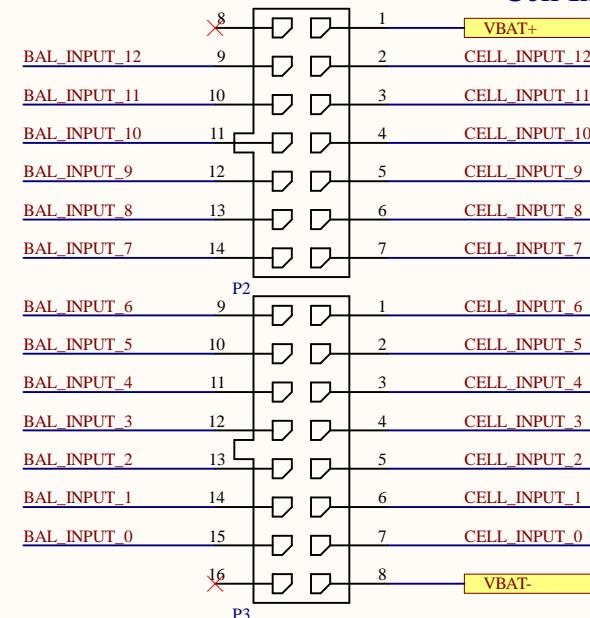


PROJECT	BMS_AFE.PjPcb	
DOCUMENT	BMS AFE - Top Sheet.SchDoc	
PART NUMBER	MS40005	VARIANT 01 - Standard
DRAWN BY	Liam Hawkins	REVISION 1.0
LAST MODIFIED	2020-03-01	SHEET 1 OF 7

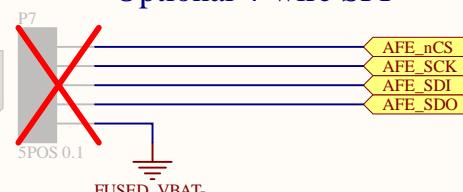
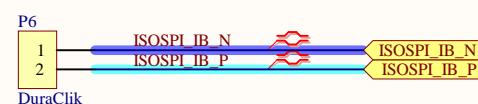
## Cell Inputs



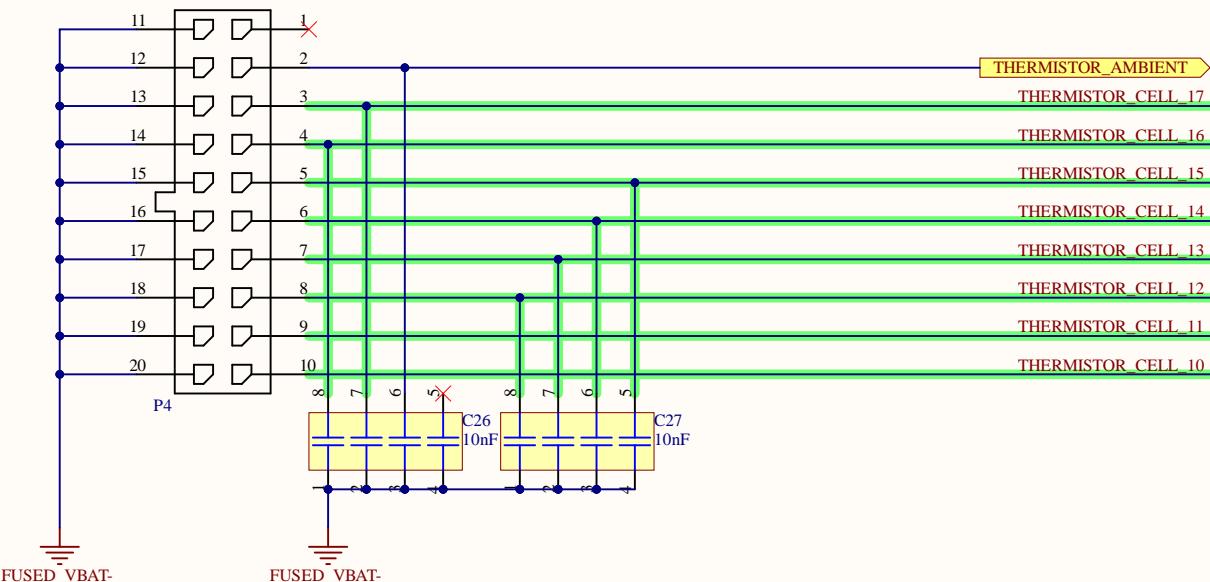
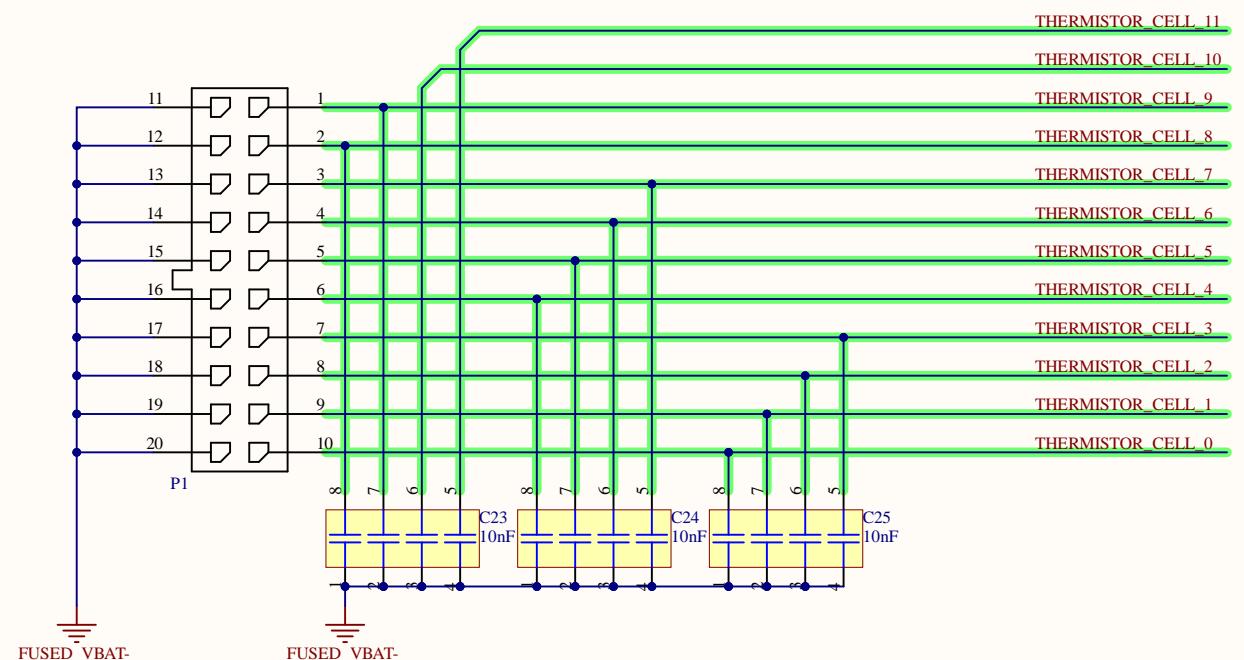
**CELL INPUT [0..12]** → **CELL INPUT [0..12]**

**BAL INPUT [0..12]** → **BAL INPUT [0..12]**

## isoSPI Connectors



## Cell Thermistors

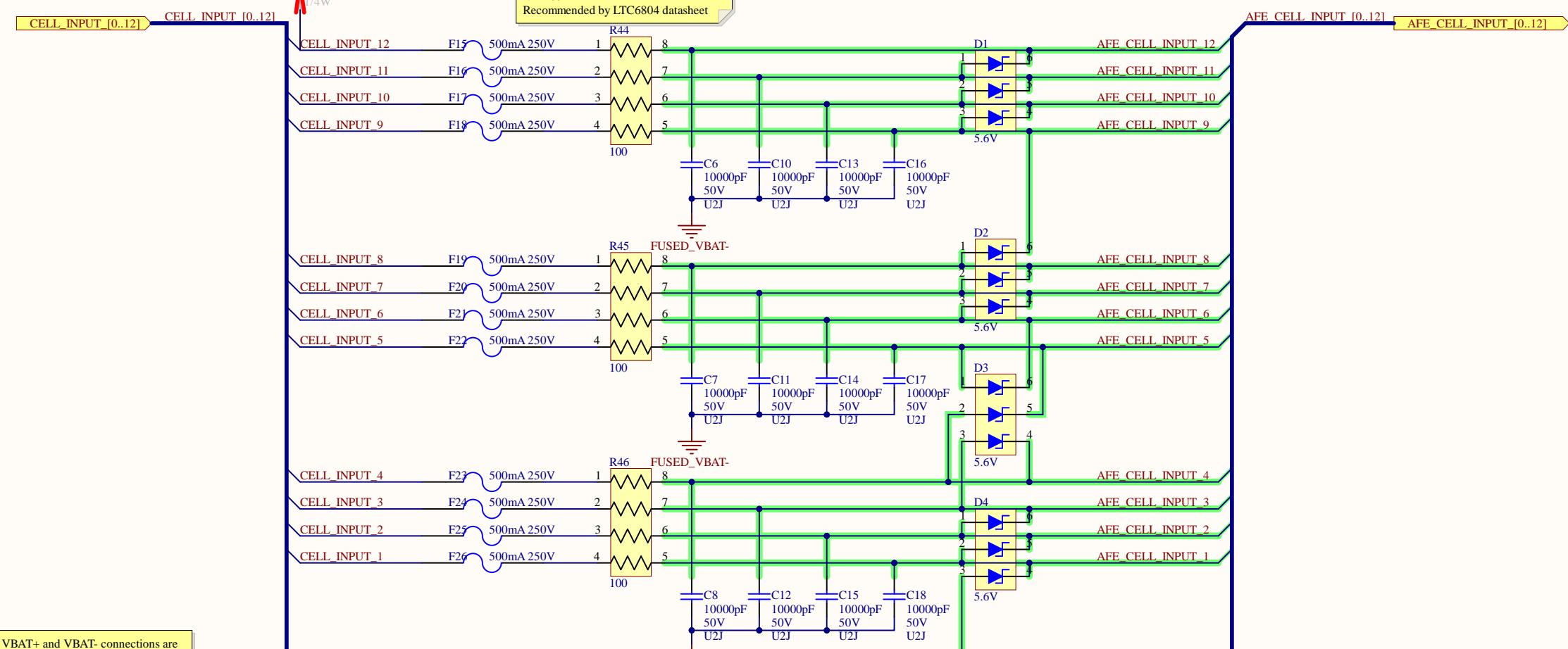
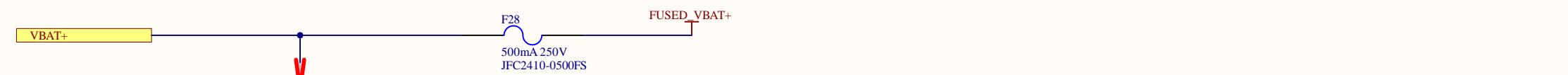


