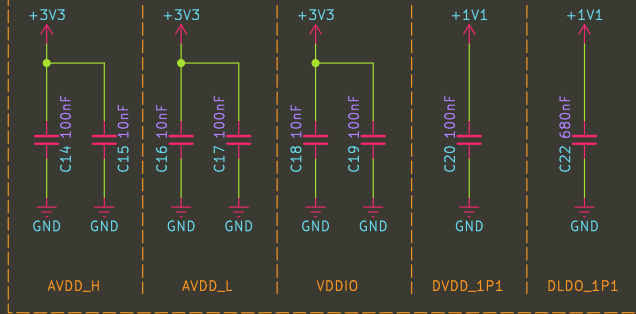
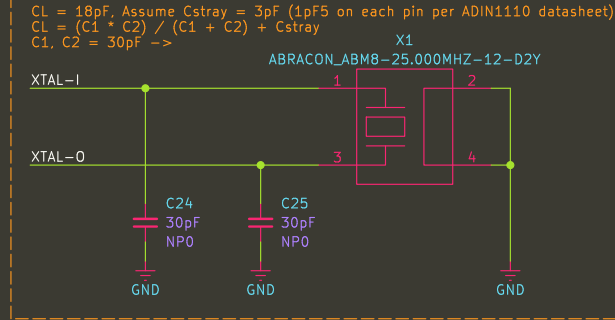


## Power Rail Caps

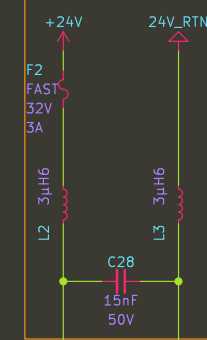


## Oscillator



TDK SPE Applications Overview  
(NOTE: Using Line-Side Injection for Power Class 15 in this design)  
<https://product.tdk.com/en/techlibrary/applicationnote/single-pair-ethernet.html>

## PoDL Line-Side Injection

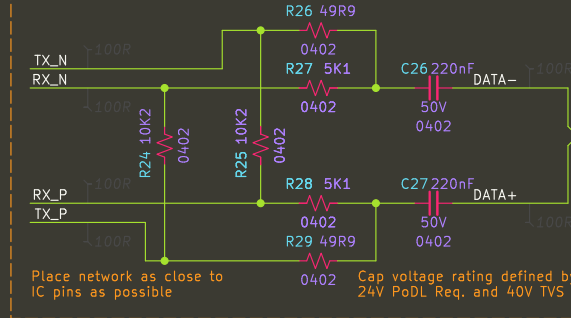


Line side injection allows for more compact choke, as it does not require 1500mA capacity

fc: 500kHz  
Drives boost converter freq

CONTACT POSITION	SIGNAL PER IEC 63171-6
1	BI_DA+
2	BI_DA-

## Mfr. Recommended Hybrid w/DC Blocking Caps



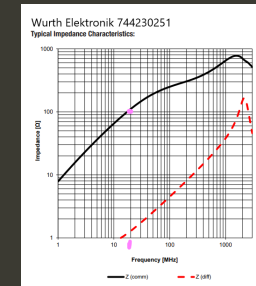
Place network as close to IC pins as possible

Cap voltage rating defined by 24V PoDL Req. and 40V TVS

## Trace Impedance Calcs



File: Trace\_Impedance\_Calcs.kicad\_sch



ADIN1110 uses 10BASE-T1L:  
- Spec'ing a CMC for 100R @ 20MHz  
Due to board size constraints, will NOT be adopting IEEE 802.3 insulation requirements (i.e. no isolating transformer)  
IEC 62368-1:  
- Withstand 1500VAC for 60s  
- Withstand 2250VDC for 60s

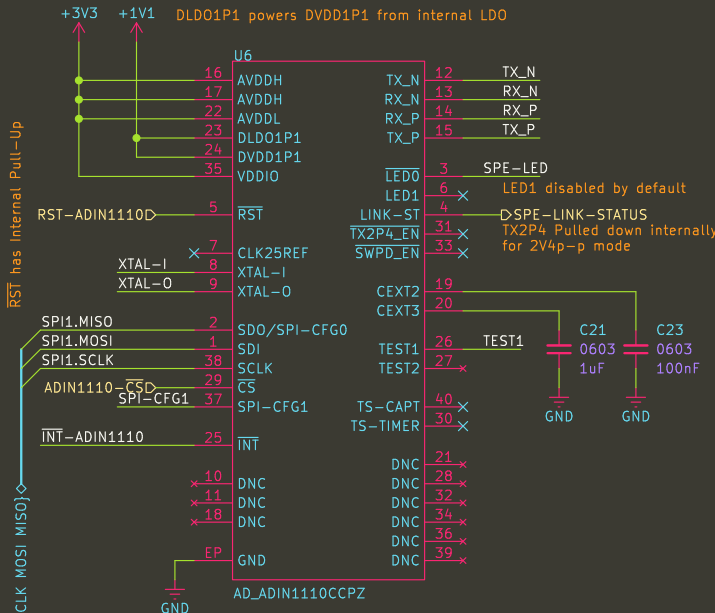
The SPE electrical requirements are specified in the following IEEE standards:

