SoM

Note:
Leave annotation
as P1, P2, P3, P4

EmCraft System On Module

NXP i.MX 8M Quad Applications Processor with DDR4 LPRAM and eMMC
Connectors: 4x dual row 80 pin 0.4mm pitch headers (P1..P4)

Alternate Functions:
CAPTOUCH_RST
SAI6_TXD0
SAI6_TXFS/RXFS
SAI6_TXC/RXC
SAI6_RXD0

Spare GPIO:
GPIO1_IO05 (was CSI_P2_PWDN)
GPIO5_IO18 (PWM4/CLKO2/I2C3_SCL)

GPIO that can be swapped around:
GPIO1_IO05 (was CSI_P2_PWDN)
GPIO1_IO12 (was IR_CAP)
GPIO3_IO19 (was LED1)
GPIO3_IO20
GPIO3_IO25
GPIO5_IO03 (was PWM3)
GPIO5_IO04 (was PWM2)
GPIO5_IO05 (was PWM1)
GPIO5_IO18 (PWM4/CLKO2/I2C3_SCL)

Librem 5 Dev Kit
Purism
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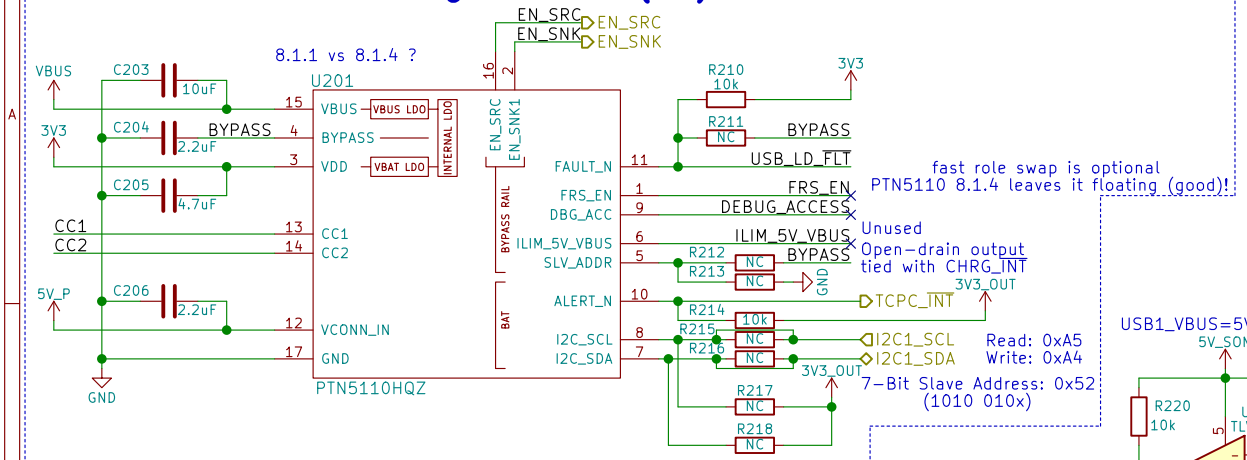
Sheet: /
File: dvk-mx8m-bsb.sch

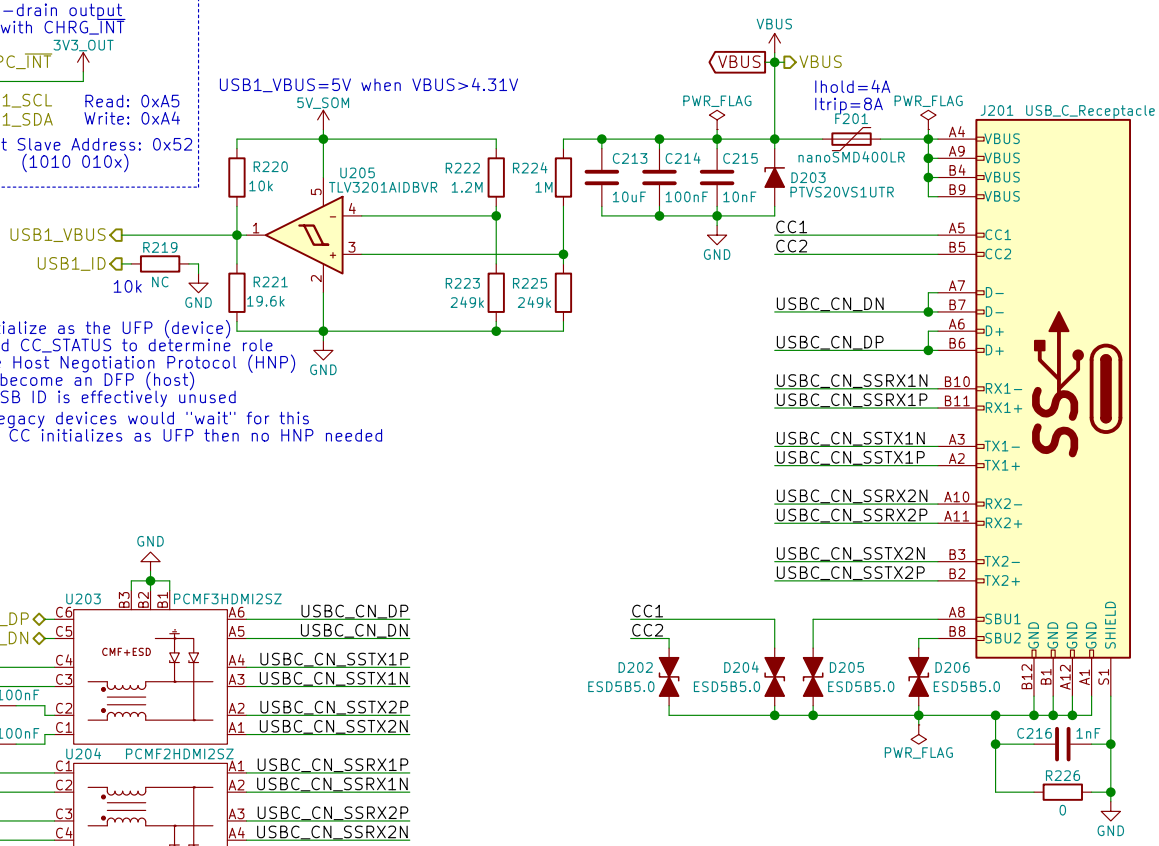
Size: A3 | Date: 2018-06-12 | Rev: v0.1.0
KiCad E.D.A. kicad 4.0.6 | Id: 1/24

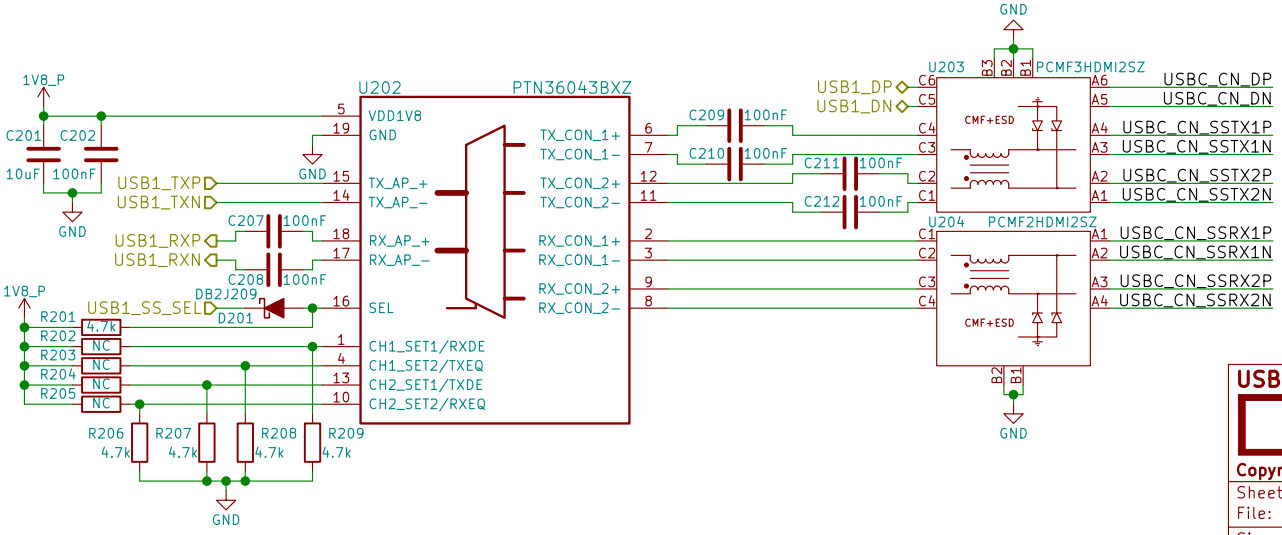
USB-C TCPC – Config Channel (CC) and PD Role Controller



"Under dead battery operation, PTN5110 applies voltage clamps to both CC pins so that the system may receive power as a Sink. To support platforms with buck-boost configuration, PTN5110 asserts EN_SNK1 pin based on validity of VBUS voltage (facilitates 5 V VBUS sinking)."

USB-C





USB Type C	eric.kuzmenko@puri.sm	
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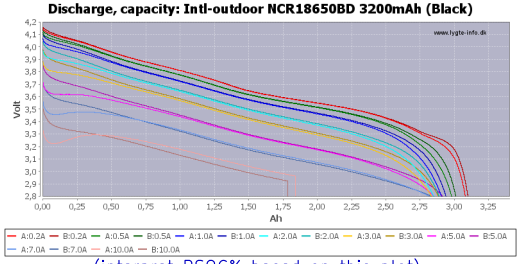
Sheet: /USB-C/		
File: usb-c.sch		
Size: A4	Date: 2018-06-11	**Rev: v0.1.0**
KiCad E.D.A. kicad 4.0.6		Id: 2/24

Battery Charge Controller



(interpret RSOC% based on this plot)

Drawing ~333.33mA, or consuming <1.2W, should give close to 10 hours going from 100% to 0% charge

use AUTO_DPDM_EN to auto-detect IINLIM

1.658≤ILIM≤2.063
ILIM(nom)≅1.859A
3.9≤VIN≤14

7-bit Slave Address: 0x6B (1101 011x)

U301 BQ25896

I(Lsat)=7A

Default LOW: adapter source

sink current ~5mA

Read: 0xD7
Write: 0xD6

Ihold=3.5A
Itrip=6.3A
Ttrip(max)=5s@8A

Vrwm(max)=5.0V
Vbr(min)=6.2V
Pd=150mW

Vf(max)=1.1V

3.5~4.25V

~110uF

0.18mA~0.95mA

VBAT(DPL)=2.15~2.5V

NCR18650B meets requirements

VBAT(ovp_default)=REG06[7:2]=4.208V (reduce to 4.192V [010110])
Worst Case:
VBAT(default_max_ovp)=(REG06[7:2]×1.005)×1.04=4.3982016V
BQ29705 provides 4.425V as OVP!

