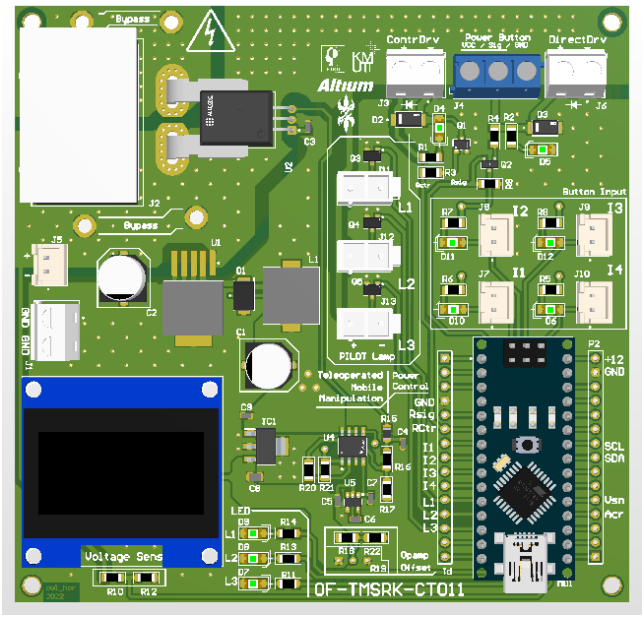
OF-TMSRK-CT011

Power Control Circuit



This circuit is designed to be the power control circuit using external relay, contactor. The microcontroller (Arduino nano) will be placed to manage the control signal, State machine, I/O button and LED, OLED SH1106 display. Voltage and current measure are also available in this circuit.

This board is specifically designed to be the power control circuit of the "Teleoperated Mobile Manipulation" Project (Smart Rod Khen).

Please read all the general information in this datasheet before use.

Contents

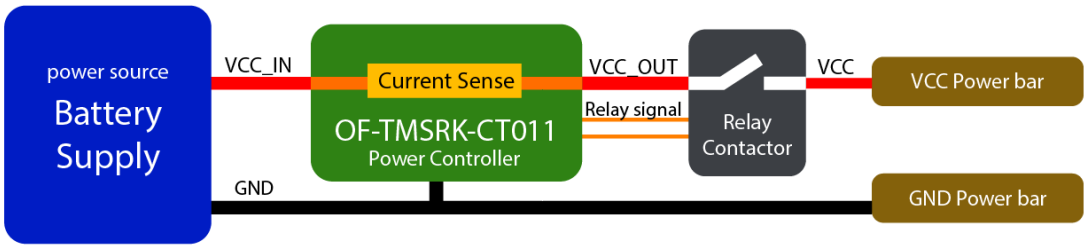
Features

- Using Arduino Nano as a controller
- Current Sense (ACS758).
- Voltage Sense (Voltage divider).
- 1 External Contactor, Relay Drive (Direct or controlled)
- SH1106 Display
- 4 Input pull up button.
- 3 Output LED-Pilot Lamp.
- Bypass hole for high current usage.

Hardware Diagram

CT011 is the power control circuit designed to enable/ disable the power line by using **"External Relay, Contactor"**. The system which CT011 can control should have the circuit layout, design as this following diagram.

VCC_IN from power source will flow through current sense module of CT011 and flow out as VCCC_OUT. CT011's GND is not designed to be a flowing path. So, GND from power source should be connected directly to the external power bar and jump GND from the bar to CT011.