- IEEE 802.3cg (10BASE-T1) with bandwidth from 0.1 to 20 MHz and reach up to 1000 m.
- IEEE 802.3bw (100BASE-T1) with bandwidth 0.3 to 66 MHz and reach up to 40 m.
- IEEE 802.3bp, (1000BASE-T1) with bandwidth 1 to 600 MHz and reach up to 40 m.

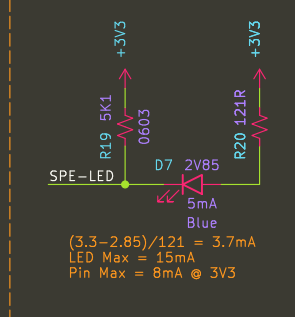
SPE Standard Basic Info:  
[https://single-pair-ethernet.com/sites/default/files/2021-03/202103speapplikationnotespe-integrationv10en\\_arp085.pdf](https://single-pair-ethernet.com/sites/default/files/2021-03/202103speapplikationnotespe-integrationv10en_arp085.pdf)

RST has Internal Pull-Up

SPI1(SCLK MOSI MISO)



## Status LED, Active Low Config



(3.3-2.85)/121 = 3.7mA  
LED Max = 15mA  
Pin Max = 8mA @ 3V3

## Pull-Ups/Config



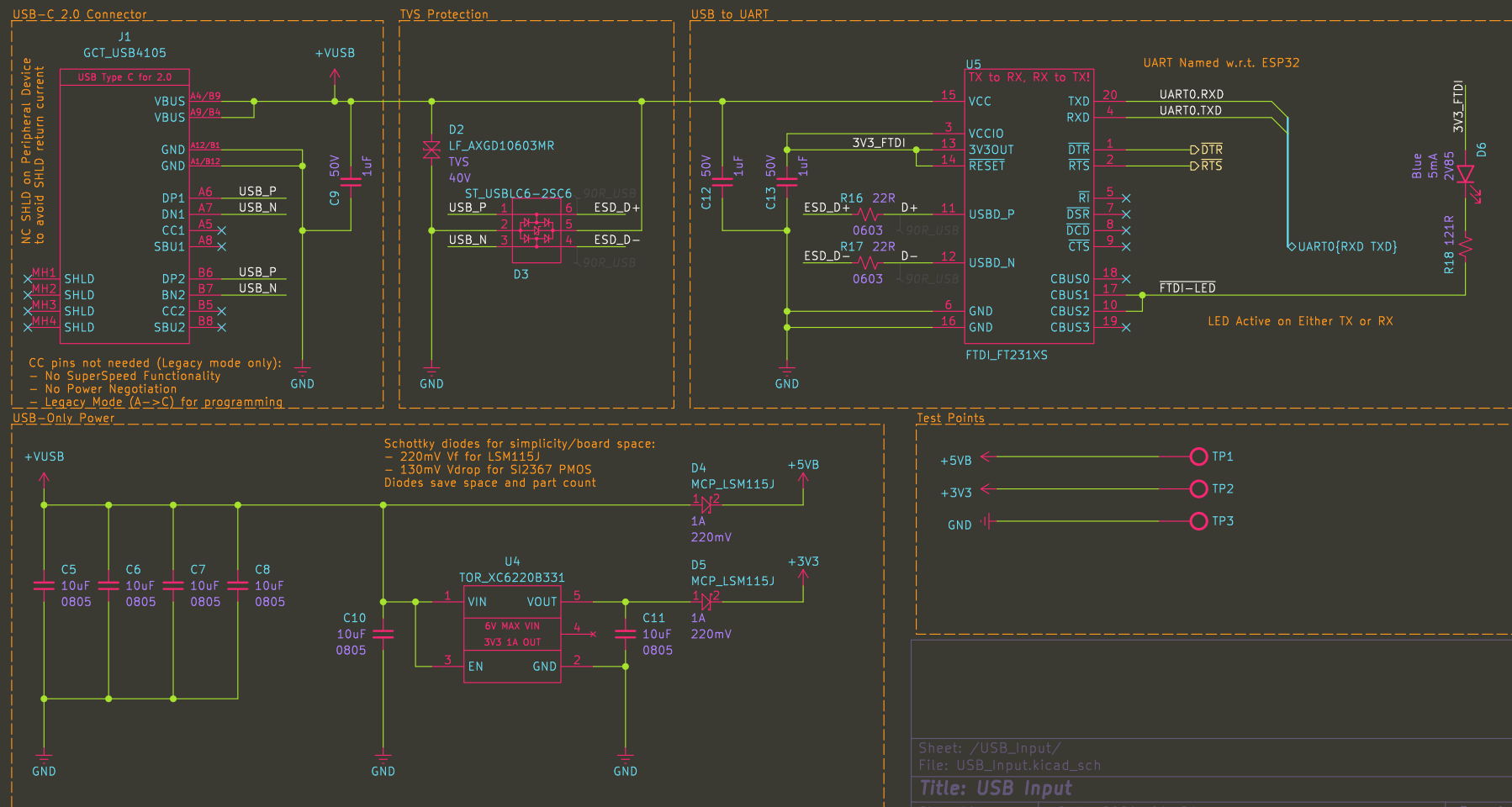
SPI Configs are PULLED AT BOOT-UP!  
- Careful when initializing devices