ICHG(default)=REG[6:0]=2048mA (reduce to ~1.6A [0011001])

reference design: http://www.ti.com/lit/ug/sluuba2b/sluuba2b.pdf

may want to include BQ29705 protection as in:
http://www.ti.com/lit/ug/tiducl1/tiducl1.pdf
schematic: http://www.ti.com/lit/df/tidrp70/tidrp70.pdf
(PTC may be good enough)

This disables charging
but maybe not VBUS->VOUT
if PTN5110HQ's FAULT_STATUS[6]==1
(Force Off VBUS bit) then set EN_HiZ=1
EN_HiZ may be auto-set when in hiccup

Reading PTN5110HQ's CC_STATUS and POWER_STATUS registers will tell TCPM (i.MX8M) when to set EN_HiZ

Also, reading PTN5110HQ's CC_STATUS and POWER_STATUS registers will tell TCPM (i.MX8M) when to set OTG_CONFIG=1
(this will also happen when PTN5110HQ sets EN_SRC HIGH)

BC1.2 is not mandated by PD spec
ICO used to determine max current
Also negotiated from CC pins (I2C)

Battery holder gives ~1mm clearance underneath the battery
Thermistor is 1.1±0.15mm thick, should fit fine with stack-up

Battery holder seems to fit up to ~68.88mm long batteries
need to test 18650 protected cells which are ~69.35mm long

Battery

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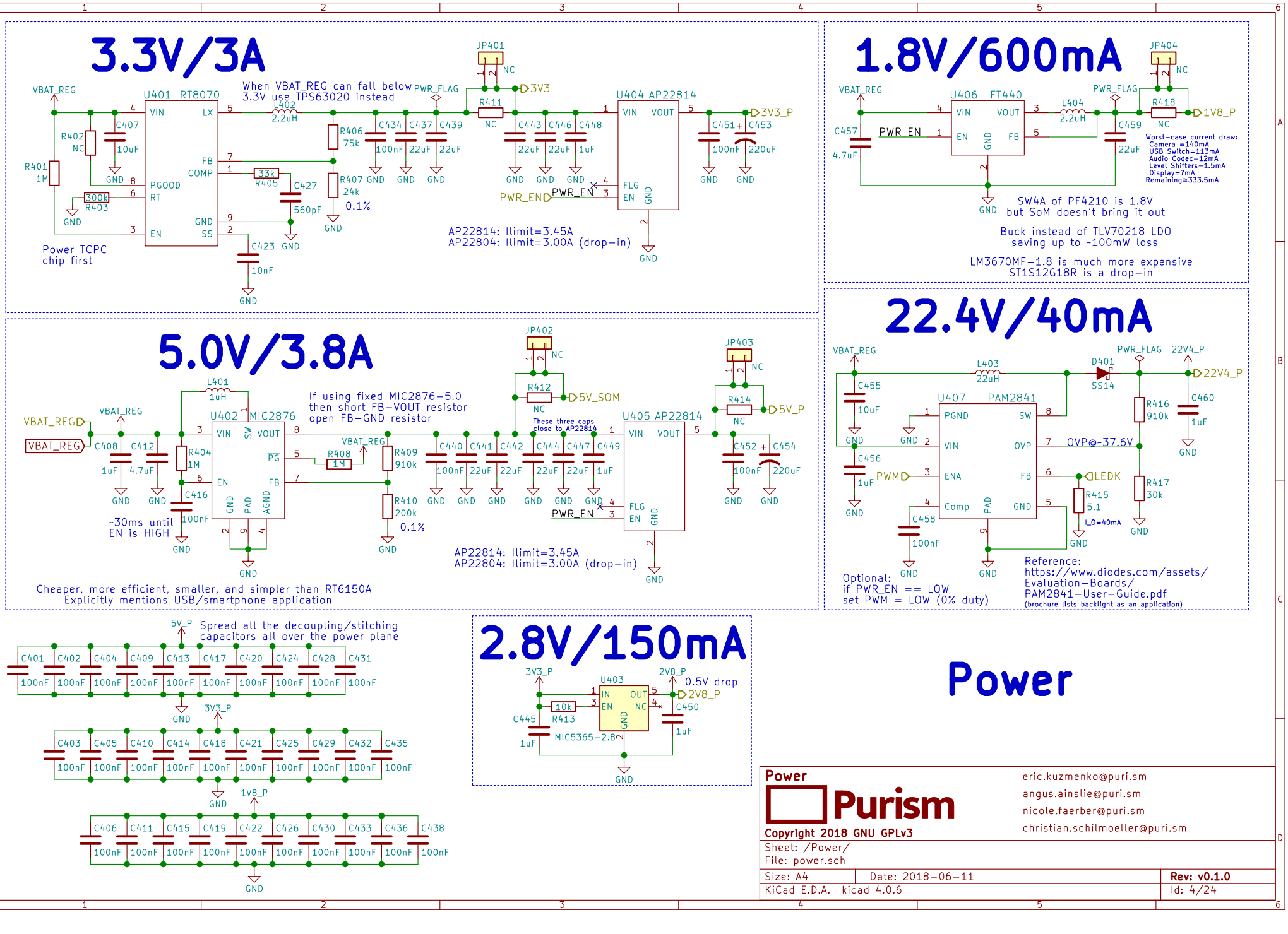
Sheet: /Battery/
File: battery.sch

Size: A4 | Date: 2018-06-11 | Rev: v0.1.0
KiCad E.D.A. kicad 4.0.6 | Id: 3/24


3.3V/3A
When VBAT_REG can fall below 3.3V use TPS63020 instead
Power TCPC chip first
AP22814: Ilimit=3.45A
AP22804: Ilimit=3.00A (drop-in)
1.8V/600mA
SW4A of PF4210 is 1.8V but SoM doesn't bring it out
Buck instead of TLV70218 LDO saving up to ~100mW loss
LM3670MF-1.8 is much more expensive
ST1S12G18R is a drop-in
Worst-case current draw:
Camera =140mA
USB Switch=113mA
Audio Codec=12mA
Level Shifters=1.5mA
Display=7mA
Remaining≥333.5mA
5.0V/3.8A
If using fixed MIC2876-5.0 then short FB-VOUT resistor open FB-GND resistor
~30ms until EN is HIGH
Cheaper, more efficient, smaller, and simpler than RT6150A
Explicitly mentions USB/smartphone application
AP22814: Ilimit=3.45A
AP22804: Ilimit=3.00A (drop-in)
22.4V/40mA
Optional: if PWR_EN == LOW set PWM = LOW (0% duty)
Reference: https://www.diodes.com/assets/Evaluation-Boards/PAM2841-User-Guide.pdf
(brochure lists backlight as an application)
Spread all the decoupling/stitching capacitors all over the power plane
2.8V/150mA
0.5V drop
Power
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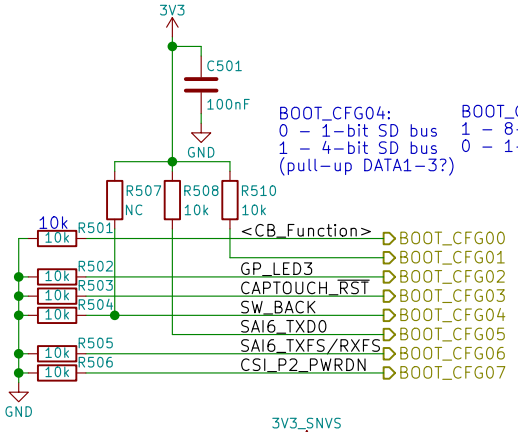
Sheet: /Power/
File: power.sch
Size: A4
Date: 2018-06-11
Rev: v0.1.0
KiCad E.D.A. kicad 4.0.6
Id: 4/24

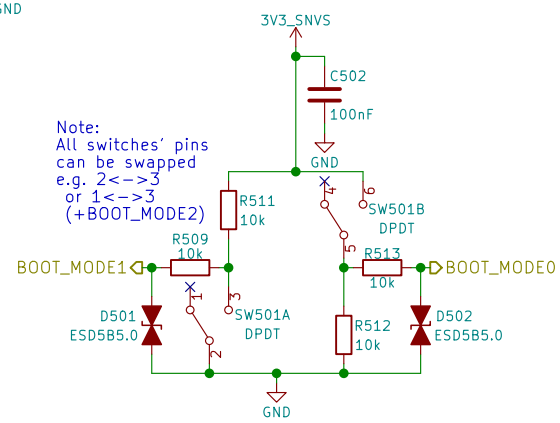
Boot Config

Only eMMC

BOOT_CFG[14:12]	Boot device
001	SD/eSD
010	MMC/eMMC
011	NAND

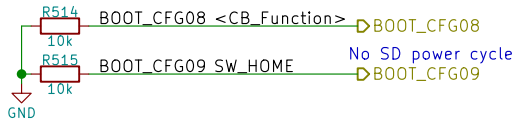
Fuse	Config	Definition	GPIO[1]	Shipped value	Settings
BOOT_CFG[11:10]	OEM	USDHC port selection	Yes	00	00 - USDHC-1
					01 - USDHC-2
					10 - USDHC-3
					else - reserved

