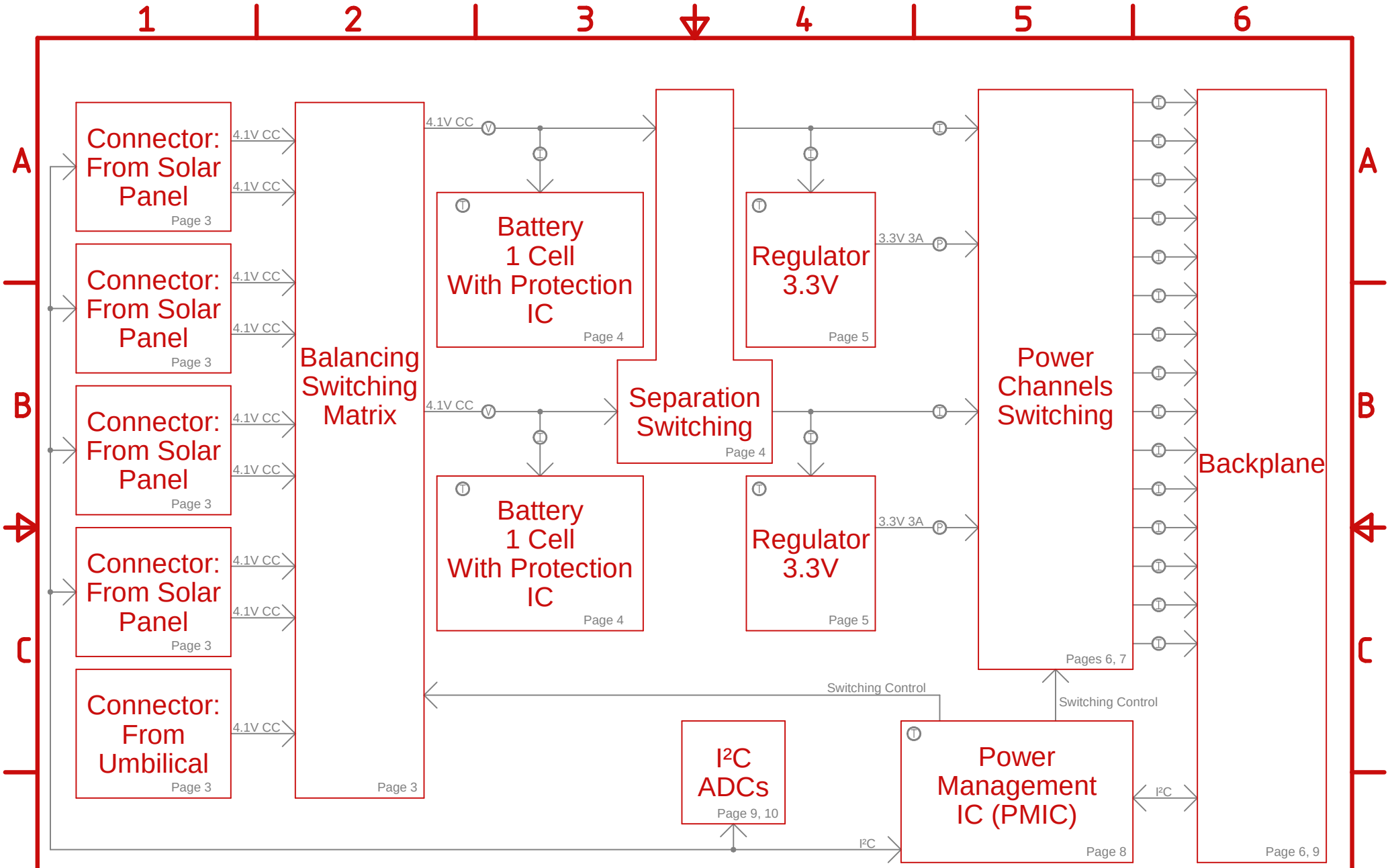


Page 1: Block Diagram
Page 2: Power Rails
Page 3: Input Switching Matrix
Page 4: Batteries
Page 5: 3.3V Regulation
Page 6: Output Switching Matrix
Page 7: Output Switching Matrix
Page 8: PMIC
Page 9: Backplane Digital & ADCs
Page 10: ADCs
Page 11: Mechanical Layout

Cougs in Space EE

Title:	Block Diagram	Size:	A
Project:	CougSat-1: EPS	SKU:	68-0002
Designer:	Bradley L. Davis	Rev:	2.1.2
Date:	7/22/2018 1:27 PM	Page:	1/11

Solar Panel 0
Solar Panel 1
Solar Panel 2
Solar Panel 3
EPS Heater 0
EPS Heater 1
Deployables Release

PV_3.3V-0: 1mA
PV_3.3V-1: 1mA
PV_3.3V-2: 1mA
PV_3.3V-3: 1mA
PR_BH-0: 250mA
PR_BH-1: 250mA
PR_DEPLOY: 2A

Switching

PR_3.3V-0: 20mA
PR_3.3V-1: 60mA
PR_3.3V-2: 20mA
PR_3.3V-3: 45mA
PR_3.3V-4: 55mA
PR_3.3V-5: 90mA
PR_3.3V-6: 105mA
PR_BATT-0: 300mA
PR_BATT-1: 400mA

IHU
IHU: SD Card
ADCS
ADCS: IMUs
ADCS: GPS
IFJR & SD Card
Comms & Radios
ADCS: Magnetorquers
Comms: TX Amplifier

Satellite Bus

CougSat-1 Payload

PR_3.3V-7: 50mA
PR_3.3V-8: 390mA
PR_3.3V-9: 25mA
PR_3.3V-10: 15mA
PR_3.3V-11: 390mA
PR_3.3V-12: 0mA
PR_BATT-2: 250mA
PR_BATT-3: 0mA
PR_BATT-4: 0mA
PR_BATT-5: 0mA
PR_BATT-6: 0mA

Payload: 0 — Germination Lighting
Payload: 1 — Germination Camera
Payload: 2 — Germination Sensors
Payload: 4 — Ionizing Radiation Sensor
Payload: 5 — Ground Camera
Payload: 6 — Unused
Payload: 7 — Germination Heater
Payload: 8 — Unused
Payload: 9 — Unused
Payload: 10 — Unused
Payload: 11 — Unused

Note: Each power rail channel (PR_) is rated for 1A
PR_DEPLOY is rated for 2A
Currents shown are the expected consumption