SPI\_CFG0 (MISO) is pulled down by IC by default  
SPI\_CFG1 desires 4K7 pull ups; using 5K1 for BoM optimization

Table 16. SPI Protocol (Hardware Configuration)

SPI Protocol	SPI_CFG1	SPI_CFG0
OPEN Alliance with Protection	0	0
OPEN Alliance Without Protection	0	1
Generic SPI with 8-bit CRC	1	0
Generic SPI Without 8-bit CRC	1	1

Impedance Requirements (USB 2.0 Speeds):  
- USB\_P/N must be 90R Differential  $\pm 15\%$   
- Diff Pair Mismatch  $< .6in$

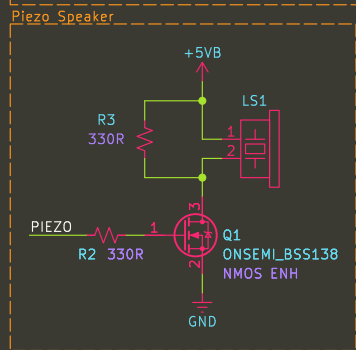
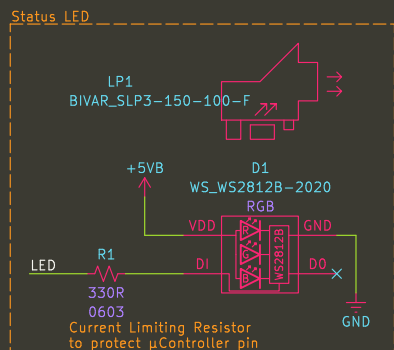
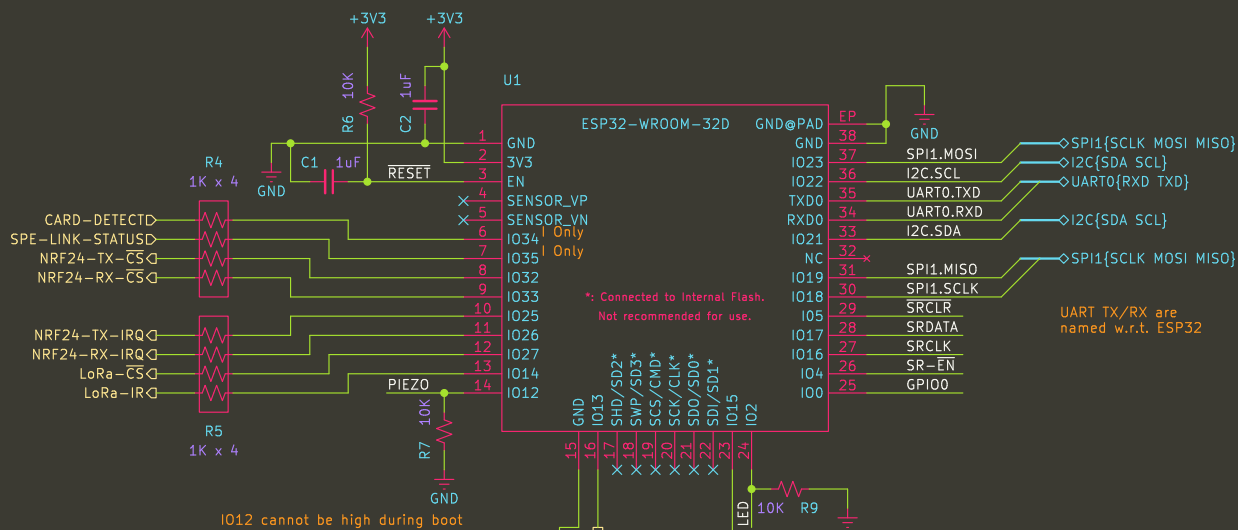