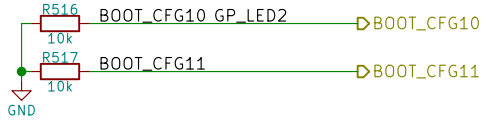


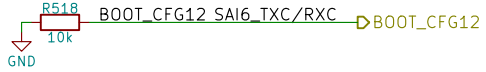


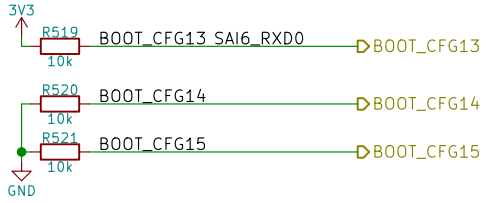
2–>1: eMMC
2–>3: USB (Serial Downloader)

BOOT_MODE[1:0]	Boot Type
00	Boot From Fuses
01	Serial Downloader
10	Internal Boot
11	Reserved









Boot Configuration

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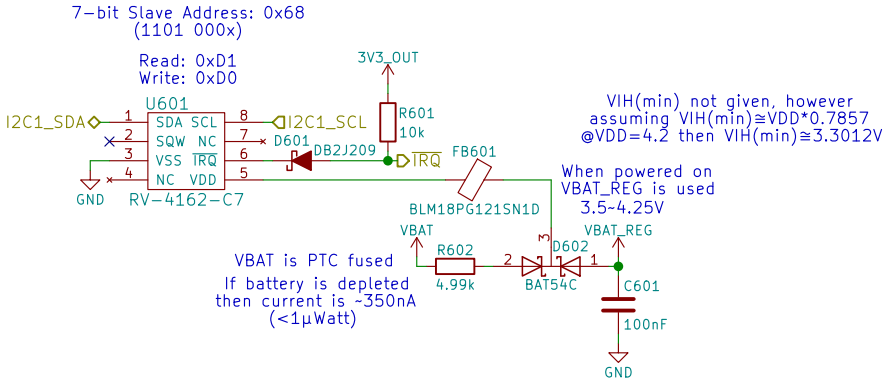
Sheet: /Boot Config/
File: boot.sch

Size: A4 | Date: 2018–06–11 | **Rev: v0.1.0**
KiCad E.D.A. kicad 4.0.6 | Id: 5/24

Real-Time Clock



Note:
Datasheet says slave address is 0xD0
with a R/W bit appended, since 0xD must
be 4-bits wide the actual 7-bit address is
0x68 (110 1000), and becomes 0xD0 during a
write operation (1101 0000)

Reference:
https://github.com/HIO-Project/linux-imx6-nano-imx_3.10.17_1.0.1_ga/
blob/8848e94b2f889fe44f6736e2d4c98851a2282275/arch/arm/boot/dts/
imx6qdl-mtp.dtsi#L351

RTC

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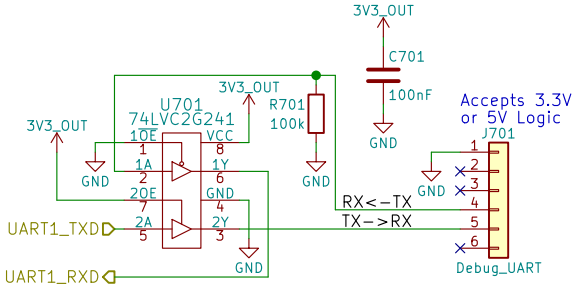
Sheet: /RTC/
File: rtc.sch

Size: A4 | Date: 2018-06-11 | **Rev: v0.1.0**
KiCad E.D.A. kicad 4.0.6 | Id: 6/24

UART Debug



UART Debug

Purism

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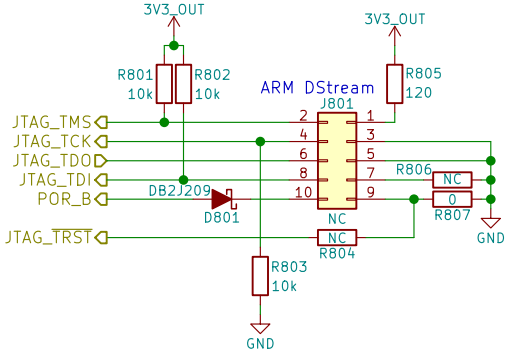
Sheet: /UART Debug/
File: uart.sch

Size: A4	Date: 2018-06-11	**Rev: v0.1.0**
KiCad E.D.A. kicad 4.0.6		Id: 7/24

JTAG



JTAG

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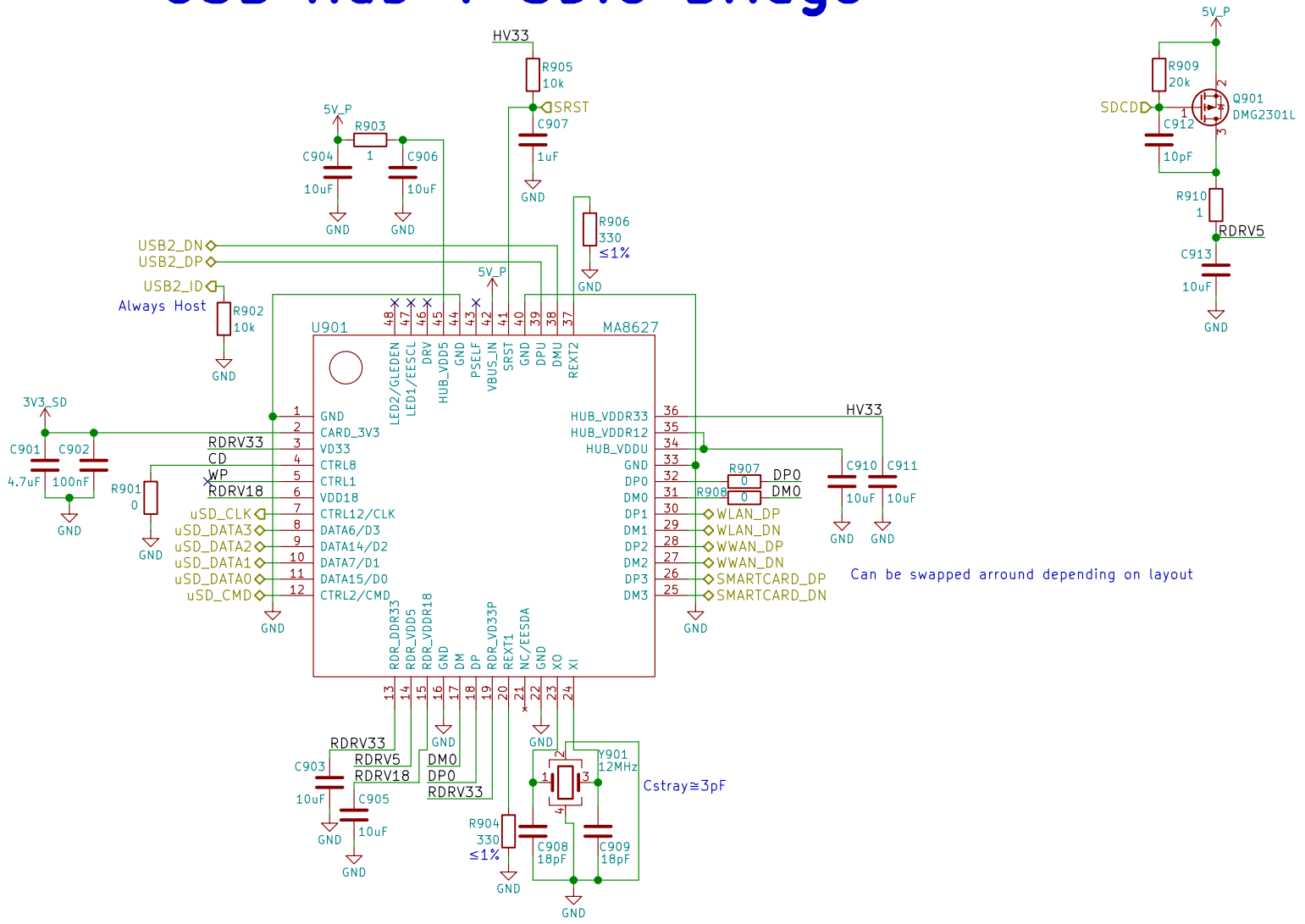
Sheet: /JTAG/
File: jtag.sch

Size: A4	Date: 2018-06-11	**Rev: v0.1.0**
KiCad E.D.A. kicad 4.0.6		Id: 8/24

USB Hub + SDIO Bridge



USB Hub + SDIO Bridge		eric.kuzmenko@puri.sm
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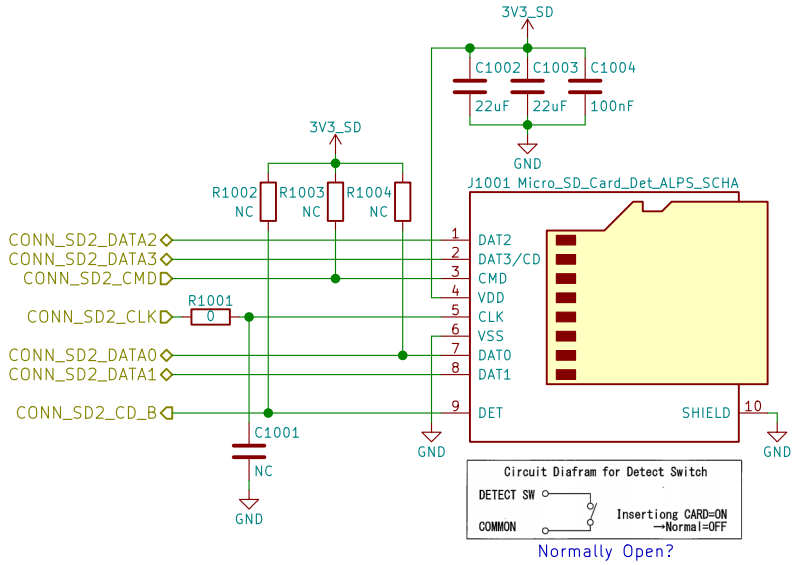
Sheet: /USB Hub + SDIO Bridge/		
File: usb_hub_sdio.sch		
Size: A4	Date: 2018-06-11	Rev: v0.1.0
KiCad E.D.A. kicad 4.0.6		Id: 9/24

