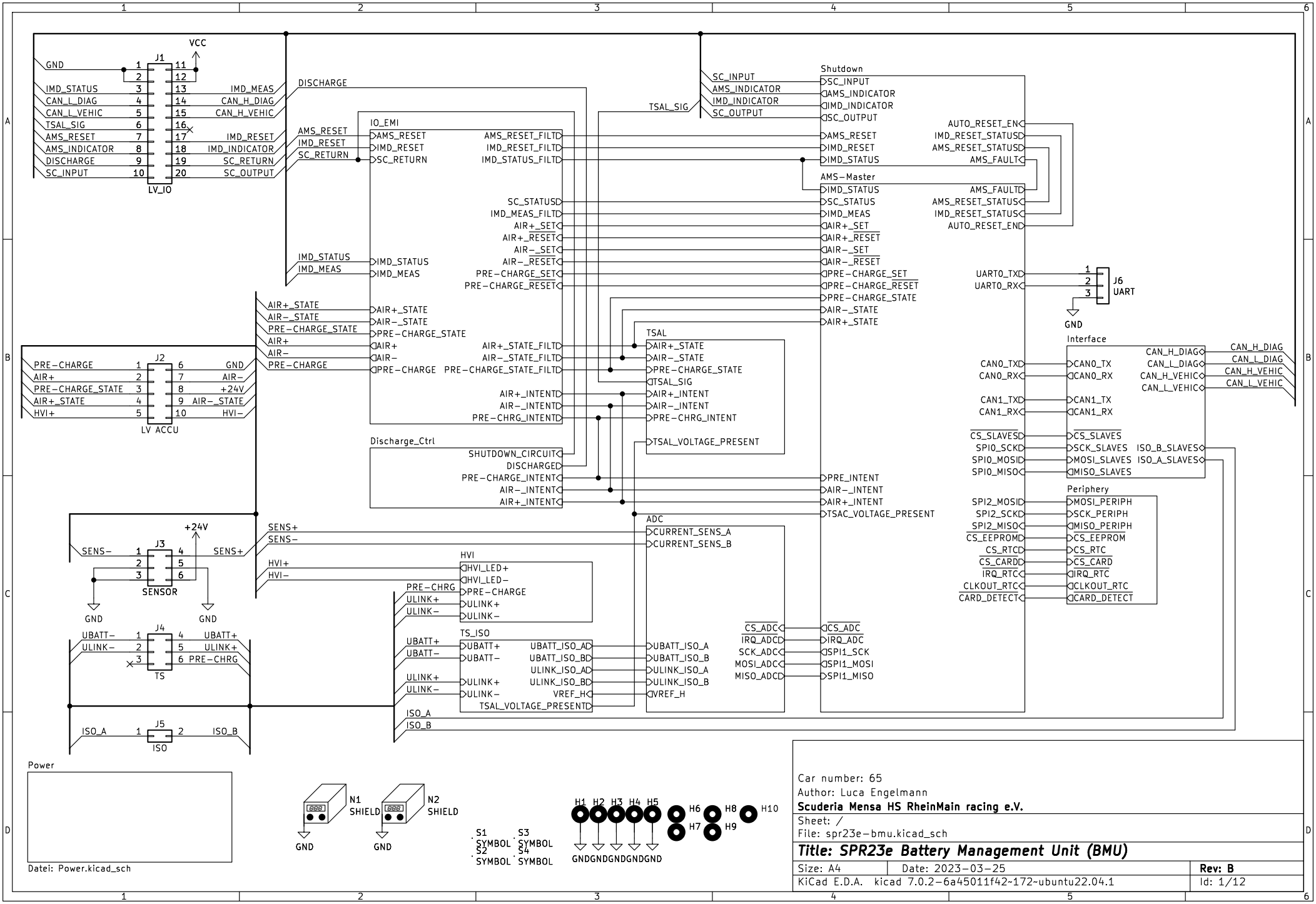
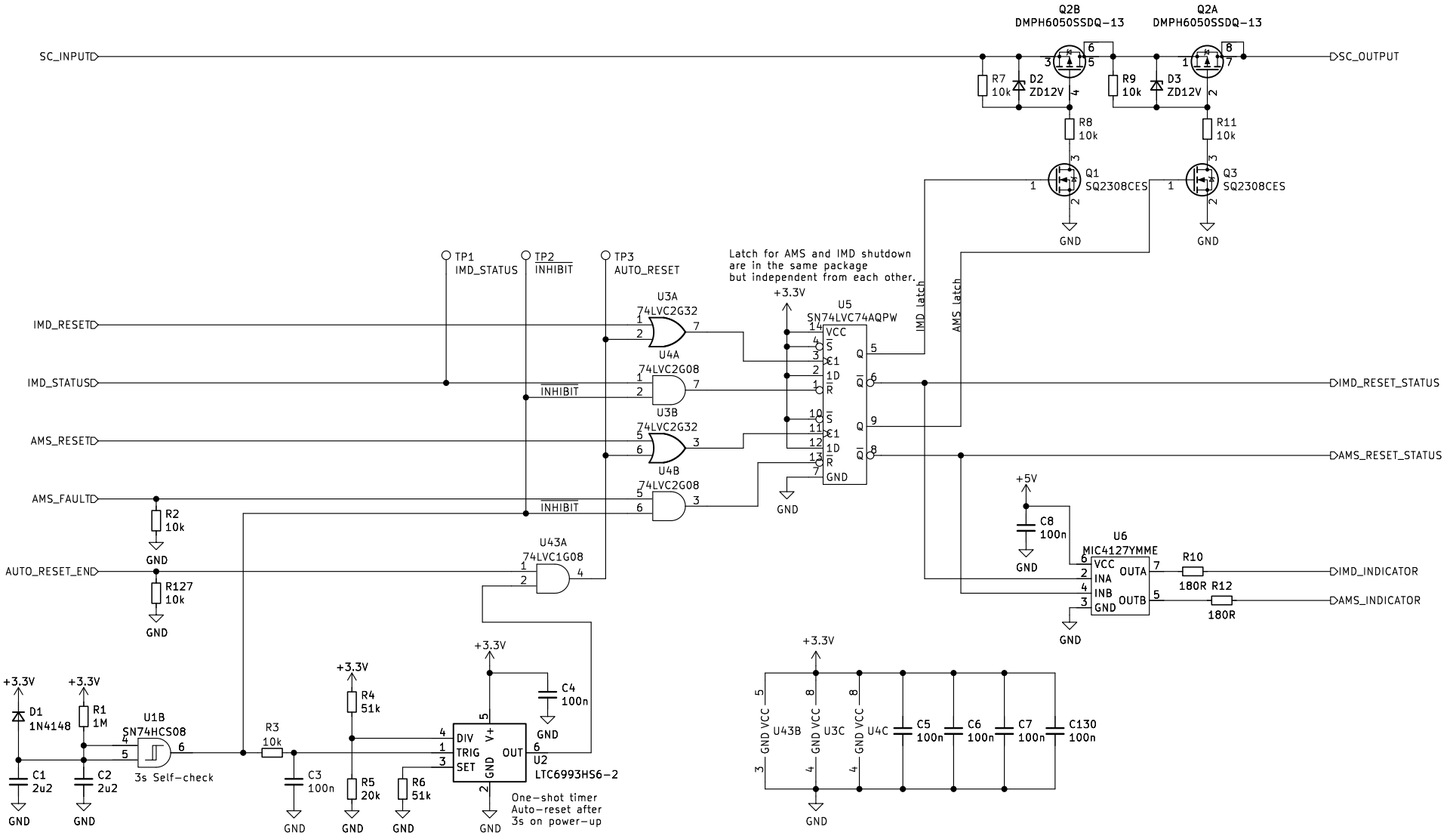

