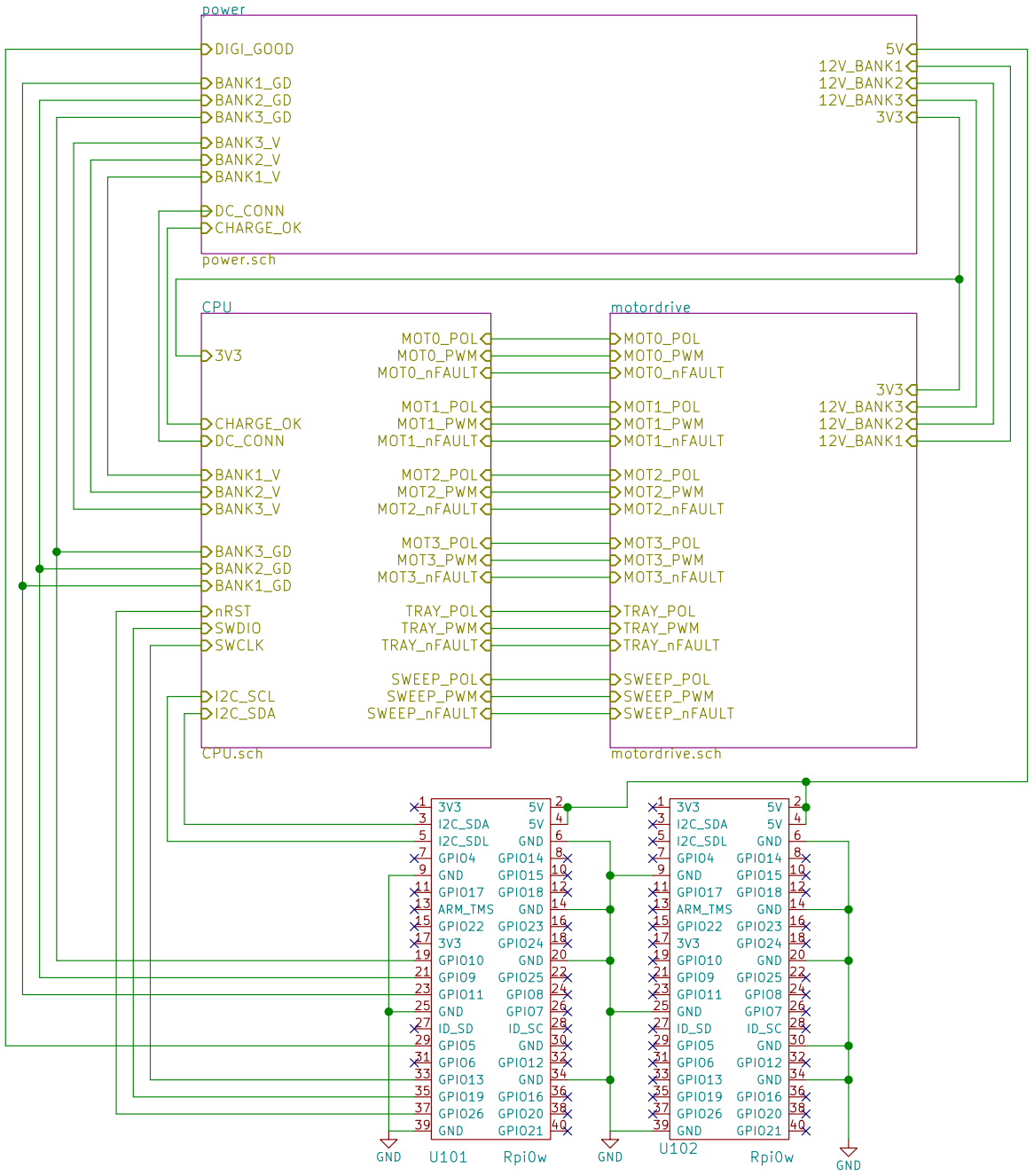


Notes on assembly

* All nonpolarized capacitors are ceramic. However, ceramic capacitors are susceptible to vibration, and so care needs to be taken w.r.t. dielectric. X7R should be used at *minimum*; optimally, C0G/NP0 would be sourced. The capacitor *must* be a designated "fail-open" capacitor, and should meet strict durability standards (e.g. automotive-grade). Kemet and Vishay have a good selection of such open-mode ("FO-CAP") capacitors. Consider placing capacitors in series to reduce the chance of single-event failure.

* All polarized capacitors are tantalum, which is reasonably rugged against vibration; if a capacitor fails, it'll be a ceramic.

* The PCB will be 4 layers; internal copper is reserved for power and ground planes. Planes lower ESR/ESL, and help decouple the supply. Components will be populated on both sides. Components without thermal ground connections on their undersides will be epoxied in place before soldering.

* The Raspberry Pis have mounting holes; place drills in the corresponding positions on the PCB (when doing footprints) and secure.

* Provide a CHASSIS connection and short it to ground.

* Significant heat will be produced by the buck converters and motor drivers. TDP should be around 1-3 Watts, considering only semiconductor loss. Place chassis connection to reduce thermal resistance between hot components and the chassis connection.

* High-current traces will use a number of stitching vias to make connections between layers.

* There will be no ground plane cuts through return current paths in the ground plane, especially the motor traces; ripple from the SMPS and H-bridge driver can kick up a significant amount of noise. Digital circuitry will be placed away from the power supply.

* Battery connectors must be chosen such that it is mechanically impossible to connect the pack in reverse polarity.

* The mechanical team will determine how the PCB is mounted in the completed rover assembly and must specify the position of the mount to within a 5% tolerance margin of the width of the mounting mechanism.

* Battery thermistors must make good thermal contact with the battery packs. Each cell in the battery pack must have an individual connection to the board for correct operation of the battery protection IC.

* The killswitch must be mounted on the outside of the chassis.

Notes on programming and rover operation

* The MCU may be programmed either via the baked-in USB bootloader, or by SWD connection with Raspi U101. If using the Raspi, ensure that the correct OpenOCD configuration is employed.

* The MCU is essentially responsible for this entire board, performing tasks ranging from monitoring battery voltages and temperatures to decide whether charging is safe, to producing PWM for the motors. The MCU acts as an I2C slave to Raspi U101, and exposes a register map entirely defining the state of the rover during operation. The RPi forwards telecommands to the MCU as I2C register writes.

* If 19.5V is available on the DC jack, the rover enters recharge mode and powers off the 12V motor rails. The digital component rails (5V, 3V3) are available. Charging is managed by the uC and charger ICs specced to this application.