**THERMISTOR\_CELL [0..17]** → **THERMISTOR\_CELL [0..17]**

PROJECT	BMS_AFE.PjPcb	
DOCUMENT	BMS AFE - Connectors.SchDoc	
PART NUMBER	MS40005	VARIANT 01 - Standard
DRAWN BY	Liam Hawkins	REVISION 1.0
LAST MODIFIED	2020-03-01	SHEET 2 OF 7



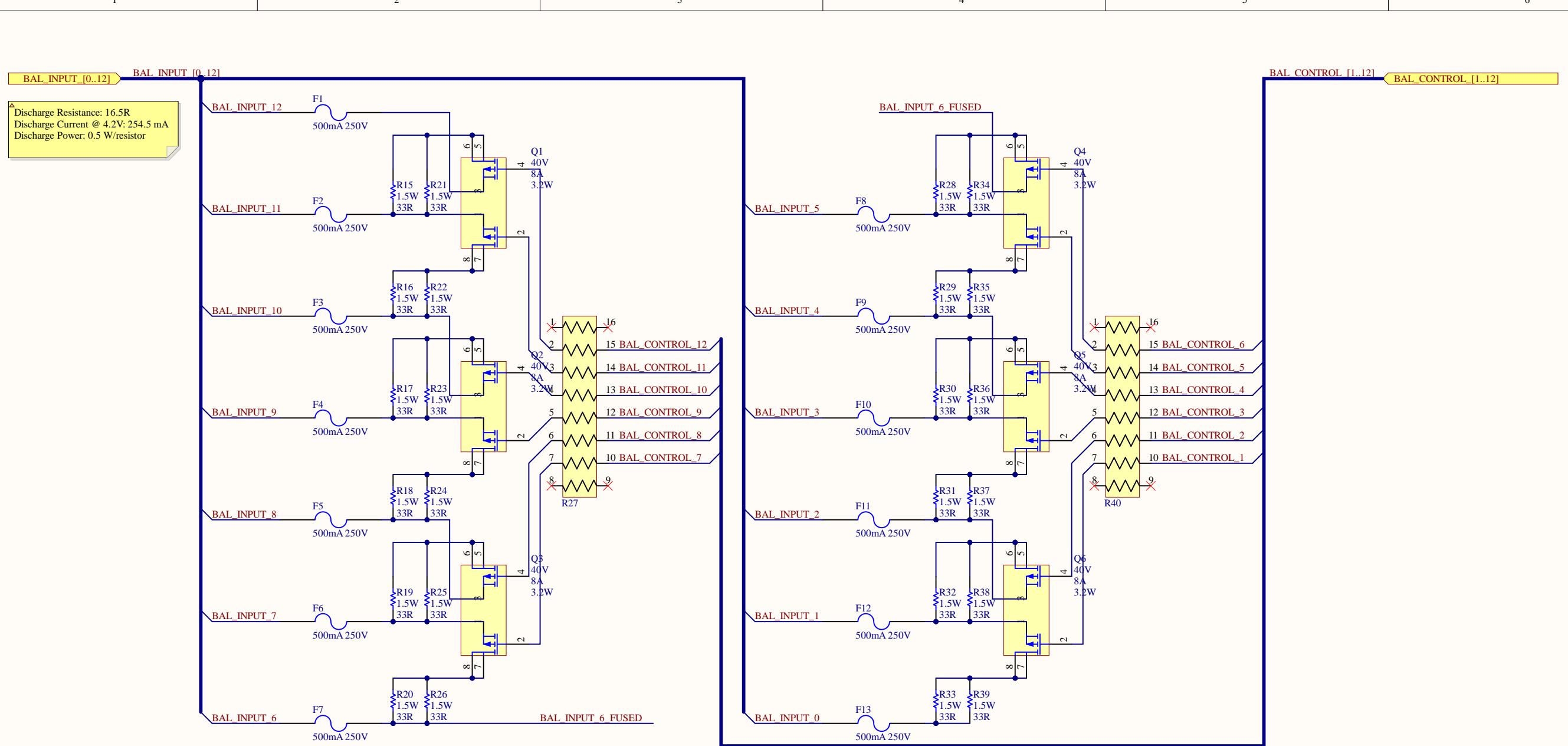
A



PROJECT	BMS_AFE.PrjPcb	
DOCUMENT	BMS AFE - Cell Inputs.SchDoc	
PART NUMBER	MS40005	VARIANT 01 - Standard
DRAWN BY	Liam Hawkins	REVISION 1.0
LAST MODIFIED	2020-03-01	SHEET 3 OF 7

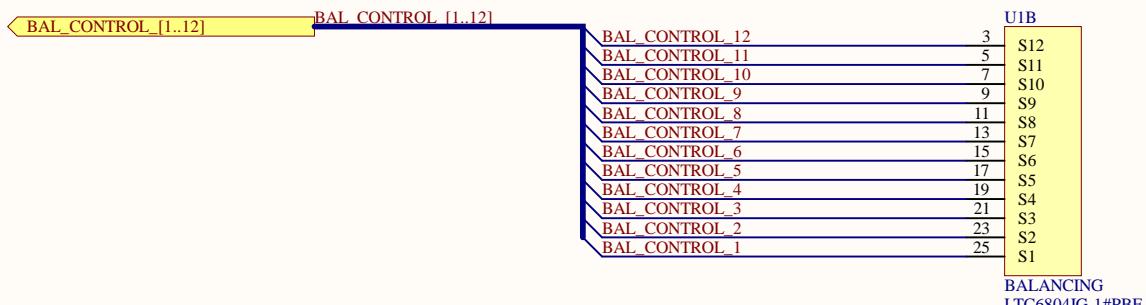
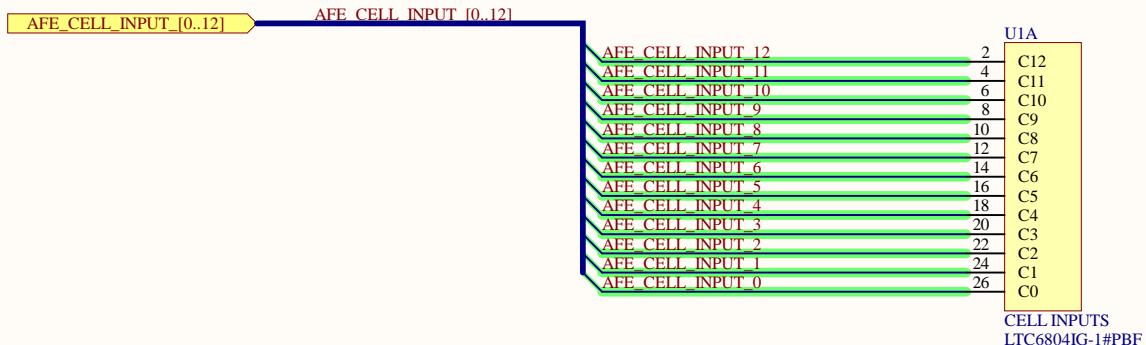
MIDNIGHT SUN

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University of Waterloo  
(519) 888-4567 x32978  
hardware@uwmidsun.com

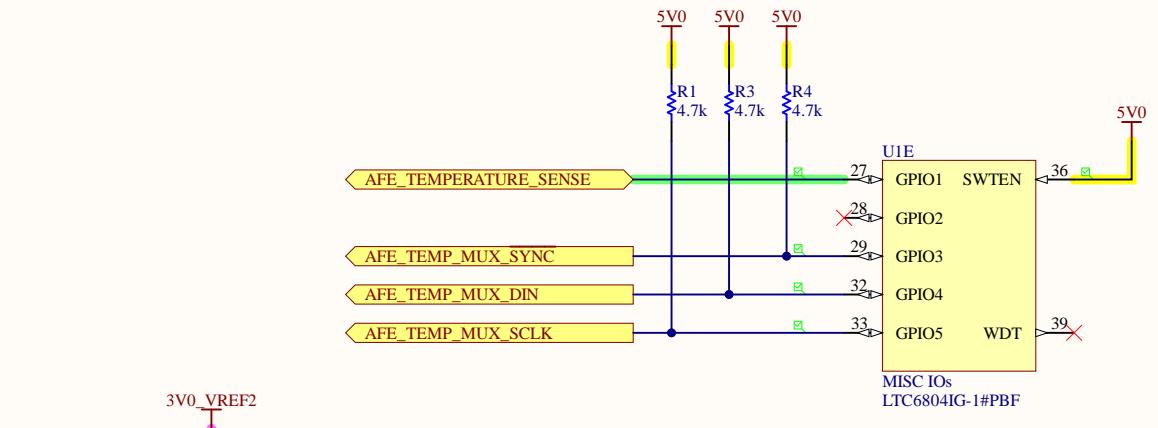


PROJECT	BMS_AFE.PnjPcb	
DOCUMENT	BMS AFE - Cell Balancing.SchDoc	
PART NUMBER	MS40005	VARIANT 01 - Standard
DRAWN BY	Liam Hawkins	REVISION 1.0
LAST MODIFIED	2020-03-01	SHEET 4 OF 7