Umbilical Charging
UMB_IN

Solar Panels
PV_IN-0
PV_IN-1
PV_IN-2
PV_IN-3
PV_IN-4
PV_IN-5
PV_IN-6
PV_IN-7

Note: Each cell is 1W
MPPT ICs output (PV_IN):
CV 4.1V
CC 300mA

Note: Umbilical charger output (UMB_IN):
CV 4.1V
CC 1A

Switching
Switching

VIN-A
VIN-B

Battery A
Battery B

VBATT-A
VBATT-B

Note: Each battery can output 4A continuously

Note: Each SMPS can output 3A continuously

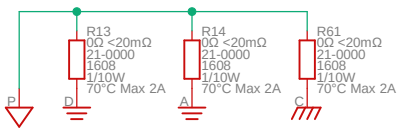
3.3V SMPS A
3.3V SMPS B

3.3V-A
3.3V-B

Power ORing

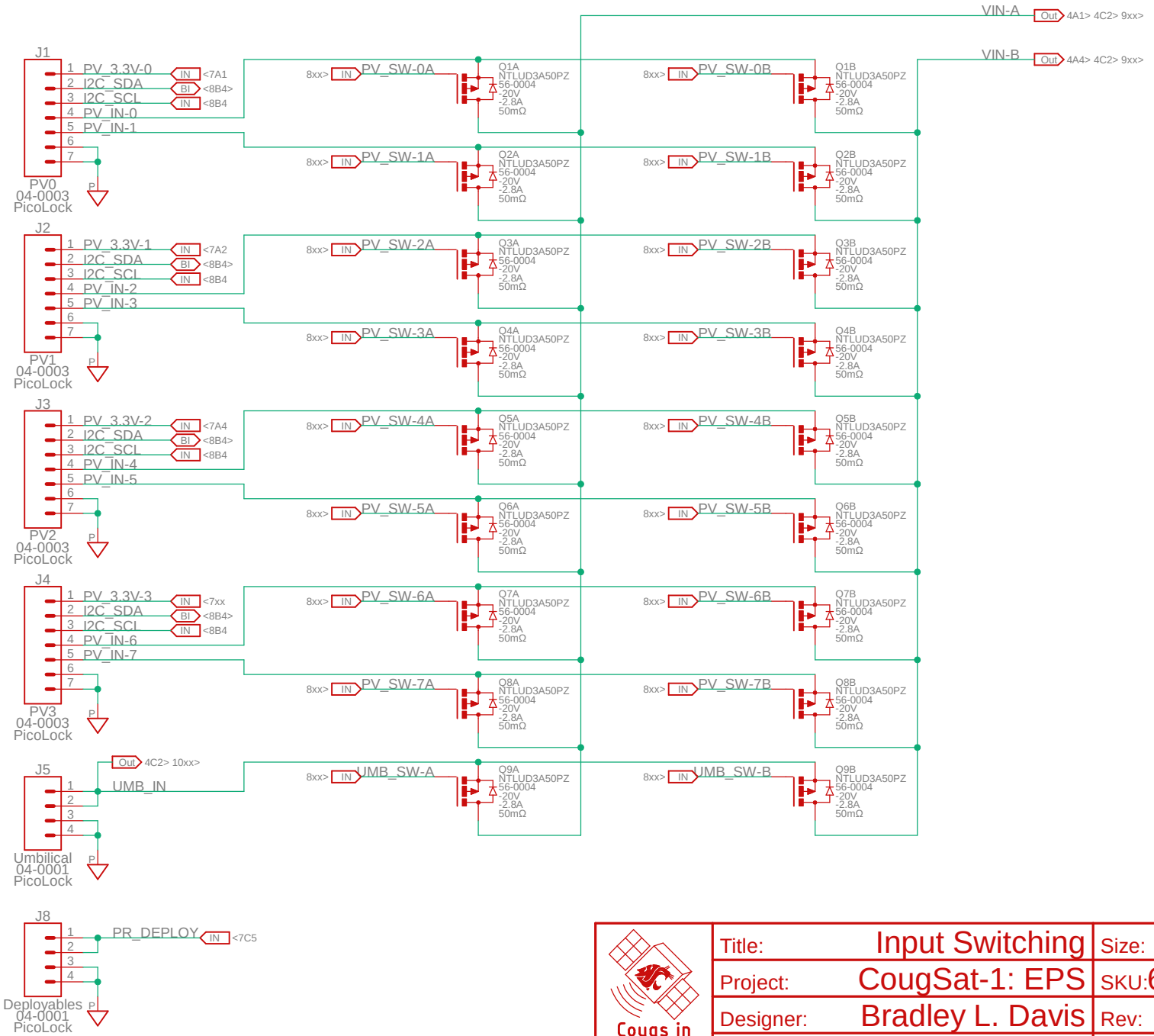
3.3V (Always on): 30mA

EPS



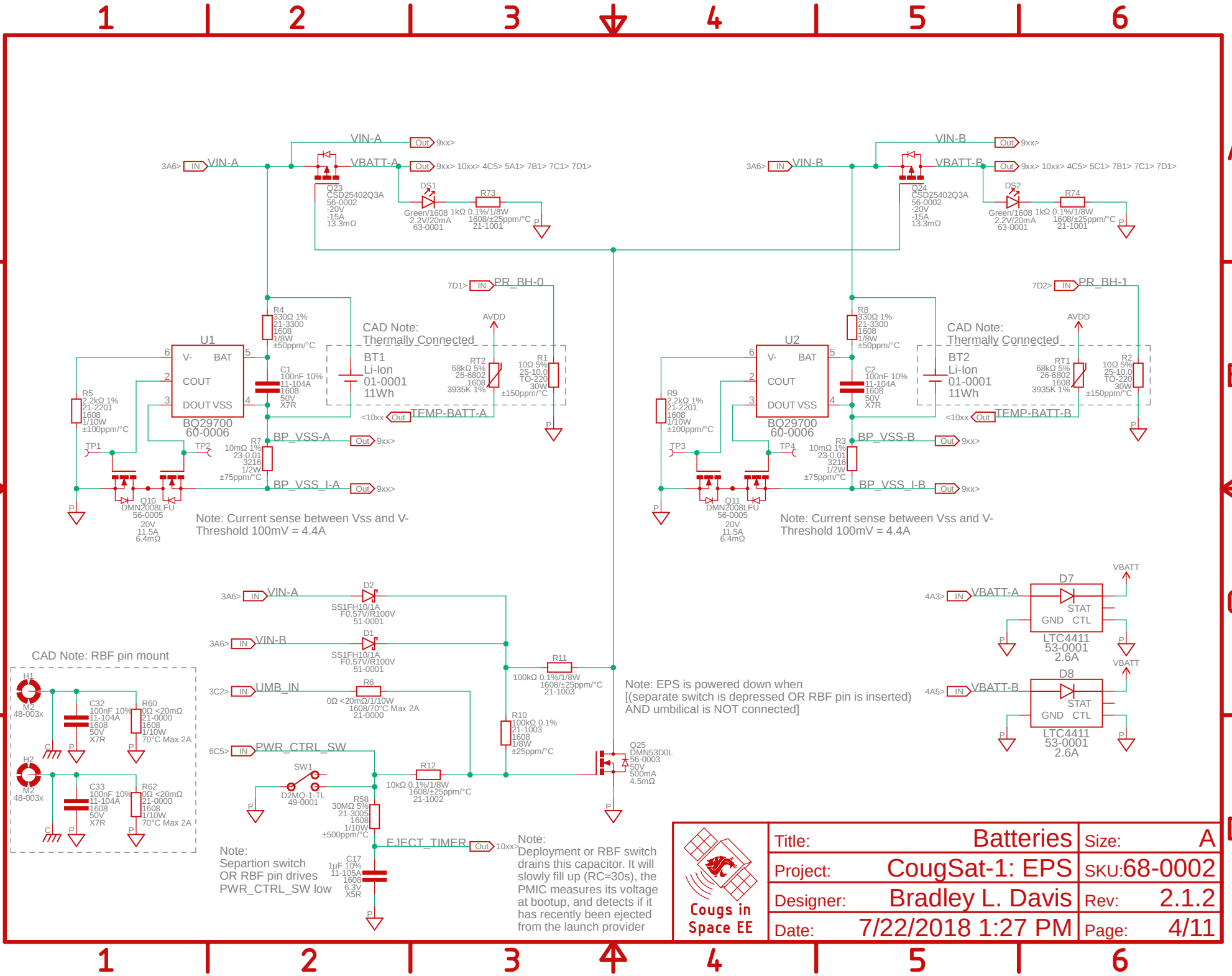
Cougs in Space EE

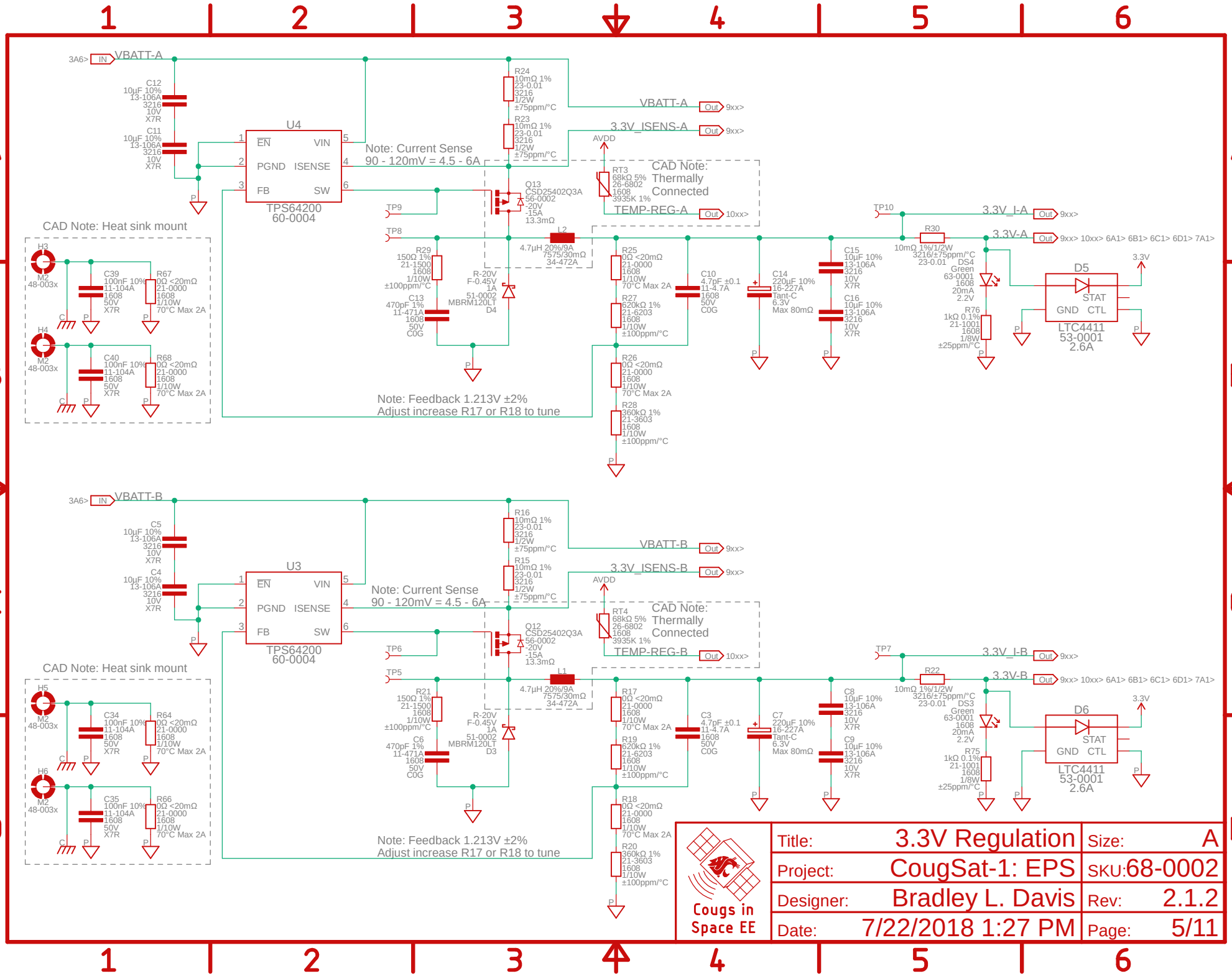
Title:	Power Rails	Size:	A
Project:	CougSat-1: EPS	SKU:	68-0002
Designer:	Bradley L. Davis	Rev:	2.1.2
Date:	7/22/2018 1:27 PM	Page:	2/11