VCC
J1
LV_IO
GND
IMD_STATUS
CAN_L_DIAG
CAN_L_VEHIC
TSAL_SIG
AMS_RESET
AMS_INDICATOR
DISCHARGE
SC_INPUT
IMD_MEAS
CAN_H_DIAG
CAN_H_VEHIC
IMD_RESET
IMD_INDICATOR
SC_RETURN
SC_OUTPUT
IO_EMI
AMS_RESET_FILT
IMD_RESET_FILT
IMD_STATUS_FILT
SC_STATUS
IMD_MEAS_FILT
AIR+_SET
AIR+_RESET
AIR−_SET
AIR−_RESET
PRE−CHARGE_SET
PRE−CHARGE_RESET
AIR+_STATE_FILT
AIR−_STATE_FILT
PRE−CHARGE_STATE_FILT
AIR+_INTENT
AIR−_INTENT
PRE−CHRG_INTENT
Shutdown
AUTO_RESET_EN
IMD_RESET_STATUS
AMS_RESET_STATUS
AMS_FAULT
AMS−Master
IMD_STATUS
SC_STATUS
IMD_MEAS
AIR+_SET
AIR+_RESET
AIR−_SET
AIR−_RESET
PRE−CHARGE_SET
PRE−CHARGE_RESET
PRE−CHARGE_STATE
AIR−_STATE
AIR+_STATE
AUTO_RESET_END
J6
UART
UART0_TX
UART0_RX
TSAL
TSAL_VOLTAGE_PRESENT
Discharge_Ctrl
SHUTDOWN_CIRCUIT
DISCHARGED
PRE−CHARGE_INTENT
AIR−_INTENT
AIR+_INTENT
J2
LV ACCU
PRE−CHARGE
AIR+
PRE−CHARGE_STATE
AIR+_STATE
HVI+
AIR−
+24V
J3
SENSOR
SENS−
SENS+
HVI
HVI_LED+
HVI_LED−
HVI−
PRE−CHRG
ULINK+
ULINK−
ADC
CURRENT_SENS_A
CURRENT_SENS_B
J4
TS
UBATT−
UBATT+
TS_ISO
UBATT_ISO_AD
UBATT_ISO_BD
ULINK_ISO_AD
ULINK_ISO_BD
VREF_H
UBATT_ISO_A
UBATT_ISO_B
ULINK_ISO_A
ULINK_ISO_B
J5
ISO
ISO_A
ISO_B
CS_ADC
IRQ_ADC
SCK_ADC
MOSI_ADC
MISO_ADC
SPI1_SCK
SPI1_MOSI
SPI1_MISO
Interface
CAN0_TX
CAN0_RX
CAN1_TX
CAN1_RX
CS_SLAVES
SPI0_SCK
SPI0_MOSI
SPI0_MISO
SCK_SLAVES
MOSI_SLAVES
MISO_SLAVES
ISO_B_SLAVES
ISO_A_SLAVES
Periphery
SPI2_MOSI
SPI2_SCK
SPI2_MISO
CS_EEPROM
CS_RTC
CS_CARD
IRQ_RTC
CLKOUT_RTC
CARD_DETECT
MOSI_PERIPH
SCK_PERIPH
MISO_PERIPH
CS_EEPROM
CS_RTC
CS_CARD
IRQ_RTC
CLKOUT_RTC
CARD_DETECT
PRE_INTENT
AIR−_INTENT
AIR+_INTENT
TSAC_VOLTAGE_PRESENT
Power
Datei: Power.kicad_sch
N1
SHIELD
N2
SHIELD
S1
SYMBOL
S2
SYMBOL
S3
SYMBOL
S4
SYMBOL
H1 H2 H3 H4 H5 H6 H7 H8 H9 H10
GNDGNDGNDGNDGNDGND
Car number: 65
Author: Luca Engelmann
Scuderia Mensa HS RheinMain racing e.V.
Sheet: /
File: spr23e−bmu.kicad_sch
Title: SPR23e Battery Management Unit (BMU)
Size: A4
Date: 2023−03−25
Rev: B
KiCad E.D.A. kicad 7.0.2−6a45011f42~172~ubuntu22.04.1
Id: 1/12