Electrical Characteristics

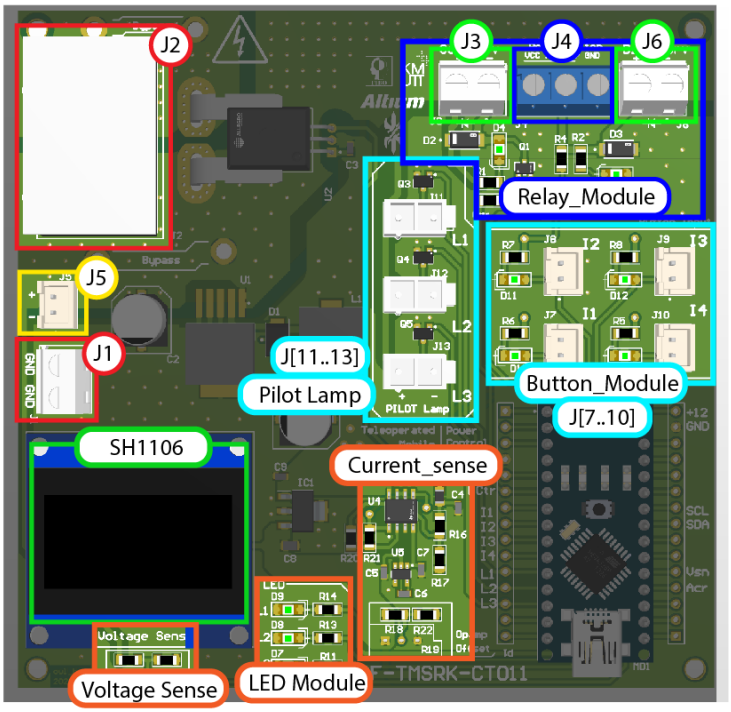
		Min	Typ.	Max	Unit
VCC Supply Voltage Rating[1]		12	24	30	V
Current Rating	Normal[2]		12		A
	Bypass[3]		50		A

[1] Selected voltage must be the rate which enable to drive relay, contactor coil and pilot lamp.

[2] Consider from trace width with 10 C rise above ambient temperature (25 C). Using IPC-2152 based calculator to approximate.

[3] Consider from absolute maximum rating of ACS758. More information at Bypass session.

General Information & Pin Map

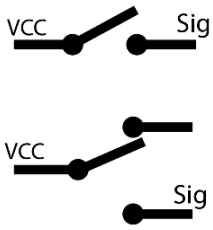
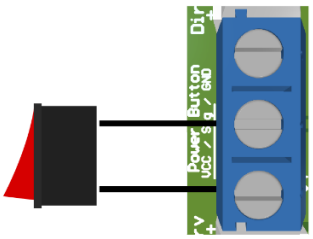
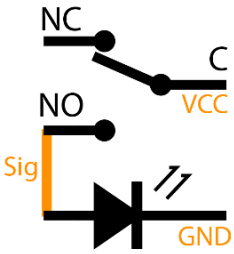
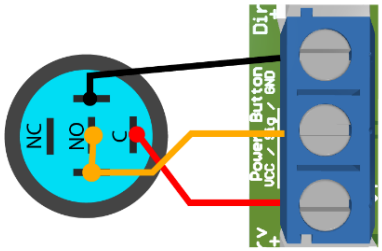


Components	Pins	Connection
J1	1,2	GND
J2	1 [VCC_IN]	VCC, Input from power Source
	2 [VCC_OUT]	VCC, Output to the power bar
J3	1,2	External Contactor / Relay (Visit: Contactor, Relay Drive Usage)
J4	1,2,3	ON/OFF Button (Visit: ON/OFF Button connection)
J5	1,2	Battery measure meter
J6	1,2	External Contactor / Relay (Visit: Contactor, Relay Drive Usage)
J[7..10]	1,2	1/0 Button (Visit: Pull up Button)
J[11..13]	1,2	Pilot Lamp Connector

Blocks	Pin Connection		Description
	CT011	Arduino Pin	
Relay_Module	R_sig	**D2**	Detect status of ON/OFF Button
	Relay_port	**D10**	Drive Relay in control mode. (Visit: Contactor, Relay Drive Usage)
Current_Sense	AA_crnt	**A0**	Current measure (Visit: Signal Conditioning for Current Sensor)
Voltage_sense	V_mea	**A1**	Voltage measure (Visit: Voltage Sense)
SH1106	SCLK	**A5**	SH1106 OLED Display I2C Proticol
	SDA	**A4**	
Button_Module	Btn_[1..4]	**D[3..6]**	General Purpose Input Button (Visit: Pull up Button)
LED_Module	LED[1..3]	**D[7..9]**	Output LED & Pilot Lamp Driver (Visit: LED & Pilot Lamp Drive)
Pilot Lamp	LED[1..3]	**D[7..9]**	Output LED & Pilot Lamp Driver (Visit: LED & Pilot Lamp Drive)