µSD



uSD Card	eric.kuzmenko@puri.sm angus.ainslie@puri.sm nicole.faerber@puri.sm christian.schilmoeller@puri.sm
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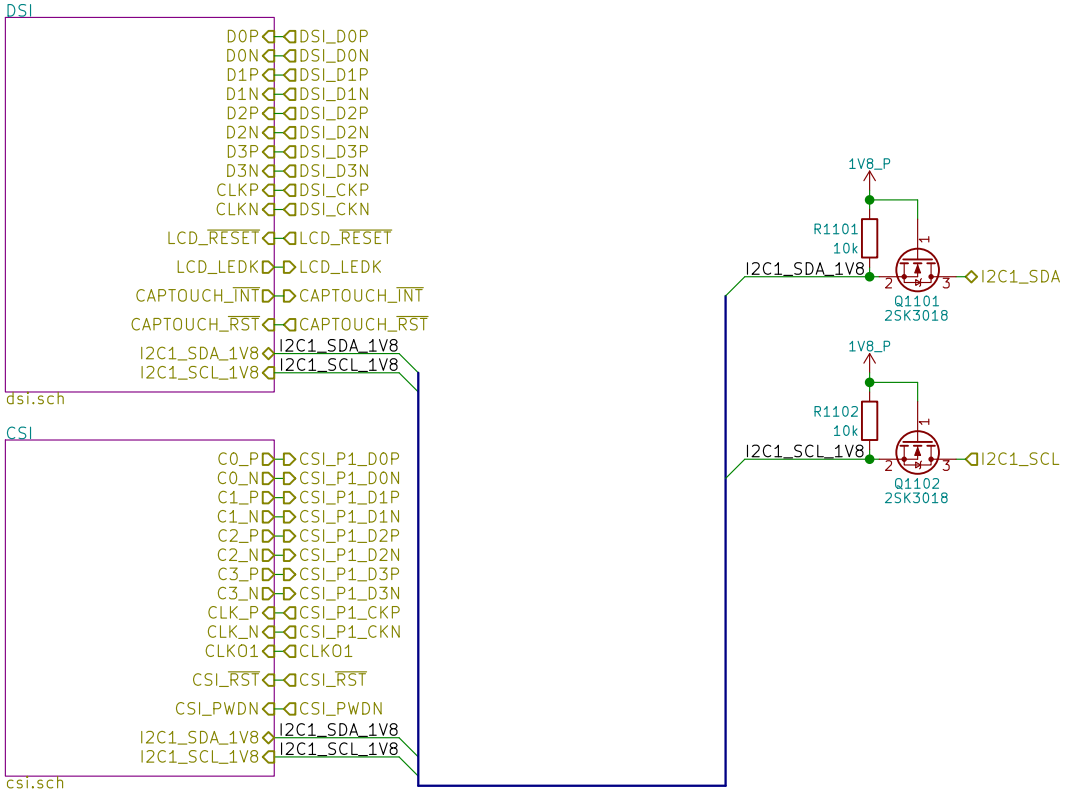
Sheet: /uSD Card/ File: sd.sch	
Size: A4 | Date: 2018-06-11	Rev: v0.1.0
KiCad E.D.A. kicad 4.0.6	Id: 10/24

MIPI



MIPI		eric.kuzmenko@puri.sm angus.ainslie@puri.sm nicole.faerber@puri.sm christian.schilmoeller@puri.sm
Purism		
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Sheet: /MIPI/ File: mipi.sch		
Size: A4	Date: 2018-06-11	**Rev: v0.1.0**
KiCad E.D.A. kicad 4.0.6		Id: 11/24

Display & Touch Controller

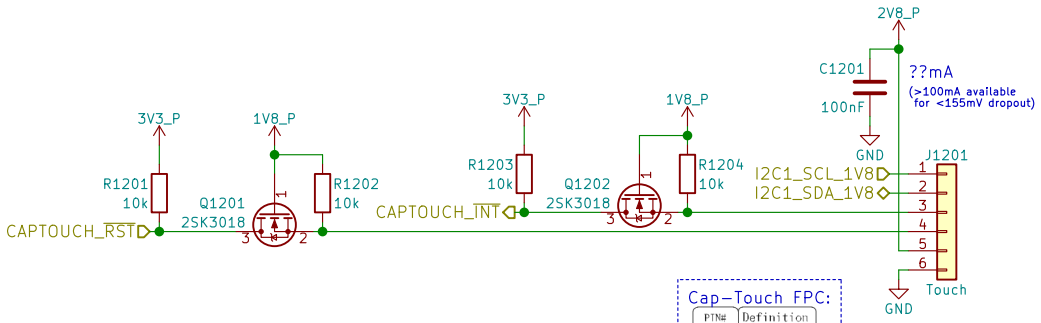
LCD PN:
Shenzhen Jinghong Electronics Co., Ltd.
JH057N00900

Note:
No power-up sequence is
given in the spec sheet

7-bit Slave Address: 0x5D
(1011 101x)

Read: 0xBB
Write: 0xBA

Cap-Touch Controller IC PN:
Goodix GT5688



Cap-Touch FPC:

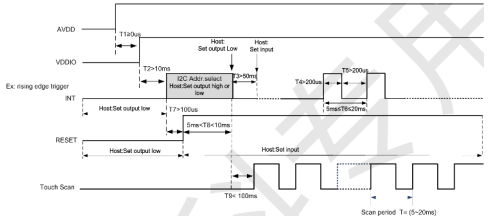
PIN#	Definition
1	SCL
2	SDA
3	INT
4	RESET
5	VDD2.85
6	GND

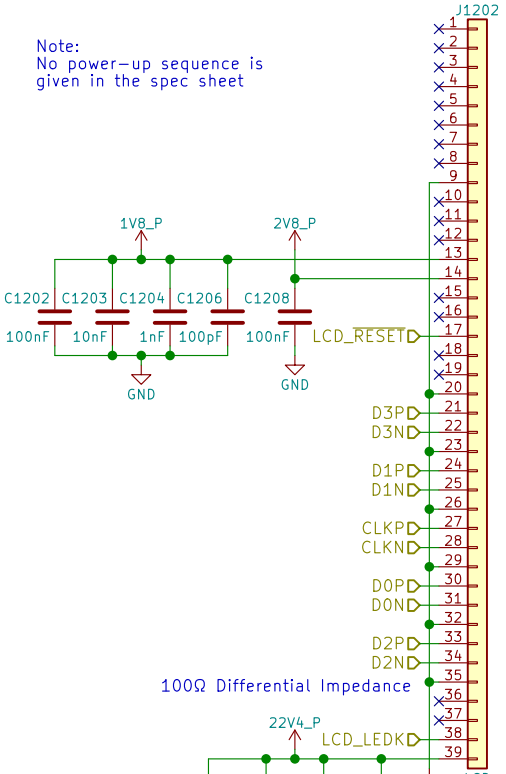
Front: Back:

The upper 7 bits are the address,
and bit 0 is used to select read or write.
GT5688 has two slave device addresses to choose from:

INT	7-Bit Address	8-Bit Write Address	8-Bit Read Address
LOW	0x5D	0xBA	0xBB
HIGH	0x14	0x28	0x29

Every time you power on or reset, you need
to use the INT pin to set the I2C address:





DSI FPC:
Front: Back:

Backlight Array:

MIPI DSI

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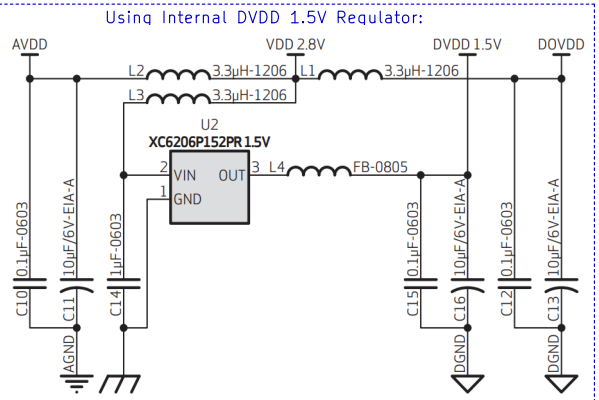
Sheet: /MIPI/DSI/
File: dsi.sch

Size: A4	Date: 2018-06-11	Rev: v0.1.0
KiCad E.D.A. kicad 4.0.6		Id: 12/24

Camera

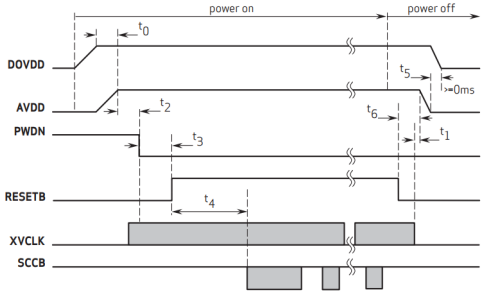


2.7 POWER UP SEQUENCE
Based on the system power configuration (1.8V or 2.8V for I/O power, using external DVDD or internal DVDD, requiring access to the I2C during power up period or not), the power up sequence will differ. If 1.8V is used for I/O power, using the internal DVDD is preferred. If 2.8V is used for I/O power, due to a high voltage drop at the internal DVDD regulator, there is a potential heat issue. Hence, for a 2.8V power system, OmniVision recommends using an external DVDD source. Due to the higher power down current when using an external DVDD source, OmniVision strongly recommends cutting off all powers, including the external DVDD, when the sensor is not in use in the case of 2.8V I/O and external DVDD.

