified.

Description	Rating
Applied Voltage, $V_{PIN-TO-PIN}$ [4]	265VAC or ±145VDC
Applied Voltage, $V_{PIN-TO-GND}$	±400V
Applied Voltage, $V_{PIN-TO-CHASSIS}$ [5]	±400V
Peak Current	±50A

(1) Stresses beyond those listed may cause permanent device damage. Functional operation range of the device is defined in Recommended Operating Ratings or Electrical Characteristics. Exposure to absolute max ratings for extended periods may reduce device reliability.
(2) As designed and characterized, not fully tested in production.
(3) Voltages are relative to Stacks GND, as connected to the Core or other Decks.
(4) Voltage between any pins of the same relay pole.
(5) Relative to chassis, as defined as the DC-37 (D-sub) metal shell.

Recommended Operating Ratings, Per Contact

T_A = 25C, unless otherwise specified.

Parameter	Conditions	Min	Typ	Max	Unit
AC Voltage		-	-	250	VAC
Peak Voltage		-	-	±350	V
DC Voltage		-	-	±120	VDC
AC Current		-	-	3.8	A
DC Current	Continuous (Non-switching)	-	-	±3.8	A
	Switching Voltage ≤ 35V	-	-	±3.8	A
	35V < Switching Voltage ≤ 45V	-	-	±2	A
	45V < Switching Voltage ≤ 60V	-	-	±1	A
	50V < Switching Voltage ≤ 100V	-	-	±0.4	A
	100V < Switching Voltage	-	-	±0.3	A

Electrical Characteristics[2]

T_A = 25C, unless otherwise specified.

Parameter	Symbol	Conditions	Ratings
RELAY			
Operate time			8ms max
Release time			6ms max
Bounce time			10ms
Max Operating Frequency		Mechanical	20 Hz
		Electrical, 8A load	0.1 Hz
Endurance (Mechanical)			30×10^6 operations

Parameter	Symbol	Conditions	Ratings		
Electrical Life		250VAC, 4A Resistive Load	150,000 operations		
		250VAC, 1A Resistive Load	500,000 operations		

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
FUSE CHARACTERISTICS						
Type				Fast		
Current Rating				4		A
Voltage Rating				250		V
Interrupt Rating		250VAC	-	-	1500	A
Nominal Melting I^{2}t			-	15.0	-	A^2 sec
Opening Time		210% Current Rating	-	-	30	min
		275% Current Rating	0.01	-	2	sec
		400% Current Rating	0.003	-	0.3	sec
		1000% Current Rating	-	-	0.02	sec
CURRENT SENSE MEASUREMENT						
Gain Error [1] [3]		RMS measurement	-	-	±2.5	%
Offset Error [1] [3]		RMS measurement	-	-	±50	mA
RMS Bandwidth			-	1.1	-	kHz
FUSE DETECT						
Voltage for Fuse Detect [1]			±3.0	-	-	V
Impedance Across Fuse Terminals		Fuse Blown, Input voltage < 25V	1	1.2	-	kΩ
		Fuse Blown, Input voltage > 25V	-	-	1	MΩ

(1) Parameter 100% production tested at T_A = 25C
(2) As designed and characterized, not fully tested in production unless otherwise specified.

AC Solid State Relay

There is one AC solid state relay, Relay 4. This relay is a triac-based solid state relay. It includes fusing for protection. The fuse is a standard replaceable cartridge fuses (with leads) in line with the terminals.

Note: Since this relay is triac-based, it requires a zero-crossing to turn off. If DC is applied to the relay, once the relay is commanded on it will remain on regardless of command until the current falls below the holding current.

Replaceable Fuse: Littelfuse PN 0216001.MXESPP or equivalent (1A 250V, fast-acting, ceramic fuse), leads bent and clipped to fit in the socket.

Applicable Pins: DC-37 pins 17, 18.

Absolute Maximum Ratings[1][2][3]

T_A = 25C, unless otherwise specified.

Description	Rating
Applied Voltage, $V_{PIN-TO-PIN}$ [4]	265VAC or ±145VDC
Applied Voltage, $V_{PIN-TO-GND}$	±400V
Applied Voltage, $V_{PIN-TO-CHASSIS}$ [5]	±400V
Non-repetitive surge current, 60Hz, 1 cycle	±12A

(1) Stresses beyond those listed may cause permanent device damage. Functional operation range of the device is defined in Recommended Operating Ratings or Electrical Characteristics. Exposure to absolute max ratings for extended periods may reduce device reliability.
(2) As designed and characterized, not fully tested in production.
(3) Voltages are relative to Stacks GND, as connected to the Core or other Decks.
(5) Relative to chassis, as defined as the DC-37 (D-sub) metal shell.

Recommended Operating Ratings, Per Contact

T_A = 25C, unless otherwise specified.

Parameter	Conditions	Min	Typ	Max	Unit
AC Voltage		-	-	250	VAC
Peak Voltage		-	-	±350	V
AC Current		-	-	0.9	A

Electrical Characteristics[2]

T_A = 25C, unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
RELAY CHARACTERISTICS						
OFF-state Current	I_{DRM}		-	-	100	µA
ON-state Voltage	V_{TM}	Current = 10mA	-	-	2.5	V
Turn-on Rise Time	T_{ON}	Voltage = 6V, Load = 100Ω	-	-	150	µs
Holding Current	I_H		-	-	25	mA
Critical rate of rise of OFF-state voltage	dv/dt	Voltage = 600VAC	200	-	-	V/µs
FUSE CHARACTERISTICS						
Type				Fast		
Current Rating				1		A
Voltage Rating				250		V
Interrupt Rating		250VAC	-	-	1500	A
Nominal Melting I^2t			-	0.18	-	A^2 sec
Opening Time		210% Current Rating	-	-	30	min
		275% Current Rating	0.01	-	2	sec
		400% Current Rating	0.003	-	0.3	sec
		1000% Current Rating	-	-	0.02	sec

(1) Parameter 100% production tested at T_A = 25C
(2) As designed and characterized, not fully tested in production unless otherwise specified.

