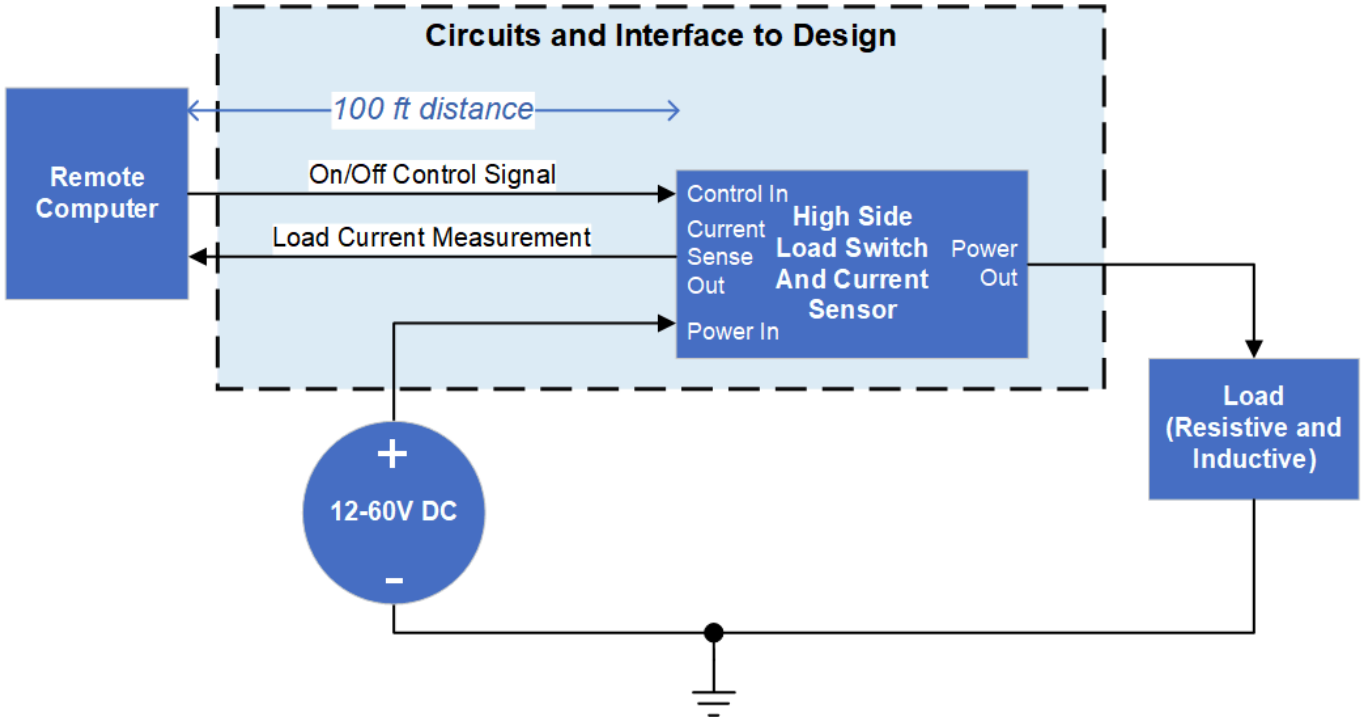
Electrical Take-Home Project - Remote Load Switch

For the following prompts, please create schematic-level designs that implement the requested circuits. You may specify any number of DC power sources that you need for the design without drawing the regulators supplying them.

For this project you are asked to create a high side load switch and current sensor circuit that can be controlled by a remote computer up to 100 feet away. This design should switch 12-60V DC power into a load, measure the load current, and report it back to the remote computer.



More detailed requirements for the load switch, current sensing, and remote interface are provided on the following page

Load Switch

Design a circuit for a high-side load switch capable of switching 12-60 VDC into an inductive load (L < 5mH) at currents of up to 10A. The switch shall be capable of operating continuously, but may be cycled on and off at a frequency lower than 1 Hz.

Load Current Measurement

The circuit shall measure and report the load current with a resolution of 10mA to the remote computer at a rate of 100Hz. Note that the load current may contain higher frequency content than DC. For purposes of this problem, only unidirectional current sensing is needed.

Remote Computer Interface

The load switch and current sensing circuits need to be interfaced to a remote computer that may be located up to 100 feet away from the circuits. Please design an interface using technologies of your choice to both send the on/off command to the switch circuit and report out the measured load current to the computer. These interfaces may be shared or separate.