2.7.1 POWER UP WITH INTERNAL DVDD
For powering up with the internal DVDD and I2C access during the power ON period, the following conditions must occur:

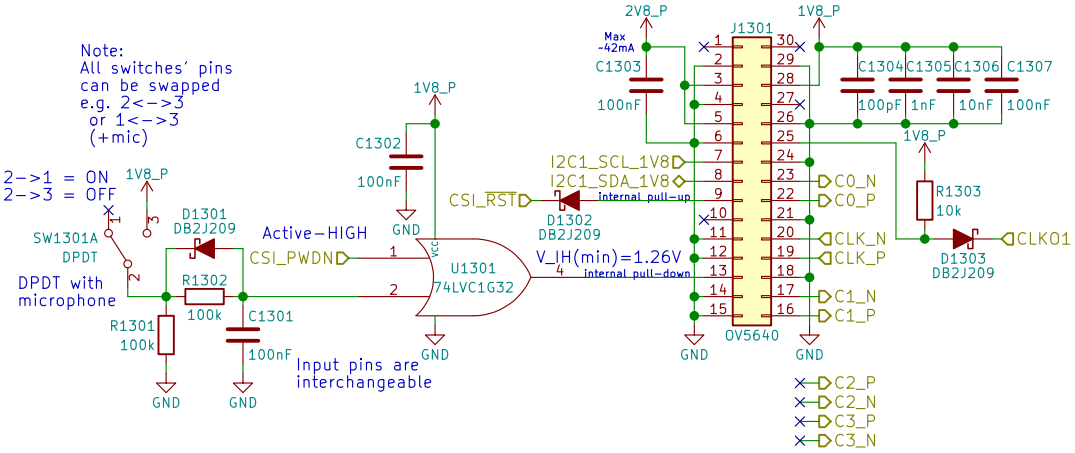
1. when DOVDD and AVDD are turned ON, make sure DOVDD becomes stable before AVDD becomes stable
2. PWDN is active high with an asynchronized design (does not need clock)
3. PWDN pin tied to digital ground if it is not controlled.
4. if PWDN pin is controlled as below, for PWDN to go low, power must first become stable (AVDD to PWDN ≥ 5 ms)
5. RESETB is active low with an asynchronized design
6. master clock XVCLK should provide at least 1 ms before host accesses the sensor's registers
7. host can access I2C bus (if shared) during entire period. 20ms after RESETB goes high, host can access the sensor's registers to initialize sensor

figure 2-3 power up timing with internal DVDD



note
t_0 ≥ 0ms, delay from DOVDD stable to AVDD stable, it is recommended to power up AVDD shortly after DOVDD has been powered up
t_1 ≥ 0ms, delay from XVCLK off to AVDD off
t_2 ≥ 5ms, delay from AVDD stable to sensor power up stable, PWDN can be pulled low after this point, XVCLK can be turned on after power on
t_3 ≥ 1ms, delay from sensor power up stable to RESETB pull up
t_4 ≥ 20ms, delay from RESETB pull high to SCCB initialization
t_5 ≥ 0ms, delay from AVDD off to DOVDD off
t_6 ≥ 0ms, delay from RESETB pull low to AVDD off

S640_DS_2_2



OV5640 CMOS Image Sensor Datasheet:
https://cdn.sparkfun.com/datasheets/Sensors/LightImaging/OV5640_datasheet.pdf

MIPI CSI

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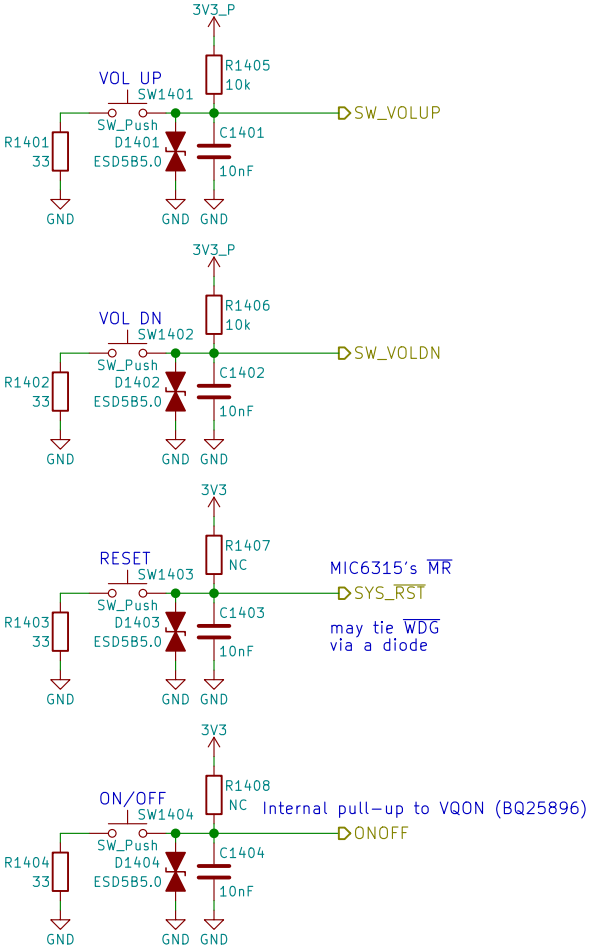
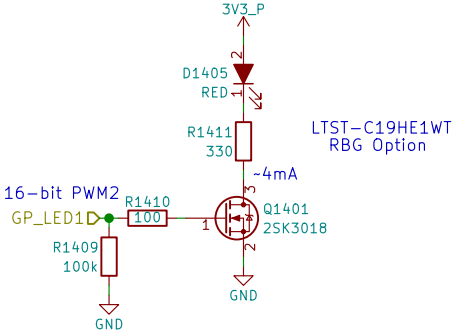
Sheet: /MIPI/CSI/
File: csi.sch

Size: A4	Date: 2018-06-11	Rev: v0.1.0
KiCad E.D.A. kicad 4.0.6		Id: 13/24

Buttons & LED



Use PWM2_PWMSAR to set the compare value (duty cycle)
Use PWM2_PWMCR[15:4] to set the PRESCALER (frequency)
Use PWM2_PWMPR to set the top of the counter (frequency)



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Sheet: /Buttons & LED/	
File: buttons_led.sch	
Size: A4 | Date: 2018-06-11	**Rev: v0.1.0**
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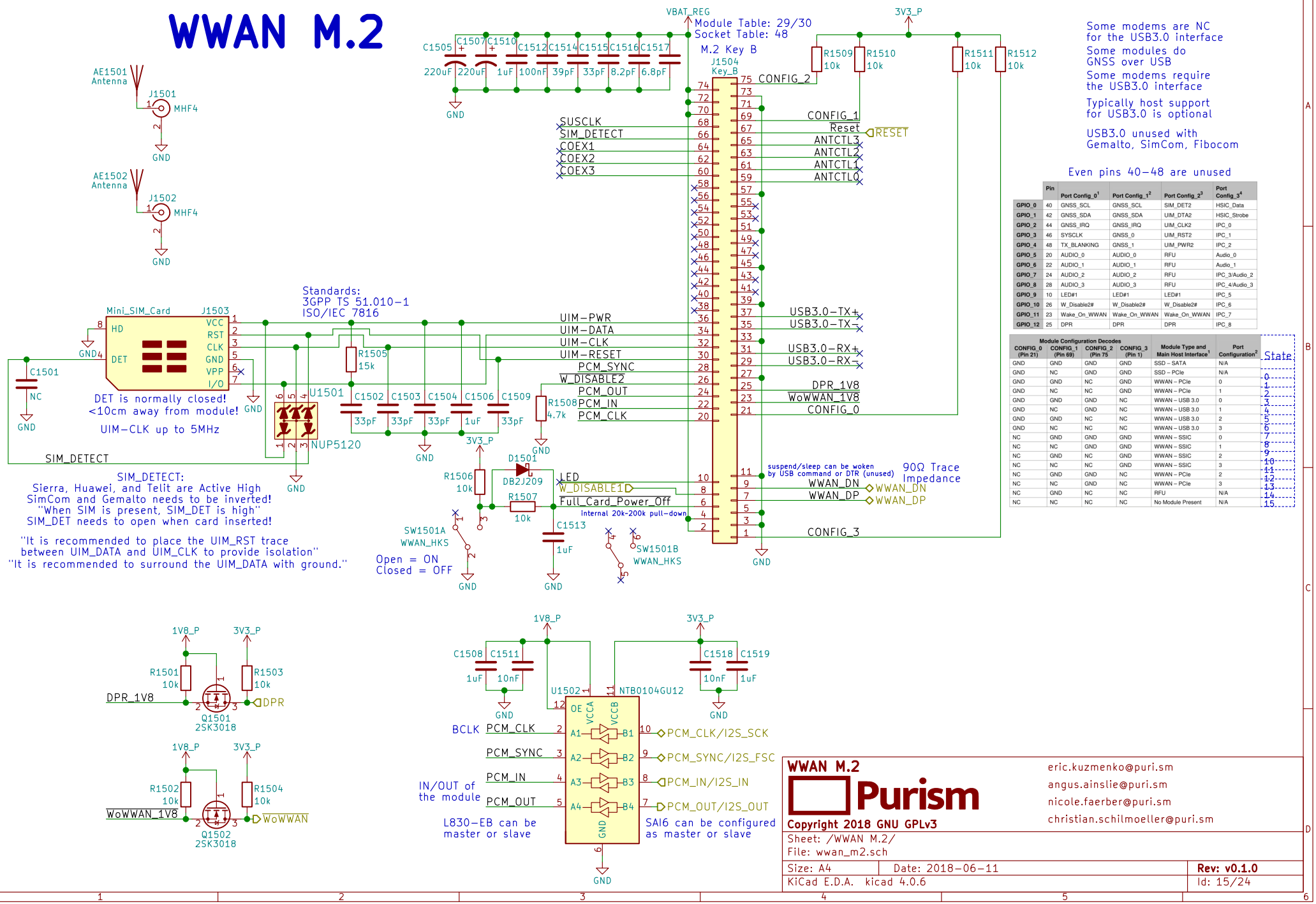
WWAN M.2



	Pin	Port Config_0[1]	Port Config_1[2]	Port Config_2[3]	Port Config_3[4]
GPIO_0	40	GNSS_SCL	GNSS_SCL	SIM_DET2	HSIC_Data
GPIO_1	42	GNSS_SDA	GNSS_SDA	UIM_DTA2	HSIC_Strobe
GPIO_2	44	GNSS_IRQ	GNSS_IRQ	UIM_CLK2	IPC_0
GPIO_3	46	SYSCLK	GNSS_0	UIM_RST2	IPC_1
GPIO_4	48	TX_BLANKING	GNSS_1	UIM_PWR2	IPC_2
GPIO_5	20	AUDIO_0	AUDIO_0	RFU	Audio_0
GPIO_6	22	AUDIO_1	AUDIO_1	RFU	Audio_1
GPIO_7	24	AUDIO_2	AUDIO_2	RFU	IPC_3/Audio_2
GPIO_8	28	AUDIO_3	AUDIO_3	RFU	IPC_4/Audio_3
GPIO_9	10	LED#1	LED#1	LED#1	IPC_5
GPIO_10	26	W_Disable2#	W_Disable2#	W_Disable2#	IPC_6
GPIO_11	23	Wake_On_WWAN	Wake_On_WWAN	Wake_On_WWAN	IPC_7
GPIO_12	25	DPR	DPR	DPR	IPC_8