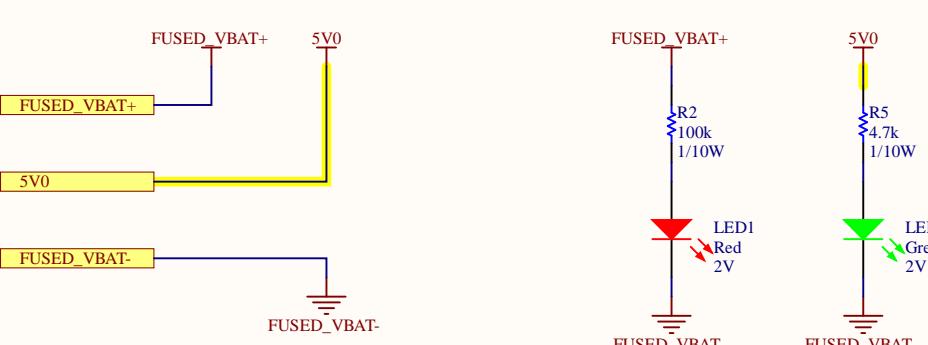
## Cell & Balancing Inputs



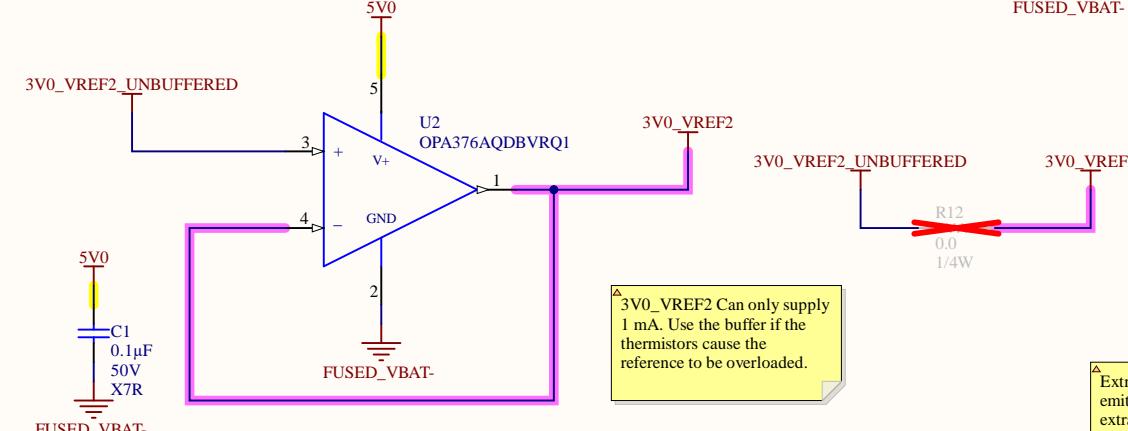
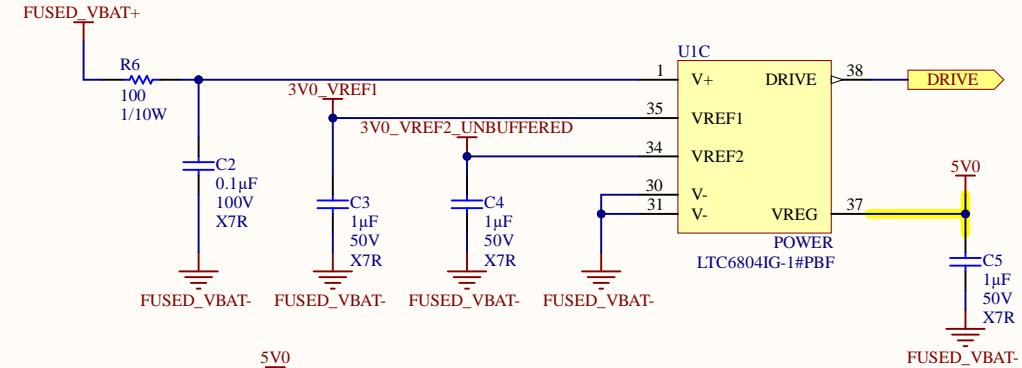
## GPIOs



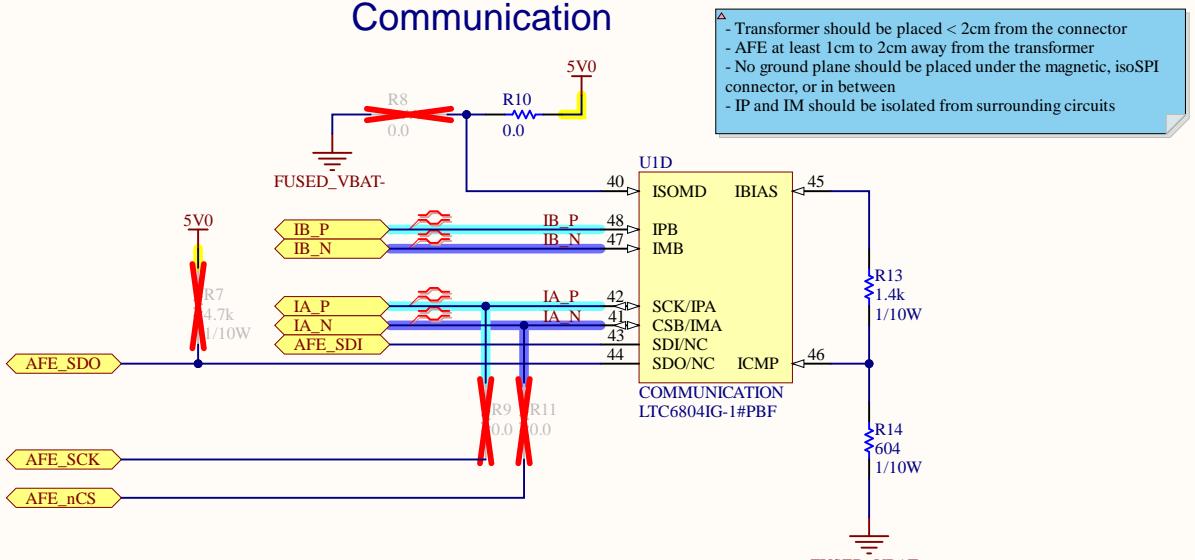
## LEDs



## Power



## Communication



**isoSPI:**  
Ib = 1 mA  
Ibias = 20 mA  
Vicmp = 602 mV  
Pulses with amplitudes greater than 602 mV/2 = ± 301 mV will be detected

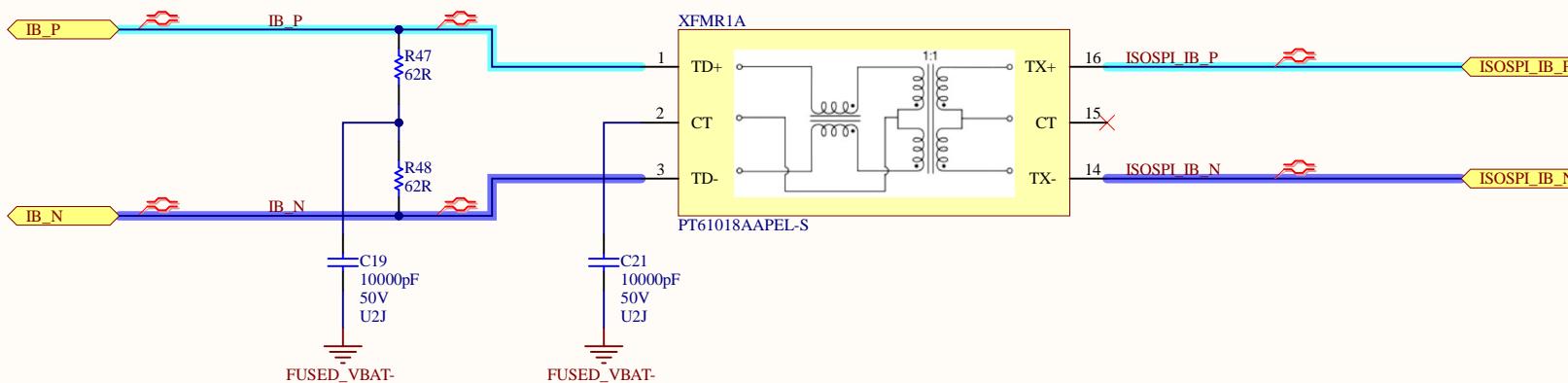
PROJECT	BMS_AFE.PjPcb	
DOCUMENT	BMS AFE - AFE.SchDoc	
PART NUMBER	MS40005	VARIANT 01 - Standard
DRAWN BY	Liam Hawkins	REVISION 1.0
LAST MODIFIED	2020-03-01	SHEET 5 OF 7

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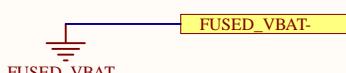
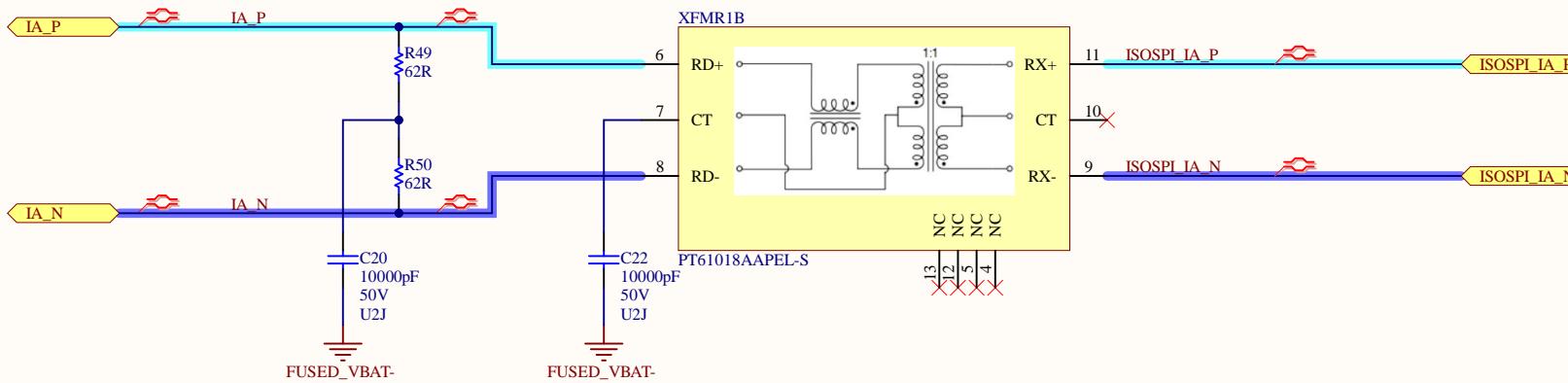
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University of Waterloo  
(519) 888-4567 x32978  
hardware@uwmidsun.com

