

USB PD Demo Board User Guide

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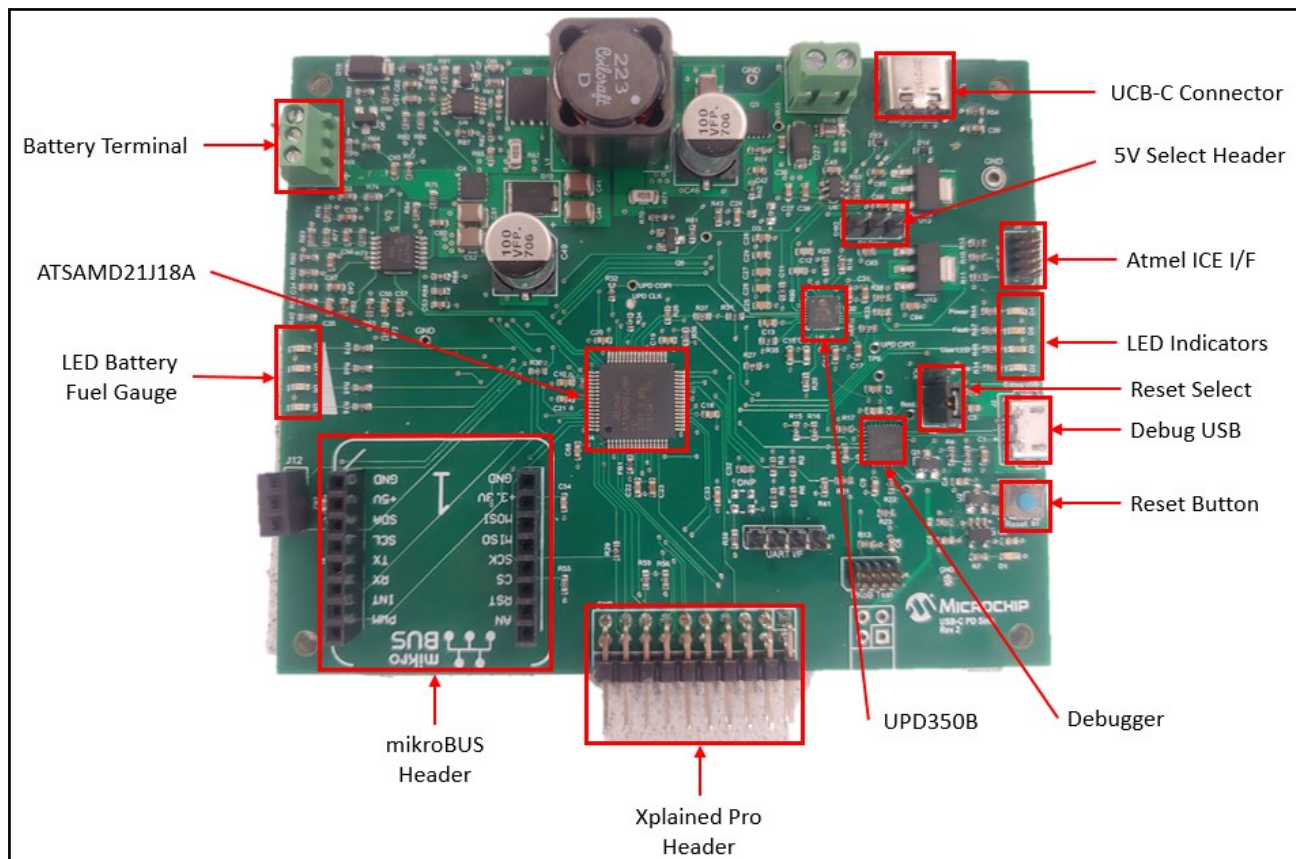


Figure 1, PD Demo Board

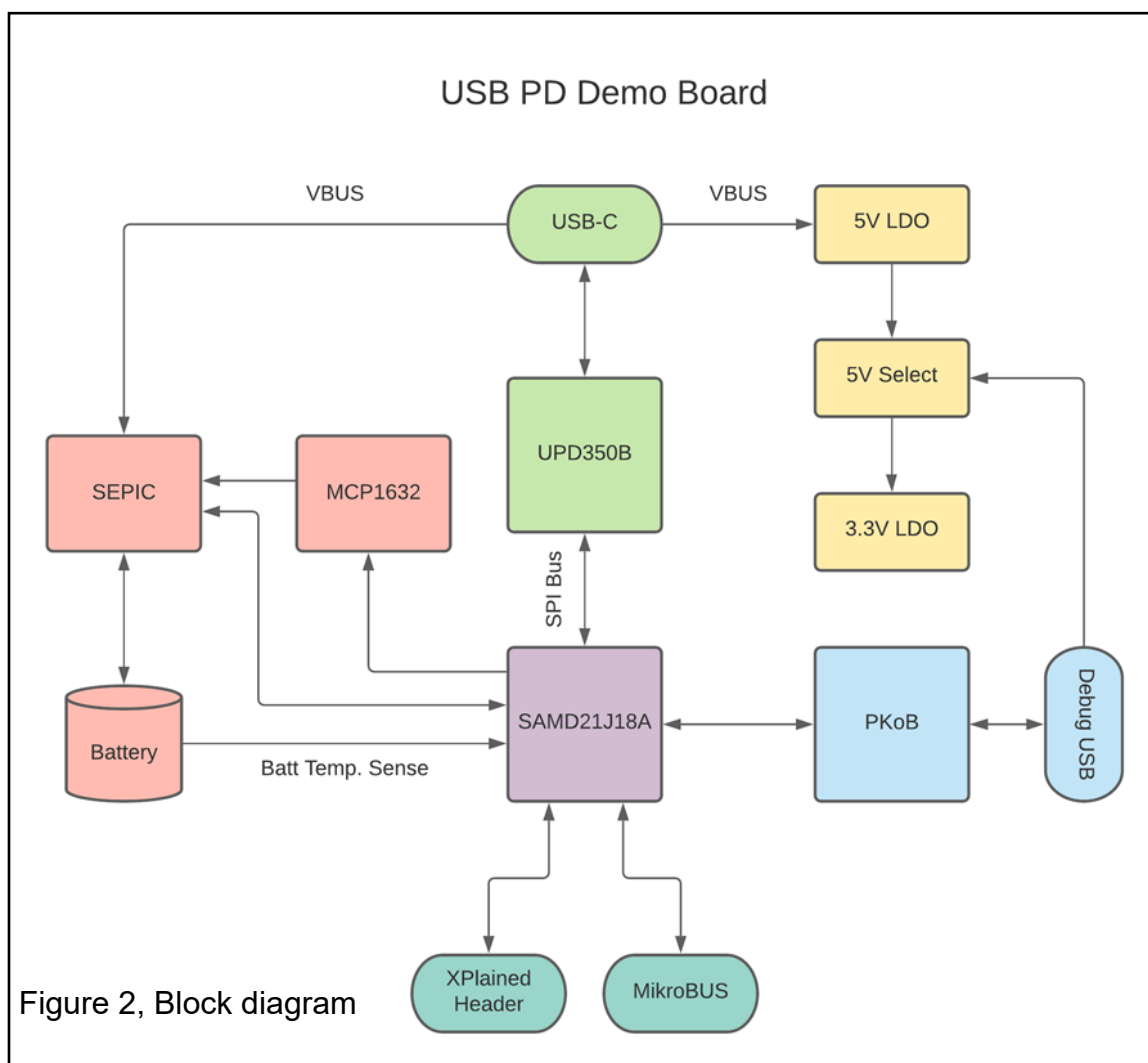
For additional information on the USB PD Demo board,
Email: usb-c_pd_sync_charger@microchip.com

Board Overview

The USB PD Demo Board is a USB power delivery battery charger demo board featuring the ATSAMD21J18A microcontroller. The board includes a PKoB for USB programming/debugging, along with an Atmel ICE interface.

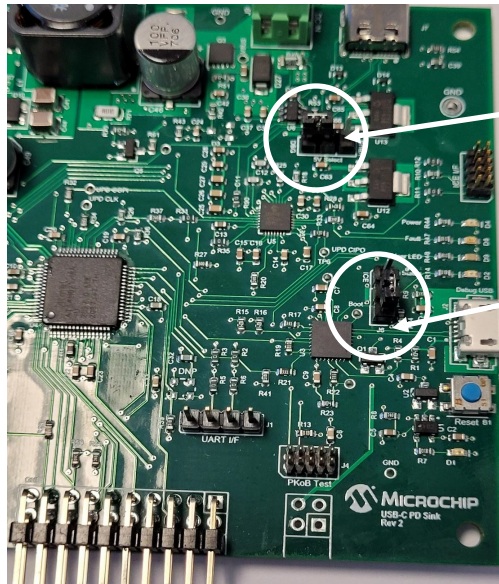
Two types of expansion headers are supported by the board. There is one Xplained Pro I/O header with a 4-pin Xplained Pro power header, and a mikro-BUS click board connector.