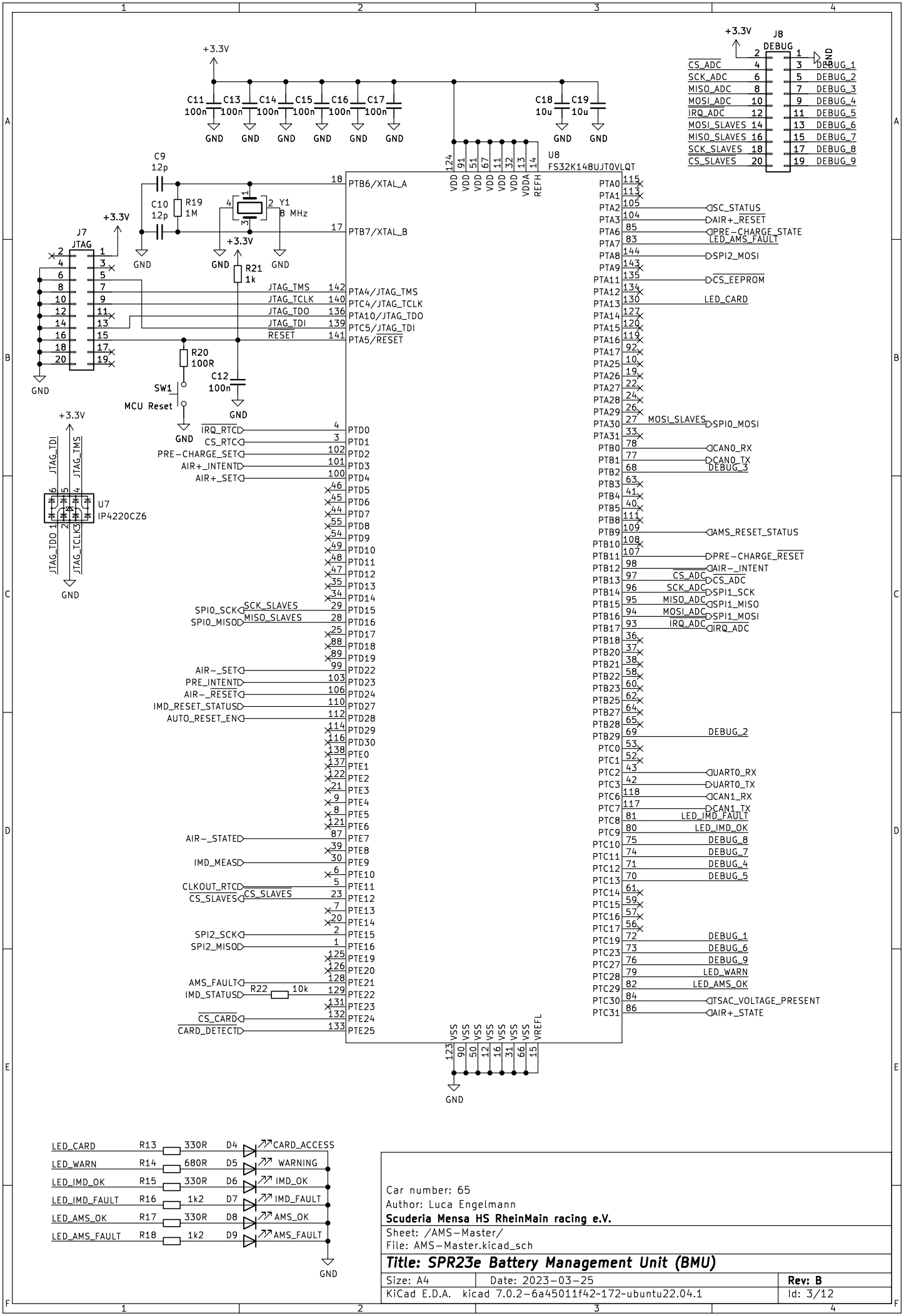


Car number: 65
Author: Luca Engelmann
Scuderia Mensa HS RheinMain racing e.V.

Sheet: /Shutdown/
File: Shutdown.kicad_sch

Title: SPR23e Battery Management Unit (BMU)

Size: A4	Date: 2023-03-25	**Rev: B**
KiCad E.D.A. kicad 7.0.2-6a45011f42~172~ubuntu22.04.1		Id: 2/12

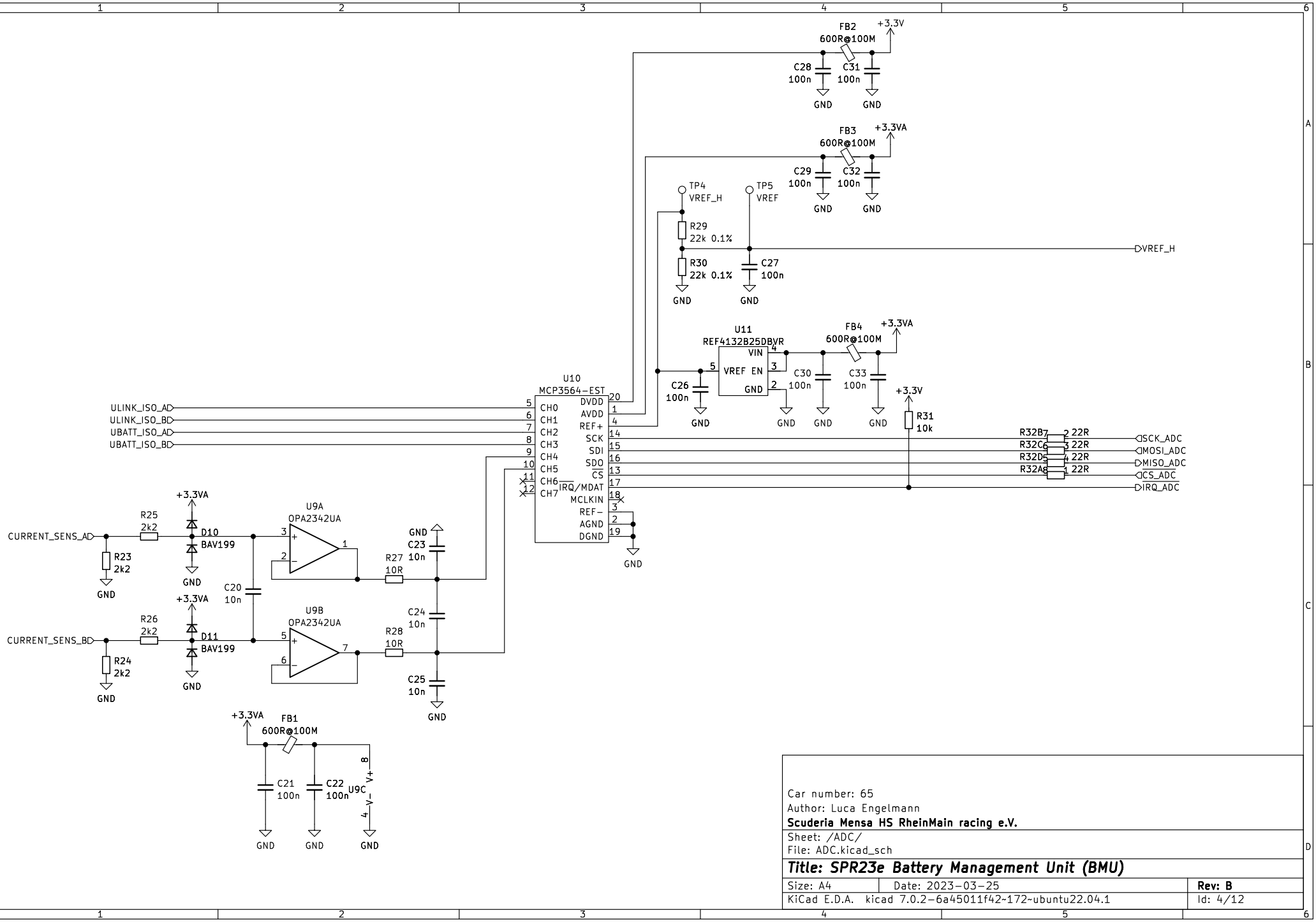


Car number: 65
Author: Luca Engelmann
Scuderia Mensa HS RheinMain racing e.V.