Sheet: /USB\_Input/  
File: USB\_Input.kicad\_sch

### Title: USB Input

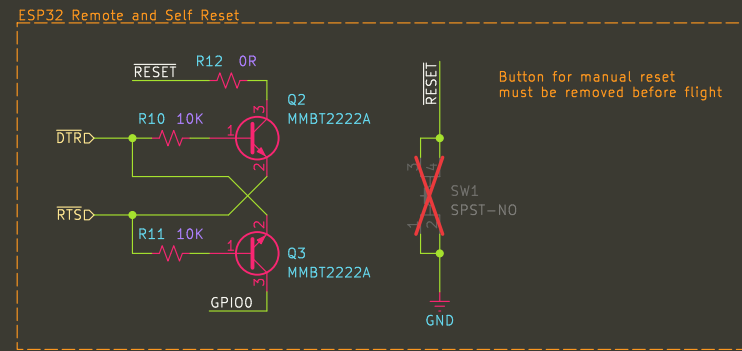
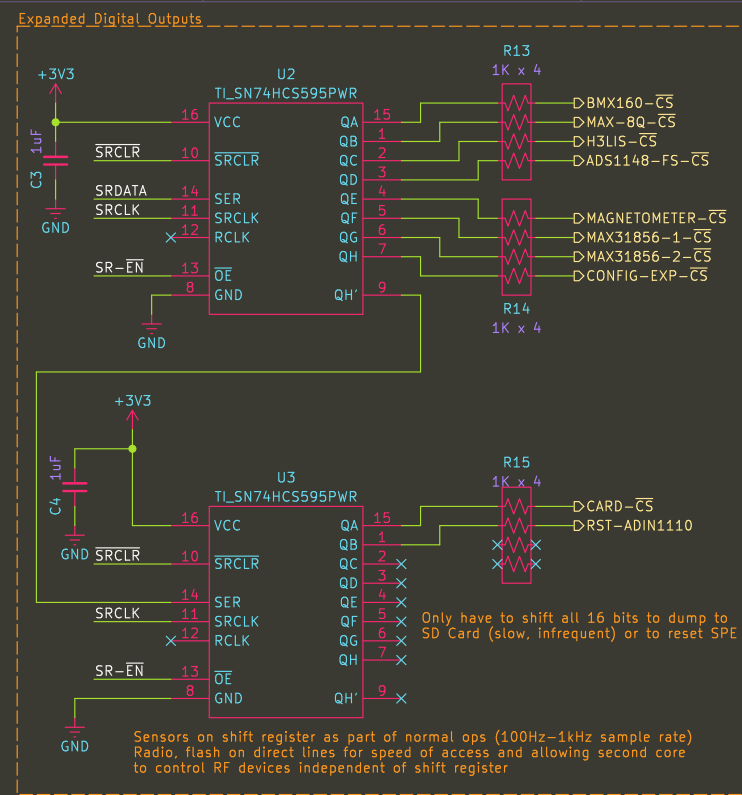
Size: A4 Date: 2024-01-21  
KiCad E.D.A. kicad 7.0.7