The battery charger's SEPIC power supply can support the full 20V/5A 100W USB PD specification.




Getting Started

1. Verify the A) 5V Select Header has a jumper on the DBG side and the B) Reset Select has a jumper on the Boot side as shown below.



A) Jumper on left side

B) Jumper on bottom

2. Download and launch MPLAB X IDE.
3. Plug the debug USB into your computer and check that MPLAB X recognizes that the kit is connected.
4. If the “Power” LED does not light up, check that the 5V select header is set to the correct source.
5. Download the PSF folder from the GitHub site (https://github.com/MicrochipTech/PD_Sink_Battery_Charger_Demo) and unzip the folder.
6. Open MPLAB X and click File > Open Project, then navigate to where you downloaded the file and go to the folder PSF_EVB_Sink> PSF > Demo > PSF_EVB_Sink > firmware and select the project file; PSF_EVB_Sink.x
7. Select the programming tool: USB Type-C Demo Board-SN: XXX
8. Build and program the demo code by pressing the  button located on the toolbar.
9. Connect the positive side of a 12V battery to the battery terminal marked “+” and the negative side of the battery to the terminal marked “-”.
10. Connect any USB PD capable charger to the USB-C connector to begin charging.

Getting Started

The demo code supports the OLED1 Xplained Pro add-on board on extension header 1. This add-on board is optional but is a useful tool for debugging and charger status monitoring. The OLED1 Xplained Pro board can be purchased here: [OLED1 Xplained Pro Board](#).

Button 3 on the OLED1 board is used to switch between two display pages. On the first page, the battery charger status is shown (either Fault, Pre-condition, CC Mode, CV Mode, or Fully Charged). If a fault has occurred, it will display what type of fault it is. If there is no fault, it will display the battery SOC as a percentage. On page 2, the negotiated PD contract is displayed in terms of negotiated voltage and current.

Note: You may have to press the board reset button after plugging in the OLED1 board if the display does not work initially.

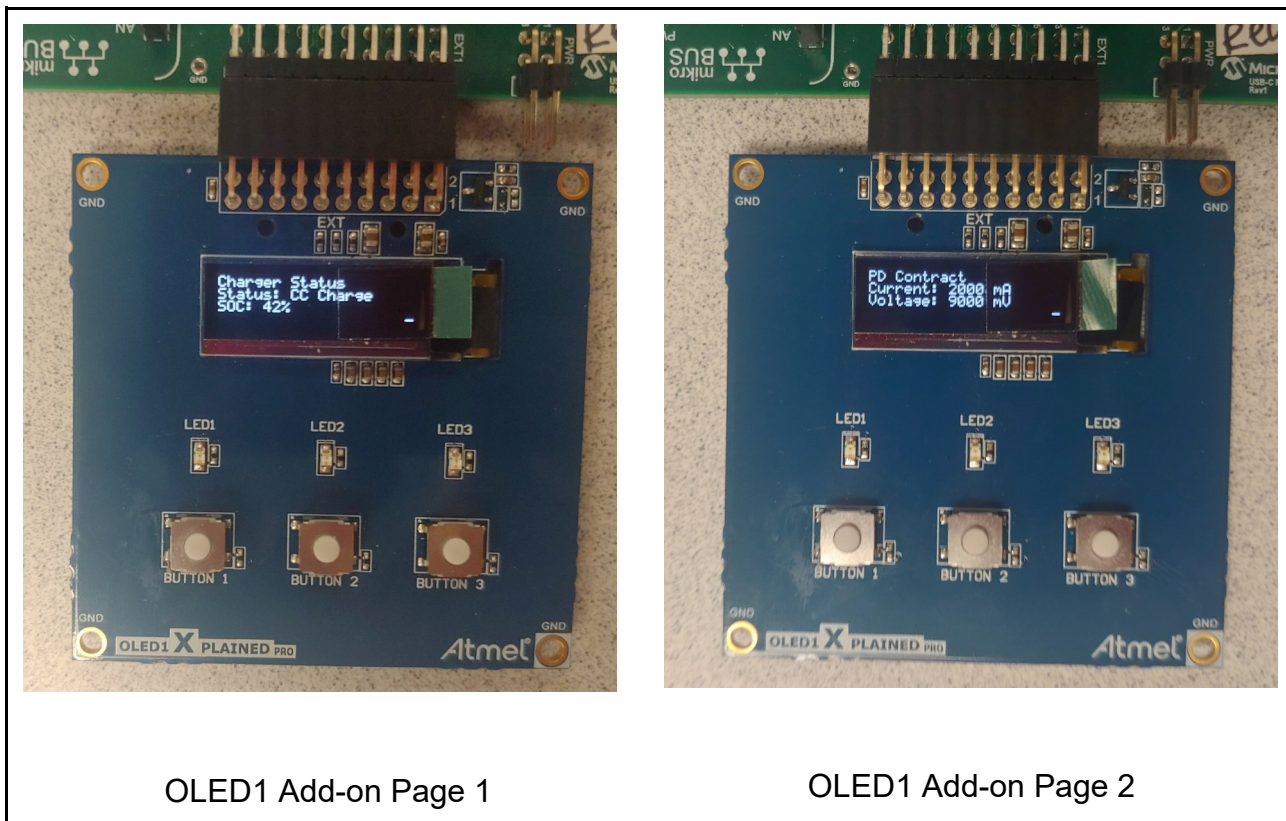


Figure 4, Different pages of OLED1 display board

Getting Started

Figures 5 and 6 detail the different state and fault codes that are recognized by the charger state machine and will be displayed on the OLED1 board. A brief description of what each code means is given.

Status Type	Integer Code	Description
FAULT	0	A fault has been detected
PRECONDITIONING	1	Battery voltage is too low for full current charging
CCMODE	2	Constant current charge mode
CVMODE	3	Constant voltage charge mode
CHARGED	4	Battery is fully charged
RECHARGE	5	Battery voltage has fallen since being charged


Figure 5, Charger state machine status codes

Fault Type	Integer Code	Description
GENERIC	0	Unknown fault
NOSOURCE	1	No PD source is attached
UVLO	2	Battery terminal voltage is too low
OVLO	3	Battery terminal voltage is too high
OVERTEMP	4	Battery temperature is too high
UNDERTEMP	5	Battery temperature is too low

Figure 6, Charger state machine fault codes


Getting Started—Debug information

Debug information is output to debug com port for the board. Using a terminal program, Tera Term, set to the correct COM port for the PD EVAL board and 115.2 KBaud, debug information will be printed to the terminal window as shown below.



```
*PD_Sync_terminal_dump.txt - Notepad
File Edit Format View Help
BOOTPROT Size 7
EEPROM Size 0
app initialized
TYPEC: TypeC Port initialization completed
PRL: Initialization Done
PSF Init Complete
VID: 0424 PID: 0350
PRL: Receiver disabled
TYPEC_UNATTACHED_SNK_ENTRY_SS
PE_SNK_STARTUP: Entered the state
TYPEC: CC1 register
TYPEC: CC2 register
TYPEC: NO DEVICES ARE PRESENT
PDPWR
battV: 0 mV - chgI: 0 mA - status: 0
pwm value: 0
battV: 9002 mV - chgI: 0 mA - status: 0
pwm value: 0
battV: 8977 mV - chgI: 0 mA - status: 0
pwm value: 0
battV: 9002 mV - chgI: 0 mA - status: 0
TYPEC: CC1 register
TYPEC: CC2 register
TYPEC: Source is Present in CC
PRL: Receiver disabled
TYPEC_ATTACHWAIT_SNK: EnteredATTACHWAIT SNK State
PDPWR,
TYPEC_ATTACHED_SNK: EnteredATTACHED SNK State
*****TYPEC CC2 ATTACH*****
PRL: Receiver enabled
PE_SNK_WAIT_FOR_CAPABILITIES: Entered the state
pwm value: 0
PRL_RX_PKT_PASSED_TO_PE: Rx Msg received passed to PE
PE_SNK_EVALUATE_CAPABILITY: Entered the state
PE_SNK_SELECT_CAPABILITY: Entered the state
PRL_TX_MSG_ON_LINE: Tx Msg sent on line
PRL_RX_PKT_PASSED_TO_PE: Rx Msg received passed to PE
PE_SNK_SELECT_CAPABILITY: Accept Message Received
PE_SNK_TRANSITION_SINK: Entered the state
PRL_RX_PKT_PASSED_TO_PE: Rx Msg received passed to PE
PE_SNK_READY: Entered the state
battV: 9002 mV - chgI: 0 mA - status: 0
PDPWRÈ
```

Debug information shown below of the charging of the battery.