Sheet: /AMS-Master/
File: AMS-Master.kicad_sch

Title: SPR23e Battery Management Unit (BMU)

Size: A4	Date: 2023-03-25	**Rev: B**
KiCad E.D.A. kicad 7.0.2-6a45011f42~172~ubuntu22.04.1		Id: 3/12

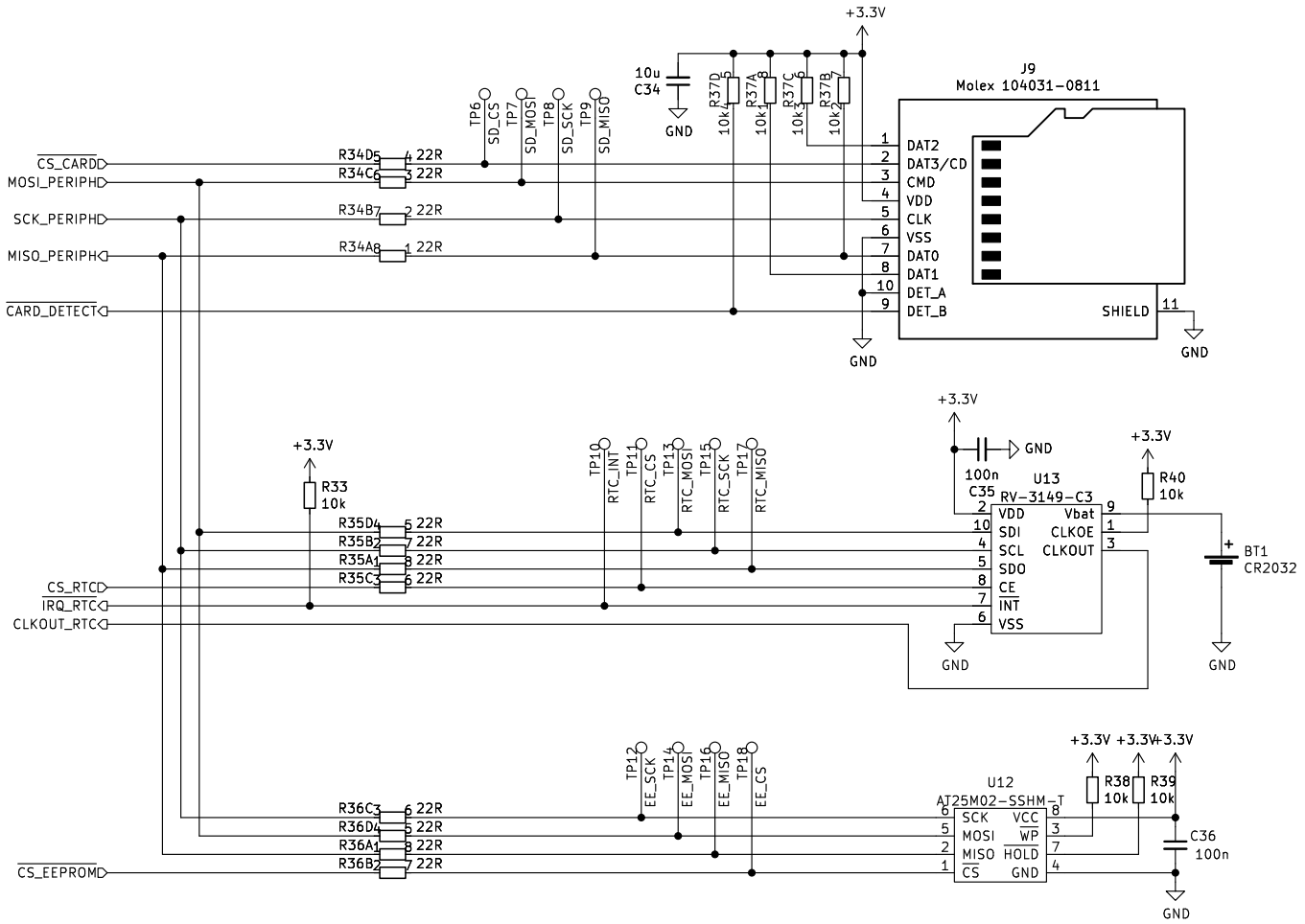


Car number: 65
Author: Luca Engelmann
Scuderia Mensa HS RheinMain racing e.V.

Sheet: /ADC/
File: ADC.kicad_sch

Title: SPR23e Battery Management Unit (BMU)

Size: A4	Date: 2023-03-25	**Rev: B**
KiCad E.D.A. kicad 7.0.2-6a45011f42~172~ubuntu22.04.1		Id: 4/12

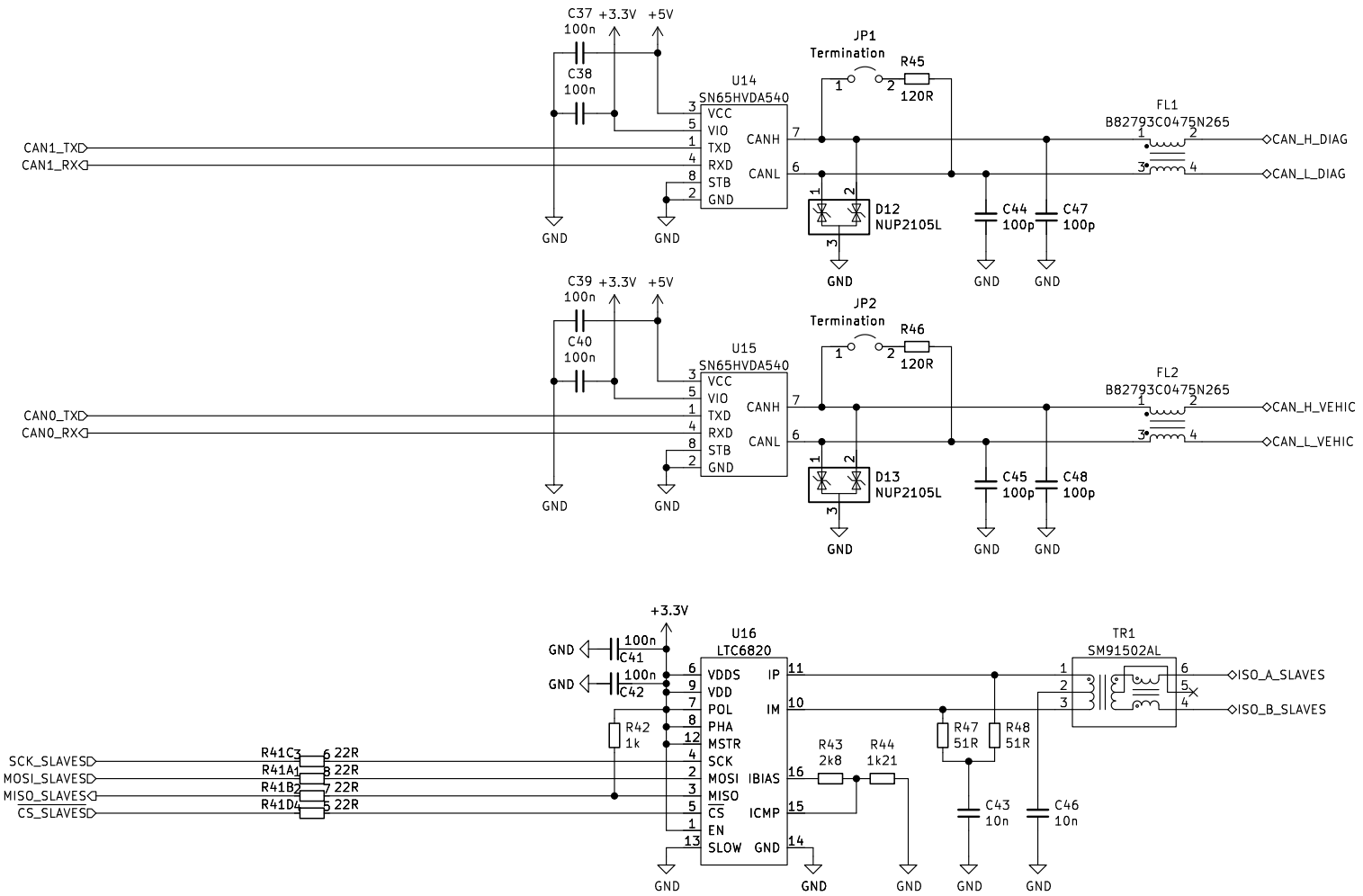


Car number: 65
Author: Luca Engelmann
Scuderia Mensa HS RheinMain racing e.V.