ON/OFF Button connection

CT011 Circuit is designed to be connected with both normal ON/OFF Button and LED Built-in ON/OFF Button

Type	Symbol	Visual	Method
Normal ON/OFF			Open Circuit-> Disable Relay Closed Circuit-> Enable relay
LED Built-in ON/OFF			Open Circuit-> Disable Relay LED Off Closed Circuit-> Enable relay LED On

Digital I/O

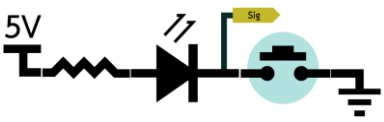
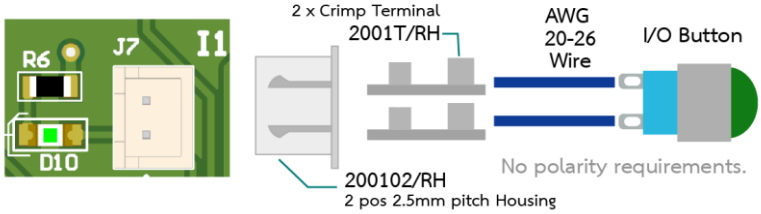
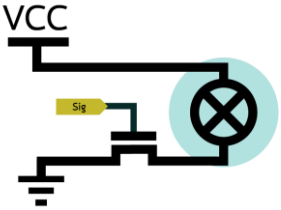
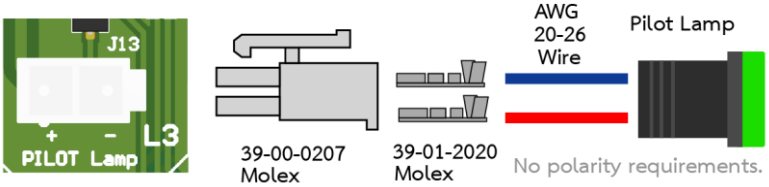
Pull up Button

There're 4 units of pull-up set for connecting with the button which can be used to receive the 1/0 signal from the buttons. Get the signal from **D[3..6]** Arduino nano pin.

LED & Pilot Lamp Drive

There're 3 units of output LED port which link with the pilot lamp socket available for showing any status that user need. Using same method to light the LED and pilot lamp, Assign 1 to the pin. D[7..9] pin of Arduino nano are connected to the LED.

Consider to use match voltage between VCC Supply and Pilot Lamp (12, 24 VDC)

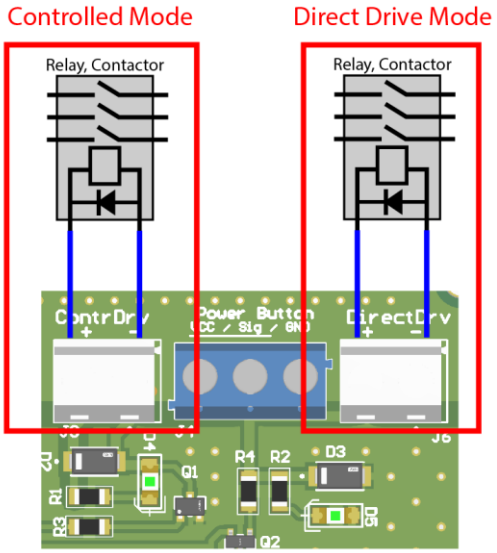
Module	Symbol	Button Connection
Pull up Button		
LED & Pilot Lamp Drive		

Contactor, Relay Drive Usage

In CT011, Relay, Contactor is designed to be controlled by 2 methods, directly and controller controlled. Relay, contactor can directly connect to the circuit board. Flyback diode and LED status are available in both 2 mode.