## isoSPI

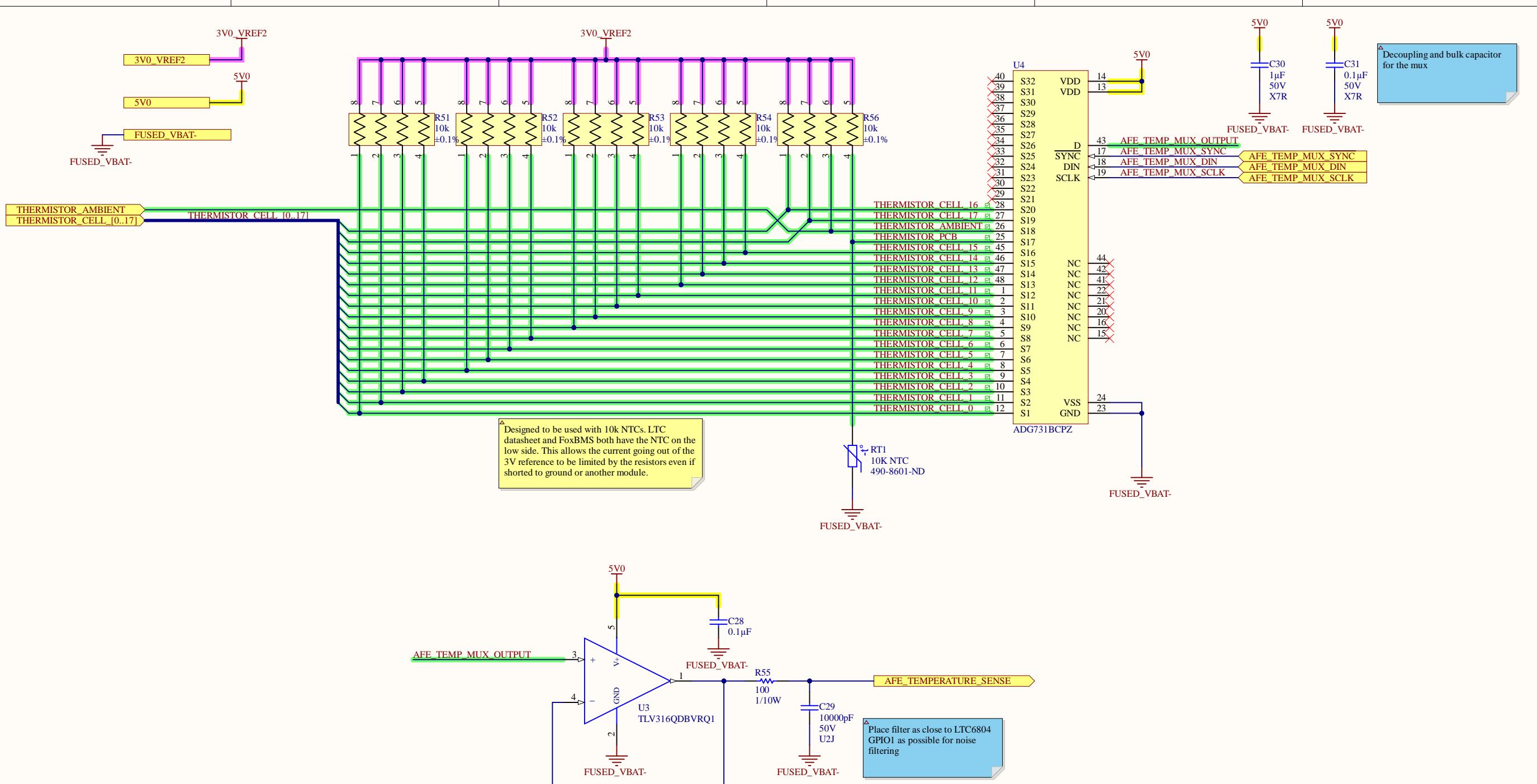
## MASTER - TO NEXT AFE



## SLAVE - FROM LTC6820



PROJECT	BMS_AFE.PrjPcb	
DOCUMENT	BMS AFE - Communications.SchDoc	
PART NUMBER	MS40005	VARIANT 01 - Standard
DRAWN BY	Liam Hawkins	REVISION 1.0
LAST MODIFIED	2020-03-01	SHEET 6 OF 7

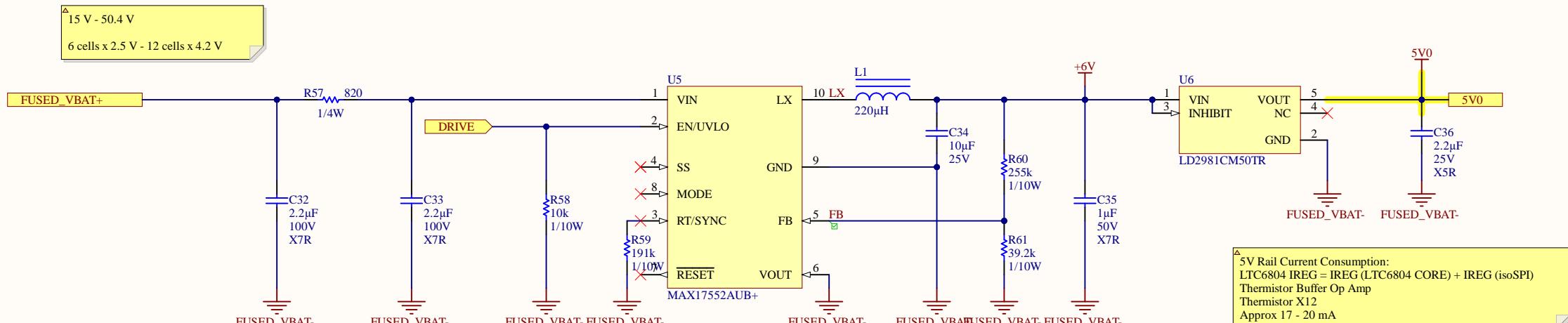


PROJECT	BMS_AFE.PrjPcb		
DOCUMENT	BMS AFE - Thermistors.SchDoc		
PART NUMBER	MS40005	VARIANT	01 - Standard
DRAWN BY	Liam Hawkins	REVISION	1.0
LAST MODIFIED	2020-03-01	SHEET	7 OF 7



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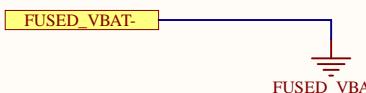
A



B

FB Set to 5.89 - 6.11 V.  
 Max dropout for LDO: 150 mV @ 25 mA across temperature

C



D

PROJECT	BMS_AFE.PnjPcb	
DOCUMENT	Title	
PART NUMBER	MS40005	VARIANT 01 - Standard
DRAWN BY	Liam Hawkins	REVISION 1.0
LAST MODIFIED	2020-03-01	SHEET * OF *