Module Configuration Decodes						State
CONFIG_0 (Pin 21)	CONFIG_1 (Pin 69)	CONFIG_2 (Pin 75)	CONFIG_3 (Pin 1)	Module Type and Main Host Interface[1]	Port Configuration[2]	
GND	GND	GND	GND	SSD – SATA	N/A	
GND	NC	GND	GND	SSD – PCIe	N/A	
GND	GND	NC	GND	WWAN – PCIe	0	0
GND	NC	NC	GND	WWAN – PCIe	1	1
GND	GND	GND	NC	WWAN – USB 3.0	0	2
GND	NC	GND	NC	WWAN – USB 3.0	1	3
GND	GND	NC	NC	WWAN – USB 3.0	2	4
GND	NC	NC	NC	WWAN – USB 3.0	3	5
NC	GND	GND	GND	WWAN – SSIC	0	6
NC	NC	GND	GND	WWAN – SSIC	1	7
NC	GND	NC	GND	WWAN – SSIC	2	8
NC	NC	NC	GND	WWAN – SSIC	3	9
NC	GND	GND	NC	WWAN – PCIe	2	10
NC	NC	GND	NC	WWAN – PCIe	3	11
NC	GND	NC	NC	RFU	N/A	12
NC	NC	NC	NC	No Module Present	N/A	13 14 15

WWAN M.2
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Audio

Reference:
http://www.52rd.com/S_txt/2011_3/TXT26685.htm
http://www.sengpielaudio.com/calculator-transferfactor.htm
https://electronics.stackexchange.com/questions/31442/how-can-i-switch-this-audio-jack-using-its-own-mechanical-switches-without-cre
(Nit6 does the same)
+Zener diode to protect against ranges outside of -0.9V to 3.3V

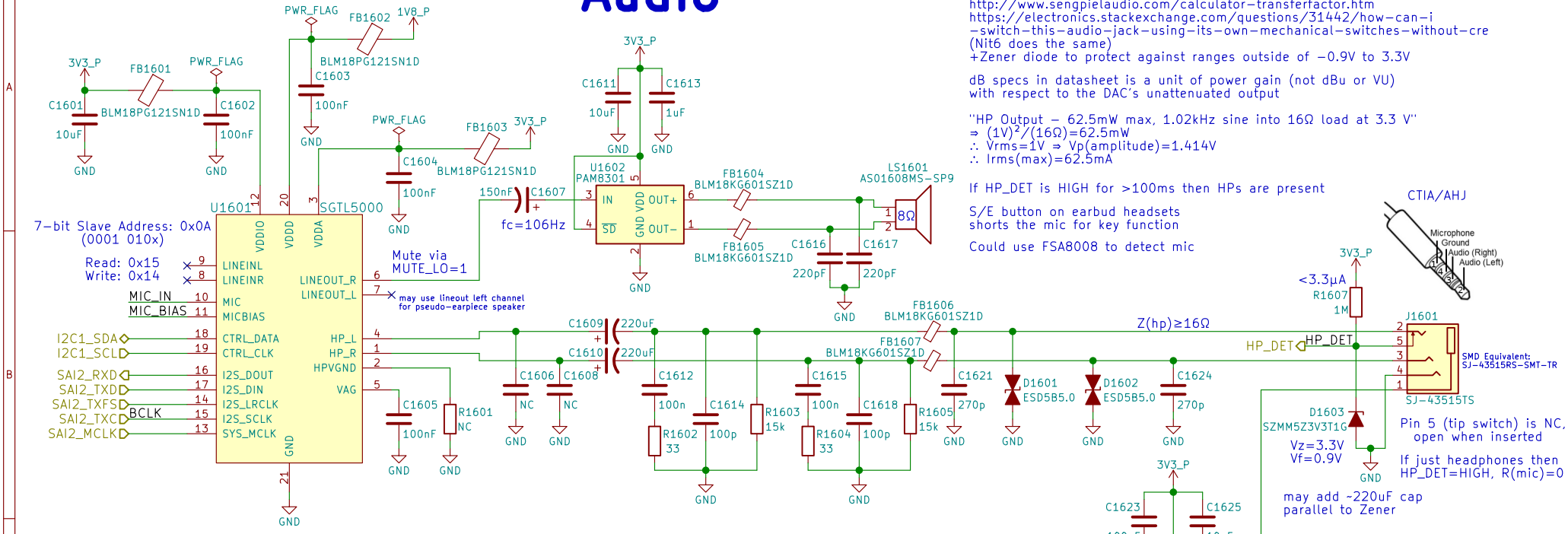
dB specs in datasheet is a unit of power gain (not dBu or VU)
with respect to the DAC's unattenuated output

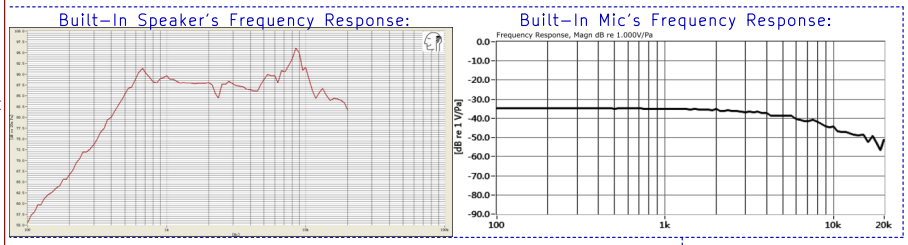
"HP Output - 62.5mW max, 1.02kHz sine into 16Ω load at 3.3 V"
⇒ $(1V)^2/(16Ω)=62.5mW$
∴ Vrms=1V ⇒ Vp(amplitude)=1.414V
∴ Irms(max)=62.5mA

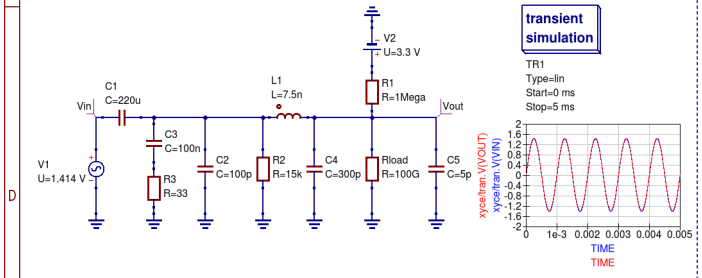
If HP_DET is HIGH for >100ms then HPs are present

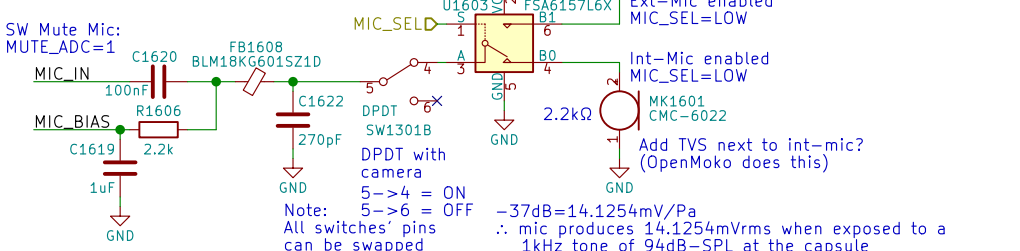
S/E button on earbud headsets
shorts the mic for key function

Could use FSA8008 to detect mic









LCR Measurements:

Earbud Microphone: @1kHz	Headset Speaker: @1kHz	Earbud Speaker: @1kHz
Ls = 3.844mH	Ls = 244.4uH	Ls = 25.2uH
Lp = 15.757H	Lp = 141.99mH	Lp = 311.0mH
Cs = 6.583uF	Cs = 103.6uF	Cs = 1.0mF
Cp = 1612.8pF	Cp = 178.77nF	Cp = 81.95nF
Rs = 1.5465kOhms	Rs = 36.860hms	Rs = 17.0300hms
Rp = 1.5478kOhms	Rp = 36.860hms	Rp = 17.0340hms
θ = -0.8deg	θ = -2.3deg	θ = 0.5deg

