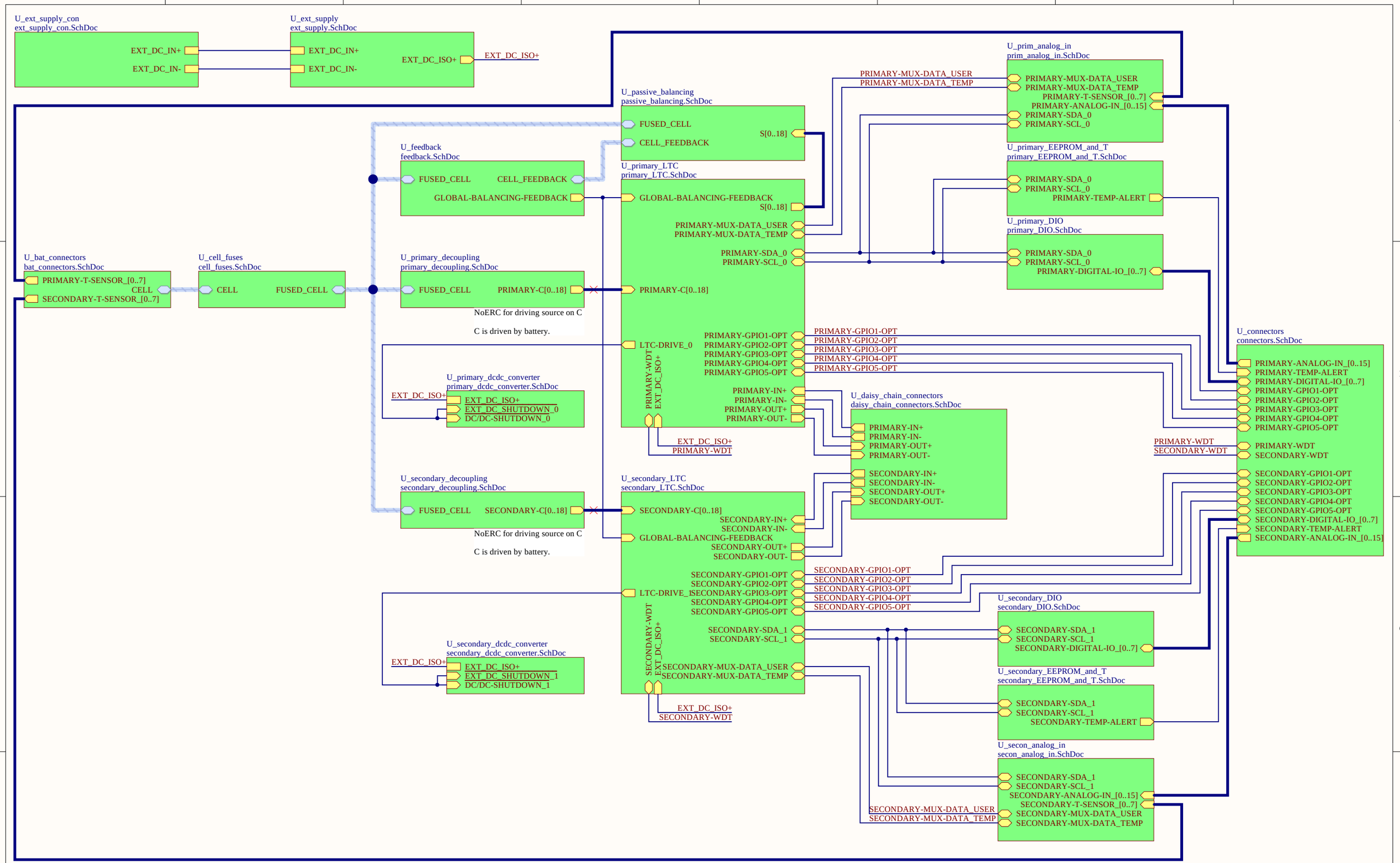
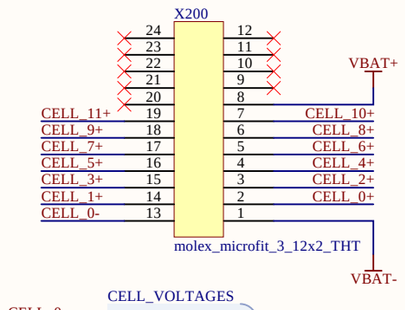