Heirarchical design includes subsheets for power management, MCU/digital control signals, and motor front-ends.

ICSEDS Electronics

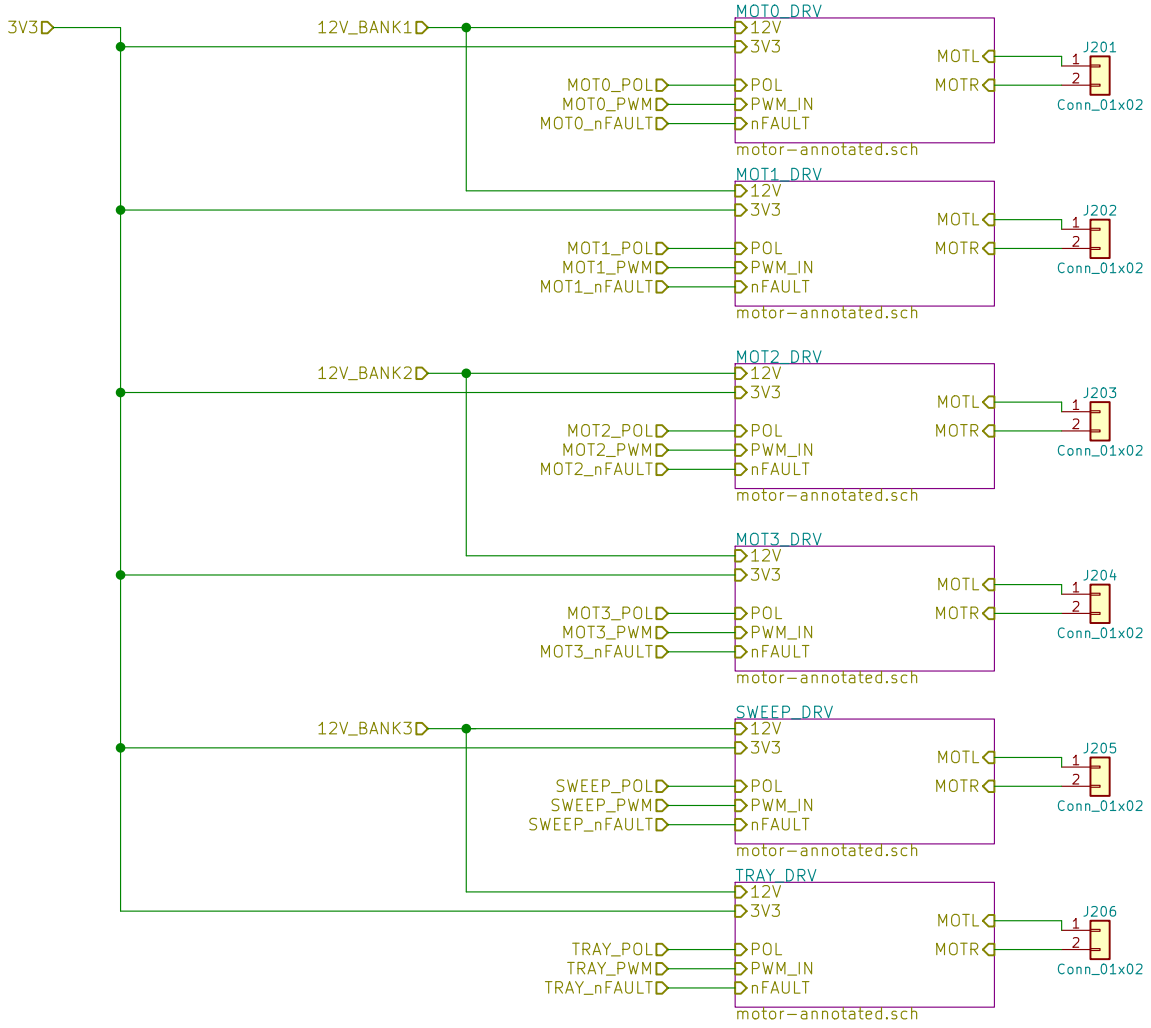
LESSR: Lunar Explorer and Soil-Sampling Rover

