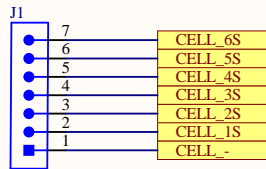
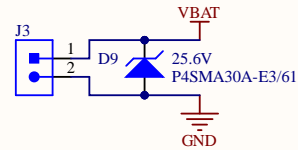


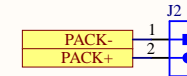
## Battery Balancing



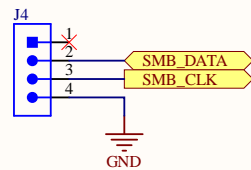
## Battery In



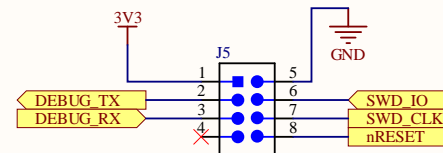
## Pack Out



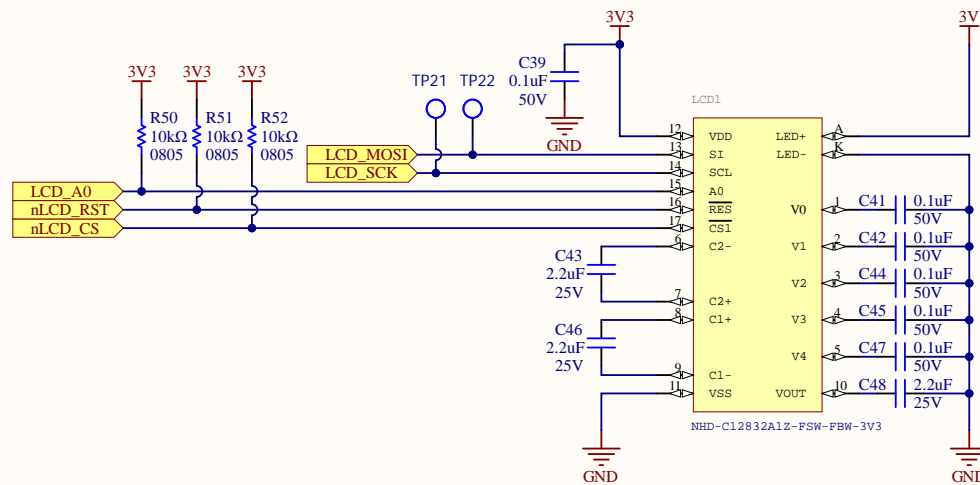
## EV2400



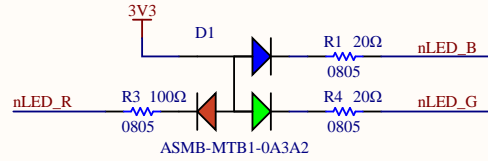
## Debug/Programing



# LCD



## Test LEDs



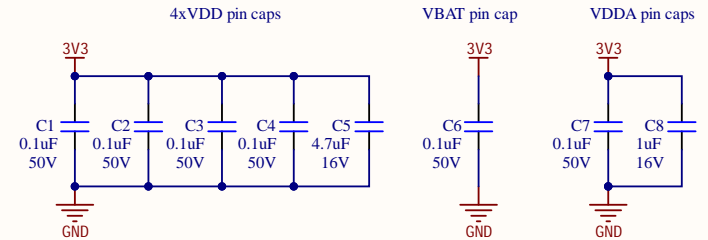
**Current Calculations**

Green LED voltage drop: 2.2V  
 $I = (3.3 - 2.2V) / 100 = 11mA$

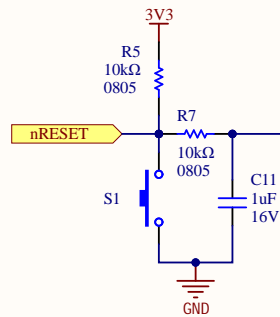
RGB LED voltage drops:  
 - Red: 2.1V:  $I = (3.3 - 2.1V) / 100 = 12mA$   
 - Blue: 3.1V:  $I = (3.3 - 3.1V) / 20 = 10mA$   
 - Green: 3.1V:  $I = (3.3 - 3.1V) / 20 = 10mA$