General Environments

This circuit should be considered to be deployed into a vehicle environment (like an aircraft or road vehicle). These environments may include

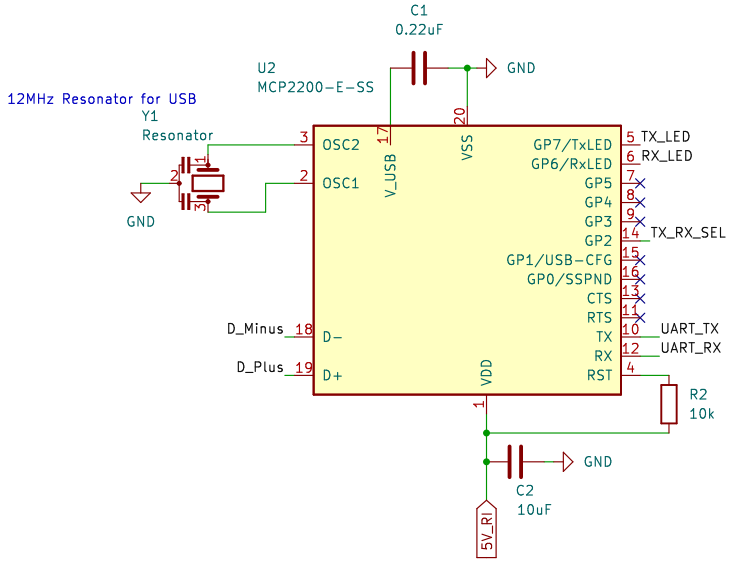
- -40 to +70°C ambient temperatures
- Standard atmospheric pressure
- Some potential exposure to conducted and radiated electromagnetic interference
- Moderate mechanical shock and vibration

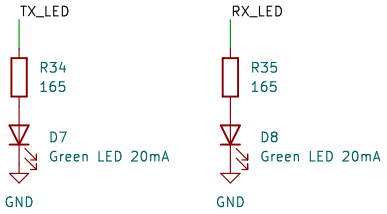
Deliverables

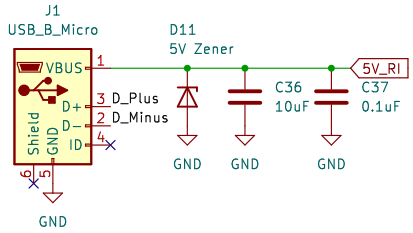
- Written document describing your design choices and any analysis that supports them.
    - Present your work such that another engineer can understand your design with the material provided.
- Schematics containing the requested load switch, current sensing, and interface circuits
    - Note: The schematics can be done either in CAD or by hand
- Bill of materials (BOM)
    - For critical components (i.e. IC's/transistors) specify part numbers
    - Passive components can be specified by value and other key characteristics that you think would be necessary to adequately describe the component

USB to UART Interface

C5 Bypass CAP needed since only powering off BUS Voltage.

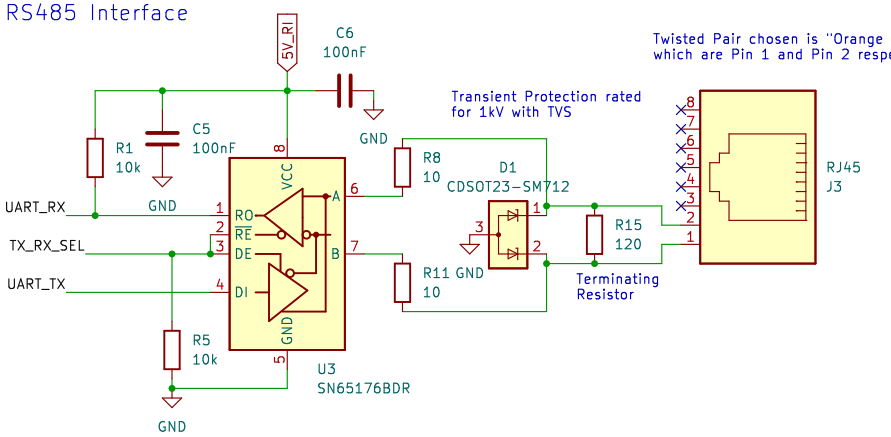






UART to RS485 Interface

Twisted Pair chosen is "Orange White" and "Orange" which are Pin 1 and Pin 2 respectively. T568B Pinout Used.