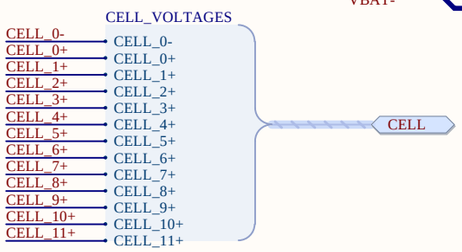
fox BMS www.foxbms.org	developed by: Fraunhofer IISB Schottkystr. 10 91058 Erlangen Germany	Fraunhofer IISB www.iisb.fraunhofer.de	Project: BMS-Slave 12-Cell	Description: Overview
			Author: foxBMS Team	License: Creative Commons Attribution 4.0

File	Version	Release Date	Sheet
hierarchy.SchDoc	2.1.7	2019-03-28	1 / 21

Batterie Cell Voltage Sense Connector

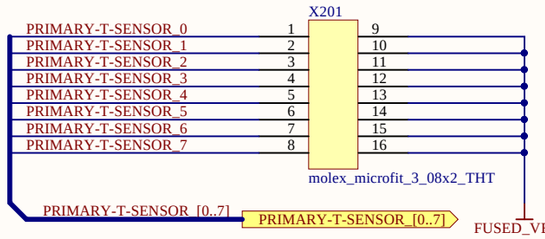
24p connector equal for 12/15/18/20 cell version