Sheet: /

File: Rover.sch

Title: LESSR: Lunar Explorer and Soil-Sampling Rover

Size: A4	Date: 2018-03-15	**Rev: A**
KiCad E.D.A. kicad 4.0.7		Id: 1/20



ICSEDS Electronics

LESSR: Lunar Explorer and Soil-Sampling Rover

Sheet: /motordrive/

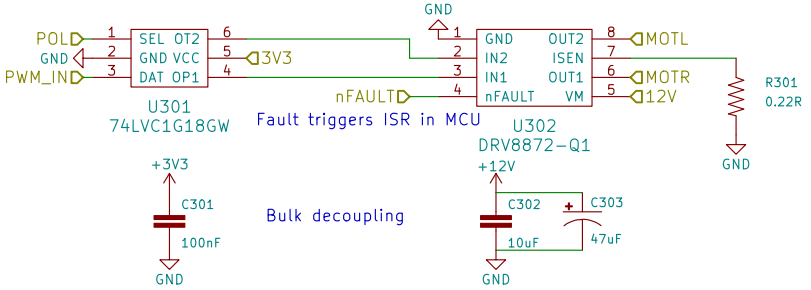
File: motordrive.sch

Title: Motor driver power and control signal distribution

Size: A4	Date: 2018-03-15	**Rev: A**
KiCad E.D.A. kicad 4.0.7		Id: 2/20

Multiplexer: select polarity and apply PWM to only one pin

H-bridge, rated to 3.5A at operating voltage



ICSEDS Electronics

LESSR: Lunar Explorer and Soil-Sampling Rover

Sheet: /motordrive/MOTO_DRV/

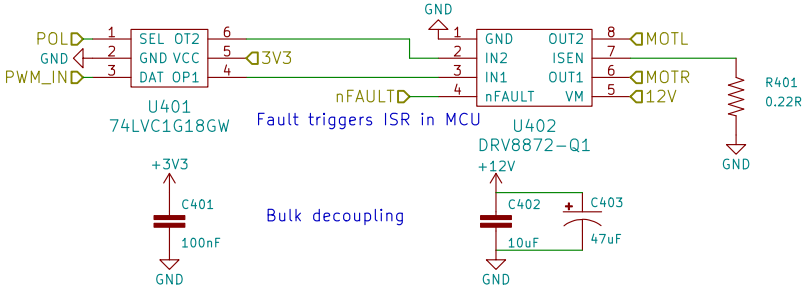
File: motor-annotated.sch

Title: Motor driver, polarity select & PWM distribution

Size: User	Date: 2018-03-15	**Rev: A**
KiCad E.D.A. kicad 4.0.7		Id: 3/20

Multiplexer: select polarity and apply PWM to only one pin

H-bridge, rated to 3.5A at operating voltage



ICSEDS Electronics

LESSR: Lunar Explorer and Soil-Sampling Rover

Sheet: /motordrive/MOT1_DRV/

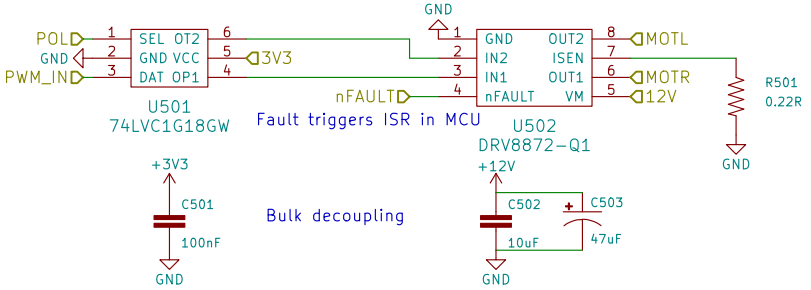
File: motor-annotated.sch

Title: Motor driver, polarity select & PWM distribution

Size: User	Date: 2018-03-15	**Rev: A**
KiCad E.D.A. kicad 4.0.7		Id: 4/20

Multiplexer: select polarity and apply PWM to only one pin

H-bridge, rated to 3.5A at operating voltage



ICSEDS Electronics

LESSR: Lunar Explorer and Soil-Sampling Rover

Sheet: /motordrive/MOT2_DRV/

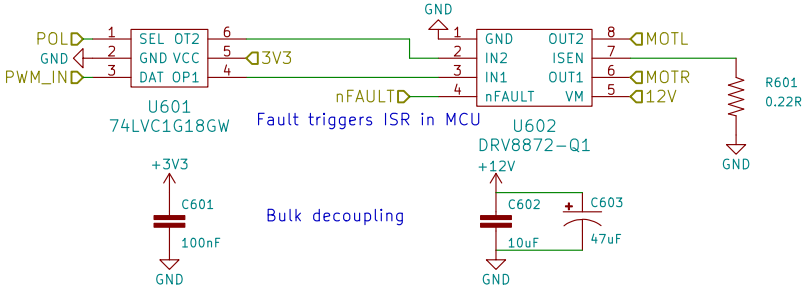