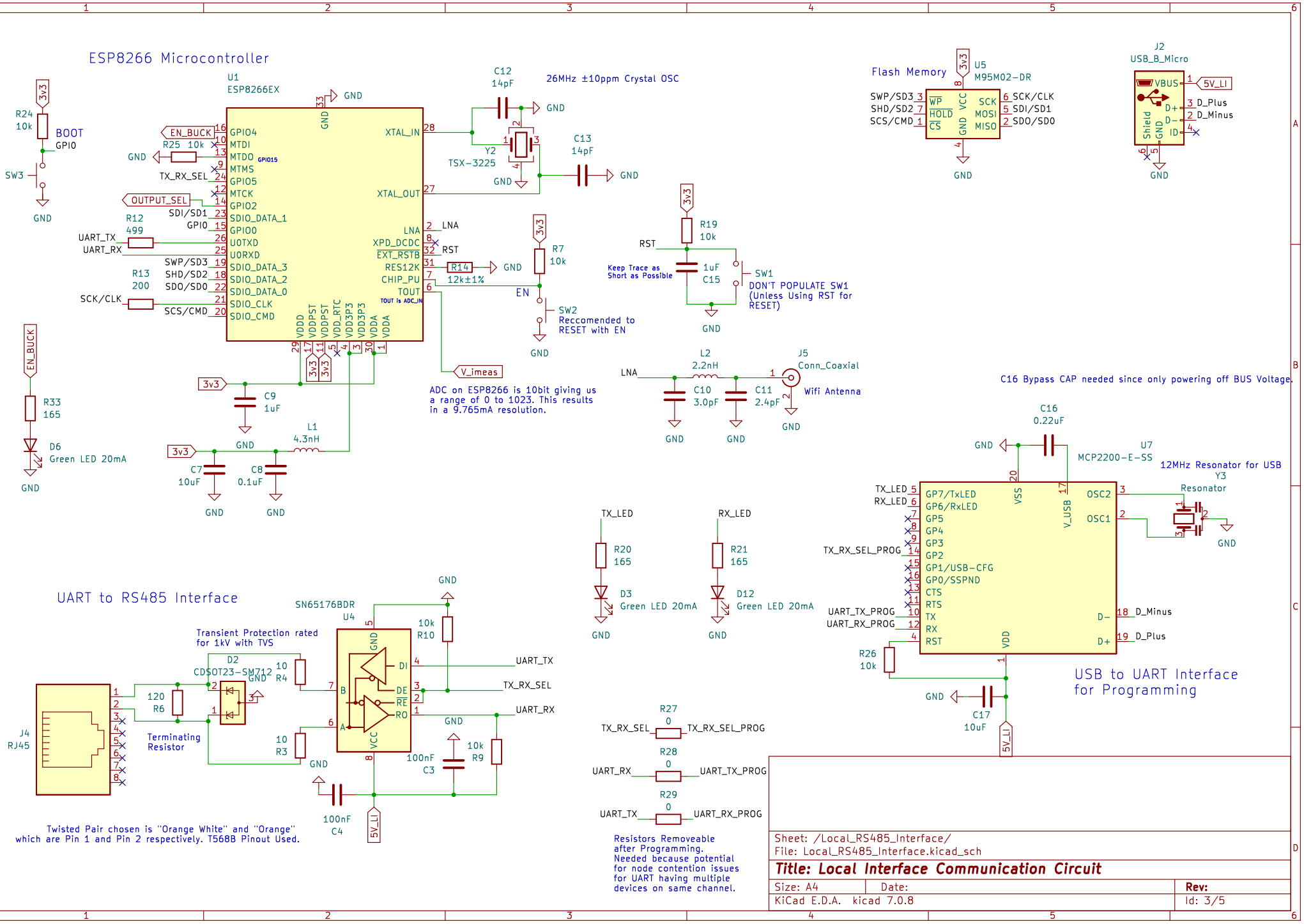


James Ewing
EE Design Challenge
Remote Current Sense and High Side Switch

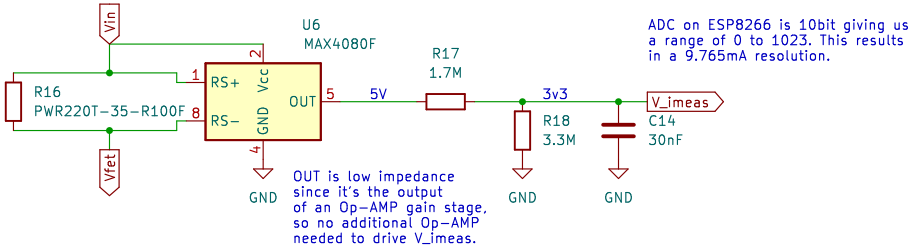
Sheet: /Remote_RS485_Interface/
File: Remote_RS485_Interface.kicad_sch.kicad_sch

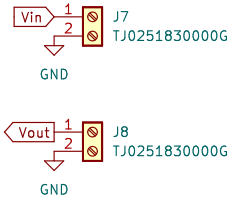
Title: Remote Interface Communication Circuit

Size: A4	Date:	Rev:
KiCad E.D.A. kicad 7.0.8		Id: 2/5

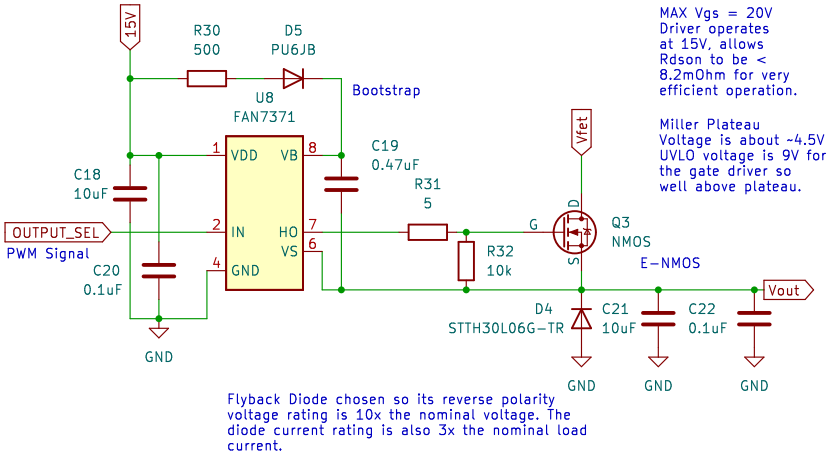

ESP8266 Microcontroller
U1
ESP8266EX
26MHz ±10ppm Crystal OSC
TSX-3225
Flash Memory
U5
M95M02-DR
J2
USB_B_Micro
BOOT
EN_BUCK
OUTPUT_SEL
TX_RX_SEL
UART_TX
UART_RX
SWP/SD3
SHD/SD2
SDO/SD0
SCK/CLK
SCS/CMD
LNA
RST
EN
V_imeas
ADC on ESP8266 is 10bit giving us a range of 0 to 1023. This results in a 9.765mA resolution.
Keep Trace as Short as Possible
DON'T POPULATE SW1 (Unless Using RST for RESET)
SW2 Reccomended to RESET with EN
Wifi Antenna
C16 Bypass CAP needed since only powering off BUS Voltage.
12MHz Resonator for USB
MCP2200-E-SS
USB to UART Interface for Programming
UART to RS485 Interface
SN65176BDR
Transient Protection rated for 1kV with TVS
Terminating Resistor
Twisted Pair chosen is "Orange White" and "Orange" which are Pin 1 and Pin 2 respectively. T568B Pinout Used.
Resistors Removeable after Programming. Needed because potential for node contention issues for UART having multiple devices on same channel.
Sheet: /Local_RS485_Interface/
File: Local_RS485_Interface.kicad_sch
Title: Local Interface Communication Circuit
Size: A4
Date:
Rev:
KiCad E.D.A. kicad 7.0.8
Id: 3/5