Rev: 1.0.1  
Id: 3/7

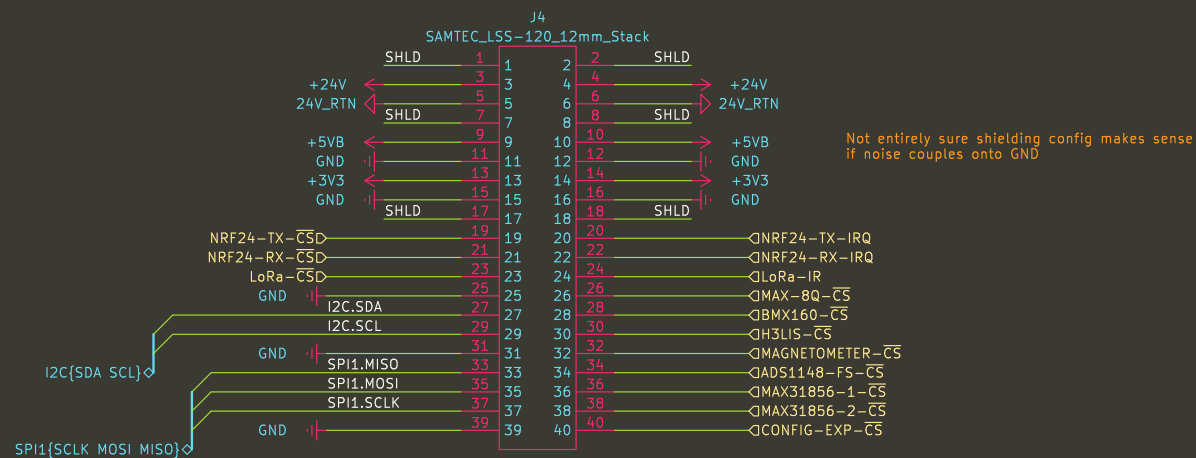


GPIO Pin References

No.	Name	Type	GPIO	True GPIO	RTC_GPIO	ADC	TIOU0	DAC	SP	UART	Parallel QSPI	ITAG	SIO0 Slave	Ethernet	SD/SDIO/MMC
25	GPIO0	IO	GPIO0	No	RTC_GPIO11	ADC_GPIO11	TIOU0_GPIO11			UART					SD/SDIO/MMC
26	GPIO1	IO	GPIO1	No	RTC_GPIO12	ADC_GPIO12	TIOU0_GPIO12			UART					SD/SDIO/MMC
27	GPIO2	IO	GPIO2	No	RTC_GPIO13	ADC_GPIO13	TIOU0_GPIO13			UART					SD/SDIO/MMC
28	GPIO3	IO	GPIO3	No	RTC_GPIO14	ADC_GPIO14	TIOU0_GPIO14			UART					SD/SDIO/MMC
29	GPIO4	IO	GPIO4	No	RTC_GPIO15	ADC_GPIO15	TIOU0_GPIO15			UART					SD/SDIO/MMC
30	GPIO5	IO	GPIO5	No	RTC_GPIO16	ADC_GPIO16	TIOU0_GPIO16			UART					SD/SDIO/MMC
31	GPIO6	IO	GPIO6	No	RTC_GPIO17	ADC_GPIO17	TIOU0_GPIO17			UART					SD/SDIO/MMC
32	GPIO7	IO	GPIO7	No	RTC_GPIO18	ADC_GPIO18	TIOU0_GPIO18			UART					SD/SDIO/MMC
33	GPIO8	IO	GPIO8	No	RTC_GPIO19	ADC_GPIO19	TIOU0_GPIO19			UART					SD/SDIO/MMC
34	GPIO9	IO	GPIO9	No	RTC_GPIO20	ADC_GPIO20	TIOU0_GPIO20			UART					SD/SDIO/MMC
35	GPIO10	IO	GPIO10	No	RTC_GPIO21	ADC_GPIO21	TIOU0_GPIO21			UART					SD/SDIO/MMC
36	GPIO11	IO	GPIO11	No	RTC_GPIO22	ADC_GPIO22	TIOU0_GPIO22			UART					SD/SDIO/MMC
37	GPIO12	IO	GPIO12	No	RTC_GPIO23	ADC_GPIO23	TIOU0_GPIO23			UART					SD/SDIO/MMC
38	GPIO13	IO	GPIO13	No	RTC_GPIO24	ADC_GPIO24	TIOU0_GPIO24			UART					SD/SDIO/MMC
39	GPIO14	IO	GPIO14	No	RTC_GPIO25	ADC_GPIO25	TIOU0_GPIO25			UART					SD/SDIO/MMC
40	GPIO15	IO	GPIO15	No	RTC_GPIO26	ADC_GPIO26	TIOU0_GPIO26			UART					SD/SDIO/MMC
41	GPIO16	IO	GPIO16	No	RTC_GPIO27	ADC_GPIO27	TIOU0_GPIO27			UART					SD/SDIO/MMC
42	GPIO17	IO	GPIO17	No	RTC_GPIO28	ADC_GPIO28	TIOU0_GPIO28			UART					SD/SDIO/MMC
43	GPIO18	IO	GPIO18	No	RTC_GPIO29	ADC_GPIO29	TIOU0_GPIO29			UART					SD/SDIO/MMC
44	GPIO19	IO	GPIO19	No	RTC_GPIO30	ADC_GPIO30	TIOU0_GPIO30			UART					SD/SDIO/MMC
45	GPIO20	IO	GPIO20	No	RTC_GPIO31	ADC_GPIO31	TIOU0_GPIO31			UART					SD/SDIO/MMC
46	GPIO21	IO	GPIO21	No	RTC_GPIO32	ADC_GPIO32	TIOU0_GPIO32			UART					SD/SDIO/MMC
47	GPIO22	IO	GPIO22	No	RTC_GPIO33	ADC_GPIO33	TIOU0_GPIO33			UART					SD/SDIO/MMC
48	GPIO23	IO	GPIO23	No	RTC_GPIO34	ADC_GPIO34	TIOU0_GPIO34			UART					SD/SDIO/MMC