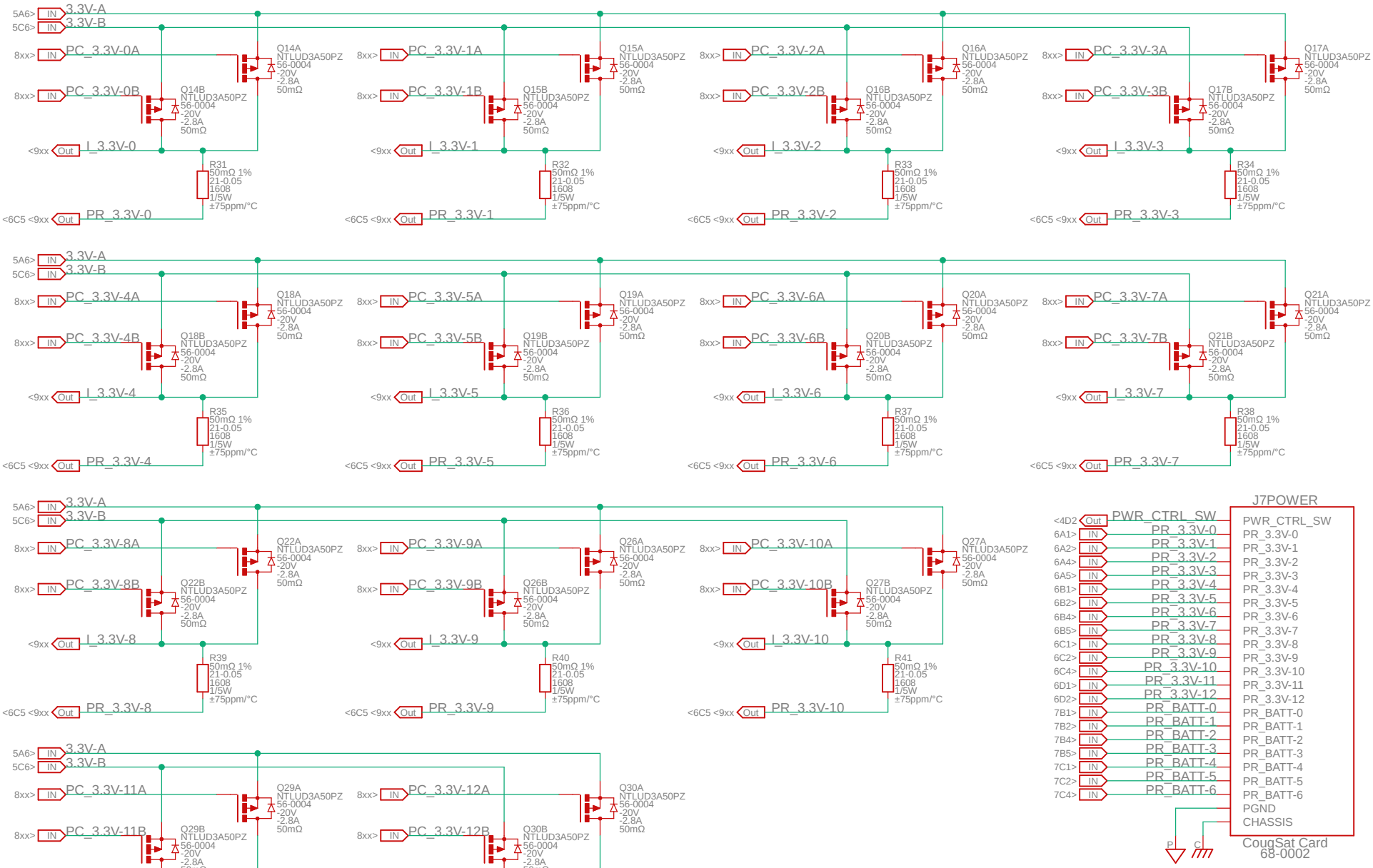


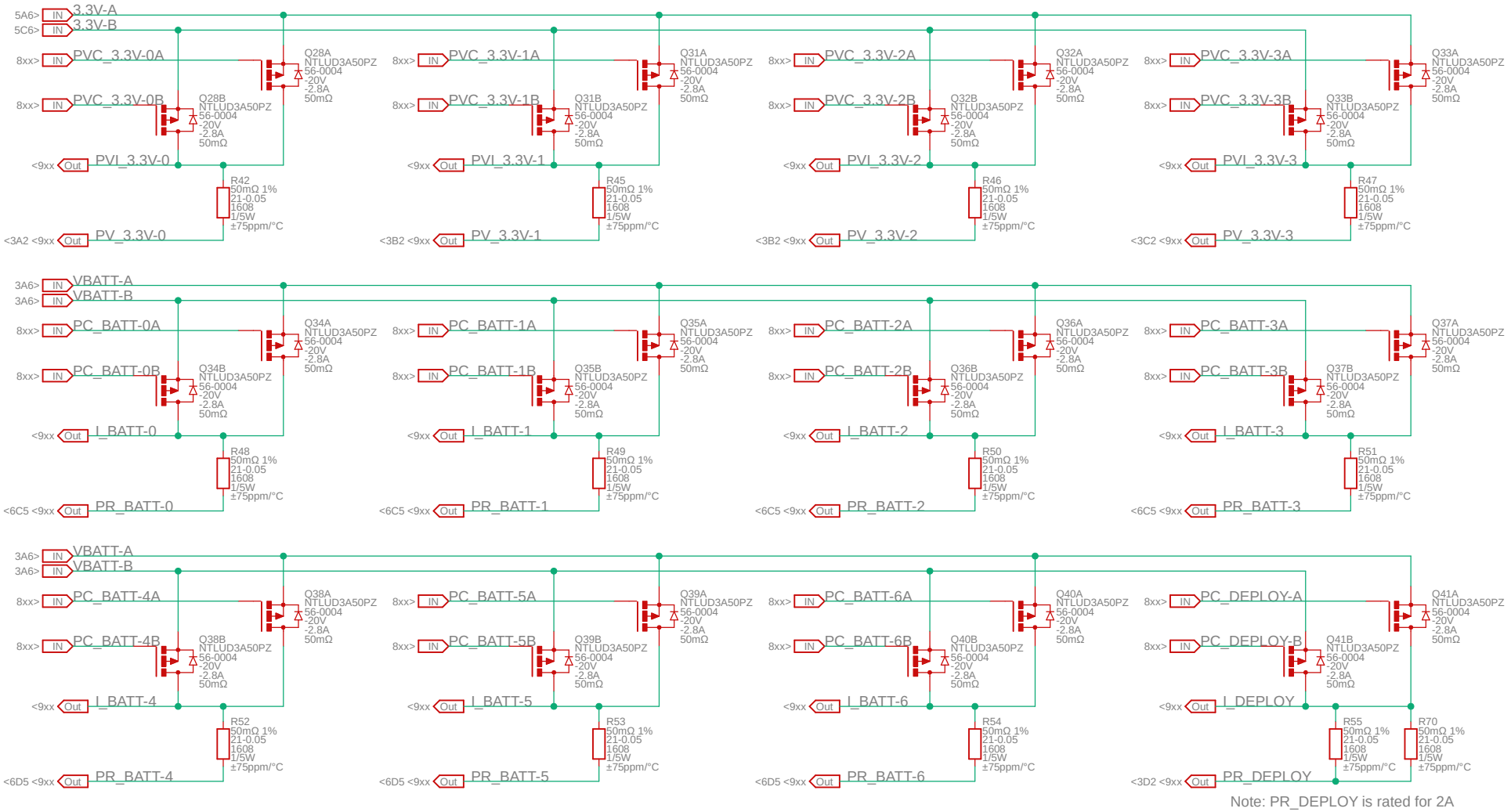
Cougs in Space EE

Title:	Input Switching	Size:	A
Project:	CougSat-1: EPS	SKU:	68-0002
Designer:	Bradley L. Davis	Rev:	2.1.2
Date:	7/22/2018 1:27 PM	Page:	3/11


VIN-A
VBATT-A
Q23 CSD25402Q3A 56-0002 -20V -15A 13.3mΩ
DS1 Green/1608 2.2V/20mA 63-0001
R73 1kΩ 0.1%/1/8W 1608/±25ppm/°C 21-1001
PR_BH-0
AVDD
U1 BQ29700 60-0006
R4 330Ω 1% 21-3300 1608 1/8W ±50ppm/°C
R5 2.2kΩ 1% 21-2201 1608 1/10W ±100ppm/°C
C1 100nF 10% 11-104A 1608 50V X7R
BT1 Li-Ion 01-0001 11Wh
CAD Note: Thermally Connected
RT2 68kΩ 5% 26-6802 1608 3935K 1%
R1 10Ω 5% 25-10.0 TO-220 30W ±150ppm/°C
TEMP-BATT-A
BP_VSS-A
R7 10mΩ 1% 23-0.01 3216 1/2W ±75ppm/°C
BP_VSS_I-A
TP1
TP2
Q10 DMN2008LFU 56-0005 20V 11.5A 6.4mΩ
Note: Current sense between Vss and V- Threshold 100mV = 4.4A
VIN-B
VBATT-B
Q24 CSD25402Q3A 56-0002 -20V -15A 13.3mΩ
DS2 Green/1608 2.2V/20mA 63-0001
R74 1kΩ 0.1%/1/8W 1608/±25ppm/°C 21-1001
PR_BH-1
U2 BQ29700 60-0006
R8 330Ω 1% 21-3300 1608 1/8W ±50ppm/°C
R9 2.2kΩ 1% 21-2201 1608 1/10W ±100ppm/°C
C2 100nF 10% 11-104A 1608 50V X7R
BT2 Li-Ion 01-0001 11Wh
CAD Note: Thermally Connected
RT1 68kΩ 5% 26-6802 1608 3935K 1%
R2 10Ω 5% 25-10.0 TO-220 30W ±150ppm/°C
TEMP-BATT-B
BP_VSS-B
R3 10mΩ 1% 23-0.01 3216 1/2W ±75ppm/°C
BP_VSS_I-B
TP3
TP4
Q11 DMN2008LFU 56-0005 20V 11.5A 6.4mΩ
Note: Current sense between Vss and V- Threshold 100mV = 4.4A
D2 SS1FH10/1A F0.57V/R100V 51-0001
D1 SS1FH10/1A F0.57V/R100V 51-0001
UMB_IN
R6 0Ω <20mΩ/1/10W 1608/70°C Max 2A 21-0000
PWR_CTRL_SW
SW1 D2MQ-1-TL 49-0001
R11 100kΩ 0.1%/1/8W 1608/±25ppm/°C 21-1003
R10 100kΩ 0.1% 21-1003 1608 1/8W ±25ppm/°C
R12 10kΩ 0.1%/1/8W 1608/±25ppm/°C 21-1002
Q25 DMN53D0L 56-0003 50V 500mA 4.5mΩ
R58 30MΩ 5% 21-3005 1608 1/10W ±500ppm/°C
EJECT_TIMER
C17 1µF 10% 11-105A 1608 6.3V X5R
Note: Separtion switch OR RBF pin drives PWR_CTRL_SW low
Note: Deployment or RBF switch drains this capacitor. It will slowly fill up (RC≈30s), the PMIC measures its voltage at bootup, and detects if it has recently been ejected from the launch provider
Note: EPS is powered down when [(separate switch is depressed OR RBF pin is inserted) AND umbilical is NOT connected]
CAD Note: RBF pin mount
H1 M2 48-003x
H2 M2 48-003x
C32 100nF 10% 11-104A 1608 50V X7R
C33 100nF 10% 11-104A 1608 50V X7R
R60 0Ω <20mΩ 21-0000 1608 1/10W 70°C Max 2A
R62 0Ω <20mΩ 21-0000 1608 1/10W 70°C Max 2A
D7 LTC4411 53-0001 2.6A
D8 LTC4411 53-0001 2.6A
VBATT
STAT
GND CTL
Cougs in Space EE
Title: Batteries
Size: A
Project: CougSat-1: EPS
SKU:68-0002
Designer: Bradley L. Davis
Rev: 2.1.2
Date: 7/22/2018 1:27 PM
Page: 4/11