File: motor-annotated.sch

Title: Motor driver, polarity select & PWM distribution

Size: User	Date: 2018-03-15	**Rev: A**
KiCad E.D.A. kicad 4.0.7		Id: 5/20

Multiplexer: select polarity and apply PWM to only one pin

H-bridge, rated to 3.5A at operating voltage



ICSEDS Electronics

LESSR: Lunar Explorer and Soil-Sampling Rover

Sheet: /motordrive/MOT3_DRV/

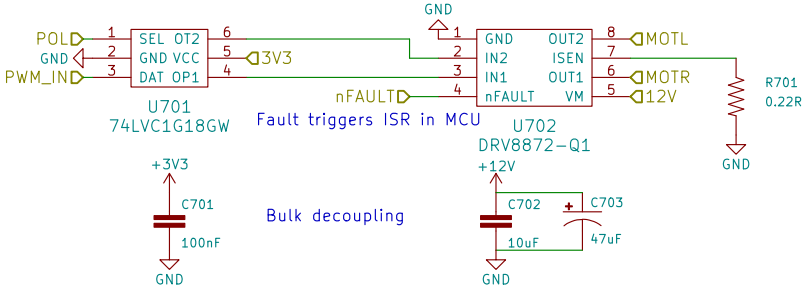
File: motor-annotated.sch

Title: Motor driver, polarity select & PWM distribution

Size: User	Date: 2018-03-15	**Rev: A**
KiCad E.D.A. kicad 4.0.7		Id: 6/20

Multiplexer: select polarity and apply PWM to only one pin

H-bridge, rated to 3.5A at operating voltage



ICSEDS Electronics

LESSR: Lunar Explorer and Soil-Sampling Rover

Sheet: /motordrive/SWEEP_DRV/

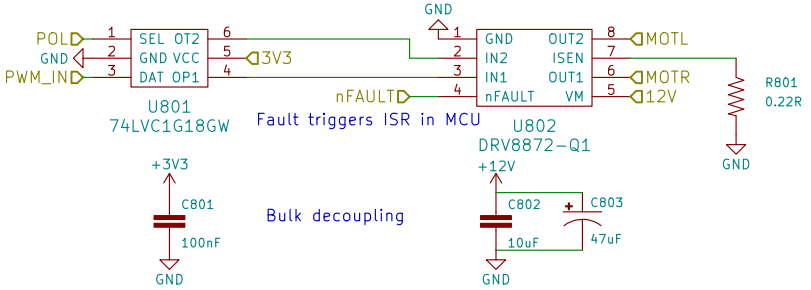
File: motor-annotated.sch

Title: Motor driver, polarity select & PWM distribution

Size: User	Date: 2018-03-15	**Rev: A**
KiCad E.D.A. kicad 4.0.7		Id: 7/20

Multiplexer: select polarity and apply PWM to only one pin

H-bridge, rated to 3.5A at operating voltage



ICSEDS Electronics

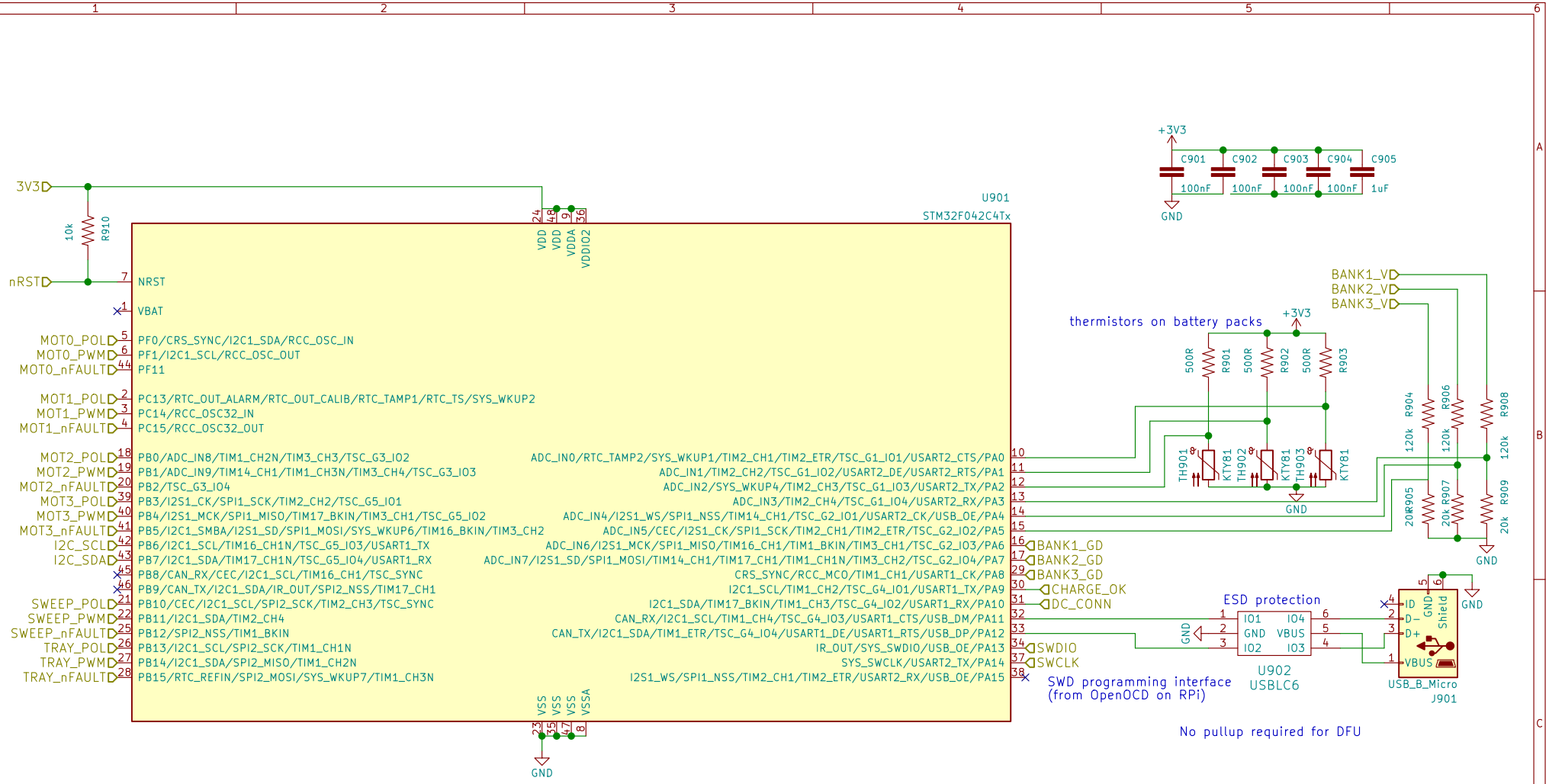
LESSR: Lunar Explorer and Soil-Sampling Rover

Sheet: /motordrive/TRAY_DRV/

File: motor-annotated.sch

Title: Motor driver, polarity select & PWM distribution

Size: User	Date: 2018-03-15	**Rev: A**
KiCad E.D.A. kicad 4.0.7		Id: 8/20



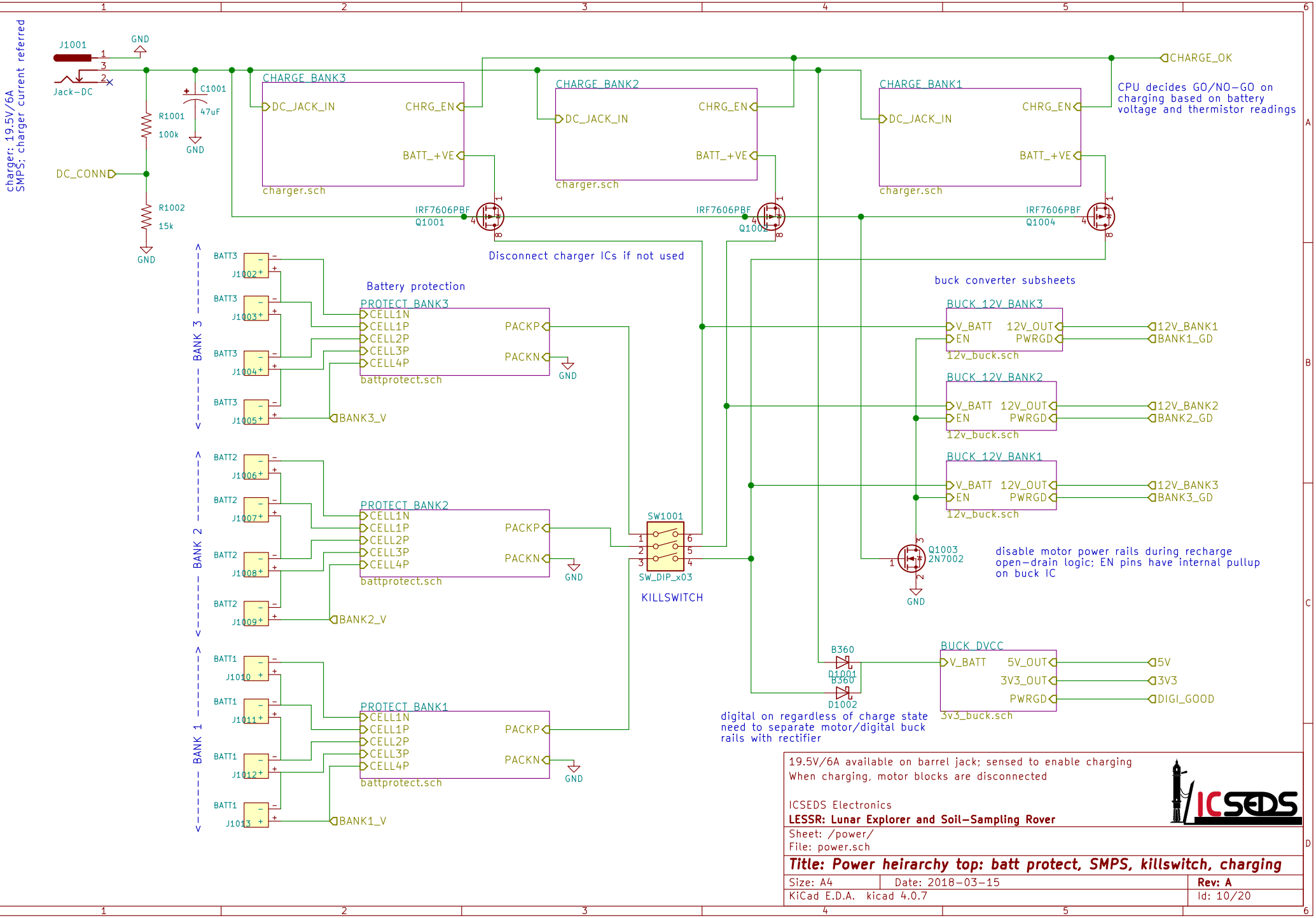
Exact MCU model number is STM32F042C6T6
Use the LQFP48 package