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 hardware@uwmidsun.com

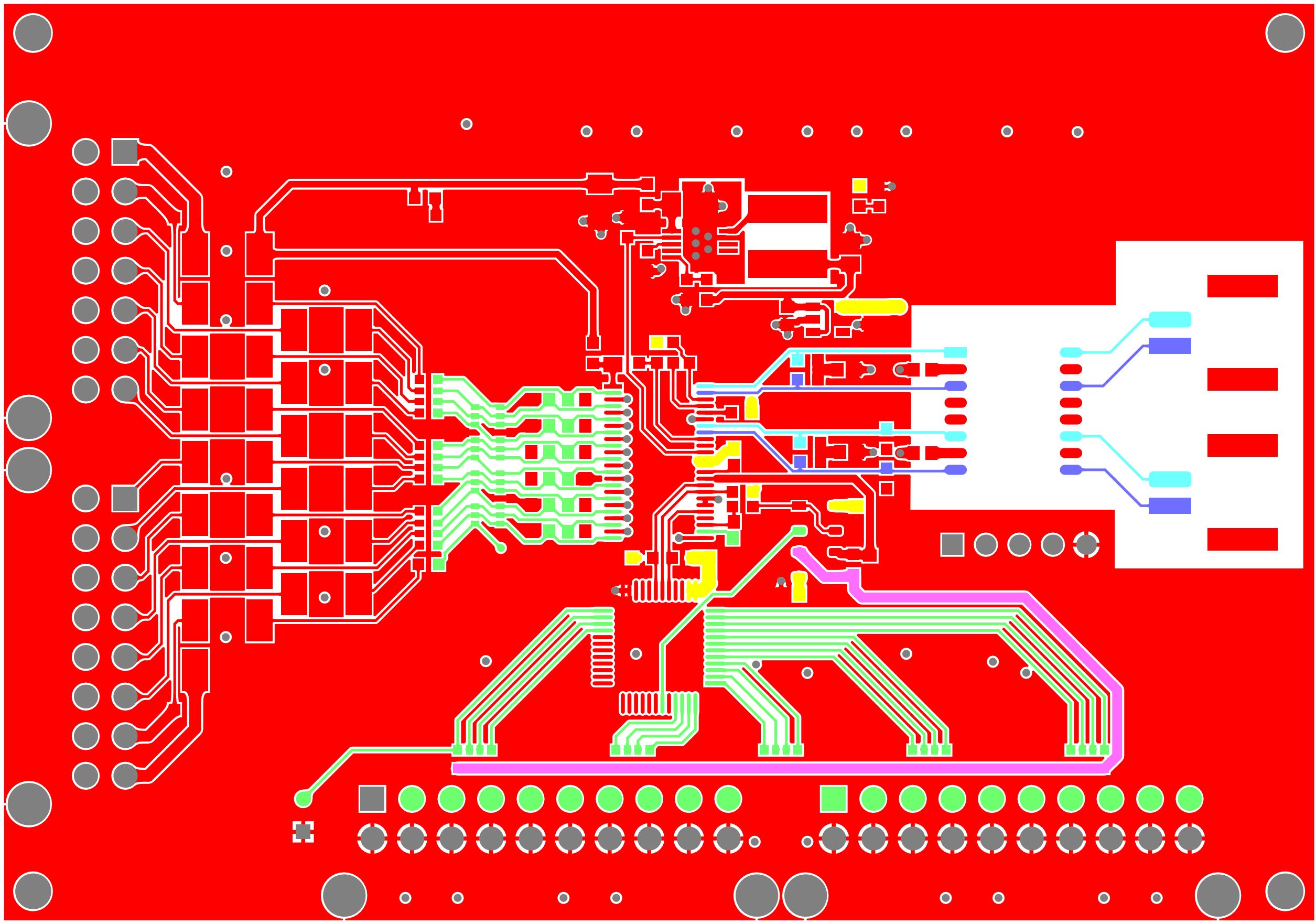
## Bill of Materials

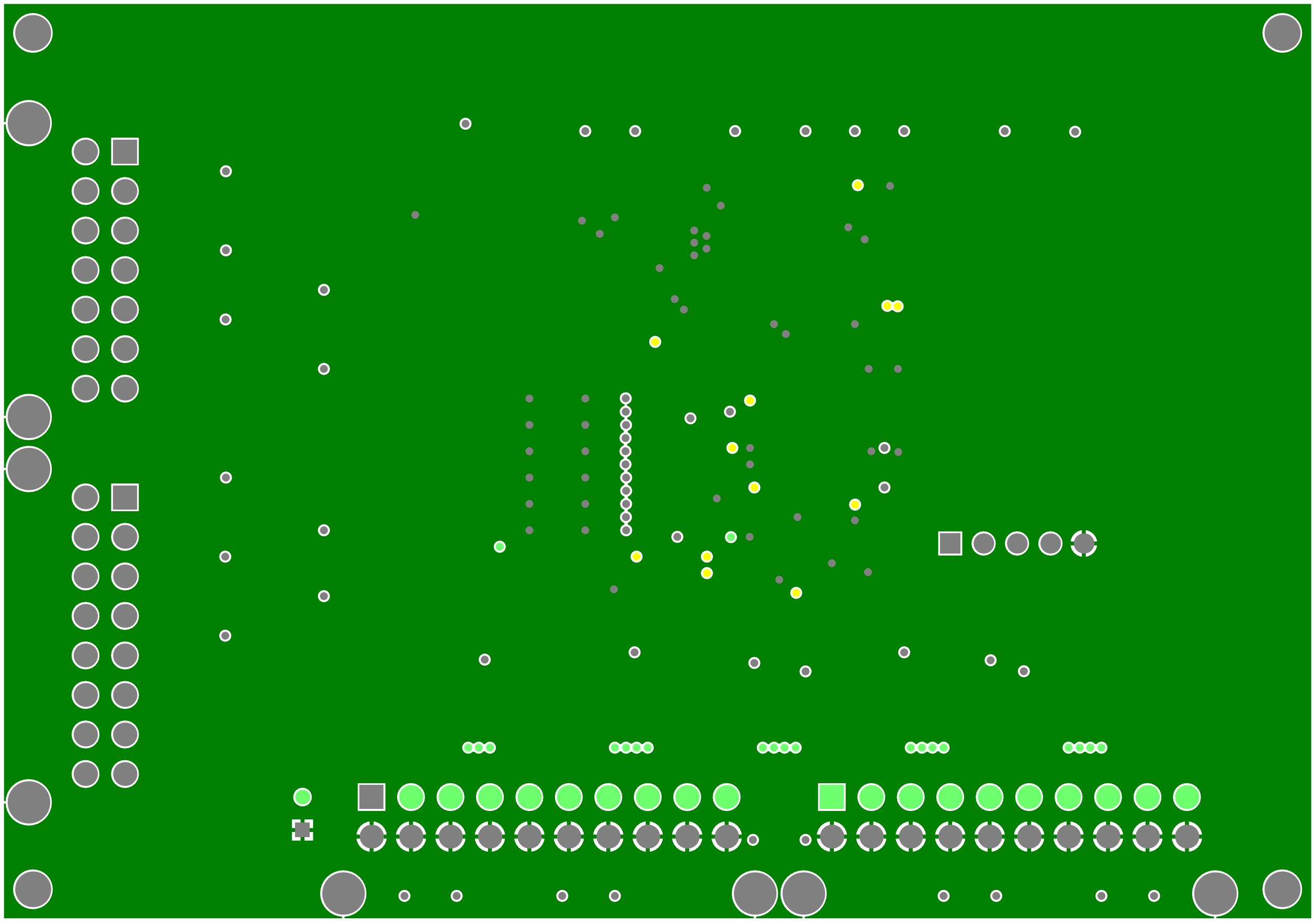
Project:	BMS_AFE.PpjPcb
Revision:	1.0
Project Lead:	Liam Hawkins
Generated On:	2020-03-01 5:09 PM
Production Quantity:	1
Currency	CAD
Total Parts Count:	145