## STM32F446RET6

## Decoupling Caps

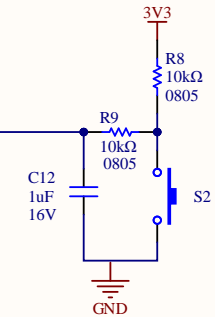


## Reset Button



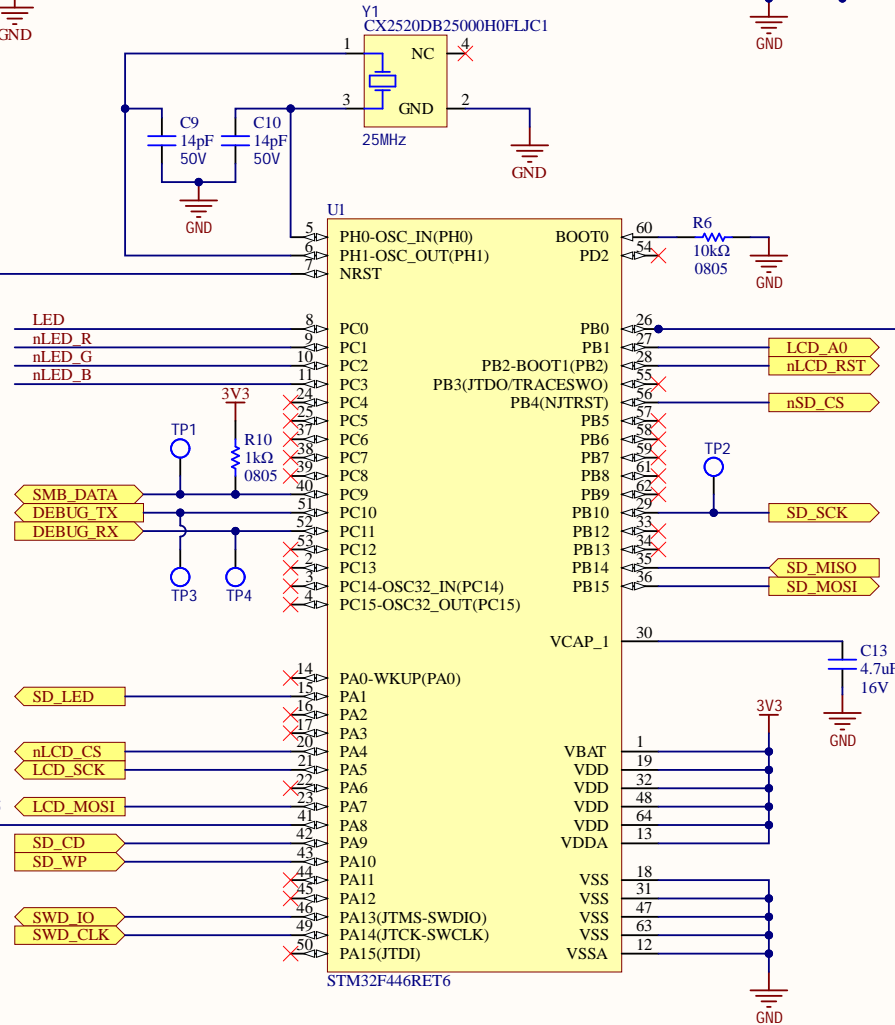
**For Debounce Circuit:**  
 $T = RC \rightarrow C = T/R$   
 $C = 10ms / 10kOhms = 1uF$