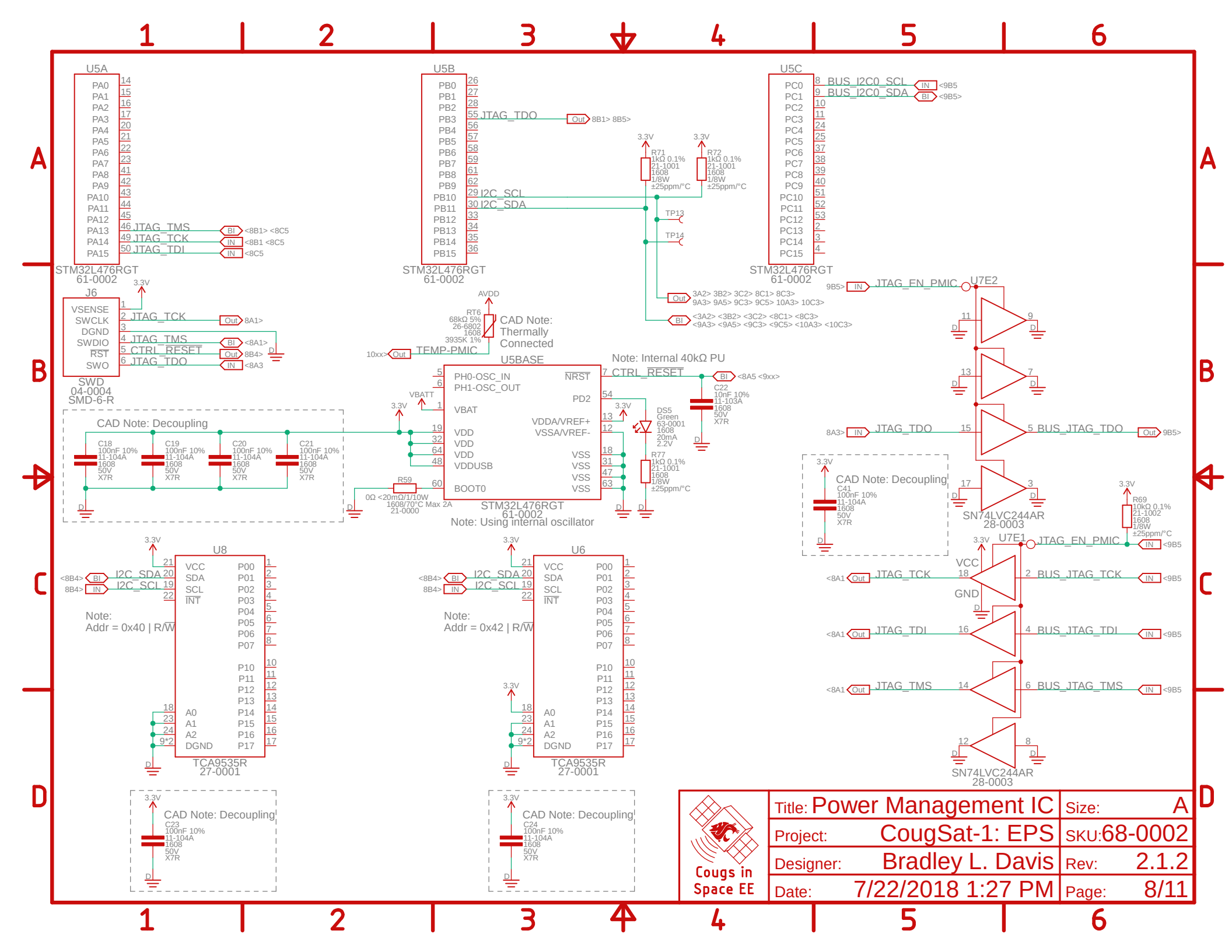

3A6> IN VBATT-A
C12 10µF 10% 13-106A 3216 10V X7R
C11 10µF 10% 13-106A 3216 10V X7R
U4
EN VIN
PGND ISENSE
FB SW
TPS64200 60-0004
R24 10mΩ 1% 23-0.01 3216 1/2W ±75ppm/°C
R23 10mΩ 1% 23-0.01 3216 1/2W ±75ppm/°C
VBATT-A Out 9xx>
3.3V_ISENS-A Out 9xx>
AVDD
Note: Current Sense
90 - 120mV = 4.5 - 6A
RT3 68kΩ 5% 26-6802 1608 3935K 1%
CAD Note: Thermally Connected
TEMP-REG-A Out 10xx>
Q13 CSD25402Q3A 56-0002 -20V -15A 13.3mΩ
TP9
TP8
L2 4.7µH 20%/9A 7575/30mΩ 34-472A
CAD Note: Heat sink mount
H3 M2 48-003x
H4 M2 48-003x
C39 100nF 10% 11-104A 1608 50V X7R
R67 0Ω <20mΩ 21-0000 1608 1/10W 70°C Max 2A
C40 100nF 10% 11-104A 1608 50V X7R
R68 0Ω <20mΩ 21-0000 1608 1/10W 70°C Max 2A
R29 150Ω 1% 21-1500 1608 1/10W ±100ppm/°C
C13 470pF 1% 11-471A 1608 50V C0G
R-20V F-0.45V 1A 51-0002 MBRM120LT D4
R25 0Ω <20mΩ 21-0000 1608 1/10W 70°C Max 2A
R27 620kΩ 1% 21-6203 1608 1/10W ±100ppm/°C
R26 0Ω <20mΩ 21-0000 1608 1/10W 70°C Max 2A
R28 360kΩ 1% 21-3603 1608 1/10W ±100ppm/°C
C10 4.7pF ±0.1 11-4.7A 1608 50V C0G
C14 220µF 10% 16-227A Tant-C 6.3V Max 80mΩ
C15 10µF 10% 13-106A 3216 10V X7R
C16 10µF 10% 13-106A 3216 10V X7R
TP10
R30 10mΩ 1%/1/2W 3216/±75ppm/°C 23-0.01 DS4
3.3V_I-A Out 9xx>
3.3V-A Out 9xx> 10xx> 6A1> 6B1> 6C1> 6D1> 7A1>
Green 63-0001 1608 20mA 2.2V
R76 1kΩ 0.1% 21-1001 1608 1/8W ±25ppm/°C
D5
STAT GND CTL
LTC4411 53-0001 2.6A
3.3V
Note: Feedback 1.213V ±2%
Adjust increase R17 or R18 to tune
3A6> IN VBATT-B
C5 10µF 10% 13-106A 3216 10V X7R
C4 10µF 10% 13-106A 3216 10V X7R
U3
EN VIN
PGND ISENSE
FB SW
TPS64200 60-0004
R16 10mΩ 1% 23-0.01 3216 1/2W ±75ppm/°C
R15 10mΩ 1% 23-0.01 3216 1/2W ±75ppm/°C
VBATT-B Out 9xx>
3.3V_ISENS-B Out 9xx>
AVDD
Note: Current Sense
90 - 120mV = 4.5 - 6A
RT4 68kΩ 5% 26-6802 1608 3935K 1%
CAD Note: Thermally Connected
TEMP-REG-B Out 10xx>
Q12 CSD25402Q3A 56-0002 -20V -15A 13.3mΩ
TP6
TP5
L1 4.7µH 20%/9A 7575/30mΩ 34-472A
CAD Note: Heat sink mount
H5 M2 48-003x
H6 M2 48-003x
C34 100nF 10% 11-104A 1608 50V X7R
R64 0Ω <20mΩ 21-0000 1608 1/10W 70°C Max 2A
C35 100nF 10% 11-104A 1608 50V X7R
R66 0Ω <20mΩ 21-0000 1608 1/10W 70°C Max 2A
R21 150Ω 1% 21-1500 1608 1/10W ±100ppm/°C
C6 470pF 1% 11-471A 1608 50V C0G
R-20V F-0.45V 1A 51-0002 MBRM120LT D3
R17 0Ω <20mΩ 21-0000 1608 1/10W 70°C Max 2A
R19 620kΩ 1% 21-6203 1608 1/10W ±100ppm/°C
R18 0Ω <20mΩ 21-0000 1608 1/10W 70°C Max 2A
R20 360kΩ 1% 21-3603 1608 1/10W ±100ppm/°C
C3 4.7pF ±0.1 11-4.7A 1608 50V C0G
C7 220µF 10% 16-227A Tant-C 6.3V Max 80mΩ
C8 10µF 10% 13-106A 3216 10V X7R
C9 10µF 10% 13-106A 3216 10V X7R
TP7
R22 10mΩ 1%/1/2W 3216/±75ppm/°C 23-0.01 DS3
3.3V_I-B Out 9xx>
3.3V-B Out 9xx> 10xx> 6A1> 6B1> 6C1> 6D1> 7A1>
Green 63-0001 1608 20mA 2.2V
R75 1kΩ 0.1% 21-1001 1608 1/8W ±25ppm/°C
D6
STAT GND CTL
LTC4411 53-0001 2.6A
3.3V
Note: Feedback 1.213V ±2%
Adjust increase R17 or R18 to tune
Cougs in Space EE
Title: 3.3V Regulation
Size: A
Project: CougSat-1: EPS
SKU:68-0002
Designer: Bradley L. Davis
Rev: 2.1.2
Date: 7/22/2018 1:27 PM
Page: 5/11