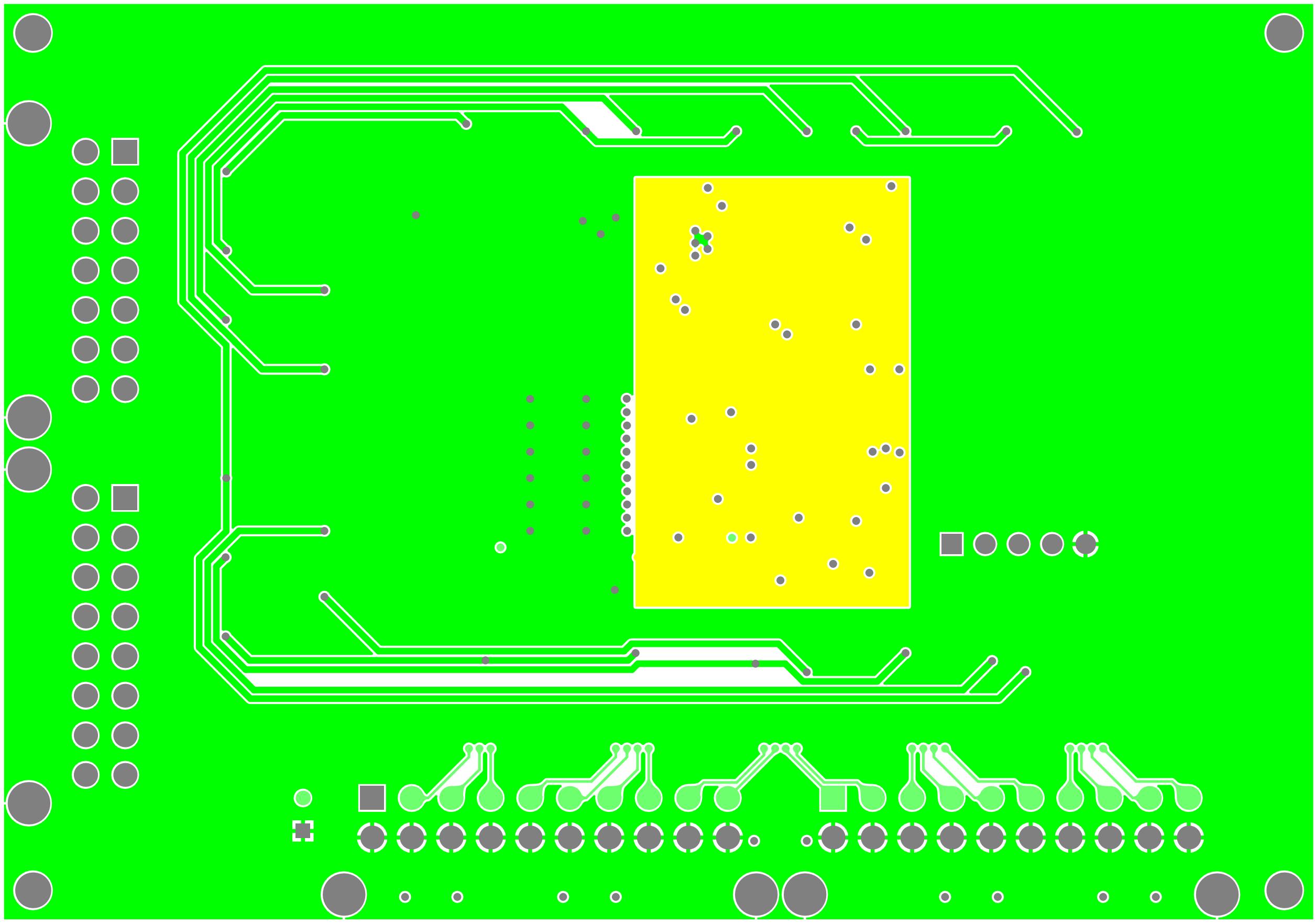
MIDNIGHT SUN

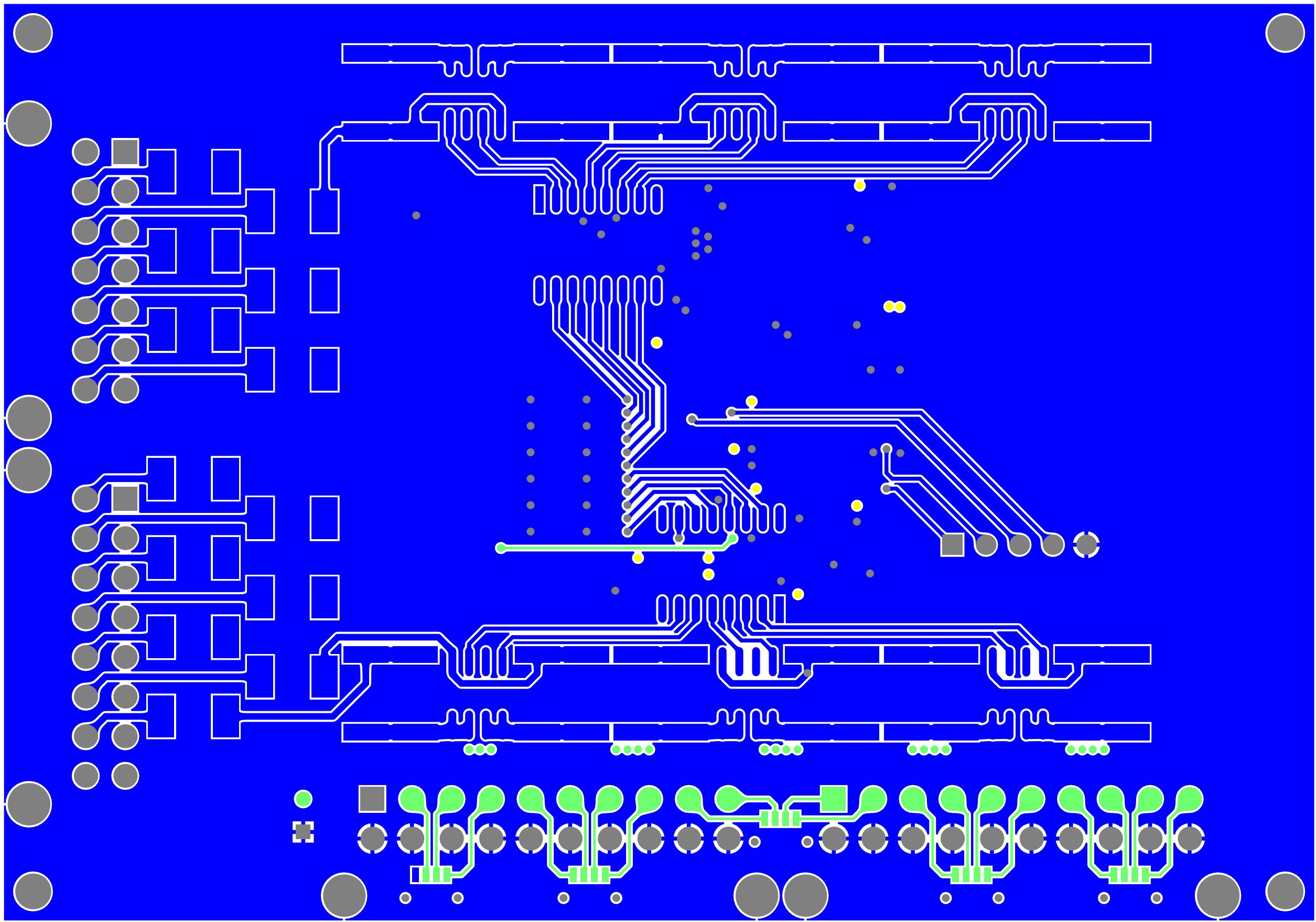


LibRef	Designator	Manufacturer 1	Manufacturer Part Number 1	Supplier 1	Supplier Part Number 1	Supplier Unit Price 1	Quantity	Supplier Subtotal 1
CAP CER 0.1UF 50V 10% X7R 0603	C1, C28, C31	Kyocera AVX	0603S5C104KAT2A	Digi-Key	478-5052-1-ND	0.13416	3	\$ 0.40
CAP CER 0.1UF 100V 10% X7R 0805	C2	Murata	GCM21BR72A104KA37L	Digi-Key	490-4789-1-ND	0.37565	1	\$ 0.38
CAP CER 1UF 50V 10% X7R 0603	C3, C4, C5, C30, C35	Taiyo Yuden	UMK107AB7105KA-T	Digi-Key	587-3247-1-ND	0.3354	5	\$ 1.68
CAP CER 10nF 50V 5% X7R 0603	C11, C12, C13, C14, C15, C16, C17, C18, C19	KEMET	C0603C103J5JACTU	Digi-Key	399-13384-1-ND	0.30052	18	\$ 5.41
CAP ARRAY 10000PF 50V X7R 0612	C23, C24, C25, C26, C27	Yageo	CA0612KRX7R9BB103	Digi-Key	311-2074-1-ND	0.55005	5	\$ 2.75
CAP CER 2.2UF 100V ±20% X7R 1206	C32, C33	Murata	GRM31CR72A225MA73L	Digi-Key	490-12773-1-ND		2	
CAP CER 10uF 25V 10% X5R 0805	C34	Murata	GRM21BR61E106KA73L	Digi-Key	490-5523-1-ND	0.34881	1	\$ 0.35
CAP CER 2.2UF 25V 10% X5R 0603	C36	Murata	GRM188R61E225KA12D	Digi-Key	490-10731-1-ND	0.2549	1	\$ 0.25
DIODE ZENER ARRAY 5.6V SOT363	D1, D2, D3, D4	Diodes	BZX84C5V6TS-7-F	Digi-Key	BZX84C5V6TS-FDICT-ND	0.56347	4	\$ 2.25
FUSE 500mA LCSC	1, F12, F13, F14, F15, F16, F17, F18, F19, F2	Shenzen JDT Fuse	JFC2410-0500FS	LCSC	C136360		28	
IND 220uH 0.59A 20%	L1	Laird Steward	TYS6045221M-10	Digi-Key	240-2742-1-ND	0.89887	1	\$ 0.90
LED RED CLEAR 2V 0603	LED1	Wurth Electronics	150060RS75000	Digi-Key	732-4978-1-ND	0.18782	1	\$ 0.19
LED GREEN CLEAR 2V 0603	LED2	Wurth Electronics	150060VS75000	Digi-Key	732-4980-1-ND	0.18782	1	\$ 0.19
CONN R/A 20POS 3MM	P1, P4	Molex	43045-2021	Digi-Key	WM20137-ND	7.62	2	\$ 15.24
CONN R/A 14POS 3MM	P2	Molex	43045-1421	Digi-Key	WM14571-ND	5.53	1	\$ 5.53
CONN R/A 16POS 3MM	P3	Molex	4304516221	Digi-Key	WM14573-ND	6.14	1	\$ 6.14
CONN 2POS DURA-CLIK 0.079"	P5, P6	Molex	5023520200	Digi-Key	WM7169CT-ND	1.69	2	\$ 3.38
MOSFET DUAL P-CH 40V 8A 3.2W 8-SOIC	Q1, Q2, Q3, Q4, Q5, Q6	Vishay Siliconix	SI4909DY-T1-GE3	Digi-Key	SI4909DY-T1-GE3CT-ND	1.37	6	\$ 8.21
RES 4.7K OHM 1% 1/10W 0603	R1, R3, R4, R5	Yageo Phycomp	RC0603FR-074K7L	Digi-Key	311-4.70KHRCT-ND	0.13416	4	\$ 0.54
RES 100K OHM 5% 1/8W 0603	R2	Yageo	RC0603JR-07100KL	Digi-Key	311-100KGRCT-ND	0.13416	1	\$ 0.13
RES 100 OHM 1% 1/10W 0603	R6, R43, R55	Yageo	RC0603FR-07100RL	Digi-Key	311-100HRCT-ND	0.13416	3	\$ 0.40
RES 0.0 OHM 1/4W 0603	R10	Vishay Dale	CRCW0603000Z0EAHP	Digi-Key	541-0.0SBCT-ND	0.20124	1	\$ 0.20
RES 1.4k OHM 1% 1/10W 0603	R13	Yageo	RC0603FR-071K4L	Digi-Key	311-1.40KHRCT-ND	0.13416	1	\$ 0.13
RES 604 OHM 1% 1/10W 0603	R14	Yageo	RC0603FR-07604RL	Digi-Key	311-604HRCT-ND	0.13416	1	\$ 0.13
RES 33 OHM 5% 1.5W 2512	2, R23, R24, R25, R26, R28, R29, R30, R31, R	Stackpole Electronics	RPC2512JT33R0	Digi-Key	RPC2512JT33R0CT-ND	0.542	24	\$ 13.01
RES ARRAY 3.3K OHM 2% 16SOIC	R27, R40	Bourns	4816P-1-332LF	Digi-Key	4816P-1-332LFCT-ND	1.76	2	\$ 3.51
RES ARRAY 100 OHM 0.5% 4RES 1206	R44, R45, R46	Vishay	ACASA100021000P100	Digi-Key	ACASA100/100-2CT-ND	0.99278	3	\$ 2.98
RES 62 OHM 0.1% 1/10W 0603	R47, R48, R49, R50	Panasonic	ERA3AE8620V	Digi-Key	P62DBCT-ND	0.46956	4	\$ 1.88
RES ARRAY 10K OHM 0.1% 4RES 1206	R51, R52, R53, R54, R56	Vishay Beyschlag	ACASA1002S1002P100	Digi-Key	749-1023-1-ND	1.07	5	\$ 5.37
RES 820 OHM 5% 1/4W 0603	R57	Rohm	ESR03EPJ821	Digi-Key	RHM820DCT-ND	0.13416	1	\$ 0.13
RES 10K OHM 1% 1/10W 0603	R58	Yageo Phycomp	RC0603FR-0710KL	Digi-Key	311-10.0KHRCT-ND	0.13416	1	\$ 0.13
RES 191K OHM 1% 1/10W 0603	R59	Yageo	RC0603FR-07191KL	Digi-Key	311-191KHRCT-ND	0.13416	1	\$ 0.13
RES 255K OHM 1% 1/10W 0603	R60	Yageo	RC0603FR-07255KL	Digi-Key	311-255KHRCT-ND	0.13416	1	\$ 0.13
RES 39.2K OHM 1% 1/10W 0603	R61	Yageo	RC0603FR-0739K2L	Digi-Key	311-39.2KHRCT-ND	0.13416	1	\$ 0.13
NTC THERMISTOR 10K 1% BEAD	RT1	Murata	NXRT15XH103FA1B030	Digi-Key	490-8601-ND	0.93911	1	\$ 0.94
IC MONITOR BATT STACK 48SSOP	U1	Analog Devices / Linear Technology	LTC6804IG-1#PBF	Digi-Key	LTC6804IG-1#PBF-ND	28.47	1	\$ 28.47
IC OP AMP GEN PURPOSE RR 5.5MHZ SOT-23-5	U2	Texas Instruments	OPA376AQDBVRQ1	Digi-Key	296-36701-1-ND	2.87	1	\$ 2.87
IC OP AMP GEN PURPOSE RR 10MHZ SOT-23-5	U3	Texas Instruments	TLV316QDBVRQ1	Digi-Key	296-45323-1-ND	1.14	1	\$ 1.14
IC 32x1 Multiplexer ADG731BCPZ	U4	Analog Devices	ADG731BSUZ	Digi-Key	ADG731BSUZ-ND	14.31	1	\$ 14.31
IC REG BUCK ADJ 0.1A 10UMAX	U5	Maxim	MAX17552AUB+	Digi-Key	MAX17552AUB+-ND	2.84	1	\$ 2.84
IC REG LDO 5V 0.1A SOT23-5	U6	STMicroelectronics	LD2981CM50TR	Digi-Key	497-7787-1-ND	0.87203	1	\$ 0.87
IC PULSE XFMR 1CT:1CT 350uH SMD	XFMR1	Bourns	PT61018AAPEL-S	Digi-Key	PT61018AAPEL-SCT-ND	5.14	1	\$ 5.14
							Total:	\$ 138.79