## Test Button



**For Debounce Circuit:**  
 $T = RC \rightarrow C = T/R$   
 $C = 10ms / 10kOhms = 1uF$

## GND Test Point



MOUNTING\_HOLES

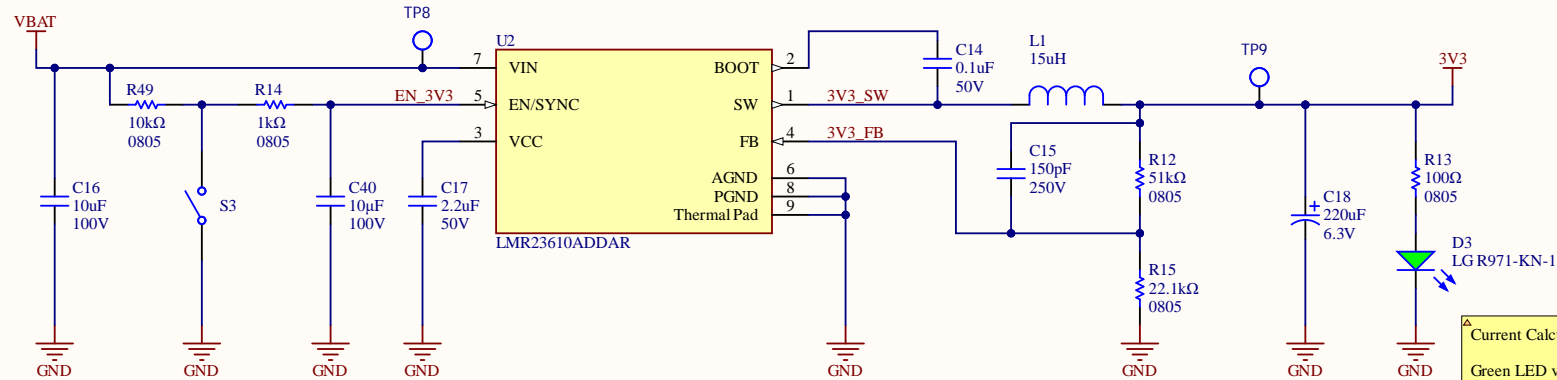
## Battery Voltage to 3V3 Buck @ 1A Max

Designed for 15V-25.2V input

Route for 0.5A in

Inductor: SRN6045-150M  
15uH, 20%, 95.8mOhm DCR (max)  
1.9A (rms), 2.3A (sat), 4.5mm tall

Route for 1A out



For Debounce Circuit:

$$T=RC \rightarrow C= T/R$$

$$C= 10ms/1kOhms= 10uF$$

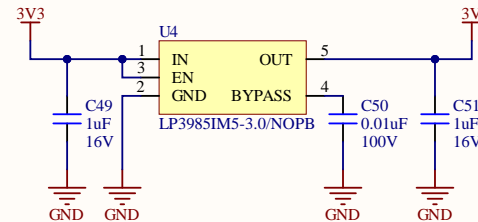
Current Calculations

$$\text{Green LED voltage drop: } 2.2V$$

$$I = (3.3-2.2V)/100 = 11mA$$

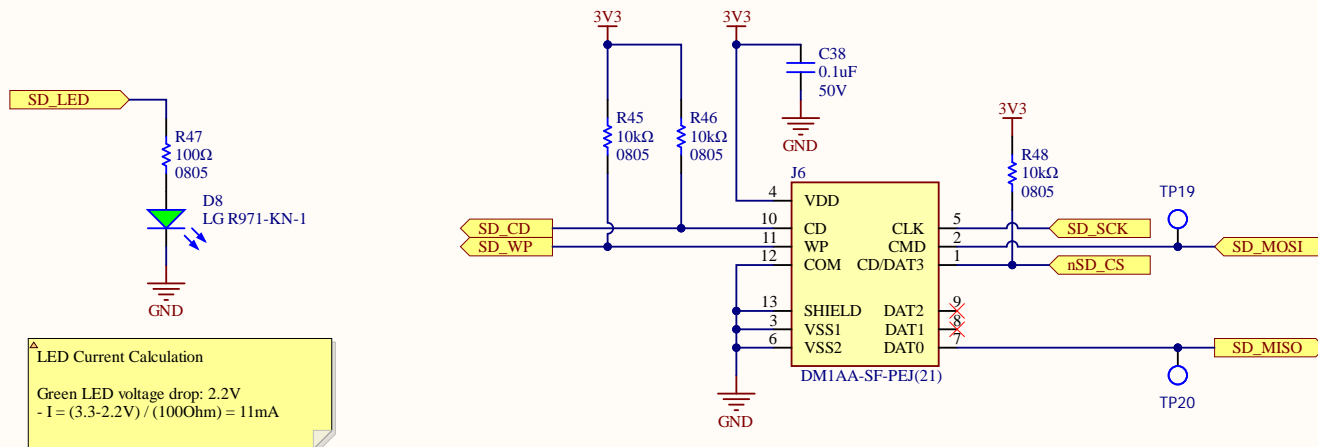
Max expected power on output = 1.65W  
Max current = 0.5A  
Expected Efficiency at 1A > 87.7%