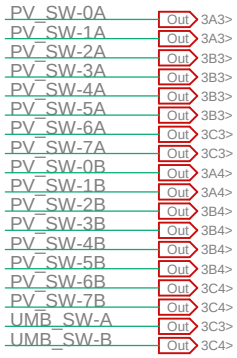

3.3V-A
3.3V-B
PC_3.3V-0A
PC_3.3V-0B
I_3.3V-0
PR_3.3V-0
Q14A NTLUD3A50PZ 56-0004 -20V -2.8A 50mΩ
Q14B NTLUD3A50PZ 56-0004 -20V -2.8A 50mΩ
R31 50mΩ 1% 21-0.05 1608 1/5W ±75ppm/°C
PC_3.3V-1A
PC_3.3V-1B
I_3.3V-1
PR_3.3V-1
Q15A NTLUD3A50PZ 56-0004 -20V -2.8A 50mΩ
Q15B NTLUD3A50PZ 56-0004 -20V -2.8A 50mΩ
R32 50mΩ 1% 21-0.05 1608 1/5W ±75ppm/°C
PC_3.3V-2A
PC_3.3V-2B
I_3.3V-2
PR_3.3V-2
Q16A NTLUD3A50PZ 56-0004 -20V -2.8A 50mΩ
Q16B NTLUD3A50PZ 56-0004 -20V -2.8A 50mΩ
R33 50mΩ 1% 21-0.05 1608 1/5W ±75ppm/°C
PC_3.3V-3A
PC_3.3V-3B
I_3.3V-3
PR_3.3V-3
Q17A NTLUD3A50PZ 56-0004 -20V -2.8A 50mΩ
Q17B NTLUD3A50PZ 56-0004 -20V -2.8A 50mΩ
R34 50mΩ 1% 21-0.05 1608 1/5W ±75ppm/°C
PC_3.3V-4A
PC_3.3V-4B
I_3.3V-4
PR_3.3V-4
Q18A NTLUD3A50PZ 56-0004 -20V -2.8A 50mΩ
Q18B NTLUD3A50PZ 56-0004 -20V -2.8A 50mΩ
R35 50mΩ 1% 21-0.05 1608 1/5W ±75ppm/°C
PC_3.3V-5A
PC_3.3V-5B
I_3.3V-5
PR_3.3V-5
Q19A NTLUD3A50PZ 56-0004 -20V -2.8A 50mΩ
Q19B NTLUD3A50PZ 56-0004 -20V -2.8A 50mΩ
R36 50mΩ 1% 21-0.05 1608 1/5W ±75ppm/°C
PC_3.3V-6A
PC_3.3V-6B
I_3.3V-6
PR_3.3V-6
Q20A NTLUD3A50PZ 56-0004 -20V -2.8A 50mΩ
Q20B NTLUD3A50PZ 56-0004 -20V -2.8A 50mΩ
R37 50mΩ 1% 21-0.05 1608 1/5W ±75ppm/°C
PC_3.3V-7A
PC_3.3V-7B
I_3.3V-7
PR_3.3V-7
Q21A NTLUD3A50PZ 56-0004 -20V -2.8A 50mΩ
Q21B NTLUD3A50PZ 56-0004 -20V -2.8A 50mΩ
R38 50mΩ 1% 21-0.05 1608 1/5W ±75ppm/°C
PC_3.3V-8A
PC_3.3V-8B
I_3.3V-8
PR_3.3V-8
Q22A NTLUD3A50PZ 56-0004 -20V -2.8A 50mΩ
Q22B NTLUD3A50PZ 56-0004 -20V -2.8A 50mΩ
R39 50mΩ 1% 21-0.05 1608 1/5W ±75ppm/°C
PC_3.3V-9A
PC_3.3V-9B
I_3.3V-9
PR_3.3V-9
Q26A NTLUD3A50PZ 56-0004 -20V -2.8A 50mΩ
Q26B NTLUD3A50PZ 56-0004 -20V -2.8A 50mΩ
R40 50mΩ 1% 21-0.05 1608 1/5W ±75ppm/°C
PC_3.3V-10A
PC_3.3V-10B
I_3.3V-10
PR_3.3V-10
Q27A NTLUD3A50PZ 56-0004 -20V -2.8A 50mΩ
Q27B NTLUD3A50PZ 56-0004 -20V -2.8A 50mΩ
R41 50mΩ 1% 21-0.05 1608 1/5W ±75ppm/°C
PC_3.3V-11A
PC_3.3V-11B
I_3.3V-11
PR_3.3V-11
Q29A NTLUD3A50PZ 56-0004 -20V -2.8A 50mΩ
Q29B NTLUD3A50PZ 56-0004 -20V -2.8A 50mΩ
R43 50mΩ 1% 21-0.05 1608 1/5W ±75ppm/°C
PC_3.3V-12A
PC_3.3V-12B
I_3.3V-12
PR_3.3V-12
Q30A NTLUD3A50PZ 56-0004 -20V -2.8A 50mΩ
Q30B NTLUD3A50PZ 56-0004 -20V -2.8A 50mΩ
R44 50mΩ 1% 21-0.05 1608 1/5W ±75ppm/°C
J7POWER
PWR_CTRL_SW
PR_3.3V-0
PR_3.3V-1
PR_3.3V-2
PR_3.3V-3
PR_3.3V-4
PR_3.3V-5
PR_3.3V-6
PR_3.3V-7
PR_3.3V-8
PR_3.3V-9
PR_3.3V-10
PR_3.3V-11
PR_3.3V-12
PR_BATT-0
PR_BATT-1
PR_BATT-2
PR_BATT-3
PR_BATT-4
PR_BATT-5
PR_BATT-6
PGND
CHASSIS
CougSat Card 68-0002
Cougs in Space EE
Title: Output Switching
Size: A
Project: CougSat-1: EPS
SKU:68-0002
Designer: Bradley L. Davis
Rev: 2.1.2
Date: 7/22/2018 1:27 PM
Page: 6/11

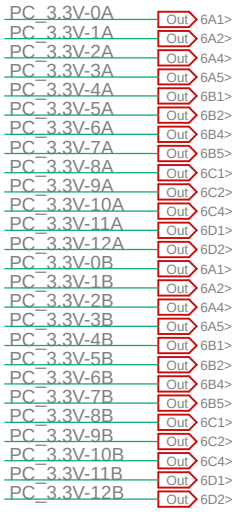


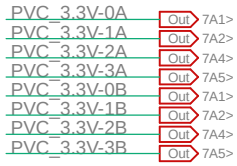
Cougs in Space EE

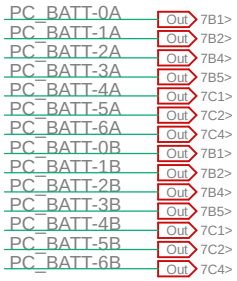
Title:	Output Switching	Size:	A
Project:	CougSat-1: EPS	SKU:	68-0002
Designer:	Bradley L. Davis	Rev:	2.1.2
Date:	7/22/2018 1:27 PM	Page:	7/11

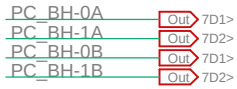

U5A
STM32L476RGT
61-0002
U5B
STM32L476RGT
61-0002
U5C
STM32L476RGT
61-0002
JTAG_TMS
JTAG_TCK
JTAG_TDI
JTAG_TDO
I2C_SCL
I2C_SDA
BUS_I2C0_SCL
BUS_I2C0_SDA
J6
SWD
04-0004
SMD-6-R
CTRL_RESET
TEMP-PMIC
CAD Note:
Thermally
Connected
U5BASE
STM32L476RGT
61-0002
Note: Internal 40kΩ PU
Note: Using internal oscillator
CAD Note: Decoupling
U8
TCA9535R
27-0001
Note:
Addr = 0x40 | R/W
U6
TCA9535R
27-0001
Note:
Addr = 0x42 | R/W
U7E2
U7E1
SN74LVC244AR
28-0003
JTAG_EN_PMIC
BUS_JTAG_TDO
BUS_JTAG_TCK
BUS_JTAG_TDI
BUS_JTAG_TMS
Cougs in
Space EE
Title: Power Management IC
Size: A
Project: CougSat-1: EPS
SKU:68-0002
Designer: Bradley L. Davis
Rev: 2.1.2
Date: 7/22/2018 1:27 PM
Page: 8/11