 *PD_Sync_terminal_dump.txt - Notepad

File Edit Format View Help

PDPWRÊ

pwm value: 0
battV: 9002 mV - chgI: 0 mA - status: 0
pwm value: 0
battV: 8990 mV - chgI: 0 mA - status: 0
pwm value: 853
battV: 8642 mV - chgI: 0 mA - status: 1
pwm value: 856
battV: 8977 mV - chgI: 0 mA - status: 1
pwm value: 883
battV: 9039 mV - chgI: 0 mA - status: 2
pwm value: 886
battV: 9139 mV - chgI: 6 mA - status: 2
pwm value: 916
battV: 9126 mV - chgI: 18 mA - status: 2
pwm value: 934
battV: 9163 mV - chgI: 94 mA - status: 2
pwm value: 937
battV: 9163 mV - chgI: 101 mA - status: 2
pwm value: 1021
battV: 9399 mV - chgI: 435 mA - status: 2
pwm value: 1024
battV: 9424 mV - chgI: 448 mA - status: 2
pwm value: 1060
battV: 9536 mV - chgI: 593 mA - status: 2
pwm value: 1096
battV: 9648 mV - chgI: 732 mA - status: 2
pwm value: 1159
battV: 9859 mV - chgI: 991 mA - status: 2
pwm value: 1198
battV: 9983 mV - chgI: 1136 mA - status: 2
pwm value: 1240
battV: 10132 mV - chgI: 1307 mA - status: 2
pwm value: 1243
battV: 10144 mV - chgI: 1313 mA - status: 2

Calibration Procedure

An optional calibration procedure can be done to improve the accuracy of the charger current sense readings. A multimeter will be required for this process.

Steps to calibrate current readings:

1. Construct the circuit shown in the diagram below.
2. In the code file “SEPIC_CTRL.c” change the CALEN variable to 1 and reprogram the board to enable the calibration.

```
#define CALEN 1 //calibration mode enable, 0 = off, 1 = on
```

3. Plug a PD power source in to the USB-C connector (not depicted below).
4. Using the data visualizer in MPLAB X, enter the current (in mA) displayed on the multimeter. Doing this for two different values will enable us to calculate the necessary calibration parameters.
5. These values are stored in EEPROM and the calibration only needs to be done once. You will have to repeat the calibration if you reprogram the board.

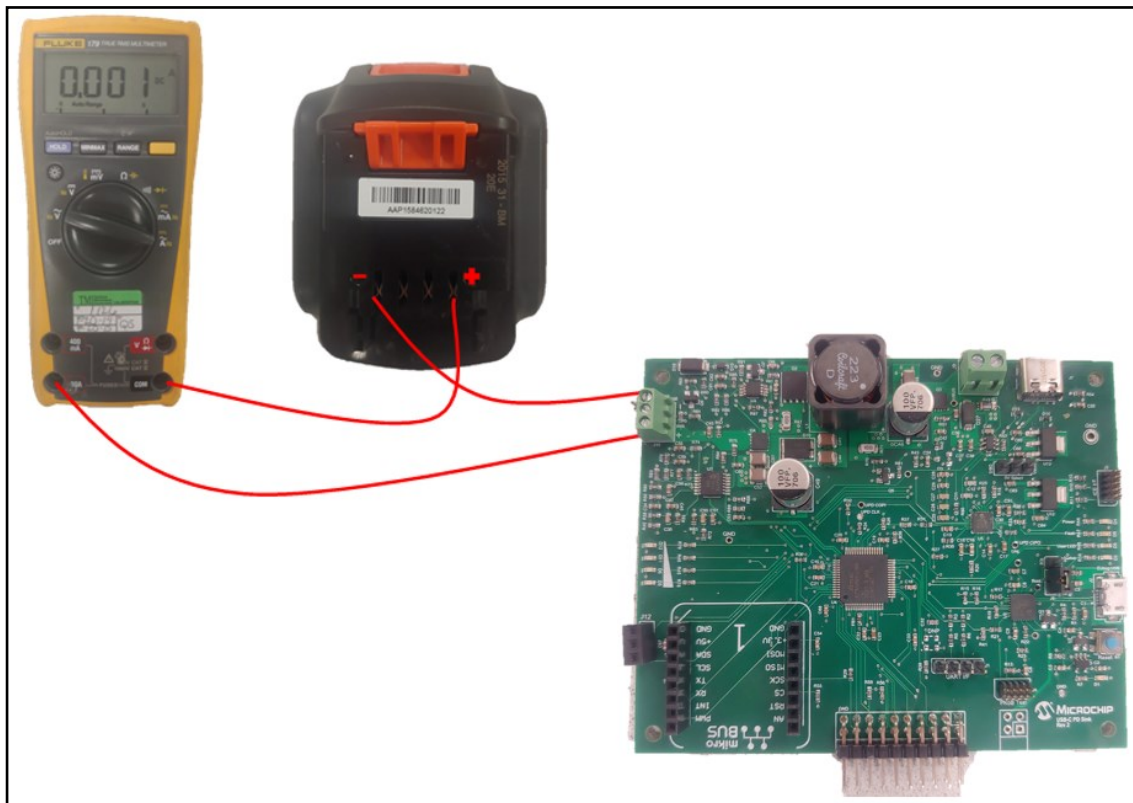


Figure 5, Calibration procedure diagram

Charger Characteristics

The charger uses a constant current/constant voltage charge algorithm. There are three main states that the charger operates in, pre-condition, constant current charge, and constant voltage charge. The charger will enter pre-condition mode if it detects the battery voltage is too low to safely charge at full current. In this mode, charge current is limited to a few hundred milliamps. Once the charger detects the battery voltage is above the pre-charge cutoff threshold, it will ramp up current to the maximum allowed charge current. This value can be hard-coded by the user or can be set to automatically calculate based on the negotiated PD contract.

The charger will continue to charge at constant current until the battery voltage nears its maximum voltage at which point it will enter constant voltage mode. In this mode, the charger checks the battery voltage every 500ms. If the voltage is above the maximum battery voltage, it will decrement current until it is at or slightly below that voltage threshold. This will maintain the battery voltage at a constant level. This process will continue until the charge current is below a specified cutoff current. At this point the charger will shutoff but will continue monitoring the battery and topping off the charge as needed.