49	GPIO24	IO	GPIO24	No	RTC_GPIO35	ADC_GPIO35	TIOU0_GPIO35			UART					SD/SDIO/MMC
50	GPIO25	IO	GPIO25	No	RTC_GPIO36	ADC_GPIO36	TIOU0_GPIO36			UART					SD/SDIO/MMC
51	GPIO26	IO	GPIO26	No	RTC_GPIO37	ADC_GPIO37	TIOU0_GPIO37			UART					SD/SDIO/MMC
52	GPIO27	IO	GPIO27	No	RTC_GPIO38	ADC_GPIO38	TIOU0_GPIO38			UART					SD/SDIO/MMC
53	GPIO28	IO	GPIO28	No	RTC_GPIO39	ADC_GPIO39	TIOU0_GPIO39			UART					SD/SDIO/MMC
54	GPIO29	IO	GPIO29	No	RTC_GPIO40	ADC_GPIO40	TIOU0_GPIO40			UART					SD/SDIO/MMC
55	GPIO30	IO	GPIO30	No	RTC_GPIO41	ADC_GPIO41	TIOU0_GPIO41			UART					SD/SDIO/MMC
56	GPIO31	IO	GPIO31	No	RTC_GPIO42	ADC_GPIO42	TIOU0_GPIO42			UART					SD/SDIO/MMC
57	GPIO32	IO	GPIO32	No	RTC_GPIO43	ADC_GPIO43	TIOU0_GPIO43			UART					SD/SDIO/MMC
58	GPIO33	IO	GPIO33	No	RTC_GPIO44	ADC_GPIO44	TIOU0_GPIO44			UART					SD/SDIO/MMC
59	GPIO34	IO	GPIO34	No	RTC_GPIO45	ADC_GPIO45	TIOU0_GPIO45			UART					SD/SDIO/MMC
60	GPIO35	IO	GPIO35	No	RTC_GPIO46	ADC_GPIO46	TIOU0_GPIO46			UART					SD/SDIO/MMC
61	GPIO36	IO	GPIO36	No	RTC_GPIO47	ADC_GPIO47	TIOU0_GPIO47			UART					SD/SDIO/MMC
62	GPIO37	IO	GPIO37	No	RTC_GPIO48	ADC_GPIO48	TIOU0_GPIO48			UART					SD/SDIO/MMC
63	GPIO38	IO	GPIO38	No	RTC_GPIO49	ADC_GPIO49	TIOU0_GPIO49			UART					SD/SDIO/MMC
64	GPIO39	IO	GPIO39	No	RTC_GPIO50	ADC_GPIO50	TIOU0_GPIO50			UART					SD/SDIO/MMC
65	GPIO40	IO	GPIO40	No	RTC_GPIO51	ADC_GPIO51	TIOU0_GPIO51			UART					SD/SDIO/MMC
66	GPIO41	IO	GPIO41	No	RTC_GPIO52	ADC_GPIO52	TIOU0_GPIO52			UART					SD/SDIO/MMC
67	GPIO42	IO	GPIO42	No	RTC_GPIO53	ADC_GPIO53	TIOU0_GPIO53			UART					SD/SDIO/MMC
68	GPIO43	IO	GPIO43	No	RTC_GPIO54	ADC_GPIO54	TIOU0_GPIO54			UART					SD/SDIO/MMC
69	GPIO44	IO	GPIO44	No	RTC_GPIO55	ADC_GPIO55	TIOU0_GPIO55			UART					SD/SDIO/MMC
70	GPIO45	IO	GPIO45	No	RTC_GPIO56	ADC_GPIO56	TIOU0_GPIO56			UART					SD/SDIO/MMC
71	GPIO46	IO	GPIO46	No	RTC_GPIO57	ADC_GPIO57	TIOU0_GPIO57			UART					SD/SDIO/MMC
72	GPIO47	IO	GPIO47	No	RTC_GPIO58	ADC_GPIO58	TIOU0_GPIO58			UART					SD/SDIO/MMC
73	GPIO48	IO	GPIO48	No	RTC_GPIO59	ADC_GPIO59	TIOU0_GPIO59			UART					SD/SDIO/MMC
74	GPIO49	IO	GPIO49	No	RTC_GPIO60	ADC_GPIO60	TIOU0_GPIO60			UART					SD/SDIO/MMC