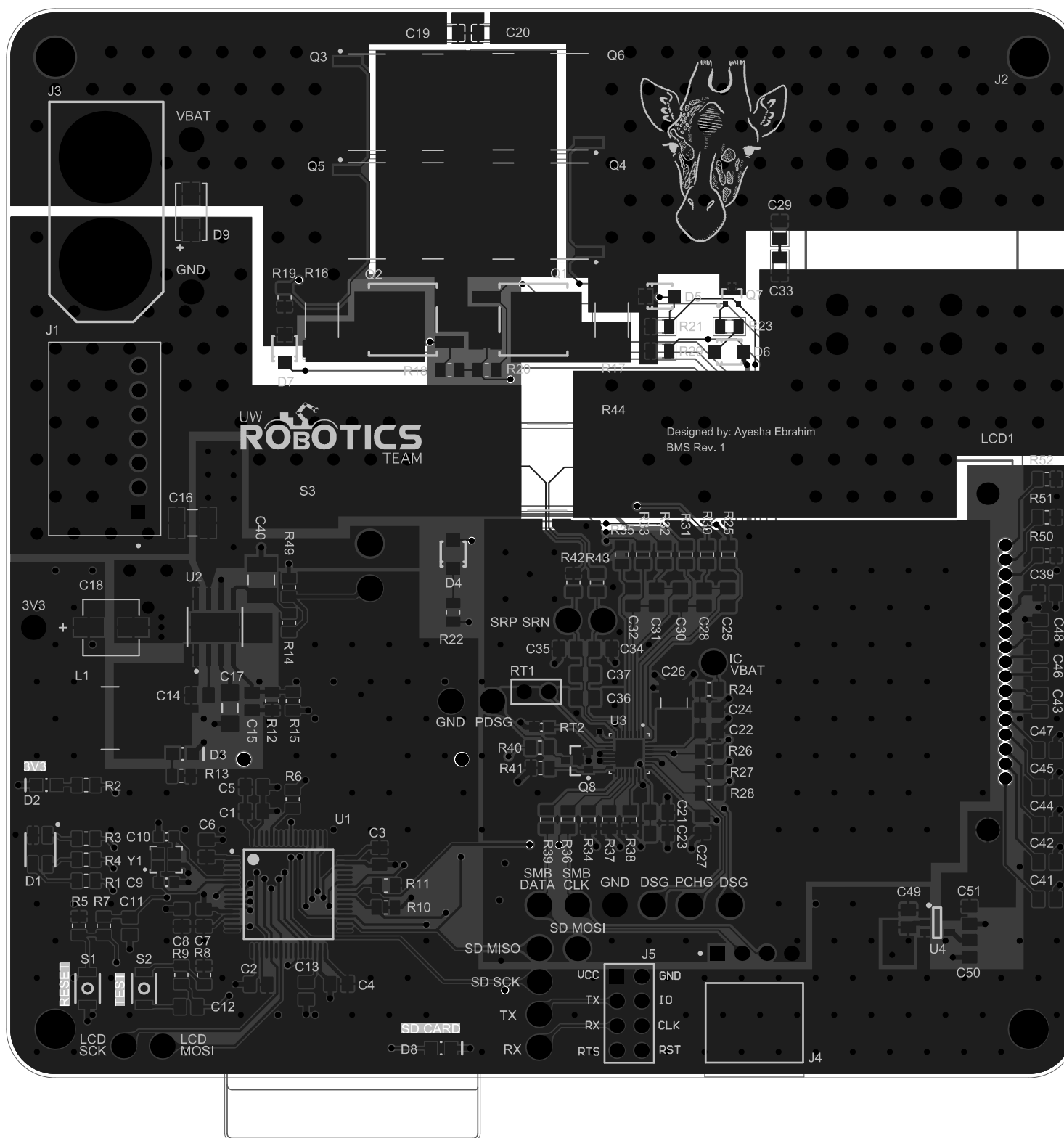
## 3V3 to 3V LDO @ 150mA Max



|                                                                                                                 |                           |
|-----------------------------------------------------------------------------------------------------------------|---------------------------|
| Title                                                                                                           | Power                     |
| Size: Letter                                                                                                    | Drawn By: Ayesha Ebrahi m |
| Date: 2020-08-09                                                                                                | Sheet 5 of 6              |
| File: C:\Users\ayesh\Documents\GitHub\MarsRover2020-PCB\Projects\Battery Management System\Rev1\SH1 - POWER.Sch |                           |