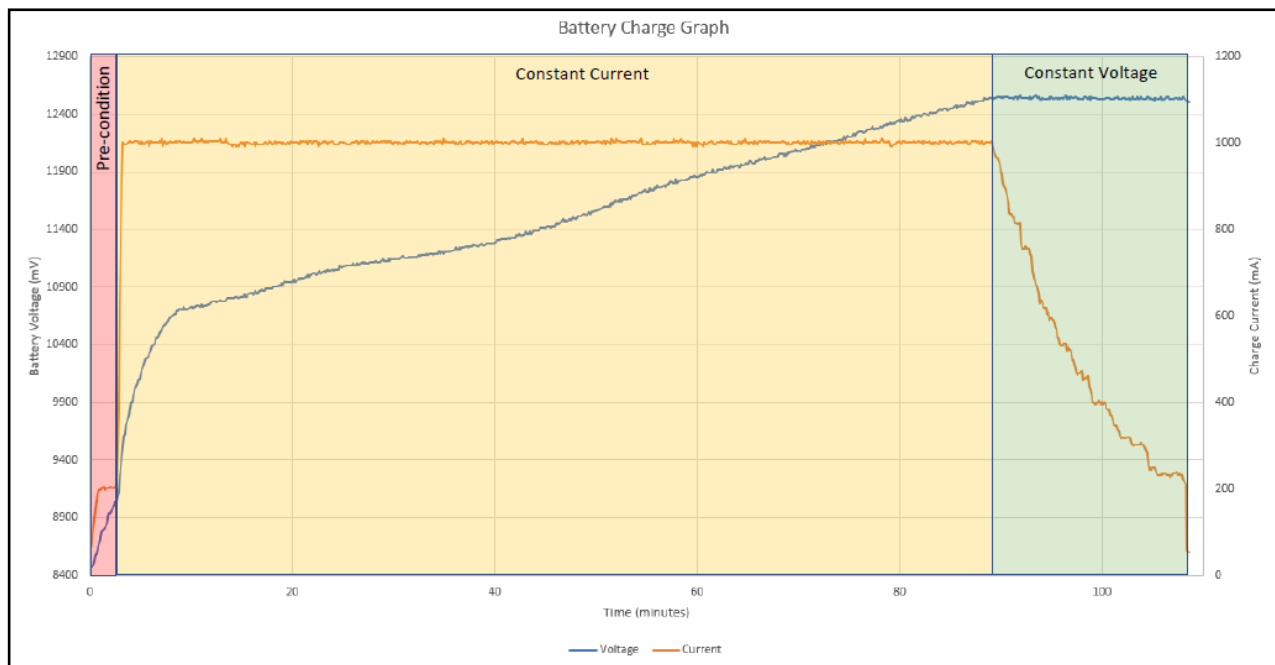


Figure 6, Charger characteristics graph

Charger Characteristics

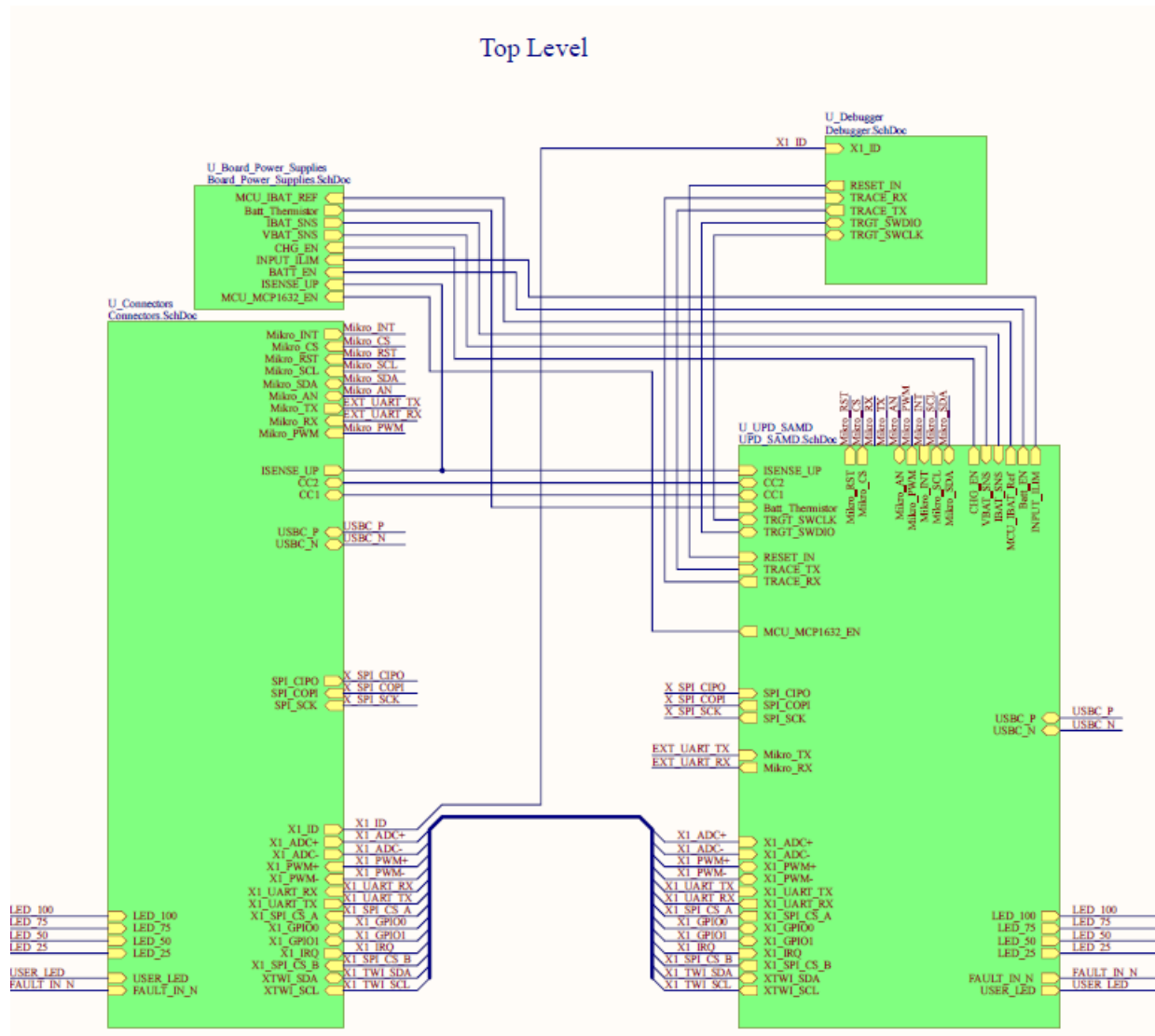
The parameters for charger state thresholds can be tuned in the “SEPIC_CTRL.c” file. Several defines are used to establish battery parameters and desired thresholds/cutoffs.

```
//set battery parameters
#define CELLVMIN 2700 //individual cell min voltage in mV
#define CELLVMAX 4200 //individual cell max voltage in mV
#define BATIMAX 3000 //max charge current in mA
#define NUMCELLS 3 //number of series cells
#define UCLO 150 //charge cutoff current in mA
#define BATTVMAX (NUMCELLS * CELLVMAX) //total battery maximum voltage
#define BATTVMIN (NUMCELLS * CELLVMIN) //total battery minimum voltage (UVLO value)
#define RECHARGETHRESH 4100*NUMCELLS //threshold for trickle charge engage
#define MINCCCHARGETHRESH 3000*NUMCELLS //threshold for full speed cc charging
#define CVTHRESH 4180*NUMCELLS //threshold to switch from CC to CV charge
```

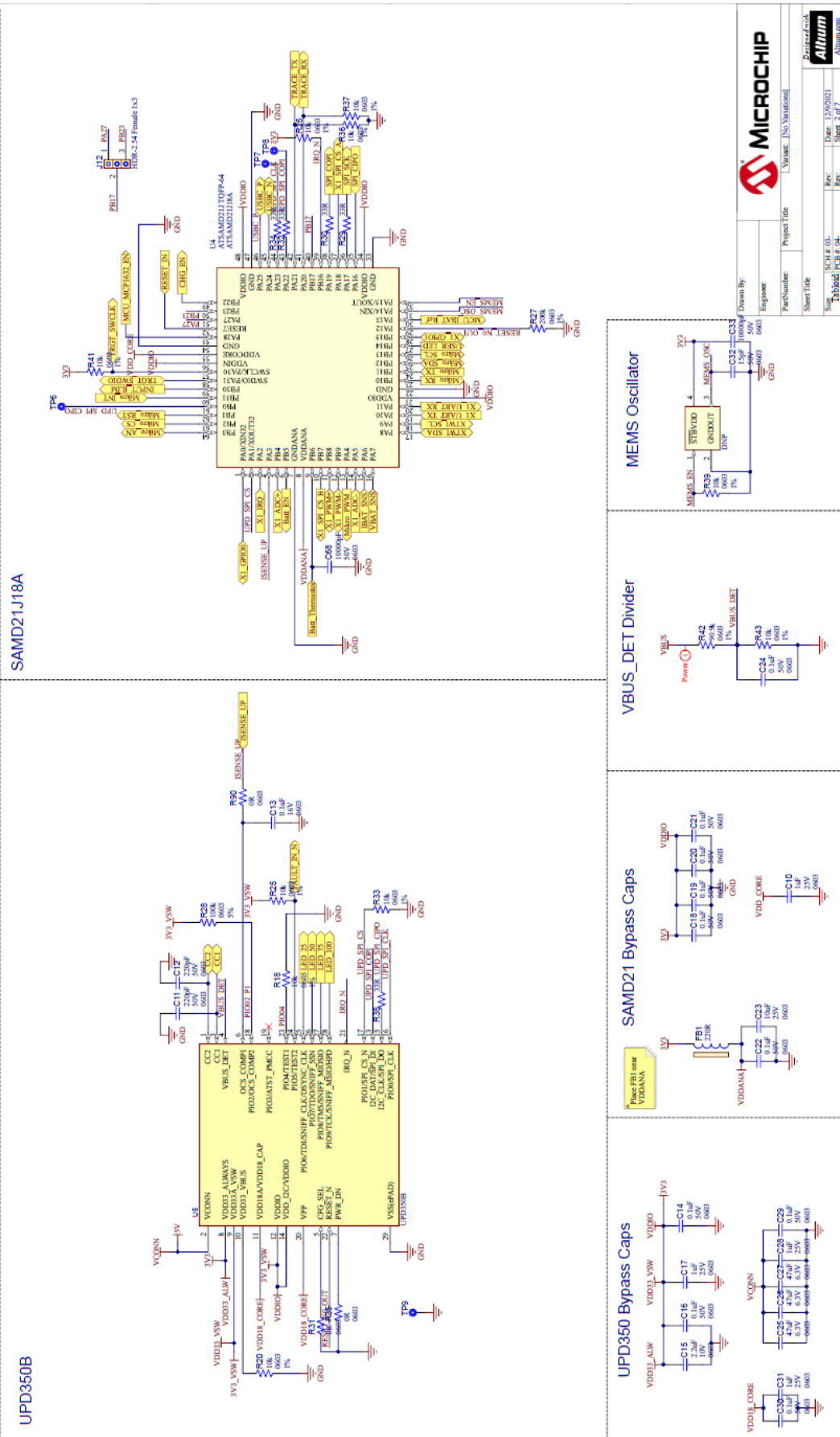
Additionally, the preferred charge current can be manually or automatically determined by modifying the code shown below.

```
320      uint16_t maxcurrent = gasCfgStatusData.sPerPortData[0].ul6NegoCurrentInmA;
321      //set this value for a manual max charge current limit,
322      //otherwise comment this line to use the PD negotiated current
323      maxcurrent = 1000;
```