***** VCC input must be the value which suitable to drive Relay coil. (12, 24 VDC)*****

Normally, there are no requirements about relay coil's pole. But some contactor which has built-in diode, the connection should followed the picture below. The direction of the contactor built-in diode and CT011 built-in diode (**D2, D3**) must be in the same direction. Short circuit may happen if the contactor's pole are switched.



In direct mode, relay, contactor's state will be in line with ON/OFF button. Connect relay, contactor's coil pin to the **DirectDrv** terminal to use this mode.

In controller controlled mode, relay, contactor's state will depend on the order from Microcontroller. For instance, Order relay, contactor to delay it's disable for x seconds after the ON/OFF button is disable. Connect relay, contactor's coil pin to the **ContrDrv** terminal to use this mode.

D2 is the pin that frankly sense the ON/OFF button status. And **D10** is the pin that order the status of relay, contactor in control mode.

Sample pseudo code for controlled mode is shown below.

```
Loop ():
      Current = ReadCurrentFlowInCircuit()
      If (D2 is 1):
            D10 = 1                          # Activate Relay
            TimeCounter = 0
      If (D2 is 0):
            If (TimeCounter is 10 Second or Current <= 1A)
                  D10 = 0                    # Deactivate Relay
                  TimeCounter = 10           # Stop Counter
            Else:
                  Run TimeCounter++
```

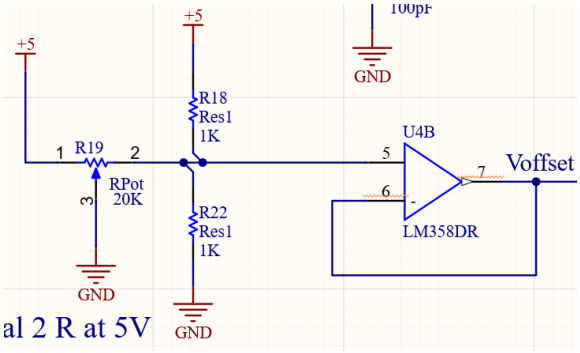
Control circuit sample code

Please visit this Github link to view the sample code using with the microcontroller.
https://github.com/owlhor/Tele_Mani_SRK

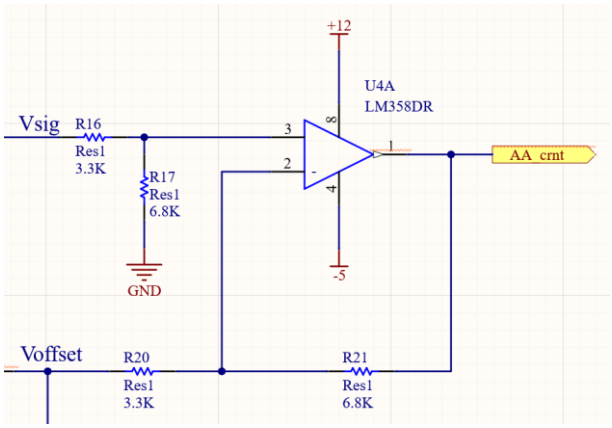
Signal Conditioning for Current Sensor

The selected current measure is ACS758LCB-050B-PFF-T. It works bidirectional. Means that Current detect range is between [-50, 50] A. And output signal voltage range is [0, 5] V. However, in this circuit needs to use only unidirectional. That makes output signal voltage range is only [2.5, 5] V. To get more range, Signal conditioning is added in this circuit.

The op amp circuits will gain the signal 2x making output signal voltage range between [2.5, 7.5] V. and down offset about 2.5V to get voltage range between [0, 5] V.



At unity gain offset, the voltage can be select fixed or adjustable. **Select either fixed or adjustable only** in soldering step preventing incorrect resistor value. If fixed is selected, Use the same Resistor value on **R18, R22** to get 2.5V (5V / 2 in voltage divider).But if adjustable is selected, any value of Rpot at **R19** can be used as long as it gets a suitable power dissipation. More than 2KΩ is recommended.