# SD Card Connector





| Description                                                                                            | Designator                                                                                  | Footprint              | Libref                 | Quantity | Manufacturer 1                   | Manufacturer Part Number 1 | Supplier Part Number 1         | Supplier 1 |
|--------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|------------------------|------------------------|----------|----------------------------------|----------------------------|--------------------------------|------------|
| CAP CER 0.1UF 50V X7R 0805                                                                             |                                                                                             | CAP2012X140N           | CAP_0.1uF_50V_0805     | 2        | Murata Electronics               | GC0218B71H1046 A01L        | 490-11955-1-ND                 | Dig-Key    |
| CAP CER 1UF 16V X7R 0805                                                                               |                                                                                             | CAPC2012X140N          | CAP_1uF_16V_0805       | 5        | Fagor                            | C108050007R788 205         | 311-1365-1-ND                  | Dig-Key    |
| Cap Ceramic 14pF 50V DC 5% SMD 0603 155C Carbonoid TFR                                                 | C9, C10                                                                                     | CAPC0603160B05_N       | C110C14088NNVC         | 2        | Samsung                          | C110C14088NNVC             | 1276-2187-1-ND                 | Dig-Key    |
| CAP CER 4.7UF 16V X5R 0805                                                                             | C13                                                                                         | CAPC2012X140N          | CAP_4.7uF_16V_0805     | 1        | Samsung Electro-Mechanics        | C121A473K02NN NE           | 1276-1066-1-ND                 | Dig-Key    |
| CAP CER 100PF 250V COG NPO 0805                                                                        | C15                                                                                         | CAPC2012X140N          | CAP_100pF_250V_0805    | 5        | Murata Electronics               | GRM031A02C1511 W01D        | 490-12755-1-ND                 | Dig-Key    |
| CAP CER 100UF 100V K75 1210 CAP CER 1uF 100V K75 10X 1210                                              | C16, C40                                                                                    | CAPC1210C3225          | CAP_10uF_100V_1210     | 1        | Murata Electronics               | GRM031C72A1006 B05L        | 490-16266-2-ND, 490-16266-1-ND | Dig-Key    |
| CAP CER 2.2UF 50V X7R 1206                                                                             | C17                                                                                         | CAPC1206C2146          | CAP_2.2uF_50V_1206     | 1        | Murata Electronics               | CGM3130R714025 W05L        | 490-4796-1-ND                  | Dig-Key    |
| CAP ALUM POLY 220uF 20% 6.3V 3MAD                                                                      | C18                                                                                         | PCAP_SVP_B6_P0403      | CAP_220uF_6.3V_3MAD    | 1        | Panasonic Electronic Components  | 65VFC220MMV                | F1683ACT-ND                    | Dig-Key    |
| CAP CER 100PF 50V COG NPO 0805                                                                         | C21, C22, C23, C24, C25, NPO 0805                                                           | CAPC2012X140N          | CAP_100pF_50V_0805     | 5        | KEMET                            | C0805C1015GAC TU           | 399-1122-1-ND                  | Dig-Key    |
| CAP CER 2.2UF 100V X7R 1210                                                                            | C26                                                                                         | CAPC1210C3225          | CAP_2.2uF_100V_1210    | 1        | Taiyo Yuden                      | FRMC22B7225MM GP           | 583-5396-1-ND                  | Dig-Key    |
| CAP CER 10000PF 100V X7R 0805                                                                          | C27, C30                                                                                    | CAPC2012X140N          | CAP_0.01uF_100V_0805   | 2        | KEMET                            | C0805C030R18AC TU          | 399-11054-1-ND                 | Dig-Key    |
| CAP CER 2.2UF 25V X7R 0805                                                                             | C43, C46, C48                                                                               | CAPC2012X140N          | CAP_2.2uF_25V_0805     | 1        | Murata Electronics               | GRM030B70E225W A73L        | 490-3331-2-ND                  | Dig-Key    |