Sheet: /Periphery/
File: Periphery.kicad_sch

Title: SPR23e Battery Management Unit (BMU)

Size: A4	Date: 2023-03-25	**Rev: B**
KiCad E.D.A. kicad 7.0.2-6a45011f42~172~ubuntu22.04.1		Id: 5/12

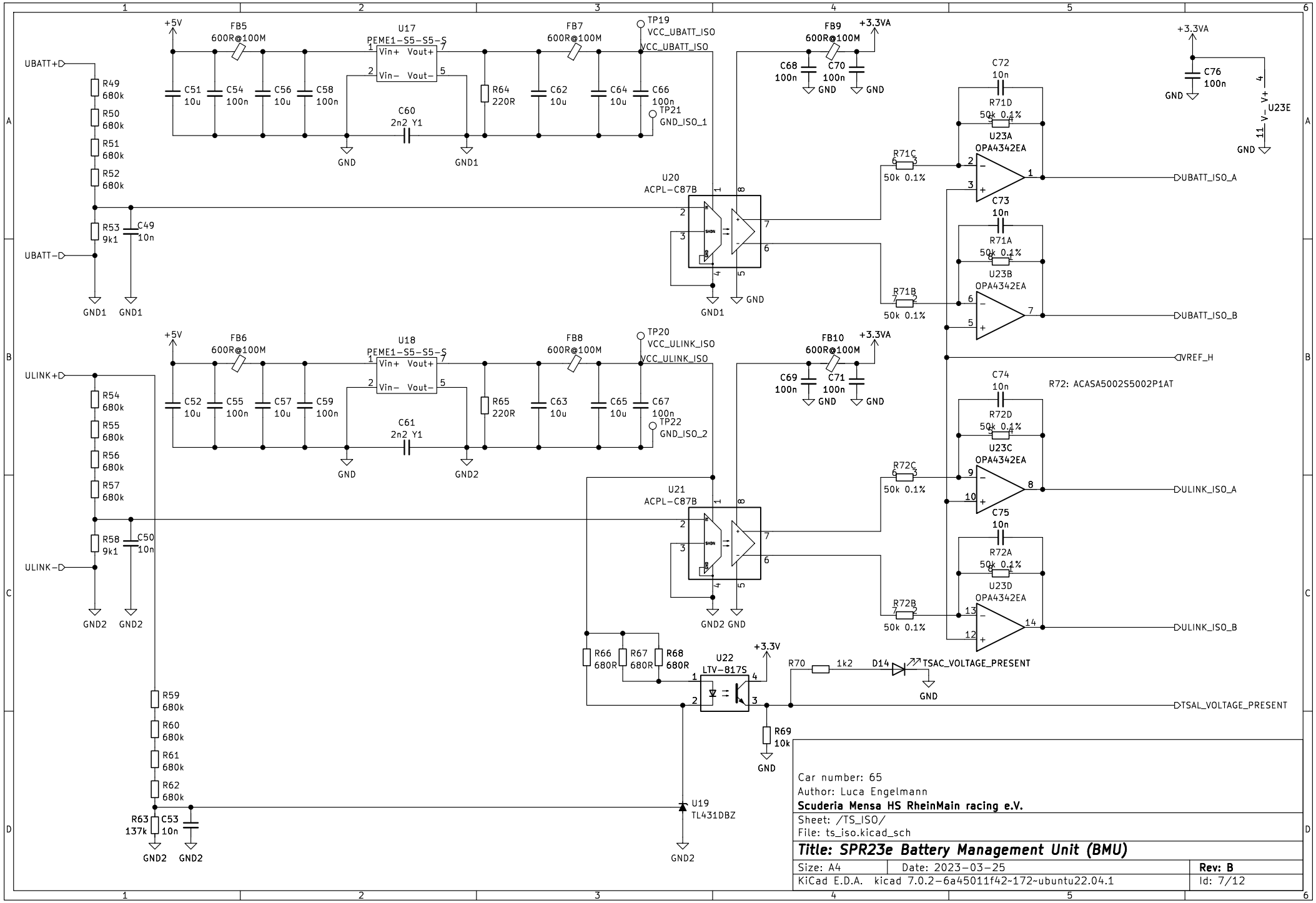


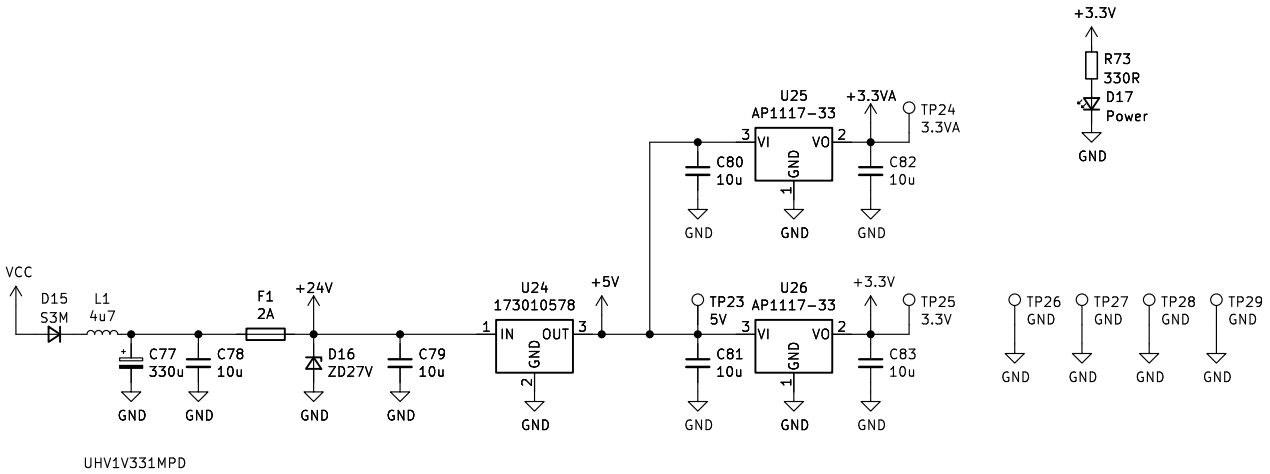
Car number: 65
Author: Luca Engelmann
Scuderia Mensa HS RheinMain racing e.V.