Current Measurement





High Side Switch

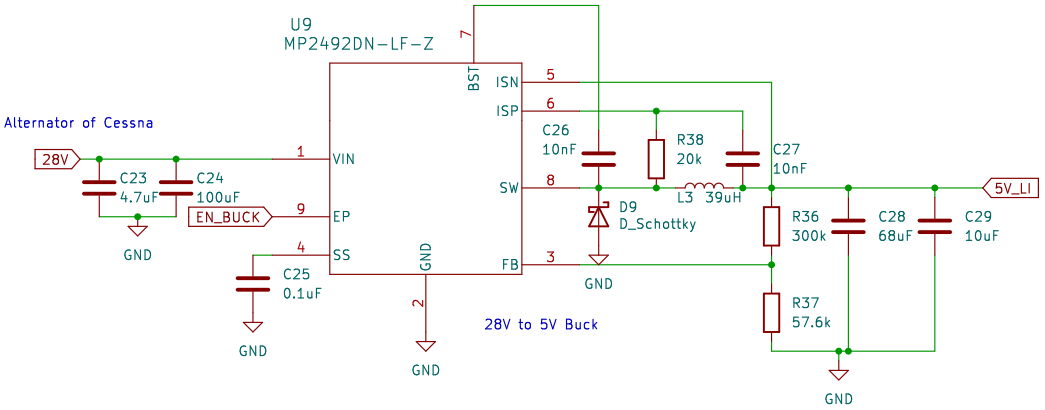


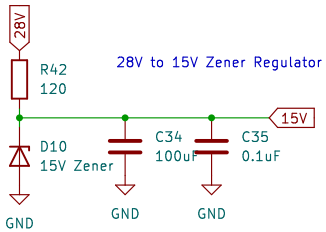
Sheet: /High_Side_Switch_and_Current_Measurement_GateDriver/
File: High_Side_Switch_and_Current_Measurement_GateDriver.kicad_sch

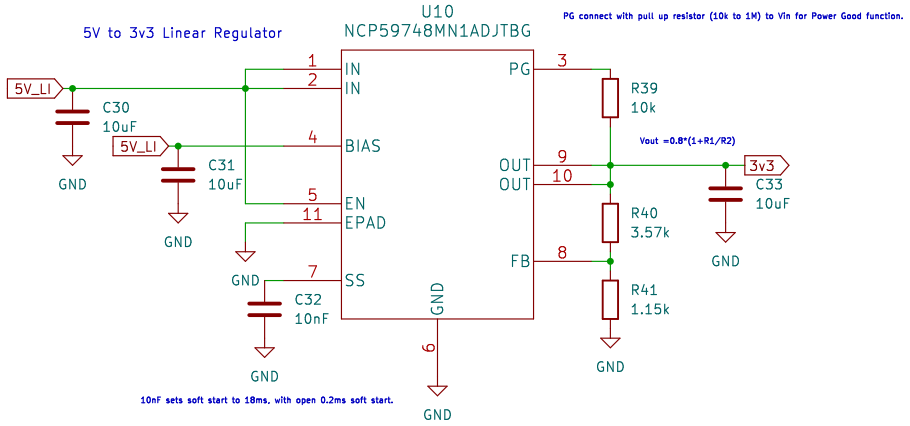
Title: Local High Side Switch and Current Measurement Circuit

Size: A4	Date:	Rev:
KiCad E.D.A. kicad 7.0.8		Id: 4/5

POWER CONVERSION







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Title:		
Size: A4	Date:	**Rev:**
KiCad E.D.A. kicad 7.0.8		Id: 5/5