| LED RGB DIFFUSED 4000K SMD                                                                             | D1                                                                                          | LED_RGB                | LED_RGB                | 1        | Brandsom                         | ASMB-MT181-8A143           | 516-3280-1-ND                  | Dig-Key    |
| LED GREEN DIFFUSED 3805 SMD                                                                            | D2, D3, D8                                                                                  | LED_0805_LINE          | WLED_LED_G             | 3        | OSRAM                            | LC-R971-KN-1               | 475-1410-1-ND                  | Dig-Key    |
| DIOCE SCHOTTKY 40V 500MA S01213                                                                        | D4, D7                                                                                      | S0D_123_FLAT           | DIO_SCHOTTKY_40V_500mA | 1        | Diodes Incorporated              | 805-40W-7-F                | 80540W-FD18-ND                 | Dig-Key    |
| DIOCE XLNIR 1W 500MA S01213                                                                            | D5                                                                                          | S0D_123_FLAT           | DIO_ZENER_1W           | 1        | Diodes Incorporated              | MM5ZC246B-7-F              | MM5ZC246B-FD18-ND              | Dig-Key    |
| DIOCE GEN PUMP 10W 300MA S01213                                                                        | D6                                                                                          | S0D_123_FLAT           | DIO_10W_300mA          | 1        | Diodes Incorporated              | 1M4148W-7-F                | 1M4148W-FD1C1-ND               | Dig-Key    |
| 1%5 DIODE 400W 25.4V UNL DO-214AC                                                                      | D9                                                                                          | DO_214AC_UNI           | PHSMA30A-E3/G1         | 1        | Infineon Semiconductors          | PHSMA30A-E3/G1             | PHSMA30A-E3/G1CCT-ND           | Dig-Key    |
| CONN HEADER RH SIDE 25PIN 2.54MM                                                                       | J1                                                                                          | ST_518-W-A07500        | CON_7M_1H_8A           | 1        | ST Sales America Inc.            | 518-W-A07500               | 455-2240-ND                    | Dig-Key    |
| CONN THERM BLOCK 2POS 15MMx1.8MMx0.5MM                                                                 | J2                                                                                          | MOLEX-0399200302       | SCREW_TERM_115A        | 1        | Molex                            | 0399200302                 | MM020114-ND                    | Dig-Key    |
| HIGH QUALITY GOLD PLATED XTAL 32.768KHZ                                                                | J3                                                                                          | XT90                   | XT90                   | 1        | DFRobot                          | XT10588                    | 1738-1438-ND                   | Dig-Key    |
| CONN HEADER R/A 25PIN 2.54MM                                                                           | J4                                                                                          | MOLEX-22-05-3041_V     | CON_4M_1H_8A           | 1        | Molex                            | 22-05-3041                 | MM4302-ND                      | Dig-Key    |
| CONN HEADER VERT 25PIN 2.54MM                                                                          | J5                                                                                          | HEADER_204             | HEADER_402             | 1        | Horwin Inc.                      | MAD-P980446                | 493-2122-ND                    | Dig-Key    |
| 12, 2+2, Position Card Connector Secure Digital - SD Surface Mount, Right Angle Gold                   | J6                                                                                          | MSD_0MT1AA-SF-PE121    | SD_CARD_CON            | 1        | Hirose Electric Co Ltd           | 0MT1AA-SF-PE121            | W840CT-ND                      | Dig-Key    |
| FIXED IND 150uH 1.9A 5% BROADWAVE SMD                                                                  | L1                                                                                          | IND_BOURNES_SMD45      | IND_15uH_1.9A          | 1        | Bourns Inc.                      | SRN045-150M                | SRN045-150MCT-ND               | Dig-Key    |
| LED COG GRAMMIC 128X32                                                                                 | LED1                                                                                        | NH4C-12832A12FSW-BW-V3 | NH4C-12832A12FSW-BW-V3 | 1        | Newhaven Display Inc.            | NH4C-12832A12FSW-BW-V3     | NH4C-12832A12FSW-BW-V3C1-ND    | Dig-Key    |