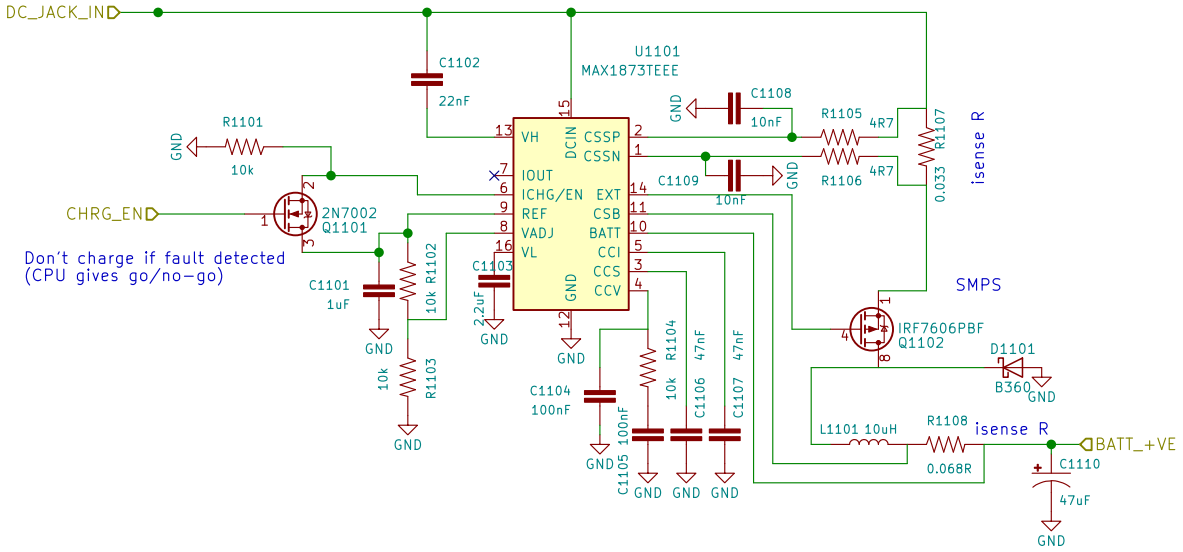
ICSEDS Electronics
LESSR: Lunar Explorer and Soil-Sampling Rover

Sheet: /CPU/
File: CPU.sch

Title: MCU, batt thermistors & vsense, USB, all control signals

Size: A4	Date: 2018-03-15	**Rev: A**
KiCad E.D.A. kicad 4.0.7		Id: 9/20


charger: 19.5V/6A
SMPS; charger current referred
J1001
Jack-DC
GND
C1001
47uF
R1001
100k
R1002
15k
DC_CONN
CHARGE_BANK3
CHARGE_BANK2
CHARGE_BANK1
DC_JACK_IN
CHRG_EN
BATT_+VE
charger.sch
CHARGE_OK
CPU decides GO/NO-GO on charging based on battery voltage and thermistor readings
IRF7606PBF
Q1001
Q1002
Q1004
Disconnect charger ICs if not used
Battery protection
BANK 3
BANK 2
BANK 1
BATT3
BATT2
BATT1
J1002
J1003
J1004
J1005
J1006
J1007
J1008
J1009
J1010
J1011
J1012
J1013
PROTECT_BANK3
PROTECT_BANK2
PROTECT_BANK1
CELL1N
CELL1P
CELL2P
CELL3P
CELL4P
PACKP
PACKN
battprotect.sch
BANK3_V
BANK2_V
BANK1_V
SW1001
SW_DIP_x03
KILLSWITCH
buck converter subsheets
BUCK_12V_BANK3
BUCK_12V_BANK2
BUCK_12V_BANK1
V_BATT
12V_OUT
EN
PWRGD
12v_buck.sch
12V_BANK1
BANK1_GD
12V_BANK2
BANK2_GD
12V_BANK3
BANK3_GD
Q1003
2N7002
disable motor power rails during recharge
open-drain logic; EN pins have internal pullup on buck IC
B360
D1001
D1002
BUCK_DVCC
5V_OUT
3V3_OUT
3v3_buck.sch
5V
3V3
DIGI_GOOD
digital on regardless of charge state
need to separate motor/digital buck rails with rectifier
19.5V/6A available on barrel jack; sensed to enable charging
When charging, motor blocks are disconnected
ICSEDS Electronics
LESSR: Lunar Explorer and Soil-Sampling Rover
Sheet: /power/
File: power.sch
Title: Power heirarchy top: batt protect, SMPS, killswitch, charging
Size: A4
Date: 2018-03-15
Rev: A
KiCad E.D.A. kicad 4.0.7
Id: 10/20



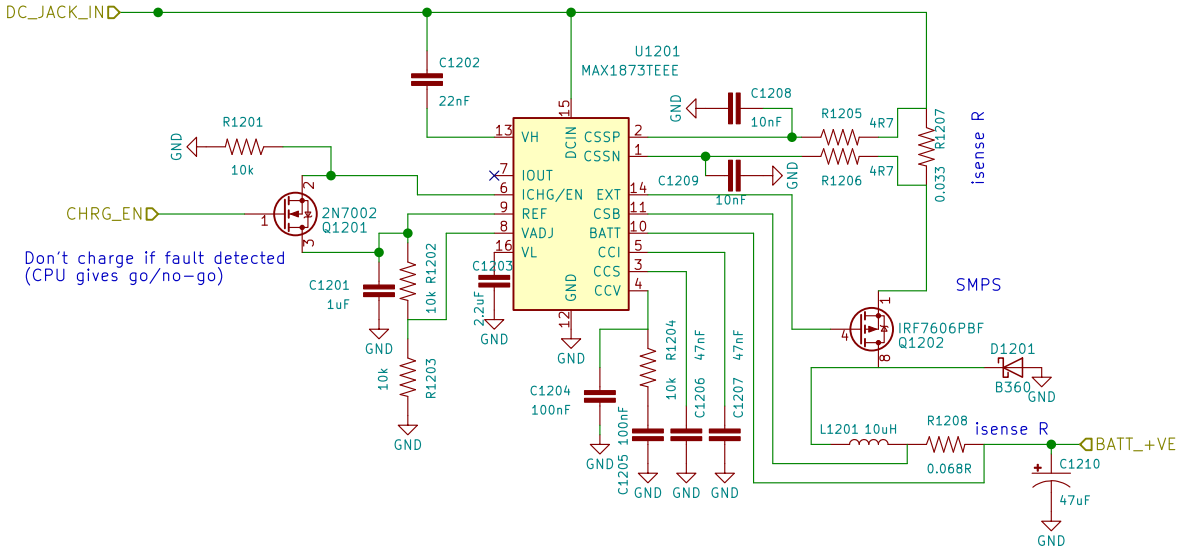
Buck converter O/P follows li-ion I/V recharge curve
MAX1873 variant T MUST be used for 4-cell configuration