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File: audio.sch

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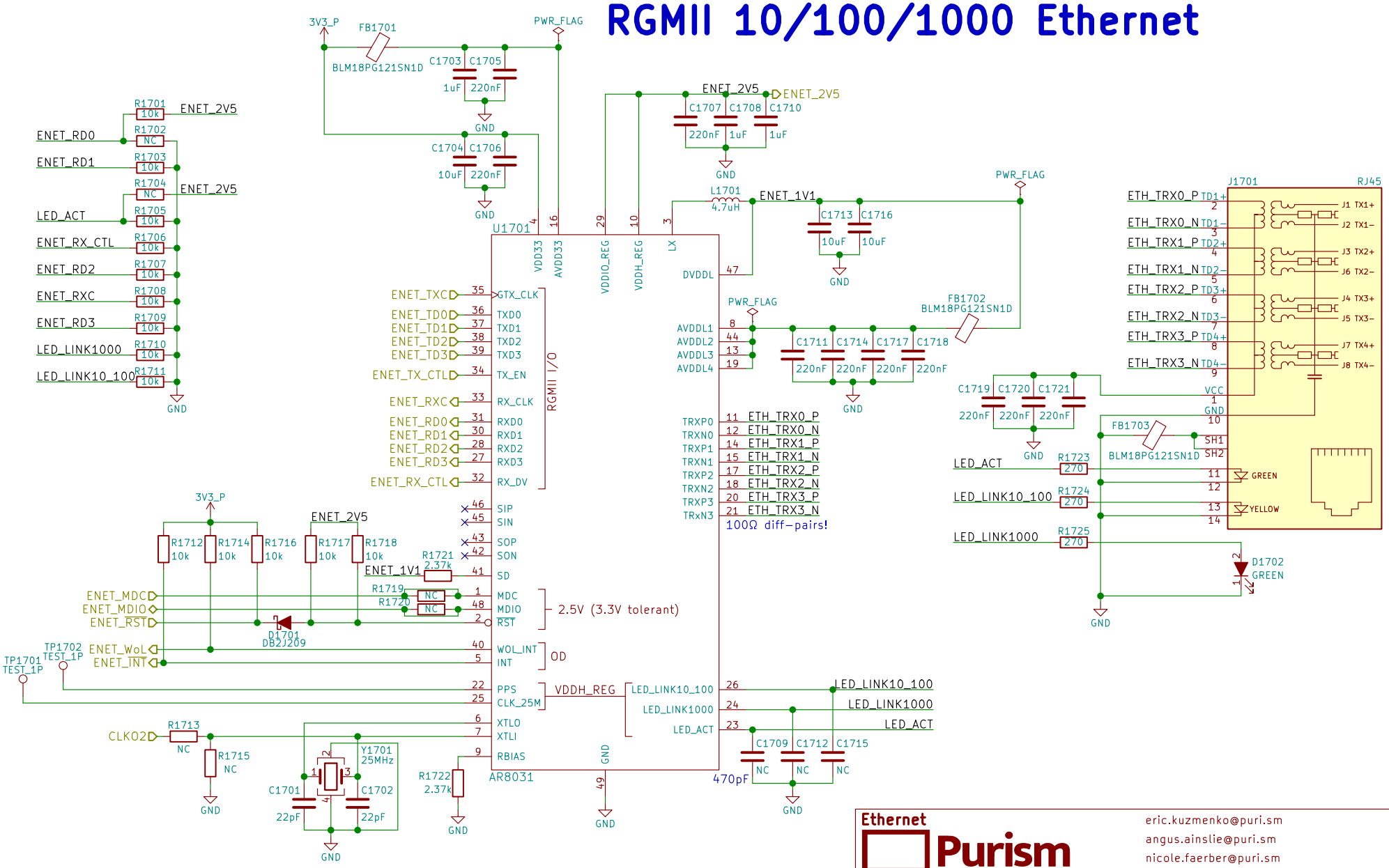
RGMII 10/100/1000 Ethernet



Ethernet

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WLAN+BT M.2

Module: Table 23
Socket: Table 46

M.2 Key E

RS9116 NC:
RTS, CTS, BT_HOST_WAKE

RS9116 datasheet says
no WIFI_WAKE
but the schematic has it

RedPine RS9116 MB0
Requires 5V on
Pin 54 if USB used

J1803 Key_E

SoC's IN/OUT

SoC's RX
Module's TX

SoC's TX
Module's RX

VIH=2.31V

RedPine RS9116
has 100k pull-up to
3.3V making SDIO_RST
~2.55V when HIGH

i.MX8M in DCE mode (POR state)
has CTS output, RTS input

6.2 M.2 Signal Directions

UARTn_UFCR[DCEDTE]=0 on POR

TX output
RX input
CTS output
RTS input

⇒TX→RX
RX←TX
CTS→CTS
RTS←RTS

Pin 54 on RS9116 is
USB_VBUS Sink

Leave BT_DISABLE
LOW for RS9116

RS9116 SUSCLK
is a GPIO (unused)

Input pins are
interchangeable

Note:
All switches' pins
can be swapped
e.g. 2<->3
or 1<->3

SW1801A
WLAN_HKS

SW1801B
WLAN_HKS

Open = ON
Closed = OFF

RS9116 is an I2C master
⇒its SCL is an output
(ok bc only device on I2C2)

RS9116 does not
use RTX & CTS

internal 10k pull-up

RX, TX, RTS, CTS
of the SoC

configure as slave

IN, OUT
of the SoC

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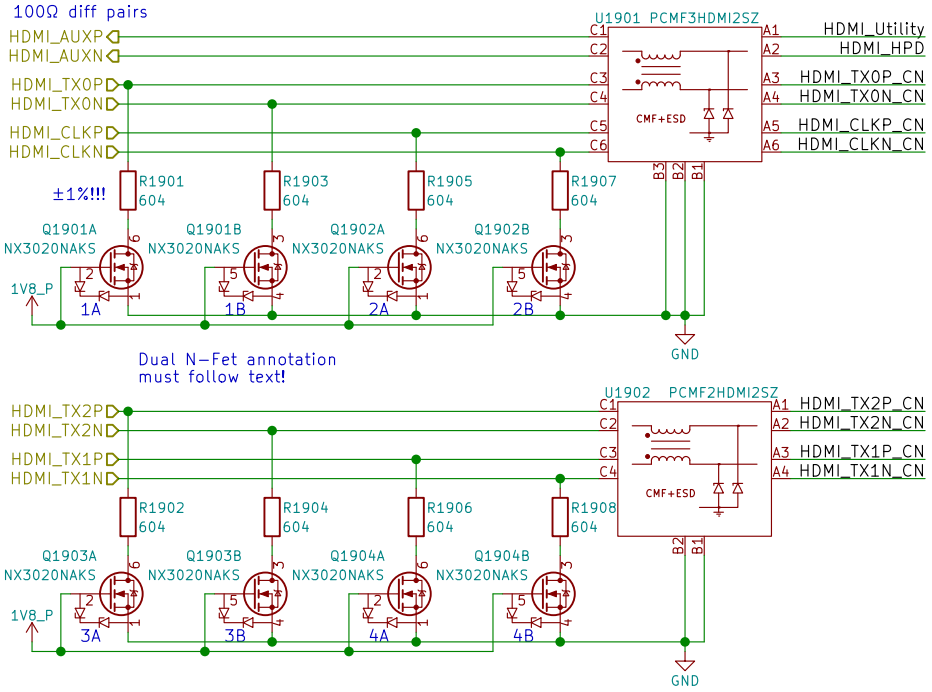
TUSB1046 can be used for DP over USB-C

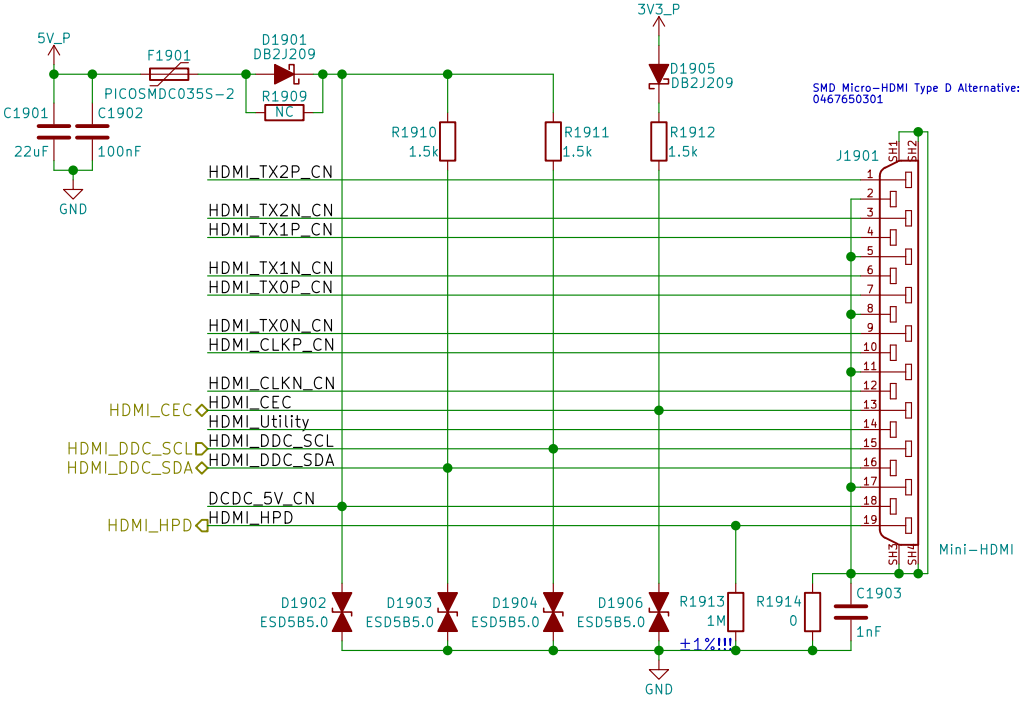
HDMI

Layout Note:
May need swap some signals
due to micro-HDMI pinout diff
depending on pin location/routing

100Ω diff pairs



Dual N-Fet annotation
must follow text!



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File: hdmi.sch		
Size: A4	Date: 2018-06-11	Rev: v0.1.0
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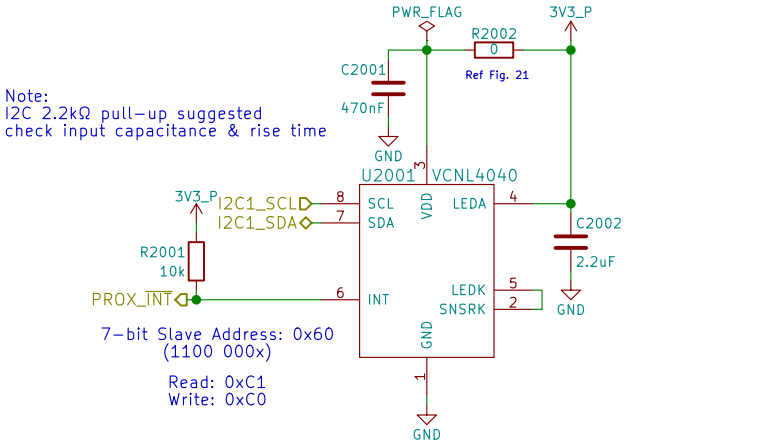
Sensors