| 6cm x 6cm                                                                                              | MH1, MH2, MH3, MH4                                                                          | MOUNTING_HOLE          | MOUNTING_HOLES         | 4        |                                  |                            |                                |            |
| MOSET P-CH 40V 40A TO252                                                                               | Q1, Q2                                                                                      | Q-PAK                  | PMOS_40V_40A           | 1        | Alpha & Omega Semiconductor Inc. | AOCD4189                   | 785-1351-1-ND                  | Dig-Key    |
| MAX7219 I2C 100V 210A POWER160                                                                         | Q3, Q4, Q5, Q6                                                                              | 6-HP50F                | NMOS_100V_210A         | 1        | ON Semiconductor                 | F08L0240N100               | F08L0240N100CT-ND              | Dig-Key    |
| NMOS N-CH 40V 310mA SOT-23                                                                             | Q7                                                                                          | SOT23                  | NMOS_40V_310mA         | 1        | Wingate                          | 2N7102BKW-115              | 1727-4788-1-ND                 | Dig-Key    |
| NMOS N-CH 50V 200mA 1.2V DRIVE SOT-23                                                                  | Q8                                                                                          | SOT23-3                | NMOS_50V_200mA         | 1        | Roehm Semiconductor              | RUC0020N0540G116           | RUC0020N0540G116CT-ND          | Dig-Key    |
| RES SMD 300OHM 1% 1/8W 0805                                                                            | R1, R4                                                                                      | RES2012X60N            | RES_200_0805           | 2        | Fagor                            | RC0805FR-0720RL            | 311-2000CT-ND                  | Dig-Key    |
| RES SMD 100 OHM 1% 1/8W 0805                                                                           | R2, R3, R24, R25, R26, R27, R28, R29, R30, R31, R32, R33, R34, R35, R36, R39, R42, R43, R47 | RES2012X60N            | RES_1000_0805          | 14       | Fagor                            | RC0805FR-07100RL           | 311-1000CT-ND                  | Dig-Key    |
| RES SMD 10K OHM 1% 1/8W 0805                                                                           | R5, R6, R7, R8, R9, R22, R27, R34, R37, R38, R45, R46, R48, R49, R50, R51, R52              | RES2012X60N            | RES_10K0_0805          | 17       | Fagor                            | RC0805FR-0710KL            | 311-1000CT-ND                  | Dig-Key    |
| RES SMD 1K OHM 1% 1/8W 0805                                                                            | R10, R11, R26, R28                                                                          | RES2012X60N            | RES_1K0_0805           | 4        | Fagor                            | RC0805FR-071RL             | 311-1000CT-ND                  | Dig-Key    |
| RES SMD 51K OHM 1% 1/8W 0805                                                                           | R12                                                                                         | RES2012X60N            | RES_51K0_0805          | 1        | Whitby Dale                      | RCW080551K09EA             | 441-5100CT-ND                  | Dig-Key    |
| RES SMD 1K OHM 1% 1/8W 0805                                                                            | R14                                                                                         | RES2012X60N            | RES_1K0_0805           | 1        | Fagor                            | RC0805FR-071RL             | 311-1000CT-ND                  | Dig-Key    |
| RES SMD 22 1K OHM 1% 1/8W 0805                                                                         | R15                                                                                         | RES2012X60N            | RES_22_1K0_0805        | 1        | Whitby Dale                      | RCW080522K19EA             | 541-2210CT-ND                  | Dig-Key    |
| RES 200 OHM 1% 1W 2512                                                                                 | R16, R17                                                                                    | RES06532X75N           | RES_2000_2512          | 1        | Stackpole Electronics Inc.       | RMCT2512T200R              | RMCT2512T200R-C1-ND            | Dig-Key    |