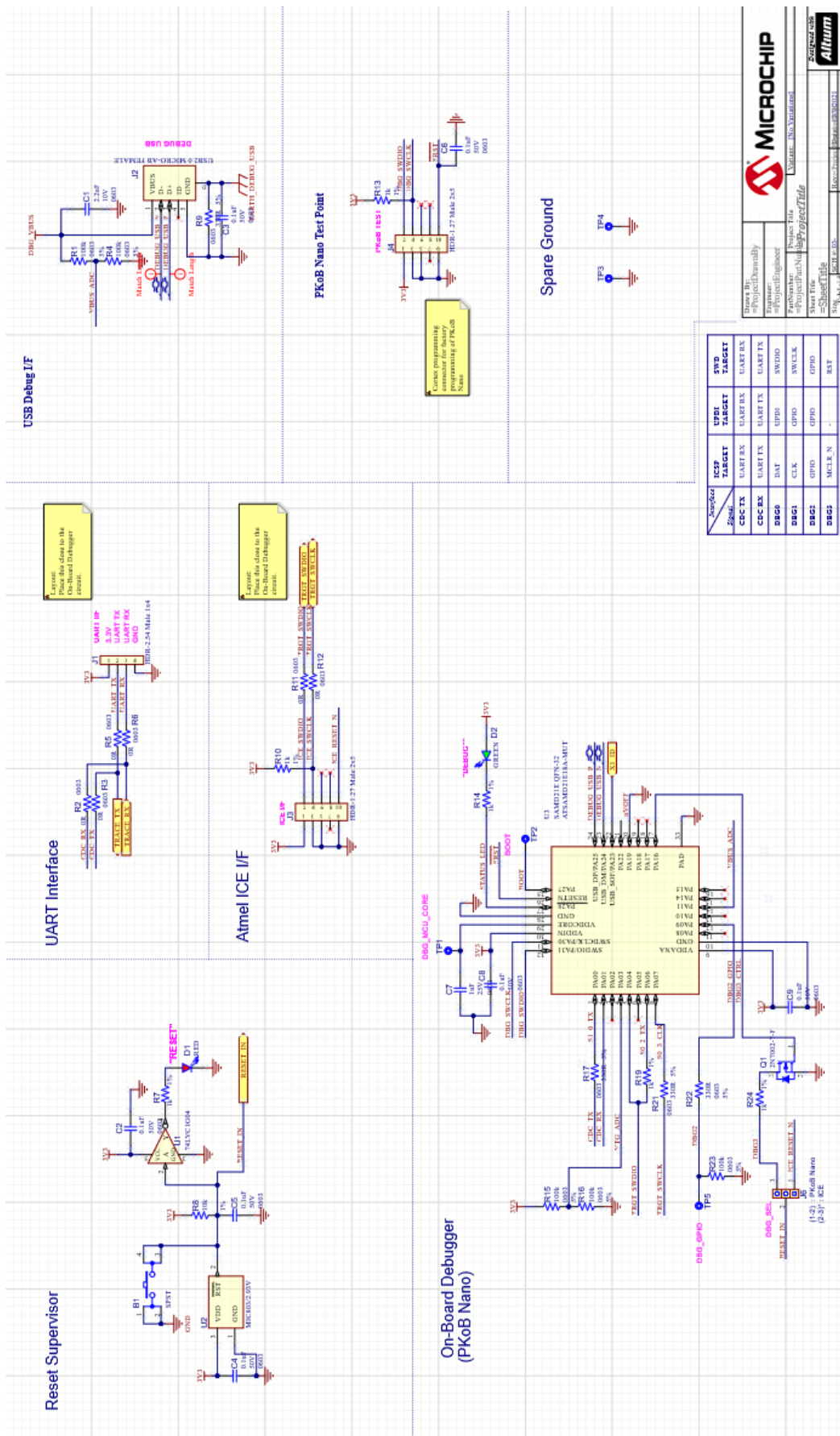
Schematics



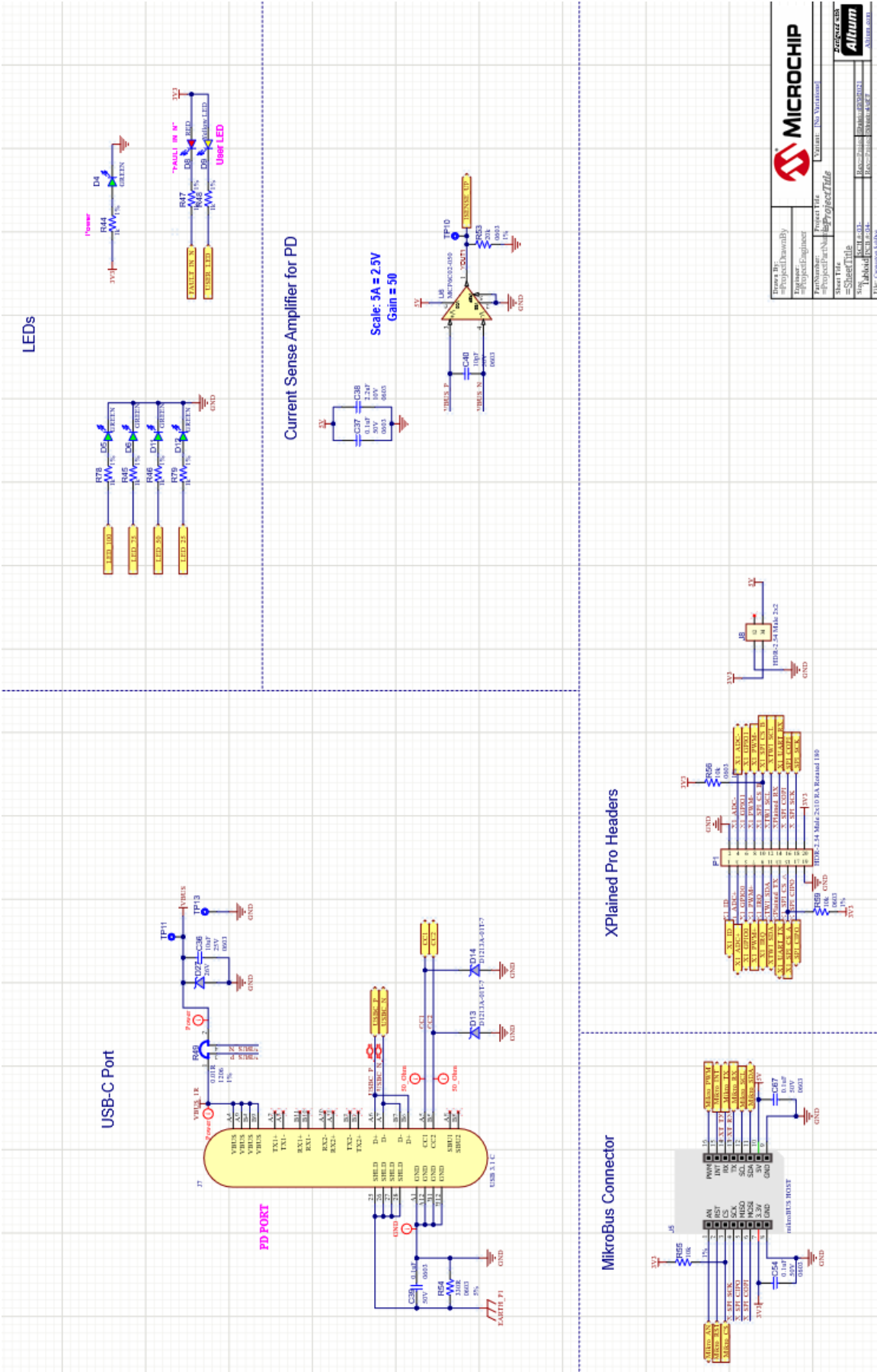
Schematics



Schematics



Schematics



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