Proximity & Ambient Light



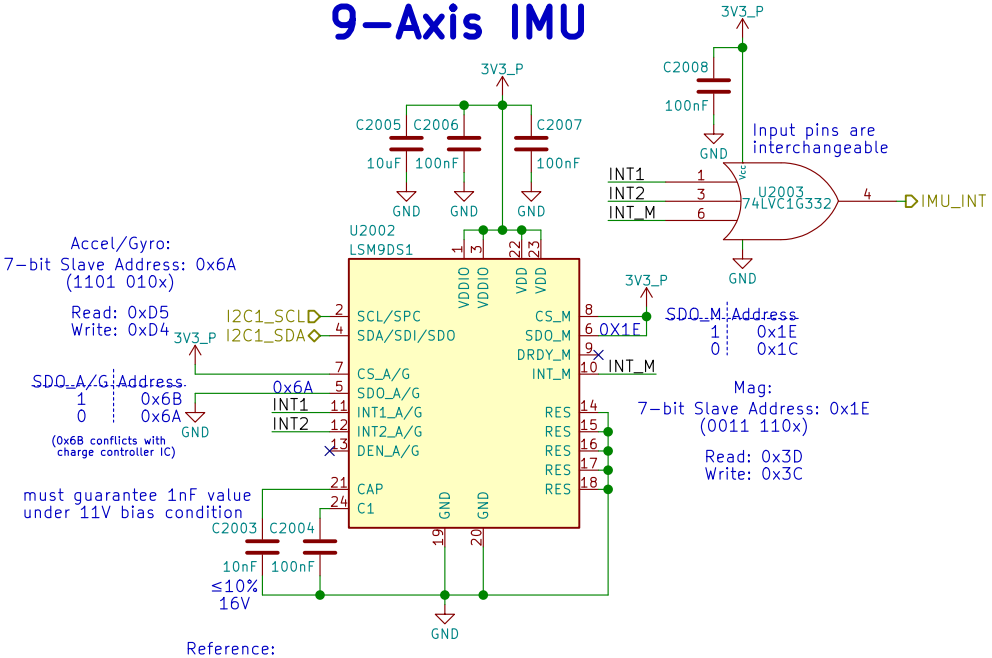
Note:
I2C 2.2kΩ pull-up suggested
check input capacitance & rise time

7-bit Slave Address: 0x60
(1100 000x)

Read: 0xC1
Write: 0xC0

Reference:
https://www.vishay.com/docs/84307/designingvcnl4040.pdf
http://www.vishay.com/docs/84931/vcnl4040sensorboardfiles.pdf

9-Axis IMU



Accel/Gyro:
7-bit Slave Address: 0x6A
(1101 010x)

Read: 0xD5
Write: 0xD4

must guarantee 1nF value
under 11V bias condition
≤10%
16V

Mag:
7-bit Slave Address: 0x1E
(0011 110x)

Read: 0x3D
Write: 0x3C

Reference:
http://www.st.com/en/evaluation-tools/steval-mki159v1.html

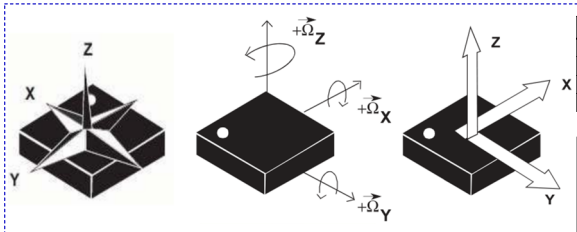


Table 19. Accelerometer and gyroscope SAD+Read/Write patterns

Command	SAD[6:1]	SAD[0] = SA0	R/W	SAD+R/W
Read	110101	0	1	11010101 (D5h)
Write	110101	0	0	11010100 (D4h)
Read	110101	1	1	11010111 (D7h)
Write	110101	1	0	11010110 (D6h)

Table 20. Magnetic sensor SAD+Read/Write patterns

Command	SAD[6:2]	SAD[1] = SDO/SA1	SAD[0]	R/W	SAD+R/W
Read	00111	0	0	1	00111001 (39h)
Write	00111	0	0	0	00111000 (38h)
Read	00111	1	0	1	00111101 (3Dh)
Write	00111	1	0	0	00111100 (3Ch)

Sensors

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Sheet: /Sensors/
File: sensors.sch

Size: A4 | Date: 2018-06-11 | Rev: v0.1.0
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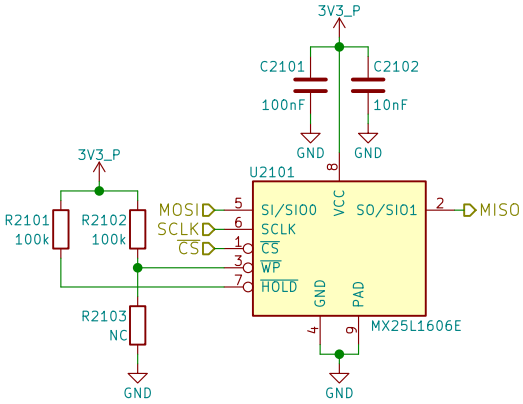
SPI NOR Flash



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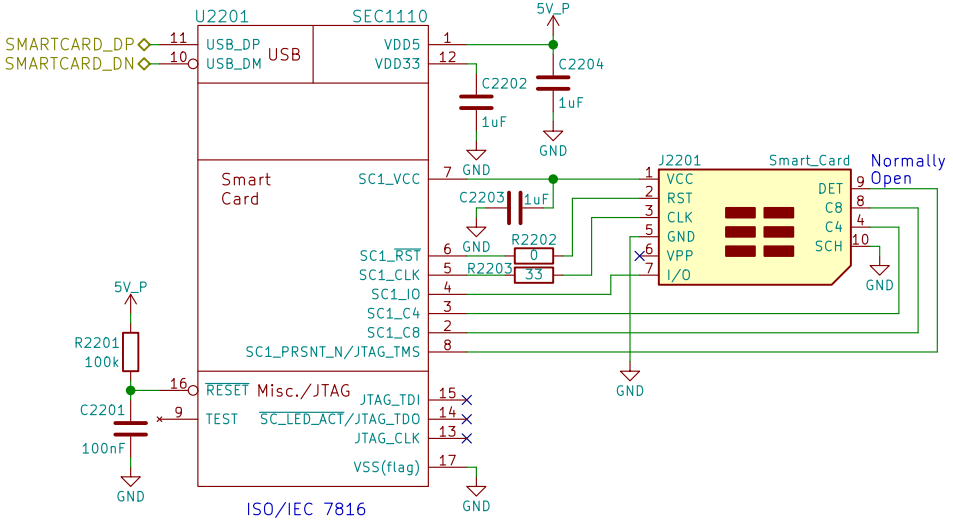
Smart Card



Reference:
http://www.microchip.com/DevelopmentTools/ProductDetails.aspx?PartNO=EVB-SEC1110

Smart Card

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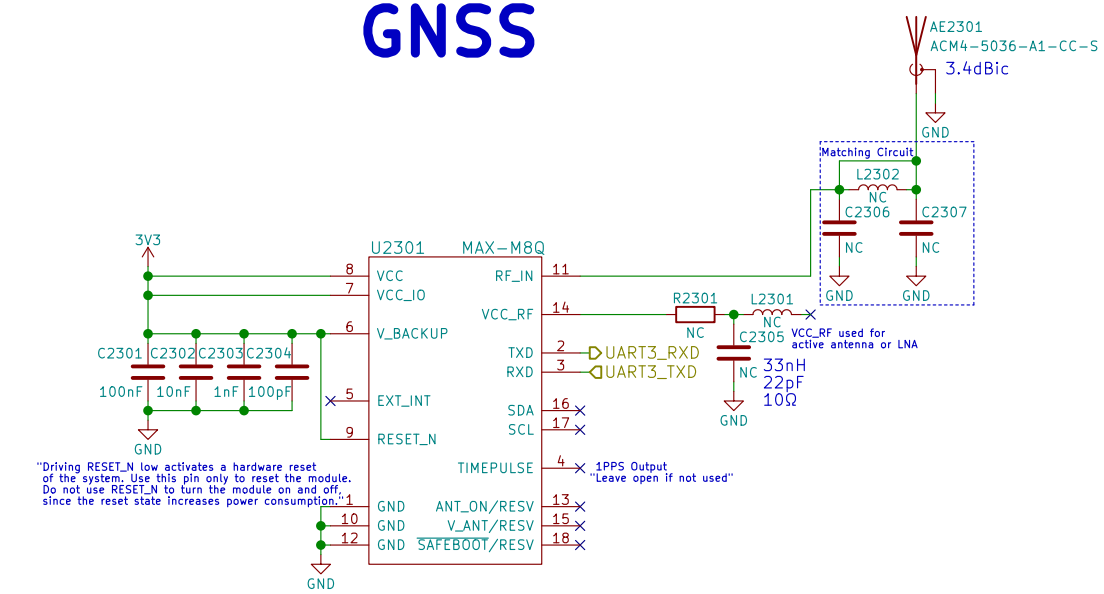
GNSS



Reference:
https://www.u-blox.com/sites/default/files/MAX-8-M8-FW3_HardwareIntegrationManual_%28UBX-15030059%29.pdf

GNSS

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File: gnss.sch

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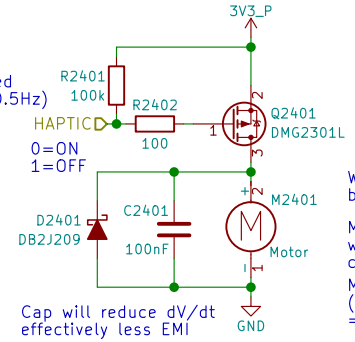
KiCad E.D.A. kicad 4.0.6		Id: 23/24

Haptic Motor

PWM pins occupied:
GPIO1_IO01 – LCD Backlight
GPIO1_IO13 – LED
GPIO1_IO14 – Ethernet (CLKO_25MHz)
GPIO1_IO15 – CSI (CLKO2)

PWM needed?
Only needs to be toggled
ON 1 sec, OFF 1 sec (0.5Hz)

Can MUX as either
GPIO or PWM2
swapping with LED



When the motor is off
both terminals are at GND

Motor will have wire leads
with a 2-pin Molex or Boom Precision
connector installed (by request)!

Metal housing is floating
(not connected to either pin)
⇒ could connect housing to GND

Cap will reduce dV/dt
effectively less EMI

Cheaper Motor Connector:
https://lcsc.com/product-detail/1-25T-Connectors_1-25T-1-2AW_C10832.html

Motor Source:
https://www.alibaba.com/product-detail/Coin-motor-vibration-dc-motor
cellphone_1994583657.html?spm=a2700.8443308.0.0.5aa13e5f1wxHgs

Motor Datasheet:
https://cloud.puri.sm/s/z8JR6DJ4KrJYzoW

Motor PN:
BY0820Z021L20

Haptic/Vibration Motor

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