ICSEDS Electronics
LESSR: Lunar Explorer and Soil-Sampling Rover

Sheet: /power/CHARGE_BANK3/
File: charger.sch

Title: Battery charger: controller, SMPS, control signals

Size: User	Date: 2018-03-15	**Rev: A**
KiCad E.D.A. kicad 4.0.7		Id: 11/20



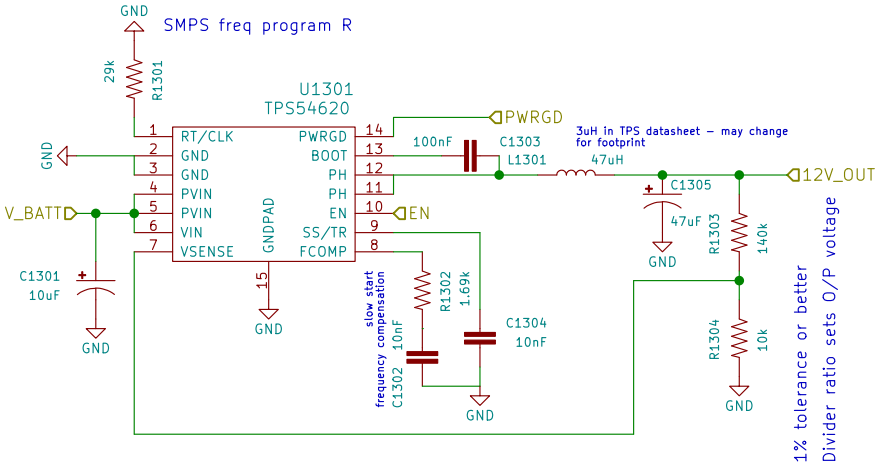
Buck converter O/P follows li-ion I/V recharge curve
MAX1873 variant T MUST be used for 4-cell configuration

ICSEDS Electronics
LESSR: Lunar Explorer and Soil-Sampling Rover

Sheet: /power/CHARGE_BANK1/
File: charger.sch

Title: Battery charger: controller, SMPS, control signals

Size: User	Date: 2018-03-15	**Rev: A**
KiCad E.D.A. kicad 4.0.7		Id: 12/20



TODO: drive motors on unified 12V; buck O/P in ||
(see TI app report SLVA389)

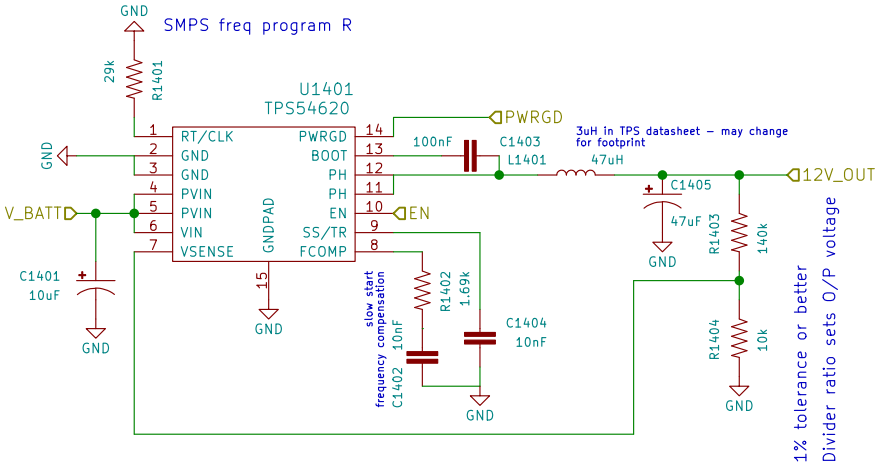
ICSEDS Electronics

LESSR: Lunar Explorer and Soil-Sampling Rover

Sheet: /power/BUCK_12V_BANK2/
File: 12v_buck.sch

Title: 14.4V -> 12V buck converter

Size: User	Date: 2018-03-15	**Rev: A**
KiCad E.D.A. kicad 4.0.7		Id: 13/20



TODO: drive motors on unified 12V; buck O/P in ||
(see TI app report SLVA389)

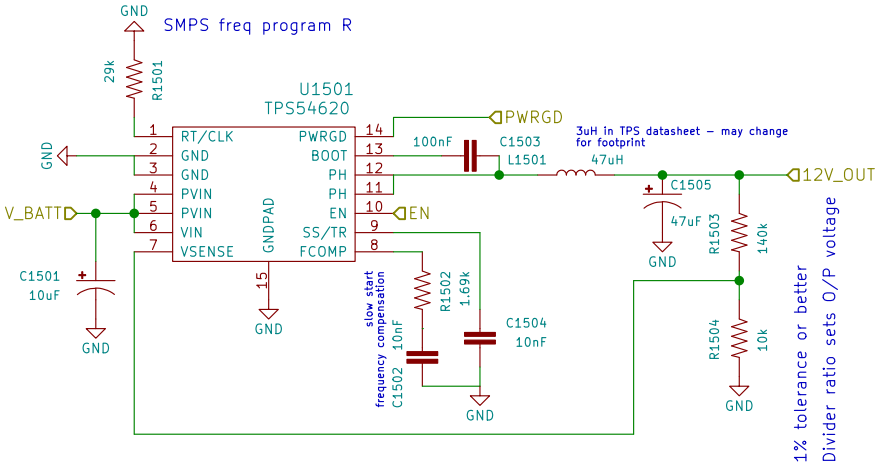
ICSEDS Electronics

LESSR: Lunar Explorer and Soil-Sampling Rover

Sheet: /power/BUCK_12V_BANK1/
File: 12v_buck.sch

Title: 14.4V -> 12V buck converter

Size: User	Date: 2018-03-15	**Rev: A**
KiCad E.D.A. kicad 4.0.7		Id: 14/20



TODO: drive motors on unified 12V; buck O/P in ||
(see TI app report SLVA389)