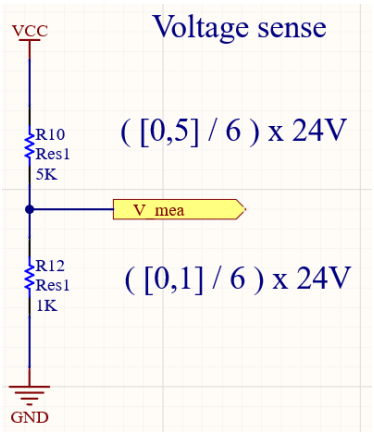
At differential amplifier. Resistor selecting are following the equation below. To get 2x gain, R21 should be 2 times more than R16. R16 = 3.3KΩ and R21 = 6.8KΩ is used in testing.

$$AA_{Crnt} = \frac{R21}{R16}(Vsig - Voffset)$$

While R16 = R20, R17 = R21

Voltage Sense

Voltage measure in CT011 is using simple voltage divider. CT011 is specifically designed for VCC from 24V battery. So, resistors selection will be considered to get the highest range in 24V condition. However, resistors value can be changed up to the application.



V_mea value which is the value read by the controller can be calculated from the equation below.

$$Vmea = (\frac{R12}{R10 + R12}) \times VCC$$

So, VCC can be calculated back from V_mea by.

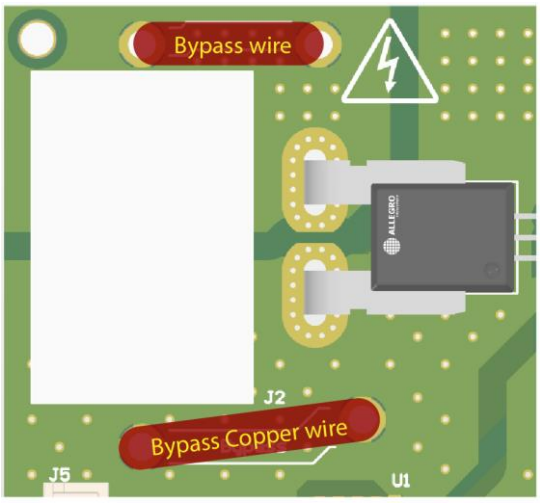
$$VCC = (\frac{R10 + R12}{R12}) \times Vmea$$

From the picture, the selected value are 5KΩ and 1KΩ. That makes V_mea in range [0, 4.5] V in case that VCC = 27V.