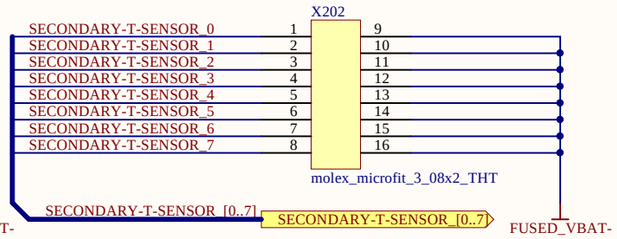




Temperature Sensor Connector

2x 16p connector equal for 12/15/18/20 cell version





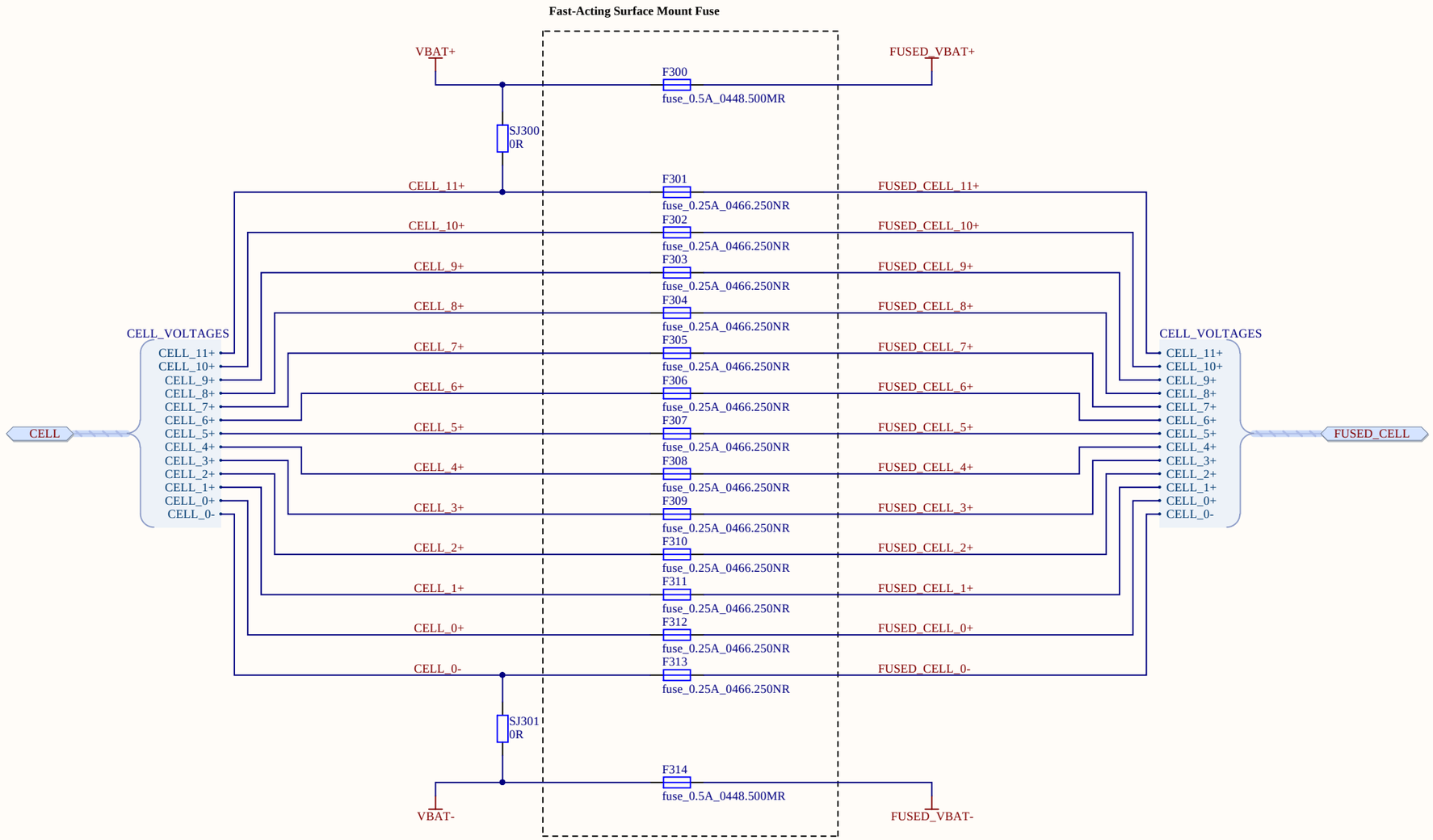
www.foxbms.org

developed by:

Fraunhofer IISB
Schottkystr. 10
91058 Erlangen
Germany

www.iisb.fraunhofer.de

Project	Description	File		
BMS-Slave 12-Cell	Connection to pack	bat_connectors.SchDoc		
Author	License	Version	Release Date	Sheet
foxBMS Team	Creative Commons Attribution 4.0	2.1.7	2019-03-28	2 / 21



For Cell Balancing/ Measuring Inputs: Max. 0.250A Balancing Current
Reaction Time:
200% Load (0.500A) = ca. 20ms
300% Load (0.750A) = <10ms

For Power Supply Inputs: Max. 0.500A Current
Reaction Time:
200% Load (1.000A) = ca. 200ms
300% Load (1.500A) = ca. 70ms