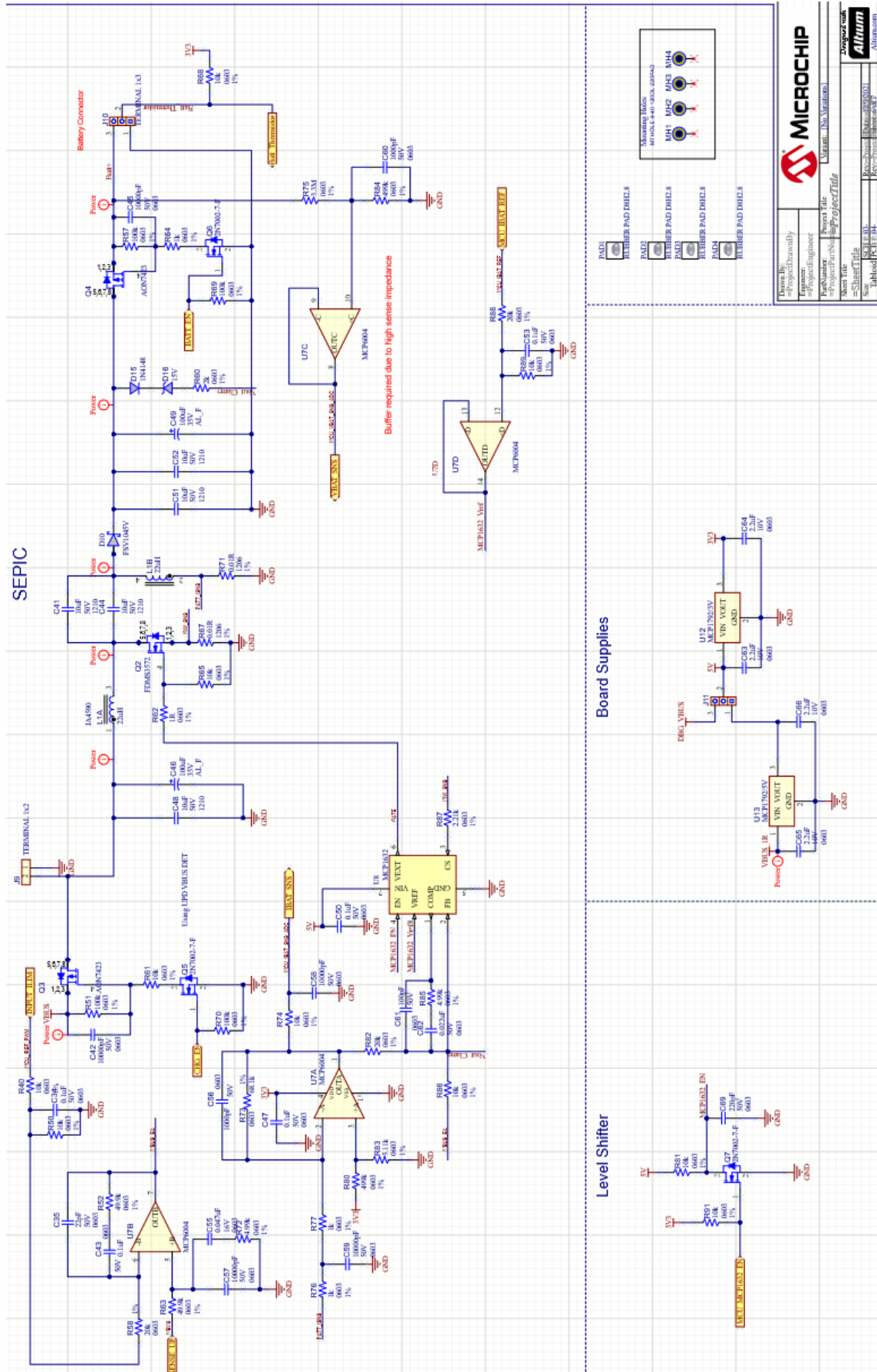
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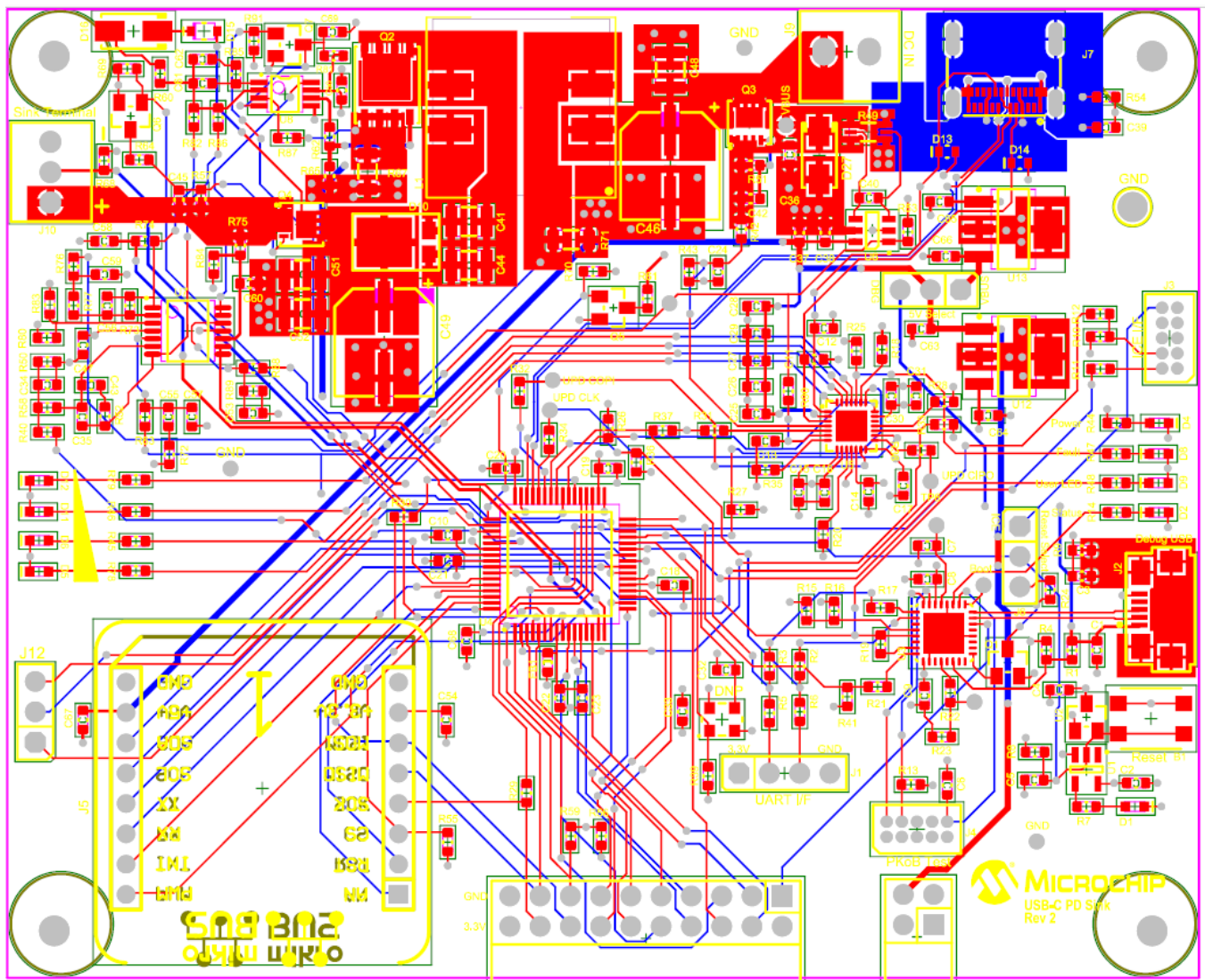
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Schematics