DC Solid State Relay

There is one DC solid state relay, Relay 5. This relay is a MOSFET-based solid state relay. It includes fusing for protection. The fuse is a surface-mount fuse in line with the terminals. Since this relay is MOSFET-based, it can handle DC or AC within its specifications.

Fuse: Bel Fuse PN: C1S 750 (0.75A 63V), Reference designator F1 on bottom near D-sub connector.

Applicable Pins: DC-37 pins 17, 18.

Absolute Maximum Ratings[(1)(2)(3)]

T_A = 25C, unless otherwise specified.

Description	Rating
Applied Voltage, $V_{PIN-TO-PIN}$ [(4)]	±60VDC
Applied Voltage, $V_{PIN-TO-GND}$	±300V
Applied Voltage, $V_{PIN-TO-CHASSIS}$ [(5)]	±300V

(1) Stresses beyond those listed may cause permanent device damage. Functional operation range of the device is defined in Recommended Operating Ratings or Electrical Characteristics. Exposure to absolute max ratings for extended periods may reduce device reliability.
(2) As designed and characterized, not fully tested in production.
(3) Voltages are relative to Stacks GND, as connected to the Core or other Decks.
(5) Relative to chassis, as defined as the DC-37 (D-sub) metal shell.

Recommended Operating Ratings, Per Contact

T_A = 25C, unless otherwise specified.

Parameter	Conditions	Min	Typ	Max	Unit
Peak Voltage		-	-	±48	V
Current		-	-	0.7	A

Electrical Characteristics[(2)]

T_A = 25C, unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
RELAY CHARACTERISTICS						
ON-state Resistance			-	0.25	0.7	Ω
OFF-state Current		V = 60V	-	0.2	100	nA
OFF-state Capacitance		V = 0, f = 1MHz	-	90	-	pF
Turn-on Rise Time	t_{ON}	R_L = 200 Ω	-	-	3	ms
Turn-off Fall Time	t_{OFF}	V = 20V	-	-	1	
FUSE CHARACTERISTICS						
Type				Slow		
Current Rating				0.75		A
Voltage Rating		AC or DC		63		V
Interrupt Rating		63V AC or DC	-	-	50	A
Nominal Melting I^2t			-	0.01	-	A^2 sec
Opening Time	100% Current Rating	4	-	-	hrs
	200% Current Rating	1	-	120	Sec
	300% Current Rating	0.1	-	3	sec
	800% Current Rating	0.002	-	0.05	sec

(1) Parameter 100% production tested at T_A = 25C
(2) As designed and characterized, not fully tested in production unless otherwise specified.

Optoisolated Inputs

Input 0 and Input 1 are optoisolated inputs. The opto-isolated inputs act as discrete inputs and can measure $\pm$3VDC up to 250VAC directly. The inputs are galvanically isolated from Stacks ground or chassis through an opto-isolator. Both inputs share a common return line. The inputs have a PTC in series, so at low voltages the input impedance will be low but at high voltages the input impedance will be high, see Electrical Characteristics for details.

Applicable Pins: DC-37 pins 20, 35, 36.

Absolute Maximum Ratings[(1)(2)(3)]

T_A = 25C, unless otherwise specified.

Description	Rating
Applied Voltage, $V_{PIN-TO-PIN}$ [(4)]	265VAC or $\pm$145VDC
Applied Voltage, $V_{PIN-TO-GND}$	$\pm$400V
Applied Voltage, $V_{PIN-TO-CHASSIS}$ [(5)]	$\pm$400V

(1) Stresses beyond those listed may cause permanent device damage. Functional operation range of the device is defined in Recommended Operating Ratings or Electrical Characteristics. Exposure to absolute max ratings for extended periods may reduce device reliability.
(2) Relative to Stacks GND, as connected to the Core or other Decks, unless otherwise specified.
(3) As designed and characterized, not fully tested in production.
(4) Voltage between INPUT and INPUT RTN pins.
(5) Relative to chassis, as defined as the DC-37 (D-sub) metal shell.

Recommended Operating Ratings

T_A = 25C, unless otherwise specified.

Parameter	Conditions	Min	Typ	Max	Unit
Applied Voltage, AC	Continuous	-	-	250	VAC
Applied Voltage, DC	Continuous	-120	-	120	VDC

(1) Relative to INPUT RTN.

Electrical Characteristics[(2)]

T_A = 25C, unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Input Trip Threshold[(1)(3)]	V_{TH}		-	$\pm$1.2	$\pm$3.0	V
Input Impedance[(3)]	R_{IN}	$V_{IN} < 25V$	1	1.2	-	kΩ
		$V_{IN} > 25V$	-	-	1	MΩ
Action Response Time		Input rising	-	1.5	-	ms
		Input falling	-	16	-	ms

(1) Parameter 100% production tested at T_A = 25C
(2) As designed and characterized, not fully tested in production unless otherwise specified.
(3) Relative to INPUT RTN.