Remote RS485 Interface								
Id	Designator	Footprint	Quantity	Designation	Description	Purchase Link	Data Sheet	
1	U3, U4	SOP 8	2	SN65176BDR	RS485 Transceivers	https://www.digik	https://mm.digike	Link
2	J3,J4	RJ45	2		Shielded RJ45 Connectors	https://www.digik	https://app.adam	Link
3	R1, R2, R3, R4	Imperial: 0402	4	10 ohm	RS485 Res Pulse Proof Thick Film	https://www.digik	https://www.te.cc	Link
4	R5, R6	Imperial: 0402	2	120 ohm	120 ohm, RS485 Term Res			
5	R7, R8, R9, R10, R15	Imperial: 0402	4	10k	10k ohm Res, UART-RS485			
6	D1, D2	SOT23	2	TVS CDSOT23-SM712	TVS Diode, RS485	https://www.digik	https://www.bour	Link
7	C1, C2, C3, C4	Imperial: 0402	4	100nF	Ceramic Cap, RS485			
8	U5	USB to UART	2	MCP2200-I/SO	USB to UART Interface	https://www.mou	https://www.mou	Link
9	C5	Imperial: 0402	1	0.22uF	Bypass CAP	https://www.digik	https://mm.digike	Link
10	C6	Imperial: 0402	1	10uF	Bus CAP (Can't be more than 10uF)	https://www.digik	https://www.mura	Link
11	J1, J2	Micro-USB	1		USB Connection to Rem PC			
12	Y1	3 Pads (Dim Given)	2	12MHz 33pF	Ceramic Resonator	https://www.digik	https://www.mura	Link
13	R11	Imperial: 0402	1	10k	RES for RESET			
14	D11		1	5V Zener	Clamp Zener			
Local RS485 Interface								
Id	Designator	Footprint	Quantity	Designation	Description	Purchase Link	Data Sheet	
1	U1	ESP8266 (Slave)	1					
2	R12	Imperial: 0402	1	499 ohm	UARTRX Res			
3	R13	Imperial: 0402	1	200 ohm	SDIO_CLK Res			
4	R14	Imperial: 0402	1	12k±1%	RES12K Res			
5	C7	Imperial: 0402	1	10uF				
6	C8	Imperial: 0402	1	0.1uF				
7	C9	Imperial: 0402	1	1uF				
8	C10	Imperial: 0402	1	3.0pF				
9	C11	Imperial: 0402	1	2.4pF				
10	J5	SMA	1	Wifi SMA Coax Conn				
11	U2	S08N	1	8266 Flash Memory	M95M02-DR	https://www.digik	https://www.st.cc	Link
12	C12, C13	Imperial: 0402	2	14pF	Crystal OSC Caps			
13	Y2	4 Pads (Custom)	1	26Mhz ±10ppm	Crystal Oscillator	https://www.digik	https://support.e	Link
14	L1	Imperial: 0603	1	4.3nH				
15	L2	Imperial: 0603	1	2.2nH				
High Side Switch and Current Sense								
Id	Designator	Footprint	Quantity	Designation	Description	Purchase Link	Data Sheet	Notes
1	U6	8SOIC	1	MAX4080	High Side Current Sensor	https://www.digik	https://www.anal	Link
2	R17	Imperial: 0402	1	1.7M				
3	R18	Imperial: 0402	1	3.3M				
4	C14	Imperial: 0402	1	30nF				
5	R16	THT	1	0.1ohm, 35W	Current Sense Resistor	https://www.new	https://www.farn	Link

6	Q1	TO-252	1	AOD66920	Load Switch	https://www.digik	https://aosmd.co	Link
7	D3	D2PAK	1	STTH30L06G-TR	Flyback Diode	https://www.digik	https://mm.digike	Link
8	J6, J7	Screw Terminal Conn	2	300VAC 20A	TJ0251830000G	https://www.digik	http://www.anyte	Link
9	U5		1	FAN73711	Gate Driver	https://www.digik	https://www.onse	Link
10	C17		1	0.47uF	Bootstrap Capacitor	https://www.digik	https://calchip.cc	Link
11	R19		1	500 ohm	Bootstrap Resistor	https://www.digik	https://fscdn.rohr	Link
12	D4		1	PU6JB	Bootstrap Diode	https://www.digik	https://www.taiw	Link
13	C18, C21		2	10uF	Bypass Caps			
14	C20, C22		2	0.1uF	Bypass Caps			
15	R20		1	5ohm	Gate Resistor			
Power Conversion								
Id	Designator	Footprint	Quantity	Designation	Description	Purchase Link	Data Sheet	Notes
1	U9	8SOIC	1	MP2492DN-LF-Z	28V to 15V Buck	https://www.digik	https://www.mon	Link
2	C23		1	4.7uF				
	C24		1	100uF				
	C25, C35, C37		3	0.1uF				
	C26, C27, C32		3	10nF				
	C28		1	68uF				
	C29, C30, C31, C33, C36		5	10uF				
	R36		1	300k				
	R37		1	57.6k				
	R38		1	20k				
	D9		1	Schottky 15V Vbr				
	R39		1	10k				
	R40		1	3.57k				
	R41		1	1.15k				
	U10		1	NCP59748MN1ADJTBG	5V to 3v3 Linear Regulator	https://www.digik	https://www.onse	Link
	D10		1	3SMAJ5929B-TP	15V Zener	https://www.digik	https://www.mcc	Link
	C34		1	100uF				