PCB Print



Bill of Materials

Quantity	Designator	Description	Manufacturer 1	Manufacturer Part Number 1	Supplier 1	Supplier Part Number 1	Supplier Unit Price	Price / Board	Populated	Quantity	Quantity Over	Status	MQRP-ID
1	B1	SWITCH TACT SPST 16V 100mA 7914 G 1.032E SMD	Bourns	79140-1.032E	Dig-Key	79140-1.032ECT-ND	\$0.8700	\$0.8700	YES	1		IMCL Desg	SWITCH1134
7	C1, C15, C36, C63, C64, C65, C66	CAP CER 2.2uF 16V 20% Y5V SMD 0603	Farnes	GRM188R91A2252010	Dig-Key	490-1586-1-ND	\$0.0000	\$0.0000	Yes	7		IMCL Desg	CAP0367
26	C2, C3, C4, C5, C6, C8, C9, C14, C16, C18, C19, C20, C21, C22, C24, C25, C30, C34, C37, C39, C43, C47, C50, C53, C54, C67	CAP CER 0.1uF 50V 20% Y5V SMD 0603	Kyocera AVX	06035G104ZA2A	Dig-Key	478-3724-1-ND	\$0.0000	\$0.0000	Yes	26		IMCL Desg	CAP0436
5	C7, C10, C17, C28, C31	CAP CER 1uF 25V 20% XER SMD 0603	Farnes	EC1-1V41E105M	Dig-Key	FOCB56CT-ND	\$0.1300	\$0.6500	Yes	5		IMCL Desg	CAP0439
3	C11, C12, C69	CAP CER 22uF 50V 5% NP0 SMD 0603	KEMET	C0603C221J9GACTU	Dig-Key	399-1066-1-ND	\$0.0000	\$0.0000	Yes	3		IMCL Desg	CAP0552
1	C13	CAP CER 0.1uF 16V 10% X7R SMD 0603	Taiyo Yuden	EMK107B710KX-A7	Dig-Key	587-1240-1-ND	\$0.1000	\$0.1000	Yes	1		IMCL Desg	CAP0001
2	C23, C36	CAP CER 10uF 25V 20% X2R SMD 0603	Murata	GRM188R61E100MA750	Dig-Key	490-7202-1-ND	\$0.3400	\$0.6800	YES	2		IMCL Desg	CAP1461
3	C25, C26, C27	CAP CER 47uF 6.3V 20% X5R SMD 0603	Murata	GRM188R60J47ME15	Dig-Key	490-13247-1-ND	\$0.4900	\$1.4700	YES	3		IMCL Desg	CAP1661
1	C32	CAP CER 15uF 50V 5% NP0 SMD 0603	Yageo	C0603URNP060N180	Dig-Key	311-1060-1-ND	\$0.1000	\$0.1000	Yes	1		IMCL Desg	CAP0121
7	C33, C42, C45, C57, C58, C59, C68	CAP CER 10nF 50V 10% X7R SMD 0603 AEC-Q200, CAP CER 10000pF 50V 20% X7R SMD 0603	Kyocera AVX	06035C103K42ZA, 0603	Dig-Key	478-7927-1-ND, 478-122	\$0.1300	\$0.9100	YES	7		IMCL Desg	CAP2186, CAP
1	C35	CAP CER 22uF 50V 5% NP0 SMD 0603	Cal-Chip	GMC10CG220J50N1FL	Cal-Chip	GMC10CG220J50N1FL	\$0.1000	\$0.1000	Yes	1		IMCL Desg	CAP0004
1	C40	CAP CER 10uF 50V 5% NP0 SMD 0603	KEMET	C0603C100J50GACTU	Dig-Key	399-1049-2-ND	\$0.0000	\$0.0000	Yes	1		IMCL Desg	CAP0142
5	C41, C44, C48, C51, C52	CAP CER 10uF 50V 20% X7R SMD 1210 1TDK	TDK	C3225X7RH106M250A0	Dig-Key	445-14933-1-ND	\$0.9400	\$4.7000	YES	5		IMCL Desg	CAP1238
2	C46, C49	CAP ALU 10uF 35V 30% SMD	Farnes	EEE-1F10V 351AF	Dig-Key	FCE446CT-ND	\$0.9200	\$1.8400	YES	2		IMCL Desg	CAP1332
1	C55	CAP CER 0.047uF 16V 10% X7R SMD 0603	Murata	GRM188R71C47KA010	Dig-Key	490-1529-1-ND	\$0.0000	\$0.0000	YES	1		IMCL Desg	CAP1146
2	C56, C60	CAP CER 100uF 50V 20% X7R SMD 0603	TDK	C1608X7R2A102K080A	Dig-Key	445-1298-1-ND	\$0.1000	\$0.2000	YES	2		IMCL Desg	CAP0001
1	C61	CAP CER 10uF 50V 5% NP0 SMD 0603	Cal-Chip	GMC10CG101J50N1FL	Cal-Chip	GMC10CG101J50N1FL	\$0.1000	\$0.1000	Yes	1		IMCL Desg	CAP0036
1	C62	CAP CER 0.022uF 50V 5% X7R SMD 0603	Kyocera AVX	06035C223JA12A	Dig-Key	478-3722-2-ND	\$0.0000	\$0.0000	YES	1		IMCL Desg	CAP0626
2	D1, D8	DO LED RED 2V 30mA 2mcd Clear SMD 0603	Vislady Lite-On	LTST-C190 ECT	Dig-Key	160-1182-1-ND	\$0.2600	\$0.5200	YES	2		IMCL Desg	D00E1058
6	D2, D4, D5, D6, D11, D12	DO LED GREEN 2V 30mA 35mcd Clear SMD 0603	Vislady Lite-On	LTST-C19 K9KT	Dig-Key	160-1446-1-ND	\$0.2600	\$1.5600	YES	6		IMCL Desg	D00E1155
1	D9	LED YELLOW DIFFUSED 1608 SMD	Rohm	SMLED12Y1W786	Dig-Key	SMLED12Y1W786CT-ND	\$0.2100	\$0.2100	YES	1		IMCL Desg	D00E1547
1	D10							\$0.0000					
2	D13, D14	DO TVS D1213-01 3.3V SMD SOD-523 AEC-Q101	Diodes	D1213A-01 T-7	Dig-Key	D1213A-01 T-7 DCT-ND	\$0.4000	\$0.8000	YES	2		IMCL Desg	D00E1502
1	D15	DO RECT 1N4148 655mV 300mA 75V SOD-323	Diodes	1N4148WS-7-F	Dig-Key	1N4148WS-FDCT-ND	\$0.1900	\$0.1900	Yes	1		IMCL Desg	D00E0066
1	D16	DO ZENER BZ03C15G 15V 1.5W SMD DO-214AC SMA	ON Semiconductor	BZ03C15G	Dig-Key	BZ03C15G06CT-ND	\$0.4400	\$0.4400	YES	1		IMCL Desg	D00E1097
1	D27	DO TVS SMAJ26A 26V 400W DO-214AC, SMA	Littelfuse	SMAJ26A	Dig-Key	SMAJ26ALFCT-ND	\$0.3800	\$0.3800	Yes	1		IMCL Desg	D00E0188
1	DNP	MCIP CLOCK OSCILLATOR SINGLE 24MHz DSC1001CL5-024.0000T U3 2VQ2 SMD 05	Microchip	DSC1001CL5-024.0000	Dig-Key	DSC1001CL5-024.0000-ND	\$0.0000	\$0.0000	YES	1		IMCL Desg	MC6890
1	FB1	RESPTTE 220R@100MHz 500mA SMD 0603	Murata	BLM18A02215N1D	Dig-Key	490-1012-1-ND	\$0.1000	\$0.1000	YES	1		IMCL Desg	FB0114
1	J1	CON HDR2.54 Male 1x4 Gold 5.84MM TH VERT	Würth Electronics	61300411121	Dig-Key	732-5317-ND	\$0.1900	\$0.1900	Yes	1		IMCL Desg	CON0148
1	J2	CON USB2.0 MICRO-A B FEMALE SMD 0603	Hirose	Z62-AB-5PA(S1)	Dig-Key	H125279CT-ND	\$0.0000	\$0.0000	YES	1		IMCL Desg	CON0436
2	J3, J4	CON HDR-1.27 Male 2x5 Gold 3.05MM TH VERT	Amphenol ICC / FCI	20021111-0001014LF	Dig-Key	209-3712-ND	\$0.7700	\$1.5400	YES	2		IMCL Desg	CON1497
2	J5	SOCKET 1x60pin HOST DIP 16 TH	Sullins	PPCT081FLBNRC	Dig-Key	S7006-ND	\$0.6500	\$1.3000	YES	1		IMCL Desg	SKT1046
1	J6, J11	CON HDR2.54 Male 1x3 5.84MM TH VERT	Santec	TSW-103-07-T-S	Dig-Key	SAM103-03-ND	\$0.2400	\$0.4800	Yes	2		IMCL Desg	CON0465
1	J7	CON USB3.1-C Female SMD RA	Molex	105450-0101	Dig-Key	WM1258CT-ND	\$2.1900	\$2.1900	YES	1		IMCL Desg	CON1642
1	J8	CON HDR2.54 Male 2x2 Gold 6.7MM TH RA	Molex	090120761	Dig-Key	WM5008-02-ND	\$0.4900	\$0.9800	YES	1		IMCL Desg	CON1527
1	J9	CON TERMINAL 3.81mm 1x2 Female 16-24AWG 10A TH RA	Amphenol	Y002215000003	Dig-Key	609-3918-ND	\$0.0000	\$0.0000	YES	1		IMCL Desg	CON1037
1	J10	CON TERMINAL 2.54mm 1x3 Female 20-30AWG 6A TH RA	On-Shore Technology	OSTVM03A150	Dig-Key	ED0562-ND	\$1.0900	\$1.0900	YES	1		IMCL Desg	CON1303