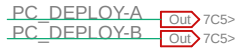








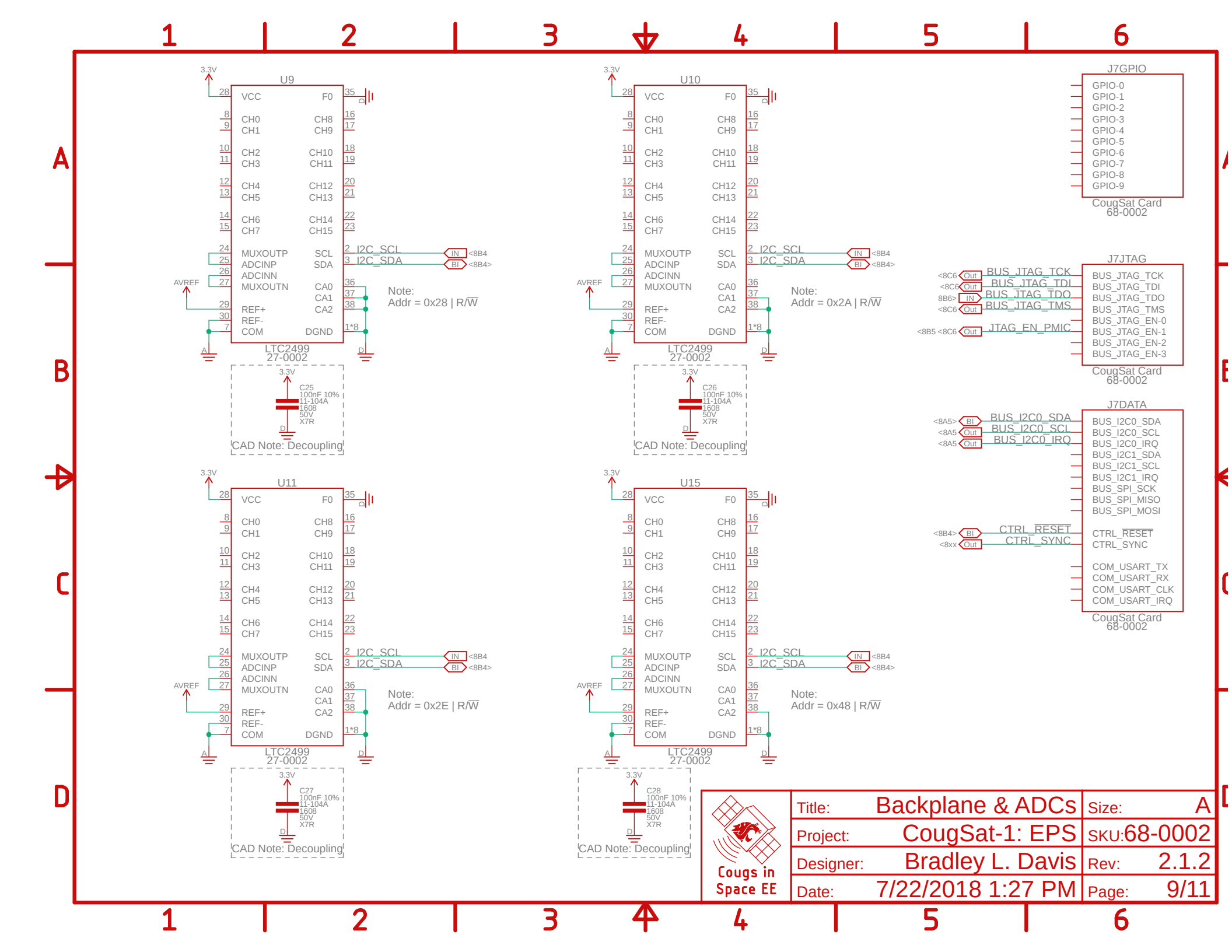


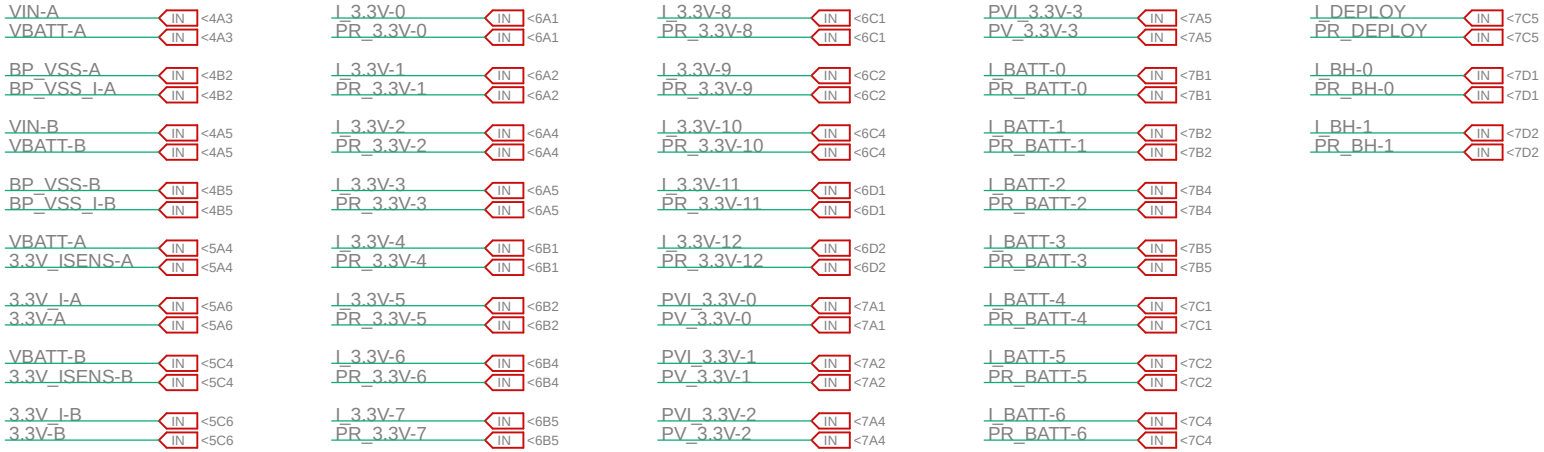


Note: Fix all off sheet designators linked to this sheet

Note: All signals above are GPIO, connect to any GPIO bank, whichever is best for routing

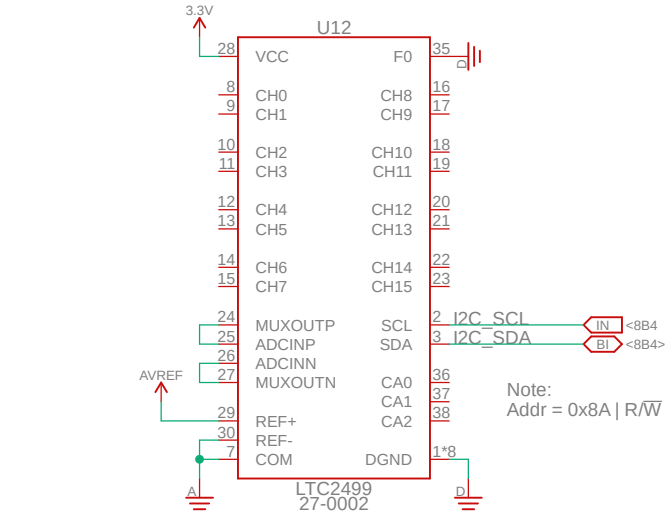
Note: Interrupt pins, place on different pin numbers (same port okay), ease for routing


U9
U10
U11
U15
LTC2499
27-0002
VCC
F0
CH0
CH1
CH2
CH3
CH4
CH5
CH6
CH7
CH8
CH9
CH10
CH11
CH12
CH13
CH14
CH15
MUXOUTP
ADCINP
ADCINN
MUXOUTN
REF+
REF-
COM
SCL
SDA
CA0
CA1
CA2
DGND
3.3V
AVREF
I2C_SCL
I2C_SDA
Note:
Addr = 0x28 | R/W
Addr = 0x2A | R/W
Addr = 0x2E | R/W
Addr = 0x48 | R/W
C25
C26
C27
C28
100nF 10%
11-104A
1608
50V
X7R
CAD Note: Decoupling
J7GPIO
GPIO-0
GPIO-1
GPIO-2
GPIO-3
GPIO-4
GPIO-5
GPIO-6
GPIO-7
GPIO-8
GPIO-9
CougSat Card
68-0002
J7JTAG
BUS_JTAG_TCK
BUS_JTAG_TDI
BUS_JTAG_TDO
BUS_JTAG_TMS
JTAG_EN_PMIC
BUS_JTAG_EN-0
BUS_JTAG_EN-1
BUS_JTAG_EN-2
BUS_JTAG_EN-3
J7DATA
BUS_I2C0_SDA
BUS_I2C0_SCL
BUS_I2C0_IRQ
BUS_I2C1_SDA
BUS_I2C1_SCL
BUS_I2C1_IRQ
BUS_SPI_SCK
BUS_SPI_MISO
BUS_SPI_MOSI
CTRL_RESET
CTRL_SYNC
COM_USART_TX
COM_USART_RX
COM_USART_CLK
COM_USART_IRQ
Cougs in Space EE
Title: Backplane & ADCs
Size: A
Project: CougSat-1: EPS
SKU:68-0002
Designer: Bradley L. Davis
Rev: 2.1.2
Date: 7/22/2018 1:27 PM
Page: 9/11