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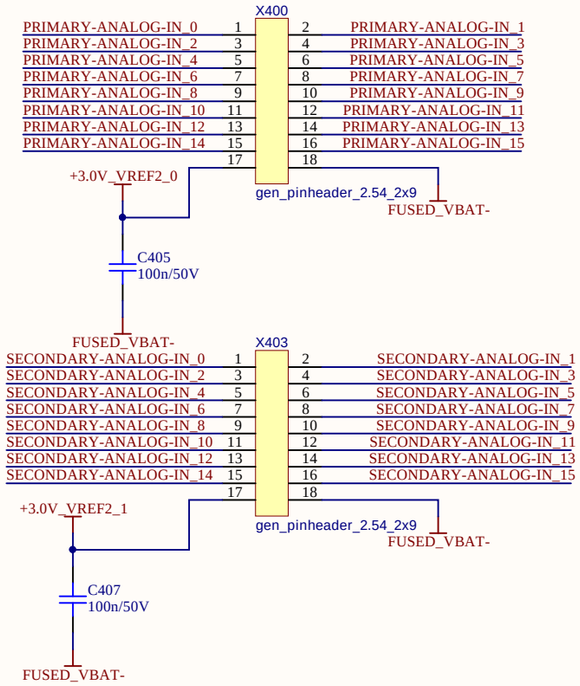
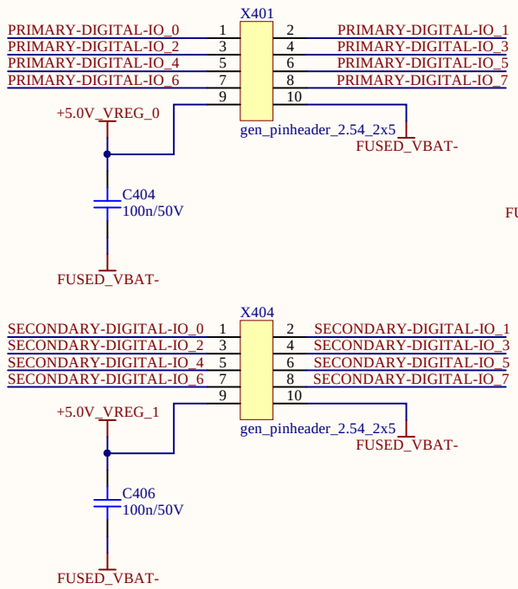
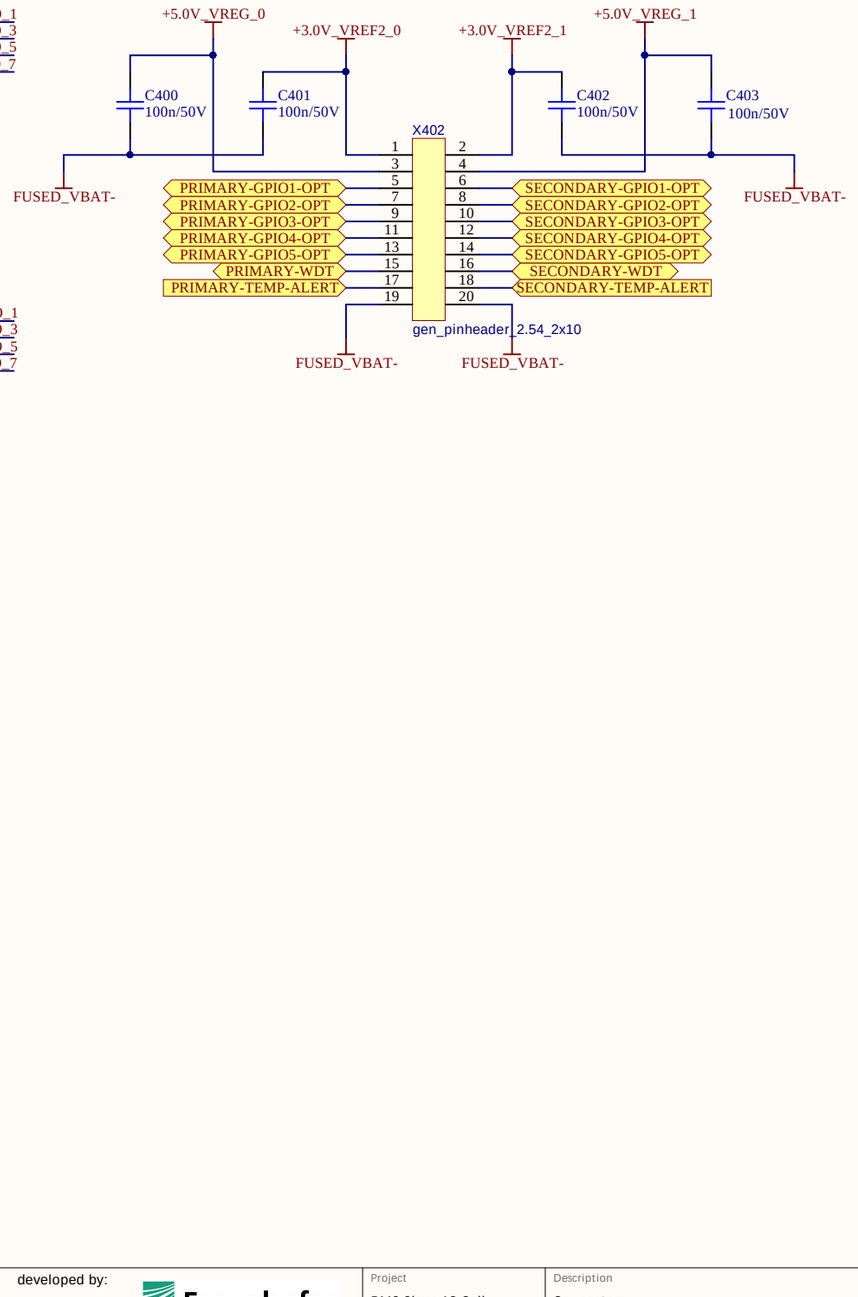
Project	Description	File		
BMS-Slave 12-Cell	Cell Voltage Sense Fuses	cell_fuses.SchDoc		
Author	License	Version	Release Date	Sheet
foxBMS Team	Creative Commons Attribution 4.0	2.1.7	2019-03-28	3 / 21

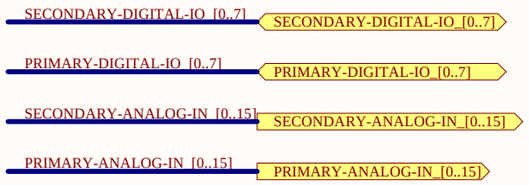
Pin-Header for additional analog and digital inputs/outputs