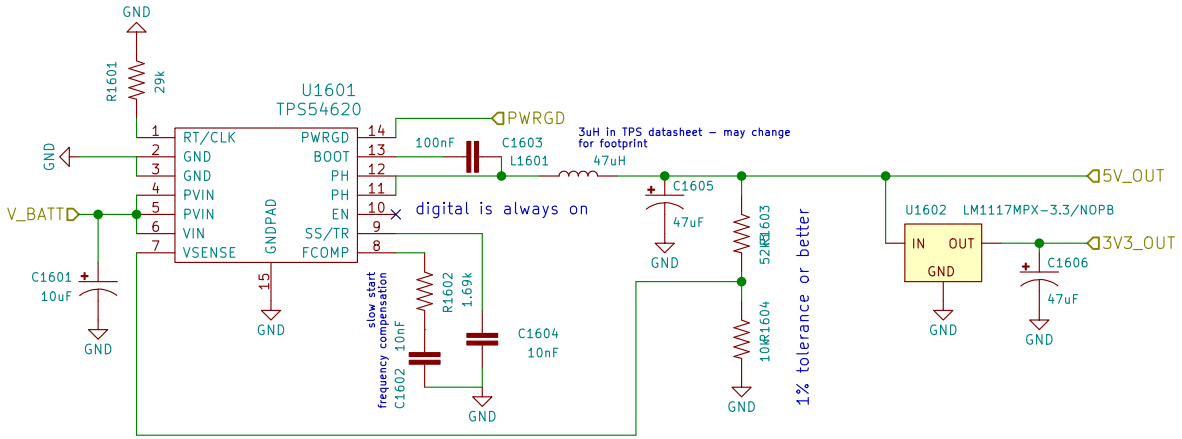
ICSEDS Electronics

LESSR: Lunar Explorer and Soil-Sampling Rover

Sheet: /power/BUCK_12V_BANK3/
File: 12v_buck.sch

Title: 14.4V -> 12V buck converter

Size: User	Date: 2018-03-15	**Rev: A**
KiCad E.D.A. kicad 4.0.7		Id: 15/20



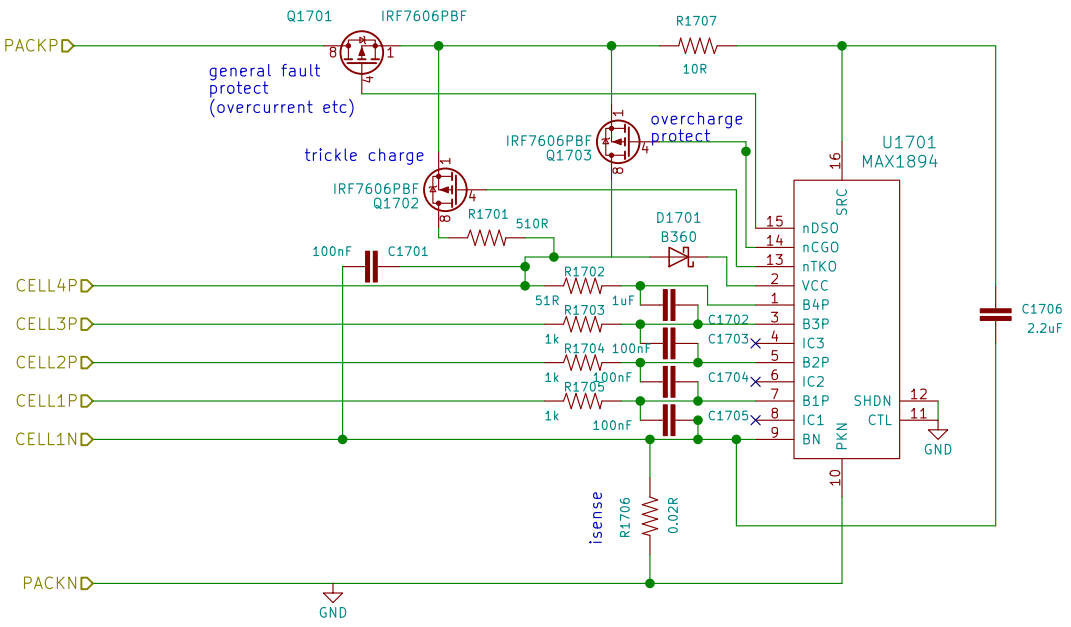
TODO: use RaspiOW integrated 3V3 lin regs
Power source for all digital logic & control signals

ICSEDS Electronics
LESSR: Lunar Explorer and Soil-Sampling Rover

Sheet: /power/BUCK_DVCC/
File: 3v3_buck.sch

Title: Buck to 5V, linear regulator to 3V3

Size: User	Date: 2018-03-15	**Rev: A**
KiCad E.D.A. kicad 4.0.7		Id: 16/20



MAX1894XEEE is 4-cell variant of IC

ICSEDS Electronics

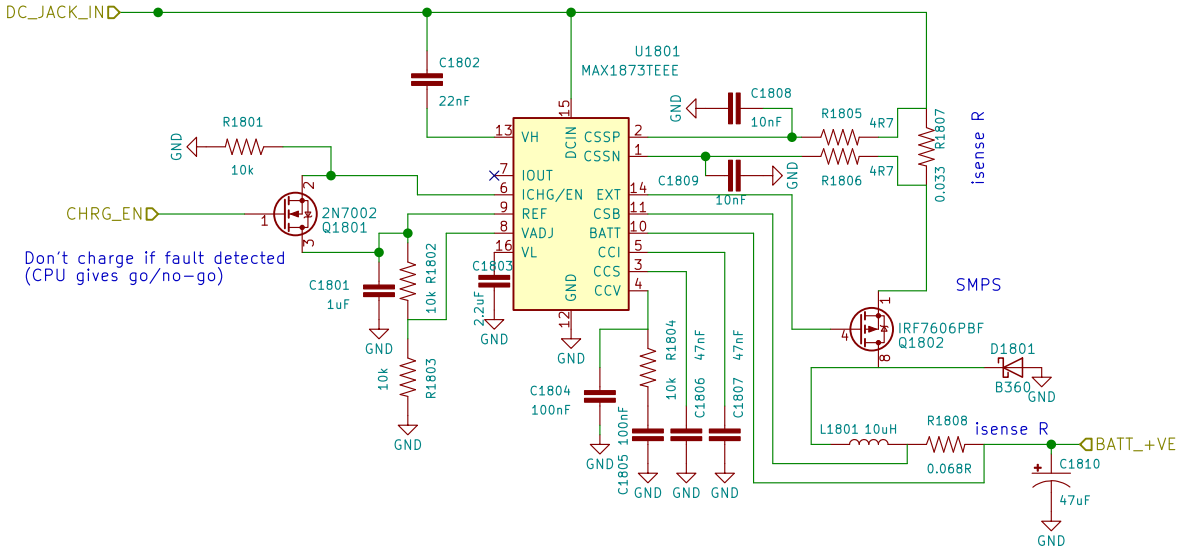
LESSR: Lunar Explorer and Soil-Sampling Rover