| RES SMD 10M OHM 1% 5W 1/8W 0805                                                                        | R18, R19, R20, R21, R40, R41                                                                | RES2012X60N            | RES_10M0_0805          | 6        | Fagor                            | RC0805GR-0710ML            | 311-10M0CT-ND                  | Dig-Key    |
| RES SMD 510 OHM 1% 1/8W 0805                                                                           | R22                                                                                         | RES2012X60N            | RES_5100_0805          | 1        | Fagor                            | RC0805FR-0710SL            | 311-5100CT-ND                  | Dig-Key    |
| RES SMD 1 1K OHM 1% 1/8W 0805                                                                          | R29                                                                                         | RES2012X60N            | RES_1_1K0_0805         | 1        | Fagor                            | RC0805FR-071KL             | 311-1100CT-ND                  | Dig-Key    |
| RES 0.001 OHM 1% 10W 5931                                                                              | R44                                                                                         | RES-5931               | RES_1m0_5931           | 1        | Whitby Dale                      | WDL5931T1L000EA            | 441-10012-1-ND                 | Dig-Key    |
| THERMISTOR NTC 10K OHM 130K BEAD                                                                       | R71                                                                                         | 480T02 - PTH           | THERM_10K_FRE_1A NGING | 1        | Murata                           | NWT150H10FA2-B100          | 490-5630-ND                    | Dig-Key    |
| THERMISTOR NTC 10K OHM 0603                                                                            | R72                                                                                         | RES0603160B05_N        | THERM_10K_0603         | 1        | TDK                              | NTC1643F103F11             | 445-2564-1-ND                  | Dig-Key    |
| Tactile Switch (Ergo)                                                                                  | S1, S2                                                                                      | B30-1000P              | SW_TACTILE             | 1        | Omron Electronics Inc-EMC Div    | B30-1000P                  | SW1000CT-ND                    | Dig-Key    |
| SWITCH SLIDE SPST 500mA (DC) 8.5A (AC) 120V                                                            | S3                                                                                          | GF123054               | GF-123-054             | 1        | CW Industries                    | GF-123-054                 | CW1233-ND                      | Dig-Key    |
| Loop Endpoint through-hole pad                                                                         |                                                                                             | TESTPOINT_LOOP         | TESTPOINT_LOOP         | 2        | Keystone Electronics             | 5002                       | 36-5002-ND                     | Dig-Key    |
| ARM Cortex M4 32-bit MCU w/ 4KB Flash, 128KB Internal RAM, 50 I/Os, 64 Pins, LQFP -40 to 85 degC, Tray | U1                                                                                          | STM-LQFP44_L           | MCU_STM32F446RET6      | 1        |                                  |                            | 491-15376-ND                   | Dig-Key    |
| IC REG BUCK ADJUSTABLE 1A BCPWR POWER                                                                  | U2                                                                                          | B-SD PowerPad          | BUCK_1.28VOUT_1A       | 1        | Texas Instruments                | LMR23610A0DAR              | 296-47267-1-ND                 | Dig-Key    |
| MANAGEMENT IC: Battery Multi-Function Controller IC Lithium Ion Polymer 32 VCFN (4x4)                  | U3                                                                                          | BQ40Z08RSM             | BATT_MANAGER           | 1        | Texas Instruments                | BQ40Z08RSM                 | 296-BQ40Z08RSMCT-ND            | Dig-Key    |
| IC REG LINEAR 3V 150MA SOT23-5                                                                         | U4                                                                                          | SOT23-5                | LP3985MS-1/0NCP8       | 1        | Texas Instruments                | LP3985MS-1/0NCP8           | LP3985MS-1/0NCP8B-ND           | Dig-Key    |
| CRYSTAL 25.0000MHz 12PF SMD                                                                            | F1                                                                                          | SCV25470T10A4404N      | CRYSTAL_25MHZ          | 1        | Epson America Inc                | CXCS250025000H-01UC1       | 1253-1724-1-ND                 | Dig-Key    |