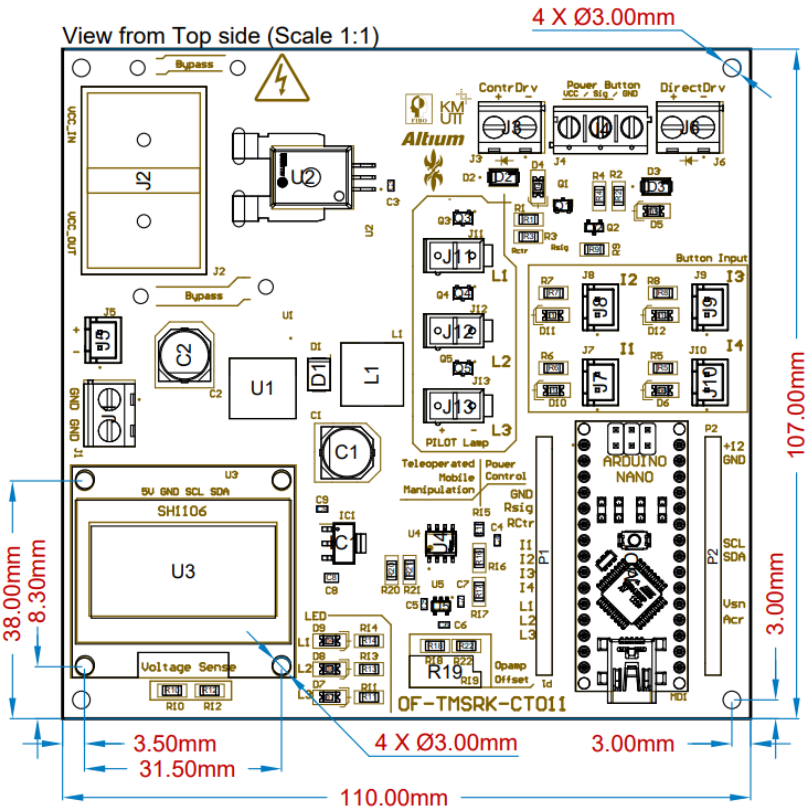
Bypass

The current Rating of CT011 is normally suitable at 12A. However, getting more current rating needs to increase VCC copper thickness or trace width for many millimeters. That cause the oversize circuit board and high cost. To solve this problem, Pads are available to insert copper wire onto the circuit which manifold increase the current rating while using the normal copper thickness and suitable size circuit board.

Adding bypass copper wire. AWG 12-16 are recommended. The current rating can be increased up to 50-70A up to the spec of AWG wire. However, the current rating must not more than 50A due to the measured range of ACS758.