Sheet: /power/PROTECT_BANK3/

File: battprotect.sch

Title: Battery OV/UV/charge/discharge/pack-short fault protection

Size: User	Date: 2018-03-15	**Rev: A**
KiCad E.D.A. kicad 4.0.7		Id: 17/20



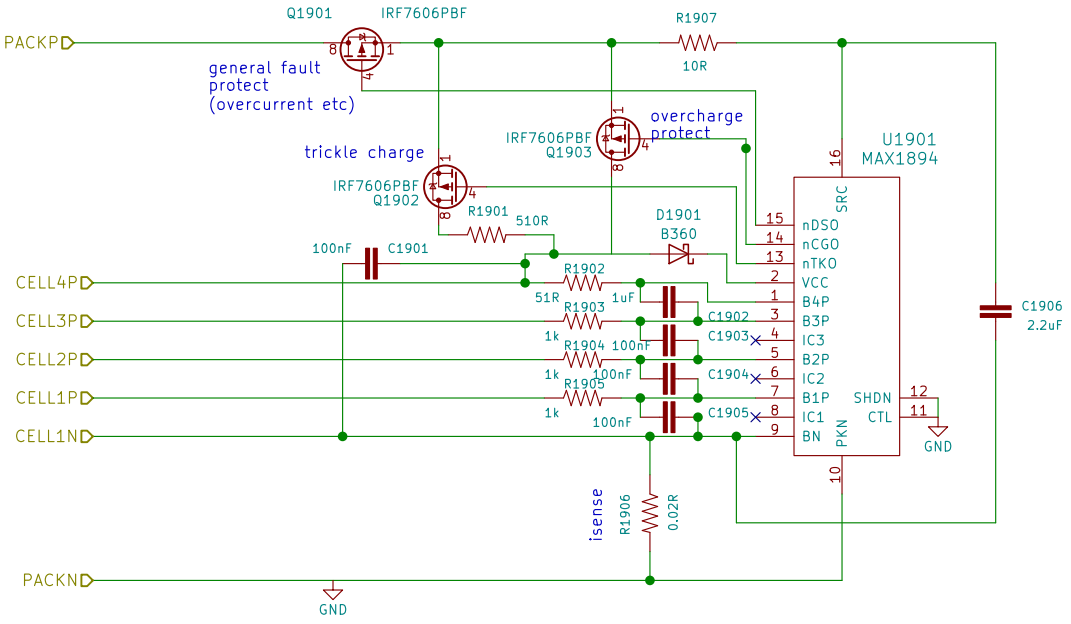
Buck converter O/P follows li-ion I/V recharge curve
MAX1873 variant T MUST be used for 4-cell configuration

ICSEDS Electronics
LESSR: Lunar Explorer and Soil-Sampling Rover

Sheet: /power/CHARGE_BANK2/
File: charger.sch

Title: Battery charger: controller, SMPS, control signals

Size: User	Date: 2018-03-15	**Rev: A**
KiCad E.D.A. kicad 4.0.7		Id: 18/20



MAX1894XEEE is 4-cell variant of IC

ICSEDS Electronics

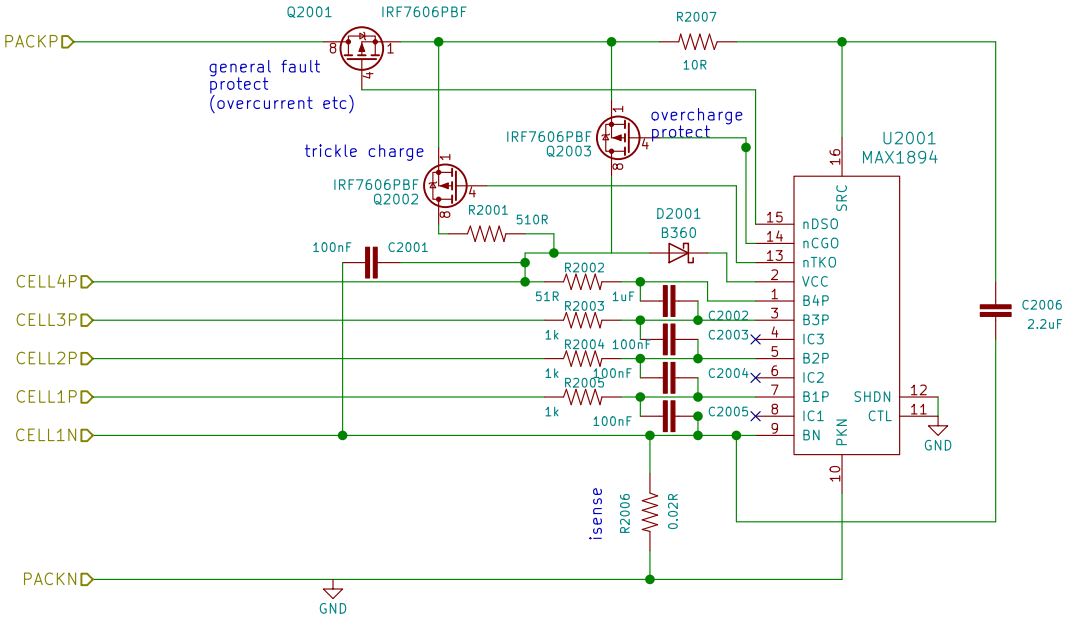
LESSR: Lunar Explorer and Soil-Sampling Rover

Sheet: /power/PROTECT_BANK2/

File: battprotect.sch

Title: Battery OV/UV/charge/discharge/pack-short fault protection

Size: User	Date: 2018-03-15	**Rev: A**
KiCad E.D.A. kicad 4.0.7		Id: 19/20



MAX1894XEEE is 4-cell variant of IC

ICSEDS Electronics

LESSR: Lunar Explorer and Soil-Sampling Rover

Sheet: /power/PROTECT_BANK1/

File: battprotect.sch

Title: Battery OV/UV/charge/discharge/pack-short fault protection

Size: User	Date: 2018-03-15	**Rev: A**
KiCad E.D.A. kicad 4.0.7		Id: 20/20