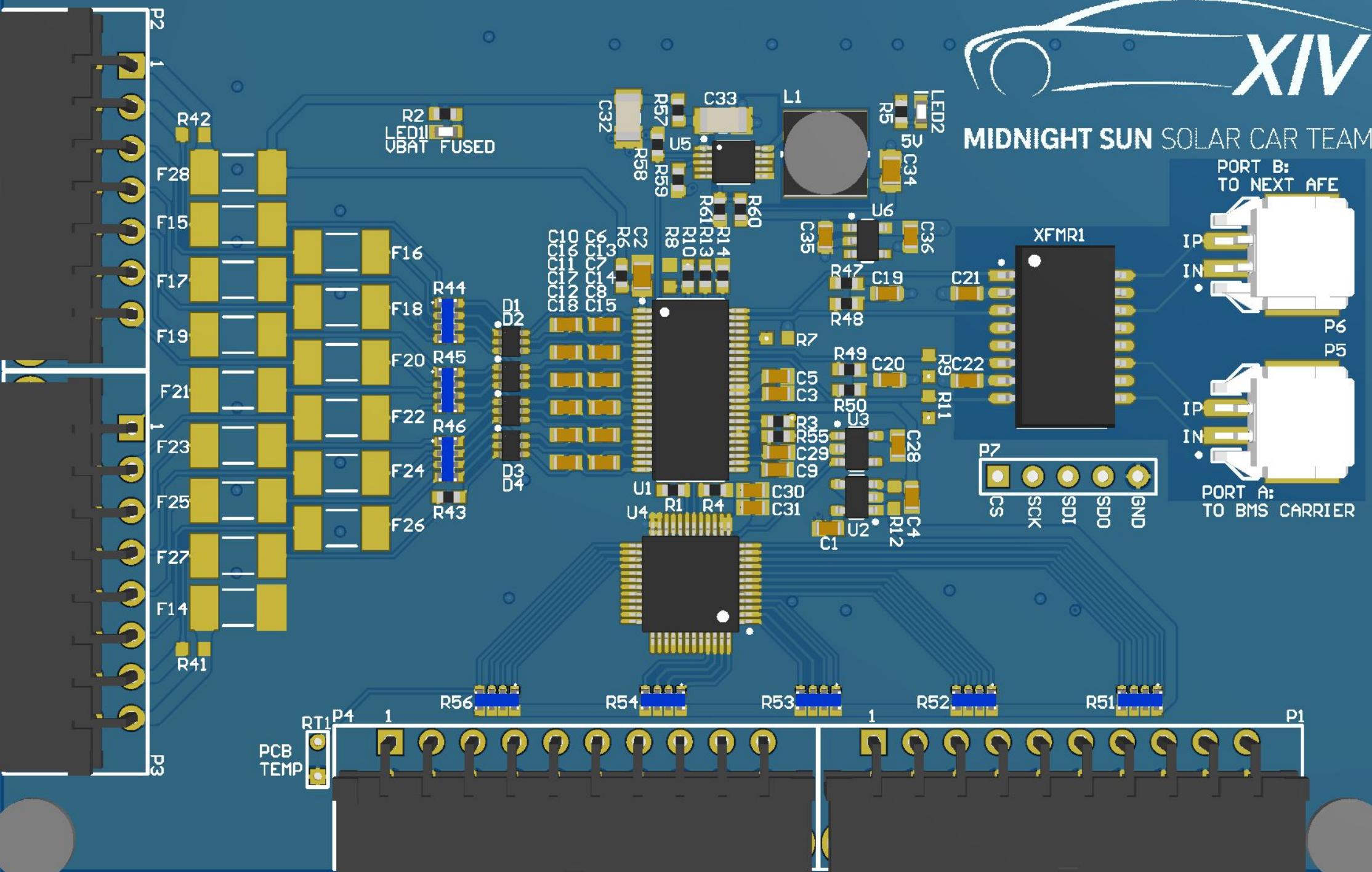


MSXIV BMS AFE  
REV 1.0

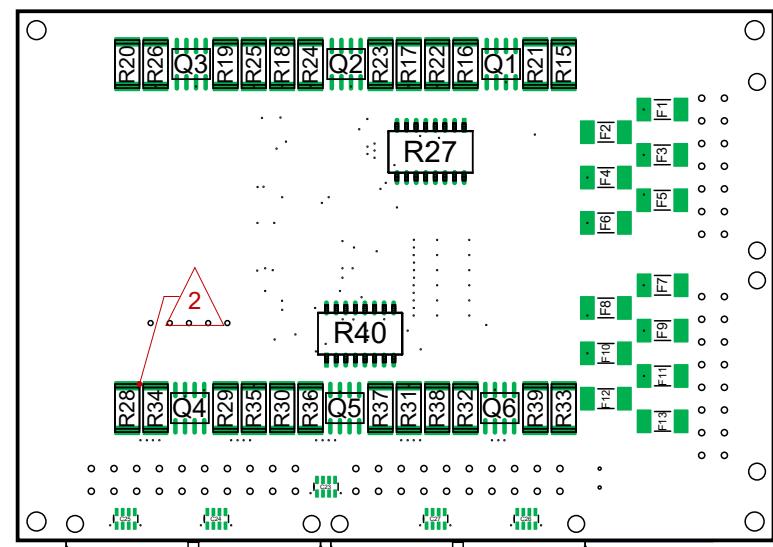
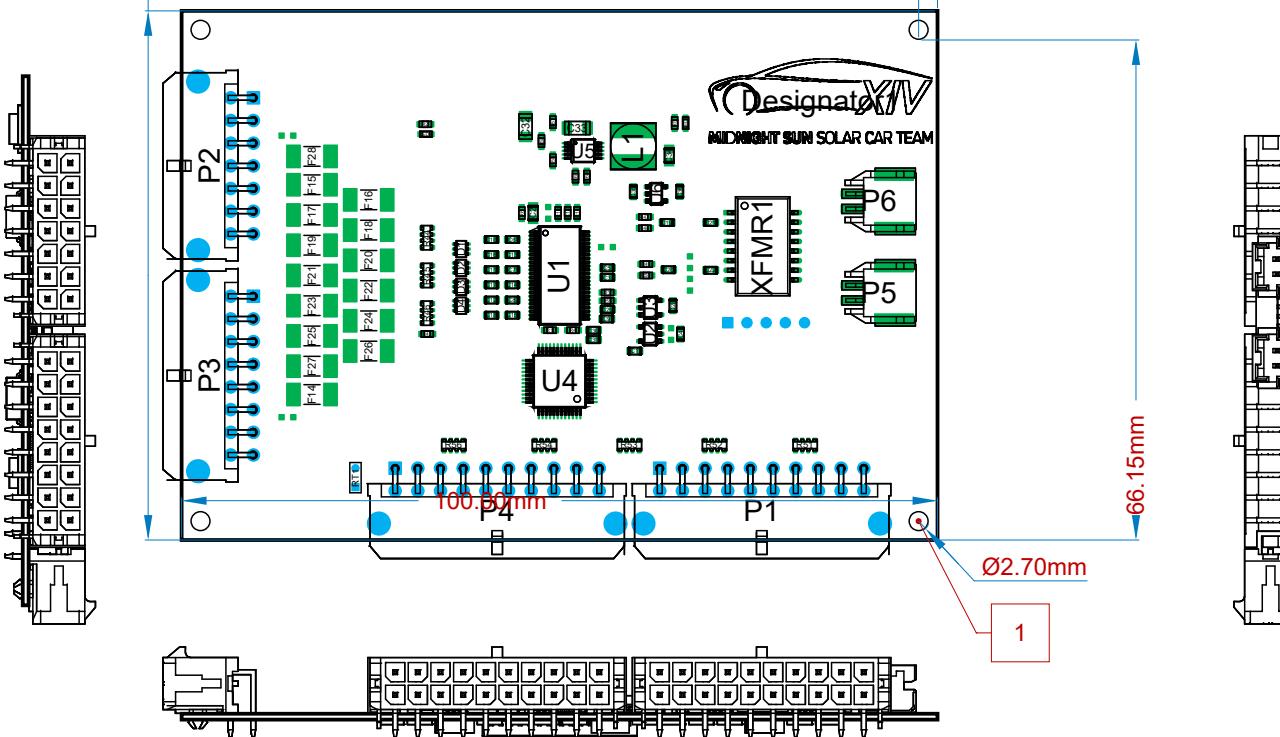