Sheet: /Interface/
File: Interface.kicad_sch

Title: SPR23e Battery Management Unit (BMU)

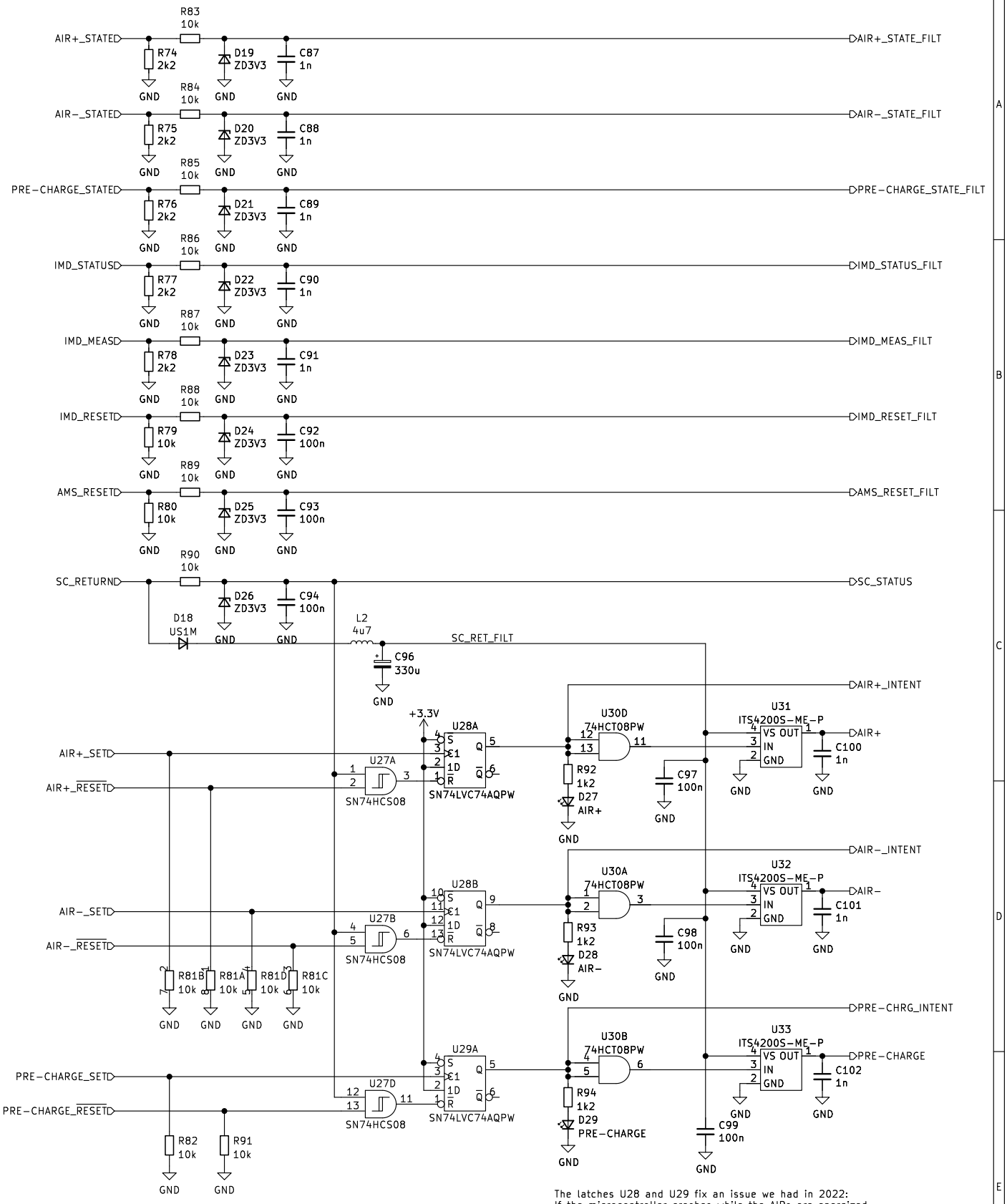
Size: A4	Date: 2023-03-25	**Rev: B**
KiCad E.D.A. kicad 7.0.2-6a45011f42~172~ubuntu22.04.1		Id: 6/12


UBATT+
UBATT-
R49 680k
R50 680k
R51 680k
R52 680k
R53 9k1
C49 10n
GND1
+5V
FB5 600R@100M
U17 PEME1-S5-S5-S
Vin+ Vout+
Vin- Vout-
C51 10u
C54 100n
C56 10u
C58 100n
C60 2n2 Y1
R64 220R
C62 10u
C64 10u
C66 100n
FB7 600R@100M
TP19 VCC_UBATT_ISO
TP21 GND_ISO_1
FB9 600R@100M
+3.3VA
C68 100n
C70 100n
U20 ACPL-C87B
R71C 50k 0.1%
R71B 50k 0.1%
C72 10n
R71D 50k 0.1%
U23A OPA4342EA
C73 10n
R71A 50k 0.1%
U23B OPA4342EA
UBATT_ISO_A
UBATT_ISO_B
C76 100n
U23E
ULINK+
ULINK-
R54 680k
R55 680k
R56 680k
R57 680k
R58 9k1
C50 10n
GND2
+5V
FB6 600R@100M
U18 PEME1-S5-S5-S
C52 10u
C55 100n
C57 10u
C59 100n
C61 2n2 Y1
R65 220R
C63 10u
C65 10u
C67 100n
FB8 600R@100M
TP20 VCC_ULINK_ISO
TP22 GND_ISO_2
FB10 600R@100M
C69 100n
C71 100n
U21 ACPL-C87B
R72C 50k 0.1%
R72B 50k 0.1%
C74 10n
R72D 50k 0.1%
U23C OPA4342EA
C75 10n
R72A 50k 0.1%
U23D OPA4342EA
R72: ACASA5002S5002P1AT
VREF_H
ULINK_ISO_A
ULINK_ISO_B
R66 680R
R67 680R
R68 680R
U22 LTV-817S
+3.3V
R70 1k2
D14
TSAC_VOLTAGE_PRESENT
TSAL_VOLTAGE_PRESENT
R69 10k
R59 680k
R60 680k
R61 680k
R62 680k
R63 137k
C53 10n
U19 TL431DBZ
Car number: 65
Author: Luca Engelmann
Scuderia Mensa HS RheinMain racing e.V.
Sheet: /TS_ISO/
File: ts_iso.kicad_sch
Title: SPR23e Battery Management Unit (BMU)
Size: A4
Date: 2023-03-25
Rev: B
KiCad E.D.A. kicad 7.0.2-6a45011f42~172~ubuntu22.04.1
Id: 7/12



UHV1V331MPD

Car number: 65		
Author: Luca Engelmann		
Scuderia Mensa HS RheinMain racing e.V.		
Sheet: /Power/		
File: Power.kicad_sch		
Title: SPR23e Battery Management Unit (BMU)		
Size: A4	Date: 2023-03-25	**Rev: B**
KiCad E.D.A. kicad 7.0.2-6a45011f42~172~ubuntu22.04.1		Id: 8/12



Car number: 65
Author: Luca Engelmann
Scuderia Mensa HS RheinMain racing e.V.