75	GPIO50	IO	GPIO50	No	RTC_GPIO61	ADC_GPIO61	TIOU0_GPIO61			UART					SD/SDIO/MMC
76	GPIO51	IO	GPIO51	No	RTC_GPIO62	ADC_GPIO62	TIOU0_GPIO62			UART					SD/SDIO/MMC
77	GPIO52	IO	GPIO52	No	RTC_GPIO63	ADC_GPIO63	TIOU0_GPIO63			UART					SD/SDIO/MMC
78	GPIO53	IO	GPIO53	No	RTC_GPIO64	ADC_GPIO64	TIOU0_GPIO64			UART					SD/SDIO/MMC
79	GPIO54	IO	GPIO54	No	RTC_GPIO65	ADC_GPIO65	TIOU0_GPIO65			UART					SD/SDIO/MMC
80	GPIO55	IO	GPIO55	No	RTC_GPIO66	ADC_GPIO66	TIOU0_GPIO66			UART					SD/SDIO/MMC
81	GPIO56	IO	GPIO56	No	RTC_GPIO67	ADC_GPIO67	TIOU0_GPIO67			UART					SD/SDIO/MMC
82	GPIO57	IO	GPIO57	No	RTC_GPIO68	ADC_GPIO68	TIOU0_GPIO68			UART					SD/SDIO/MMC
83	GPIO58	IO	GPIO58	No	RTC_GPIO69	ADC_GPIO69	TIOU0_GPIO69			UART					SD/SDIO/MMC
84	GPIO59	IO	GPIO59	No	RTC_GPIO70	ADC_GPIO70	TIOU0_GPIO70			UART					SD/SDIO/MMC
85	GPIO60	IO	GPIO60	No	RTC_GPIO71	ADC_GPIO71	TIOU0_GPIO71			UART					SD/SDIO/MMC
86	GPIO61	IO	GPIO61	No	RTC_GPIO72	ADC_GPIO72	TIOU0_GPIO72			UART					SD/SDIO/MMC
87	GPIO62	IO	GPIO62	No	RTC_GPIO73	ADC_GPIO73	TIOU0_GPIO73			UART					SD/SDIO/MMC
88	GPIO63	IO	GPIO63	No	RTC_GPIO74	ADC_GPIO74	TIOU0_GPIO74			UART					SD/SDIO/MMC
89	GPIO64	IO	GPIO64	No	RTC_GPIO75	ADC_GPIO75	TIOU0_GPIO75			UART					SD/SDIO/MMC
90	GPIO65	IO	GPIO65	No	RTC_GPIO76	ADC_GPIO76	TIOU0_GPIO76			UART					SD/SDIO/MMC
91	GPIO66	IO	GPIO66	No	RTC_GPIO77	ADC_GPIO77	TIOU0_GPIO77			UART					SD/SDIO/MMC
92	GPIO67	IO	GPIO67	No	RTC_GPIO78	ADC_GPIO78	TIOU0_GPIO78			UART					SD/SDIO/MMC
93	GPIO68	IO	GPIO68	No	RTC_GPIO79	ADC_GPIO79	TIOU0_GPIO79			UART					SD/SDIO/MMC
94	GPIO69	IO	GPIO69	No	RTC_GPIO80	ADC_GPIO80	TIOU0_GPIO80			UART					SD/SDIO/MMC
95	GPIO70	IO	GPIO70	No	RTC_GPIO81	ADC_GPIO81	TIOU0_GPIO81			UART					SD/SDIO/MMC
96	GPIO71	IO	GPIO71	No	RTC_GPIO82	ADC_GPIO82	TIOU0_GPIO82			UART					SD/SDIO/MMC
97	GPIO72	IO	GPIO72	No	RTC_GPIO83	ADC_GPIO83	TIOU0_GPIO83			UART					SD/SDIO/MMC
98	GPIO73	IO	GPIO73	No	RTC_GPIO84	ADC_GPIO84	TIOU0_GPIO84			UART					SD/SDIO/MMC
99	GPIO74	IO	GPIO74	No	RTC_GPIO85	ADC_GPIO85	TIOU0_GPIO85			UART					SD/SDIO/MMC
100	GPIO75	IO	GPIO75	No	RTC_GPIO86	ADC_GPIO86	TIOU0_GPIO86			UART					SD/SDIO/MMC