MIDNIGHT SUN SOLAR CAR TEAM

PORT B:  
TO NEXT AFE



70.00mm

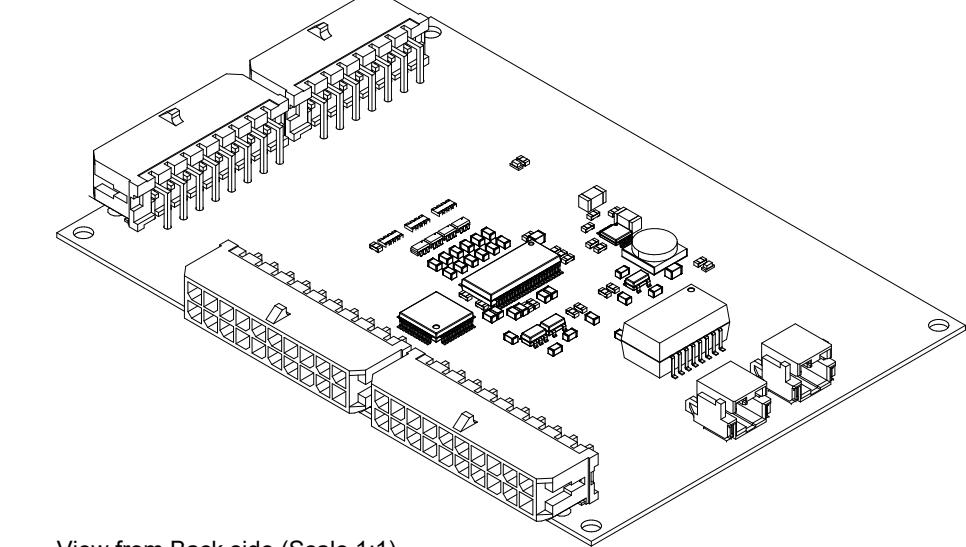


THE INFORMATION CONTAINED IN  
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PROPERTY OF  
Midnight Sun Solar Car Team. ANY  
REPRODUCTION IN PART OR AS A  
WHOLE WITHOUT THE WRITTEN  
PROPRIETARY AND CONFIDENTIAL

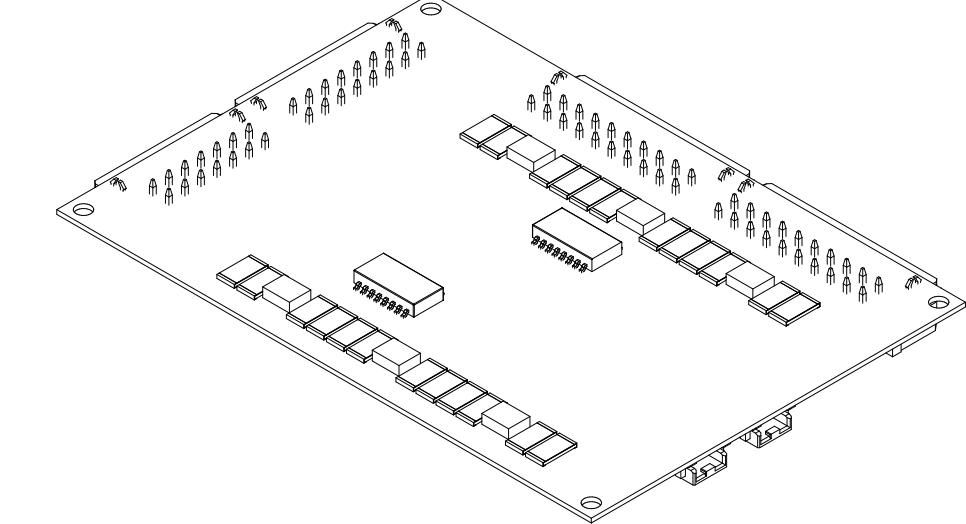
**1** Use with M2.5 screws

**2** Keep at least 5mm clearance to the surface below for cooling. Keep out area size is approximate.

View from Front side (Scale 1:1)



View from Back side (Scale 1:1)



		UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	NAME DRAWN Taping Li CHECKED ENG APPR. MFG APPR.	DATE 2020-03-01	Midnight Sun Solar Car Team	
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.	COMMENTS:		
		MATERIAL			SIZE	DWG. NO.
	NEXT ASSY	USED ON	FINISH		MS40005	
		APPLICATION	DO NOT SCALE DRAWING		SCALE: 1:1	WEIGHT:
					SHEET 1 OF 1	

## Electrical Rules Check Report

Class	Document	Message
Warning	BMS AFE - AFE.SchDoc	3V0_VREF2 contains Output Port and Unspecified Sheet Entry objects (Port 3V0_VREF2, Sheet Entry BMS AFE - AFE-3V0_VREF2(Passive)).
Warning	BMS AFE - Regulator.SchDoc	FUSED_VBAT - contains Input Pin and Unspecified Port objects (Pin U3-6, Port FUSED_VBAT).
Warning	BMS AFE - Thermistors.SchDoc	Net AFE_TEMP_MUX_OUTPUT has no driving source (Pin U5-3, Pin U6-43)
Warning	BMS AFE - Top Sheet.SchDoc	Net IB_N has no driving source (Pin R48-2, Pin U1-47, Pin XFMR1-3)
Warning	BMS AFE - Top Sheet.SchDoc	Net IB_P has no driving source (Pin R47-1, Pin U1-48, Pin XFMR1-1)
Warning	BMS AFE - AFE.SchDoc	Net NetR8_2 has no driving source (Pin R8-2, Pin R10-1, Pin U1-40)
Warning	BMS AFE - AFE.SchDoc	Net NetR13_1 has no driving source (Pin R13-1, Pin U1-45)
Warning	BMS AFE - AFE.SchDoc	Net NetR13_2 has no driving source (Pin R13-2, Pin R14-1, Pin U1-46)

## Design Rules Verification Report

Filename : C:\Users\lhawk\Documents\Midnight Sun\hardware\MSXIV\_BMS\_AFE\AFE.PcbD

Warnings 0

Rule Violations 14

Warnings	
Total	0

Rule Violations	
Clearance Constraint (Gap=0.152mm) (All),(All)	0
Clearance Constraint (Gap=0.6mm) (Disabled)(InNetClass('HV_IN')),,(InNet('+6V'))	0
Clearance Constraint (Gap=0.6mm) (Disabled)(InNetClass('HV_IN')),,(InNet('+5V'))	0
Clearance Constraint (Gap=0.6mm) (Disabled)(InNetClass('HV_IN')),,(InNet('GND'))	0
Short-Circuit Constraint (Allowed=No) (All),(All)	0
Un-Routed Net Constraint ( All )	0
Modified Polygon (Allow modified: No), (Allow shelved: No)	0
Width Constraint (Min=0.2mm) (Max=2.54mm) (Preferred=0.35mm) (All)	0
Power Plane Connect Rule(Relief Connect)(Expansion=0.508mm) (Conductor Width=0.254mm) (Air Gap=0.152mm)	0
Hole Size Constraint (Min=0.025mm) (Max=100mm) (All)	0
Hole To Hole Clearance (Gap=0.254mm) (All),(All)	0
Net Antennae (Tolerance=0mm) (All)	0
Board Clearance Constraint (Gap=0mm) (All)	14
Height Constraint (Min=0mm) (Max=25.4mm) (Prefered=12.7mm) (All)	0
Total	14

Board Clearance Constraint (Gap=0mm) (All)	
Board Outline Clearance(Outline Edge): (0.152mm < 0.295mm) Between Board Edge And Text "CELL 12" (5.5mm,58.25mm) on Bottom Overlay	
Board Outline Clearance(Outline Edge): (0.1mm < 0.295mm) Between Board Edge And Text "THERMISTORS" (99.75mm,9mm) on Bottom Overlay	
Board Outline Clearance(Outline Edge): (0.153mm < 0.295mm) Between Board Edge And Track (0.28mm,36.3mm)(10.7mm,36.3mm) on Top Overlay	
Board Outline Clearance(Outline Edge): (0.153mm < 0.295mm) Between Board Edge And Track (0.28mm,36.45mm)(0.28mm,62.55mm) on Top Overlay	
Board Outline Clearance(Outline Edge): (0.153mm < 0.295mm) Between Board Edge And Track (0.28mm,36.45mm)(10.7mm,36.45mm) on Top Overlay	
Board Outline Clearance(Outline Edge): (0.153mm < 0.295mm) Between Board Edge And Track (0.28mm,62.55mm)(10.7mm,62.55mm) on Top Overlay	
Board Outline Clearance(Outline Edge): (0.153mm < 0.295mm) Between Board Edge And Track (0.28mm,7.2mm)(0.28mm,36.3mm) on Top Overlay	
Board Outline Clearance(Outline Edge): (0.153mm < 0.295mm) Between Board Edge And Track (0.28mm,7.2mm)(10.7mm,7.2mm) on Top Overlay	
Board Outline Clearance(Outline Edge): (0.153mm < 0.295mm) Between Board Edge And Track (24.2mm,0.28mm)(24.2mm,10.7mm) on Top Overlay	
Board Outline Clearance(Outline Edge): (0.153mm < 0.295mm) Between Board Edge And Track (24.2mm,0.28mm)(59.3mm,0.28mm) on Top Overlay	
Board Outline Clearance(Outline Edge): (0.153mm < 0.295mm) Between Board Edge And Track (59.2mm,0.28mm)(59.2mm,10.7mm) on Top Overlay	
Board Outline Clearance(Outline Edge): (0.153mm < 0.295mm) Between Board Edge And Track (59.2mm,0.28mm)(94.3mm,0.28mm) on Top Overlay	
Board Outline Clearance(Outline Edge): (0.153mm < 0.295mm) Between Board Edge And Track (59.3mm,0.28mm)(59.3mm,10.7mm) on Top Overlay	
Board Outline Clearance(Outline Edge): (0.153mm < 0.295mm) Between Board Edge And Track (94.3mm,0.28mm)(94.3mm,10.7mm) on Top Overlay	