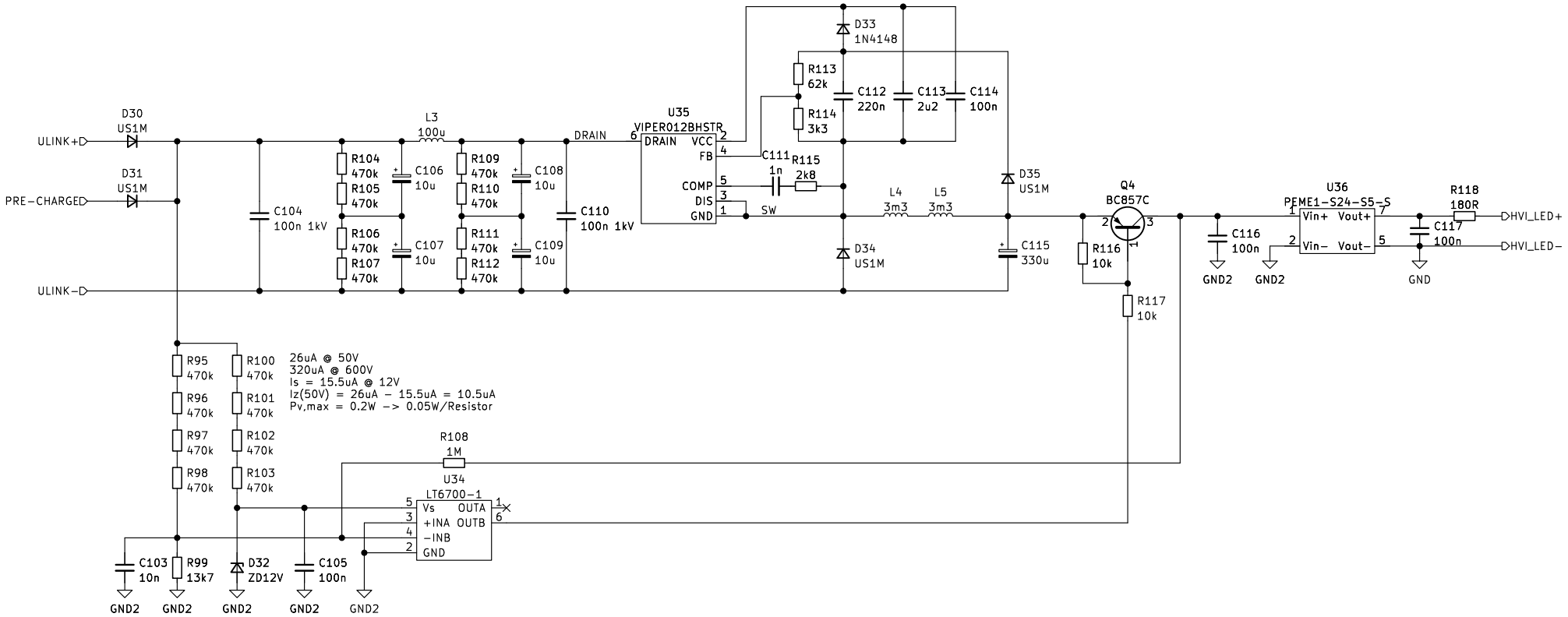
Sheet: /IO_EMI/
File: io_filt.kicad_sch

Title: SPR23e Battery Management Unit (BMU)

Size: A4	Date: 2023-03-25	**Rev: B**
KiCad E.D.A. kicad 7.0.2-6a45011f42~172~ubuntu22.04.1		Id: 9/12

U35 is a regulated buck converter, which converts the TS voltage down to 24V.
It operates in a range of 50V to 600V and is not galvanically isolated.
Below 50V, the output is unstable and starts to pulse at a slow rate.
U36 is a galvanically isolated DCDC converter, which isolates the LED supply from the TS.
To ensure a hard on/off transistion of the LED at 50V,
U34 compares the input voltage to an internal reference.
It is powered from the TS, since it has to operate even if U35 is not regulating yet.
The circuit is powered from the TSAC output as well as from the node between pre-charge
relay and pre-charge resistor. Otherwise, the circuit would load the TS voltage down
during pre-cahrge, effectively preventing the pre-charge.

R108 adds some hysteresis, resulting in a turn-on threshold of 56V and a turn-off threshold of 40V