1	J12	CON HDR2.54 Female 1x3 Gold 6.64MM TH VERT	TE Connectivity	5-84-267-1	Dig-Key	A32904-ND	\$1.4700	\$1.4700	YES	1		IMCL Desg	CON1425
1	L1	INDUCTOR DUAL 22uH 2.45A 20% SMD 1210 RW12 SMD 5	Würth Electronics	744870220	Dig-Key	732-2327-1-ND	\$2.9000	\$2.9000	YES	1		IMCL Desg	IND1405
1	P1	CON HDR2.54 Male 2x10 Rotated 180degrees Gold TH RT ANGLE	Sullins	PBC100BAN	Dig-Key	S211E-10-ND	\$1.9300	\$1.9300	YES	1		IMCL Desg	CON1547
4	PAD1, PAD2, PAD3, PAD4	MECH HW RUBBER PAD Cylindrical flat top D8x5.8 Back	Farnell	SJ5076BLACK	Farnell	1165061	\$4.7800	\$19.1200	MECH	4		IMCL Desg	MECH0087
4	Q1, Q5, Q6, Q7	TRANS FET N-CH 2N7002-7-F 60V 170mA 330mW SOT-23-3	Diodes	2N7002-7-F	Dig-Key	2N7002-FDCT-ND	\$0.2100	\$0.8400	YES	4		IMCL Desg	TRA1102
1	Q2	TRANS FET N-CH FDM3572 80V 22A 2.5W Power56-8	ON Semiconductor / Fairchild	FDM3572	Dig-Key	FDM3572TR-ND	\$0.0000	\$0.0000	YES	1		IMCL Desg	TRA1019
2	Q3, Q4	TRANS FET P-CH AON7423 20V 28A 6.2W 5-PowerNCHN	Alpha & Omega Semicon	AON7423	Dig-Key	785-1310-2-ND	\$0.0000	\$0.0000	YES	2		IMCL Desg	TRA1080
10	R1, R4, R15, R16, R23, R28, R51, R57, R69, R70	RES TRF 100K 5% 1/10W SMD 0603 (Don't Use, Duplicate, Use RS MT0038), RES TRF 100K 1% 1/8W SMD 0603	Farnes, Vishay Beys	ERJ-3GEYR104V, MC100	Dig-Key	P100GCT-ND, MC100	\$0.0370	\$0.3700	Yes	10		IMCL Desg	RES1115, RES
8	R2, R3, R5, R6, R11, R12, R31, R33, R60	RES TRF 0R 1/10W AEC-Q200 SMD 0603	Farnes	ERJ-3GEYR000V	Dig-Key	P000CT-ND	\$0.1000	\$0.8000	YES	8		IMCL Desg	RES2360
16	R7, R10, R13, R14, R19, R24, R44, R45, R46, R47, R48, R64, R76, R77, R78, R79	RES TRF 1K 1% 1/10W AEC-Q200 SMD 0603	Farnes	ERJ3ERF1001V	Dig-Key	P100HCT-ND	\$0.0380	\$0.6080	YES	16		IMCL Desg	RES2458
24	R8, R18, R20, R25, R26, R33, R36, R37, R39, R40, R41, R43, R50, R55, R66, R69, R81, R85, R86, R74, R81, R86, R89, R91	RES TRF 10K 1% 1/16W SMD 0603	TE Connectivity	5-167-8637-9	Dig-Key	A10203CT-ND	\$0.1600	\$3.8400	YES	24		IMCL Desg	RES1368
5	R9, R17, R21, R22, R54	RES TRF 330R 5% 1/10W SMD 0603	Rohm	MCRB E2PRJ331	Dig-Key	R1HM30CT-ND	\$0.0000	\$0.0000	Yes	5		IMCL Desg	RES0186
1	R27	RES TRF 200K 1% 1/10W SMD 0603	Vishay	CRW0603200K PKFA	Dig-Key	S41200HCT-ND	\$0.0000	\$0.0000	Yes	1		IMCL Desg	RES1140
5	R29, R30, R32, R34, R38	RES TRF 33R 1% 1/10W SMD 0603	Rohm	MCRB E2PRX33R0	Dig-Key	R1HM330HCT-ND	\$0.0000	\$0.0000	Yes	5		IMCL Desg	RES10701
1	R42	RES TRF 90.9K 1% 1/10W SMD 0603	Farnes	ERJ3ERF9092V	Dig-Key	P90.9KTR-ND	\$0.0000	\$0.0000	Yes	1		IMCL Desg	RES10355
1	R49	RES SHUNT 0.01R 1% 1/4W 1206	Yageo	PF1206FR070R01L	Dig-Key	311-01.01ACT-ND	\$0.4700	\$0.4700	YES	1		IMCL Desg	RES1231
2	R52, R63	RES TRF 49.9K 1% 1/10W SMD 0603	Yageo	RC0603FR07499KL	Dig-Key	311-49.9KHCT-ND	\$0.1000	\$0.2000	YES	2		IMCL Desg	RES2498
4	R53, R58, R62, R68	RES TRF 20K 1% 1/10W SMD 0603	Farnes	ERJ3ERF2002V	Dig-Key	P20.2KHCT-ND	\$0.1000	\$0.4000	Yes	4		IMCL Desg	RES10359
1	R60	RES TRF 2K 1% 1/10W SMD 0603	Farnes	ERJ3ERF2001V	Dig-Key	P2.0KHCT-ND	\$0.1000	\$0.1000	Yes	1		IMCL Desg	RES10382
1	R62	RES TRF 1R 1% 1/10W SMD 0603	Yageo	RC0603FR071RL	Dig-Key	311-1.0KHCT-ND	\$0.1000	\$0.1000	YES	1		IMCL Desg	RES1398
2	R67, R71	RES SHUNT MF 0.01R 1% 1W SMD 1210	Bourns	CRF1206-FX-R010ELF	Dig-Key	CRF1206-FX-R010ELFCT-ND	\$0.0000	\$0.0000	YES	2		IMCL Desg	RES1228
2	R72, R85	RES TRF 4.99K 1% 1/10W SMD 0603	Farnes	ERJ3ERF4991V	Dig-Key	P4.99KHCT-ND	\$0.0000	\$0.0000	Yes	2		IMCL Desg	RES10185
1	R73	RES TRF 68.1K 1% 1/10W SMD 0603	Yageo	RC0603FR07681KL	Dig-Key	311-68.1KHCT-ND	\$0.1000	\$0.1000	Yes	1		IMCL Desg	RES11041
1	R75	RES TRF 3.3M 1% 1/8W SMD 0603	Stackpole Electronics	RMCF0603PT3M30	Dig-Key	RMCF0603PT3M30CT-ND	\$0.0000	\$0.0000	Yes	1		IMCL Desg	RES1158
2	R80, R84	RES TRF 499K 1% 1/10W SMD 0603	Farnes	ERJ3ERF4993V	Dig-Key	P499KHCT-ND	\$0.1000	\$0.2000	Yes	2		IMCL Desg	RES1119
1	R83	RES TRF 5.11K 1% 1/10W SMD 0603	Yageo	RC0603FR075K11L	Dig-Key	311-5.11KHCT-ND	\$0.1000	\$0.1000	YES	1		IMCL Desg	RES1639
1	R87	RES TRF 2.21K 1% 1/10W SMD 0603 AEC-Q200	Vishay	CRW06032K21FKFA	Dig-Key	S41-2.21KHCT-ND	\$0.1000	\$0.1000	Yes	1		IMCL Desg	RES2487
1	U1	IC LOGIC 74LVC1G04 SOT-23-5	Texas Instruments	SN74LVC1G04DBVR	Dig-Key	286-11599-1-ND	\$0.3400	\$0.3400	YES	1		IMCL Desg	MC0053
1	U2	MCIP ANALOG SUPERVISOR 2.93V MC080-2904VM3-TR SOT-23-3	Microchip	MC080-2904VM3-TR	Dig-Key	576-3806-1-ND	\$0.3900	\$0.3900	YES	1		IMCL Desg	MC7416
1	U3	MCIP MCU 32-BIT 48MHz 2.5Kb 32Kb ATSAMC01216A-MUT QFN-32	Microchip	ATSAMC01216A-MUT	Dig-Key	ATSAMC01216A-MUTC	\$3.9800	\$3.9800	YES	1		IMCL Desg	MC8641
1	U4	MCIP MCU 32-BIT 48MHz 2.5Kb 32Kb ATSAMC01216A-AU TQFP-64	Microchip Technology	ATSAMC01216A-AU	Microchip Tech	ATSAMC01216A-AU	\$0.0000	\$0.0000	YES	1		IMCL Desg	MC5796
1	U5	MCIP INTERFACE UP0908 USB Type C PD PORT CONTROLLER, SPI, DB, QFN-28	Microchip	UPD0908-V06X	Dig-Key	UPD0908-V06XND	\$1.7400	\$1.7400	YES	1		IMCL Desg	MC8374
1	U6	MCIP ANALOG CURRENT SENSE AMP MCP602T-050E/CHY SOT-23-6	Microchip	MCP602T-050E/CHY	Dig-Key	MCP602T-050E/CHYCT-ND	\$0.0000	\$0.0000	YES	1		IMCL Desg	MC1900
1	U7	MCIP ANALOG OPAMP 4-Ch 1MHz MCP6004T-E/ST TSSOP-14	Microchip	MCP604T-E/ST	Microchip	MCP604T-E/ST	\$0.0000	\$0.0000	Yes	1		IMCL Desg	MC2947
1	U8	MCIP ANALOG PWM CONTROLLER 30kHz MCP1632T-AAE/MS MCP-8	Microchip	MCP1632T-AAE/MS	Dig-Key	MCP1632T-AAE/MS-ND	\$0.0000	\$0.0000	YES	1		IMCL Desg	MC6117
1	U12	MCIP ANALOG LDO 3V MCP1792 SOT-23-3	Microchip Technology	MCP1792-3302H/DB	Microchip Tech	MCP1792-3302H/DB	\$0.0000	\$0.0000	YES	1		IMCL Desg	MC5751
1	U13	MCIP ANALOG LDO 5V MCP1792 SOT-23-3	Microchip Technology	MCP1792-5002H/DB	Microchip Tech	MCP1792-5002H/DB	\$0.0000	\$0.0000	YES	1		IMCL Desg	MC8805