Sheet: /Stacking\_Connector/  
File: Stacking\_Connector.kicad\_sch

**Title: Stacking Connector**

Size: A4 Date: 2024-01-21

KiCad E.D.A. kicad 7.0.7

Rev: 1.0.1

Id: 6/7

# SPE Controlled Impedance w/Oshpark Stackup

# USB Controlled Impedance w/Oshpark Stackup

Saturn PCB Design, Inc. - PCB Toolkit V8.34 - www.saturnpcb.com

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PDN Calculator Planar Inductors PPM-XTAL Calculator Thermal Management Via Properties Wavelength Calculator XL-XC Reactance  
Embedded Resistors Er Effective Fusing Current Mechanical Information Min Conductor Spacing Ohm's Law Padstack Calculator  
Bandwidth & Max Conductor Length Conductor Impedance Conductor Properties Conversion Calculator Differential Pairs / XTALK

Differential Pairs

Conductor Width (W) **0.254 mm** Target Zdiff **100 Ohms** Differential Protocol **Ethernet**

Conductor Spacing (S) **.254 mm** +/- Tolerance = 10%

Conductor Height (H) **0.2021 mm** Target Zdiff Plus **110.000 Ohms** Zdiff **103.165 Ohms**

Applied Voltage **24 Volts** Target Zdiff Minus **90.000 Ohms** Zo **60.234 Ohms**

Coupled Length **30 mm** Formula Restrictions: 0.1 < W/H < 3.0 0.1 < S/H < 3.0 Zodd **51.583 Ohms**

Signal Risetime **1 ns** Zeven **70.337 Ohms**

Options

Base Copper Weight

- 9um
- 18um
- 35um
- 53um
- 70um
- 88um
- 106um
- 142um
- 178um

Plating Thickness

- Bare PCB
- 18um
- 35um
- 53um
- 70um
- 88um
- 106um

Differential Layer

- Edge CpId Ext
- Edge CpId Int Sym
- Edge CpId Int Asym
- Edge CpId Embed
- Broad CpId Shld
- Broad CpId NShld

Units

- Imperial
- Metric

Substrate Options

Material Selection **Custom**

Er **3.61** Tg (°C) **180**

Temp Rise (°C) **20**

Temp in (°F) = 36.0

Ambient Temp (°C) **22**

Temp in (°F) = 71.6

Print Solve!

Information

Total Copper Thickness 53 um

W/H = 1.257

S/H = 1.257

Lsat = 91.09 mm

5:20:18 PM 12/4/2023

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Embedded Resistors Er Effective Fusing Current Mechanical Information Min Conductor Spacing Ohm's Law Padstack Calculator  
PDN Calculator Planar Inductors PPM-XTAL Calculator Thermal Management Via Properties Wavelength Calculator XL-XC Reactance  
Bandwidth & Max Conductor Length Conductor Impedance Conductor Properties Conversion Calculator Differential Pairs / XTALK

Differential Pairs

Conductor Width (W) **12.75 mils** Target Zdiff **90 Ohms** Differential Protocol **USB 2.X**

Conductor Spacing (S) **10 mils** +/- Tolerance = 15%

Conductor Height (H) **7.96 mils** Target Zdiff Plus **103.500 Ohms** Zdiff **89.991 Ohms**

Applied Voltage **5 Volts** Target Zdiff Minus **76.500 Ohms** Zo **52.547 Ohms**

Coupled Length **787.4 mils** Formula Restrictions: 0.1 < W/H < 3.0 0.1 < S/H < 3.0 Zodd **44.996 Ohms**

Signal Risetime **1 ns** Zeven **61.365 Ohms**

Options

Base Copper Weight

- 0.25oz
- 0.5oz
- 1oz
- 1.5oz
- 2oz
- 2.5oz
- 3oz
- 4oz
- 5oz

Plating Thickness

- Bare PCB
- 0.5oz
- 1oz
- 1.5oz
- 2oz
- 2.5oz
- 3oz

Differential Layer

- Edge CpId Ext
- Edge CpId Int Sym
- Edge CpId Int Asym
- Edge CpId Embed
- Broad CpId Shld
- Broad CpId NShld

Units

- Imperial
- Metric

Substrate Options

Material Selection **Custom**

Er **3.61** Tg (°C) **180**

Temp Rise (°C) **20**

Temp in (°F) = 36.0

Ambient Temp (°C) **22**

Temp in (°F) = 71.6

Print Solve!

Information

Total Copper Thickness 2.10 mils

W/H = 1.602

S/H = 1.256

Lsat = 3556.01 mils

6:24:43 PM 12/9/2023

## Impedance Requirements (SPE):

- 100R characteristic impedance, selecting 10% tolerance
- Maintaining through run between lumped hybrid network, through CMC, and to pins
- Not controlling impedance on PoE injection traces

## Impedance Requirements (USB 2.0 Speeds):

- USB P/N must be 90R Differential ±15%
- Diff Pair Mismatch <.6in

Sheet: /SPE-PoDL\_Interface/Trace Impedance Calcs/  
File: Trace\_Impedance\_Calcs.kicad\_sch

## Title: SPE and USB Trace Impedance Calculations

Size: A4 Date: 2024-01-21  
KiCad E.D.A. kicad 7.0.7

Rev: 1.0.1  
Id: 7/7