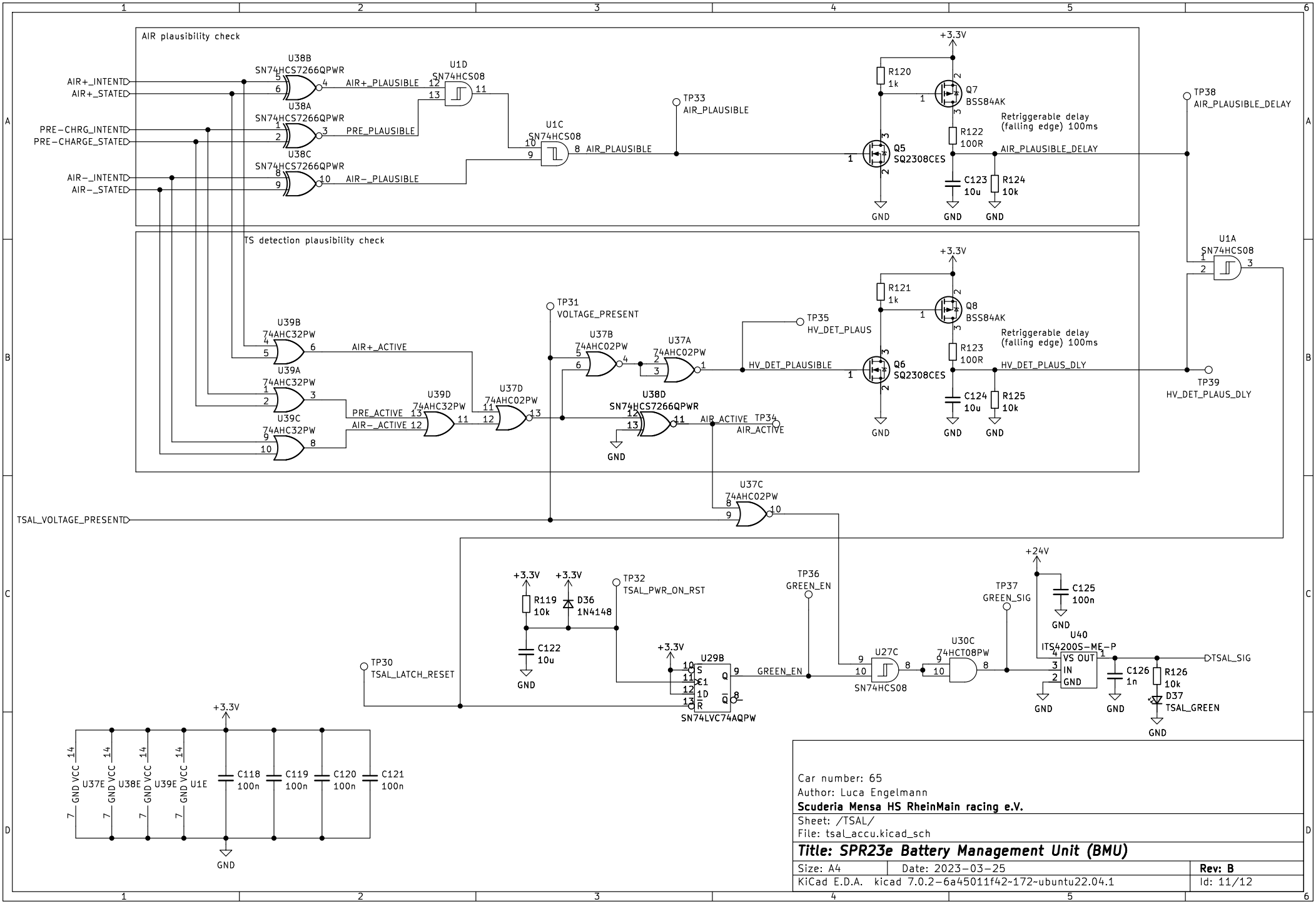


Car number: 65
Author: Luca Engelmann
Scuderia Mensa HS RheinMain racing e.V.

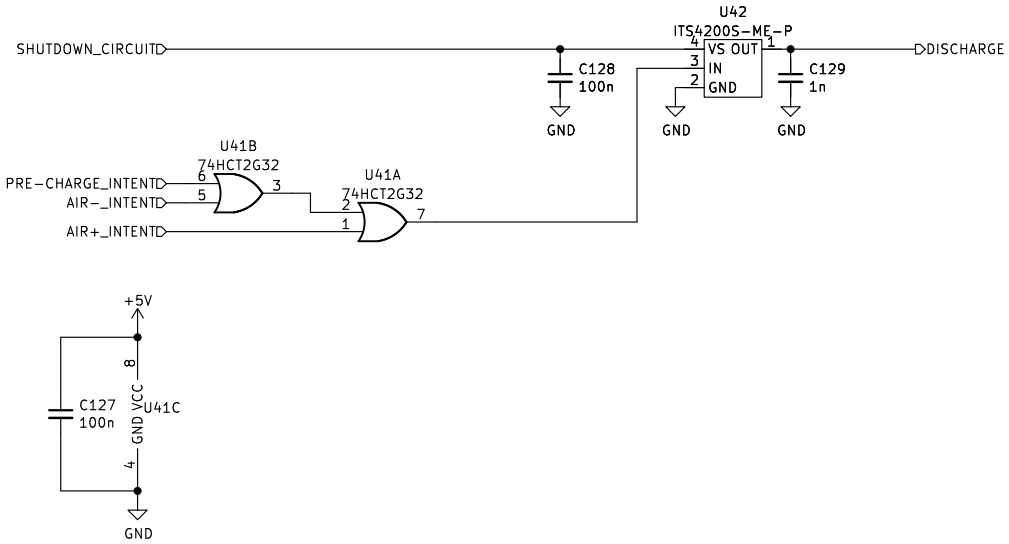
Sheet: /HVI/
File: voltage_indicator.kicad_sch

Title: SPR23e Battery Management Unit (BMU)

Size: A4	Date: 2023-03-25	**Rev: B**
KiCad E.D.A. kicad 7.0.2-6a45011f42~172~ubuntu22.04.1		Id: 10/12


AIR plausibility check
AIR+_INTENT
AIR+_STATED
PRE-CHRG_INTENT
PRE-CHARGE_STATED
AIR-_INTENT
AIR-_STATED
U38B
SN74HCS7266QPWR
U38A
SN74HCS7266QPWR
U38C
SN74HCS7266QPWR
AIR+_PLAUSIBLE
PRE_PLAUSIBLE
AIR-_PLAUSIBLE
U1D
SN74HCS08
U1C
SN74HCS08
AIR_PLAUSIBLE
TP33
AIR_PLAUSIBLE
+3.3V
R120
1k
Q7
BSS84AK
R122
100R
Q5
SQ2308CES
C123
10u
R124
10k
GND
Retriggerable delay
(falling edge) 100ms
AIR_PLAUSIBLE_DELAY
TP38
AIR_PLAUSIBLE_DELAY
TS detection plausibility check
U39B
74AHC32PW
U39A
74AHC32PW
U39C
74AHC32PW
AIR+_ACTIVE
PRE_ACTIVE
AIR-_ACTIVE
U39D
74AHC32PW
U37D
74AHC02PW
TP31
VOLTAGE_PRESENT
U37B
74AHC02PW
U37A
74AHC02PW
HV_DET_PLAUSIBLE
TP35
HV_DET_PLAUS
R121
1k
Q8
BSS84AK
R123
100R
Q6
SQ2308CES
C124
10u
R125
10k
HV_DET_PLAUS_DLY
TP39
HV_DET_PLAUS_DLY
U38D
SN74HCS7266QPWR
AIR_ACTIVE
TP34
AIR_ACTIVE
U1A
SN74HCS08
U37C
74AHC02PW
TSAL_VOLTAGE_PRESENT
+24V
C125
100n
U40
ITS4200S-ME-P
VS OUT
IN
GND
C126
1n
R126
10k
D37
TSAL_GREEN
TSAL_SIG
TP37
GREEN_SIG
U30C
74HCT08PW
U27C
SN74HCS08
TP36
GREEN_EN
+3.3V
R119
10k
D36
1N4148
C122
10u
TP32
TSAL_PWR_ON_RST
U29B
SN74LVC74AQPW
TP30
TSAL_LATCH_RESET
U37E
U38E
U39E
U1E
C118
100n
C119
100n
C120
100n
C121
100n
Car number: 65
Author: Luca Engelmann
Scuderia Mensa HS RheinMain racing e.V.
Sheet: /TSAL/
File: tsal_accu.kicad_sch
Title: SPR23e Battery Management Unit (BMU)
Size: A4
Date: 2023-03-25
Rev: B
KiCad E.D.A. kicad 7.0.2-6a45011f42~172~ubuntu22.04.1
Id: 11/12

The discharge circuit in the inverter is controlled by the
shutdown circuit. To ensure that the discharge circuit is
still enabled while the shutdown circuit is closed but TS is still off,
the intentional states of the AIRs are used. The discharge circuit is disabled
as soon as any of the AIRs is active but still re-activated if an AIR is stuck.



Car number: 65		
Author: Luca Engelmann		
Scuderia Mensa HS RheinMain racing e.V.		
Sheet: /Discharge_Ctrl/		
File: discharge.kicad_sch		
Title: SPR23e Battery Management Unit (BMU)		
Size: A4	Date: 2023-03-25	**Rev: B**
KiCad E.D.A. kicad 7.0.2-6a45011f42~172~ubuntu22.04.1		Id: 12/12