Board Dimensions

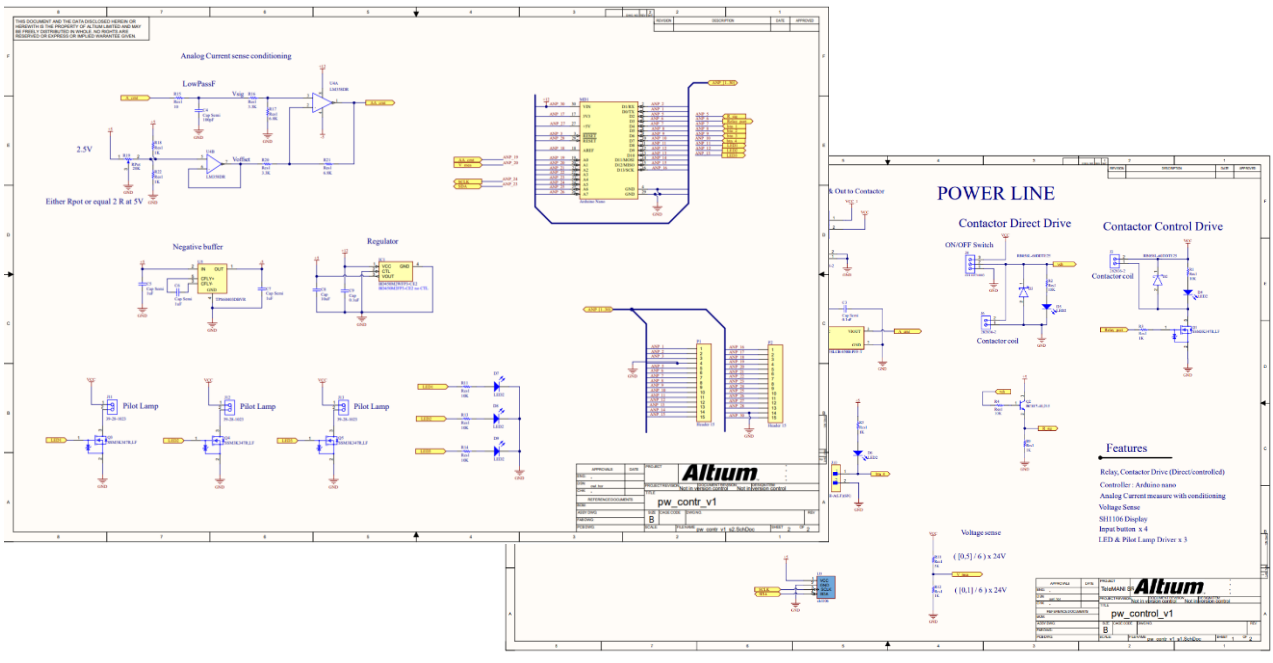


Schematics

Full Version of Schematics can be downloaded from OF-Circuit, OWL's OFFICE

https://sites.google.com/mail.kmutt.ac.th/owlhor/home/of-circuit

https://kmutt.me/ofcircuit.ct011sch



Bill of Materials

Designator	Comment	Description	Value	Qtt.
C1	Cap Pol3	Polarized Capacitor (Surface Mount)	220uF	1
C2	Cap Pol3	Polarized Capacitor (Surface Mount)	100uF	1
C3	Cap Semi	Capacitor (Semiconductor SIM Model)	0.1uF	1
C4	Cap Semi	Capacitor (Semiconductor SIM Model)	100pF	1
C5, C6, C7	Cap Semi	Capacitor (Semiconductor SIM Model)	1uF	3
C8	Cap	Capacitor	10uF	1
C9	Cap	Capacitor	0.1uF	1
D1	SS34B-HF	Schottky Diode		1
D2, D3	RB058L-60DDTE25	DIODE SCHOTTKY 60V 3A PMDS		2
D4, D5, D6, D7, D8, D9, D10, D11, D12	LED2	Typical RED, GREEN, YELLOW, AMBER GaAs LED		9
IC1	BD450M2WFP3-CE2	Integrated Circuit		1
J1, J3, J6	282836-2	Female Header, Pitch 5 mm, 1 x 2 Position		3
J2	DG78C-B-02P-13-00AH	Barrier Terminal 2P, 13mm pitch		1
J4	691102710003	5.00 mm Horizontal Entry Modular with Pressure Clamp WR-TBL, 3 pin		1
J5, J7, J8, J9, J10	B2B-XH-A(LF)(SN)	CONN HEADER VERT 2POS 2.5MM		5
J11, J12, J13	39-28-1023	Female Header, Pitch 4.2 mm, 1 x 2 Position,		3
L1	Inductor	Inductor	100uH	1
MD1	Arduino Nano	Sch style pinout with CAD		1
P1, P2	Header 15	Header, 15-Pin		2
Q1	SSM3K347R,LF	MOSFET N-CHANNEL 20V 4A SOT23F		1
Q2	BC817-40,215	TRANS NPN 45V 0.5A SOT23		1
Q3, Q4, Q5	SSM3K347R,LF	MOSFET N-CHANNEL 20V 4A SOT23F		3
R1, R2, R4, R11, R13, R14	Res1	Resistor	10K	6
R3, R5, R6, R7, R8, R9, R12, R18, R22	Res1	Resistor	1K	9
R10	Res1	Resistor	5K	1
R15	Res1	Resistor	10	1
R16, R20	Res1	Resistor	3.3K	2
R17, R21	Res1	Resistor	6.8K	2
R19	RPot	Potentiometer	20K	1
U1	LM2576S-12/NOPB	3A Step-Down Voltage Regulator, 5-pin TO-263		1
U2	ACS758LCB-050B-PFF-T	SENSOR CURRENT HALL 50A AC/DC		1
U3	sh1106	sh1106 OLED display module		1
U4	LM358DR	IC OPAMP GP 2 CIRCUIT 8SOIC		1
U5	TPS60403DBVR	-1.8 to -5.25 V, Inverting Charge Pump Regulator		1

Disclaimer

This circuit board is a part of of "Teleoperated Mobile Manipulation" ("Smart Rod Khen") Project. Which is a project of the Human-Computer Interface (HCI) lab. Institute of Field Robotics, King Mongkut's University of Technology Thonburi, Thailand. This circuit is designed by Altium Designer (Student License). Academic use purpose. Commercial use is unacceptable.

This circuit board is a student project design. So, some usage problems might have occurred. Such as error concept design, transmission line length, ground plate, etc. Industrial standards are incompletely claimed in this model.

Using a power source which not in range of recommended rating is a risk to get dangerous, breaking components, or underrating power.

Using different components, parameters from specifying in this datasheet might cause altered voltage or unusable circuits. More Information about electrical characteristics for each IC is available on each own datasheet.

Information in this document supersedes and replaces information previously supplied in any prior versions of this document.

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Department: Human Computer Interface (HCI) lab

Affiliation: Institute of Field Robotics

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PCB Design Software: Altium Designer 22 (Student License)

Datasheet Last update: 5/5/2022