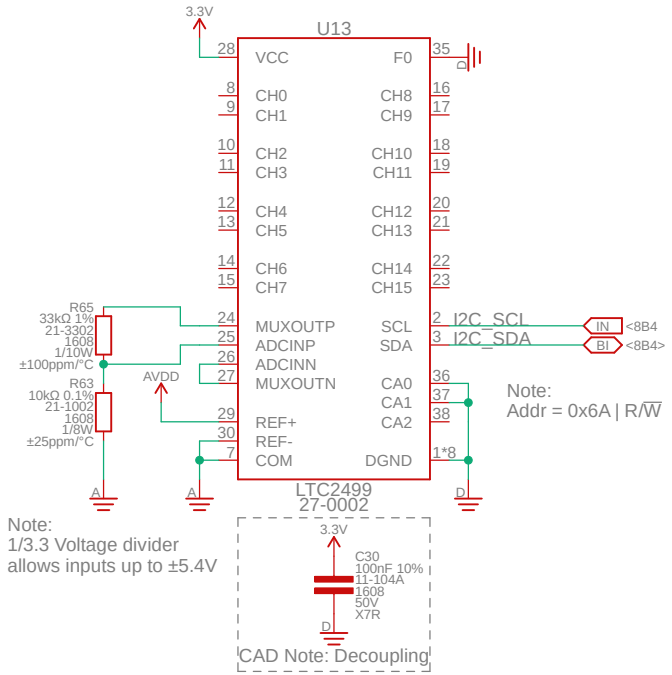


Note: Fix all off sheet designators linked to this sheet

Note: All signals above are DS, connect to any DS input, whichever is best for routing, including the DS adc on page 10

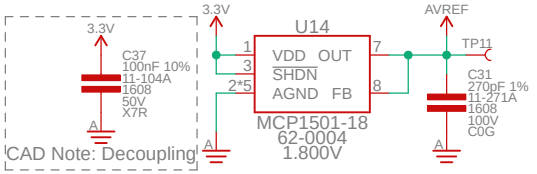


Note:
Addr = 0x8A | R/$\overline{W}$

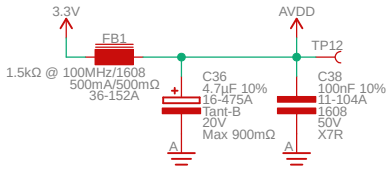


Note:
1/3.3 Voltage divider
allows inputs up to ±5.4V

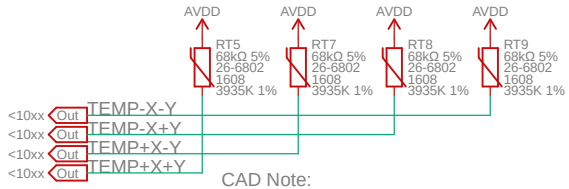
Note:
Addr = 0x6A | R/$\overline{W}$



Note:
Differential ADC voltage reference is 1.800V
At 16b, 13.73µV/LSB
Maximum input is ±900mV

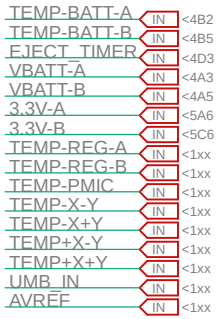


Note:
Single-Ended ADC voltage reference is 3.3V
At 16b, 25.18µV/LSB
Maximum input is ±1.65V



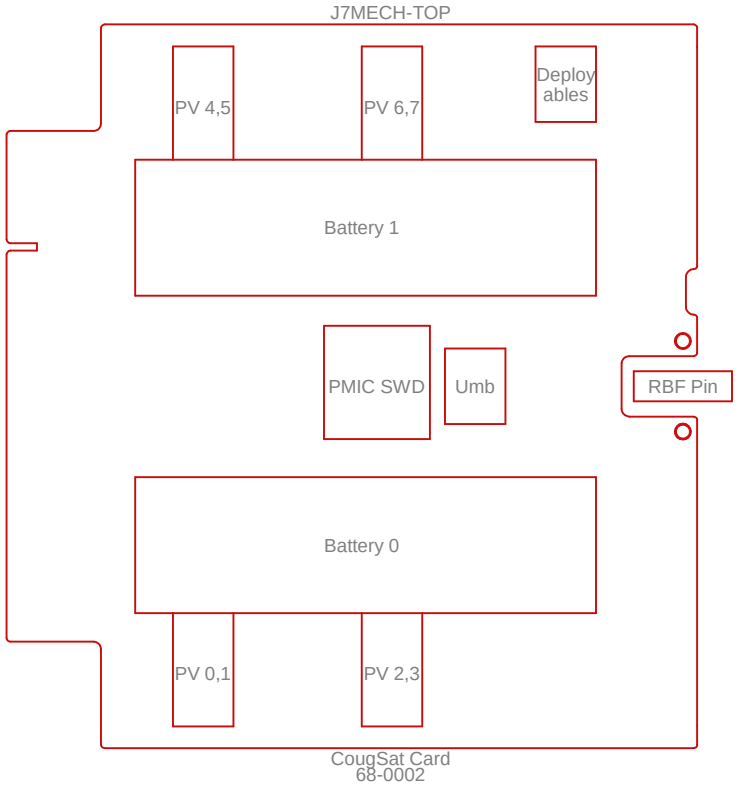
CAD Note:
Place in the corner of the PCB
that matches the connected
signal name, top side

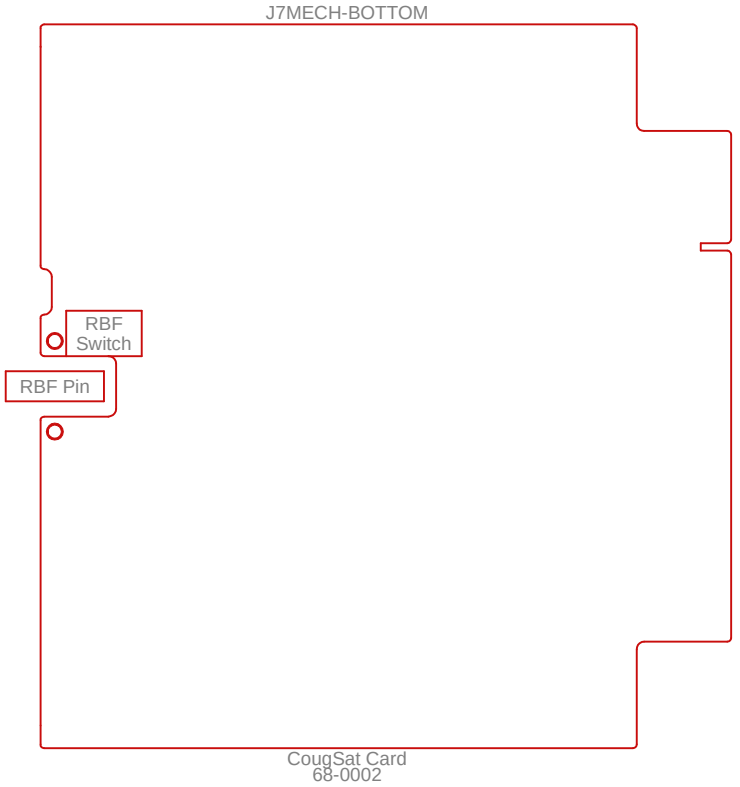
Cougs in Space EE	Title: ADCs	Size:
	Project: CougSat-1: EPS	SKU:68-0
	Designer: Bradley L. Davis	Rev: 2
	Date: 7/22/2018 1:27 PM	Page: 1



Note: Fix all off sheet designators linked to this sheet

Note: All signals above are SE, connect to any SE input, whichever is best for routing





Cougs in Space EE

Title:	Mechanical	Size:	A
Project:	CougSat-1: EPS	SKU:	68-0002
Designer:	Bradley L. Davis	Rev:	2.1.2
Date:	7/22/2018 1:27 PM	Page:	11/11