GPIO Extension Connector

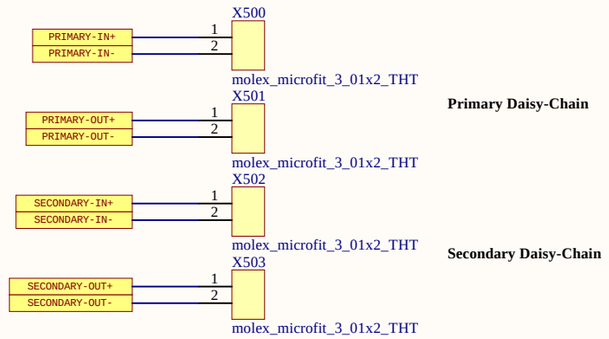




www.foxbms.org	developed by: Fraunhofer IISB Schottkystr. 10 91058 Erlangen Germany	www.iisb.fraunhofer.de	Project: BMS-Slave 12-Cell	Description: Connectors	File: connectors.SchDoc
			Author: foxBMS Team	License: Creative Commons Attribution 4.0	Version: 2.1.7 / Release Date: 2019-03-28 / Sheet: 4 / 21

Daisy Chain Connectors

4x 2p connector equal for 12/15/18/20 cell version



Primary Daisy-Chain

Secondary Daisy-Chain

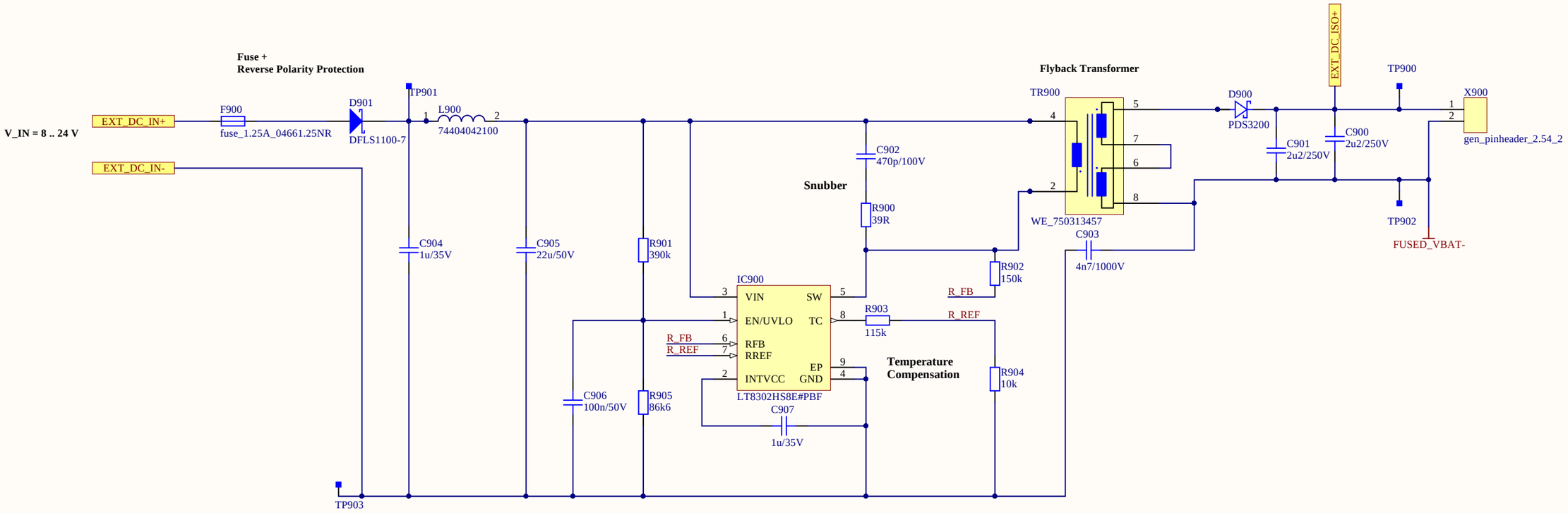
developed by:

Fraunhofer IISB
Schottkystr. 10
91058 Erlangen
Germany

www.foxbms.org

www.iisb.fraunhofer.de

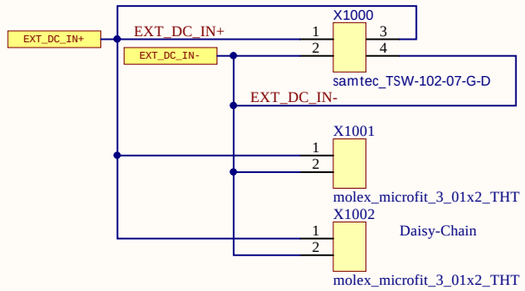
Project	Description	File		
BMS-Slave 12-Cell	Daisy Chain Connectors	daisy_chain_connectors.SchDoc		
Author	License	Version	Release Date	Sheet
foxBMS Team	Creative Commons Attribution 4.0	2.1.7	2019-03-28	5 / 21

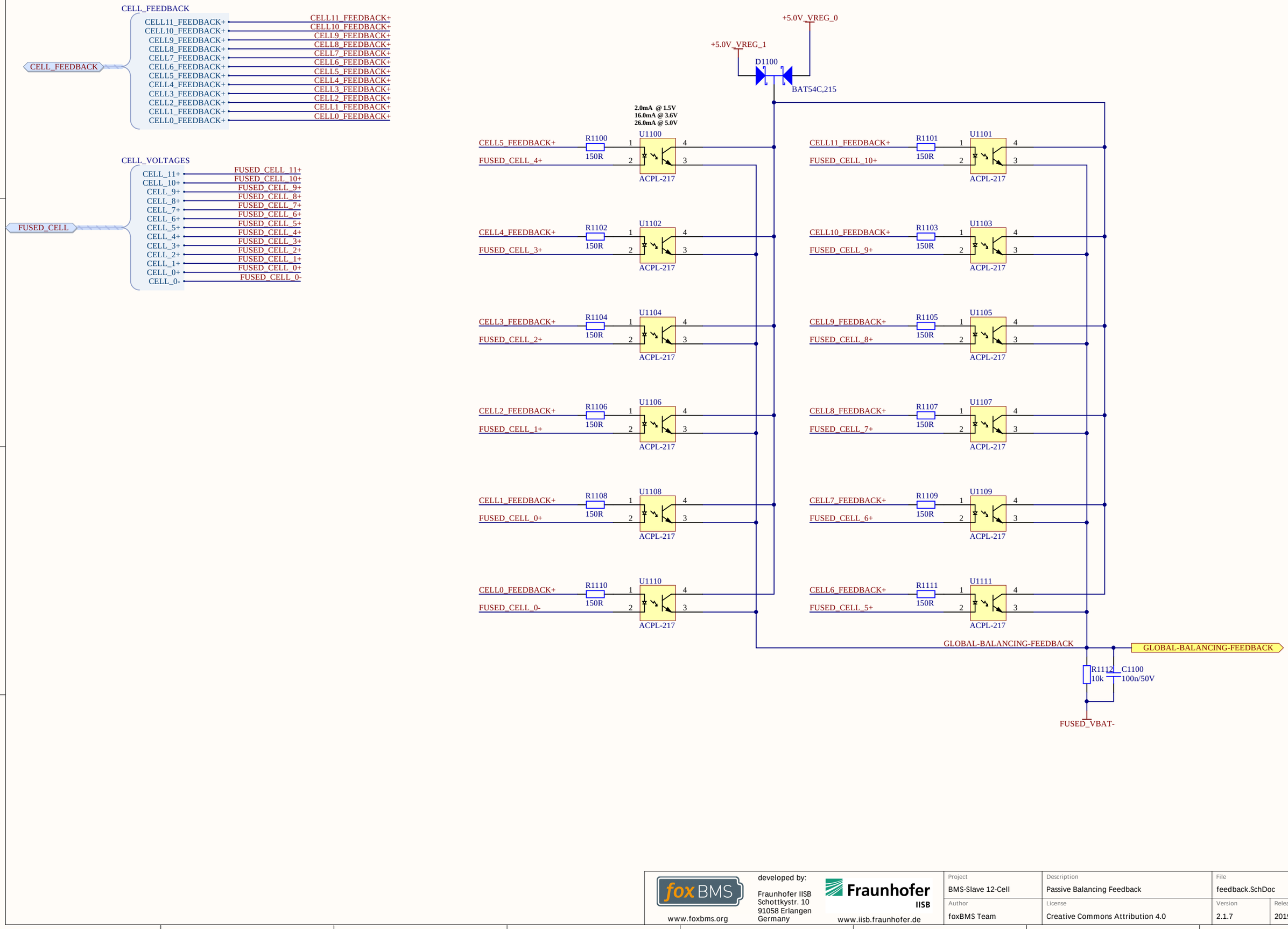


www.foxbms.org	developed by: Fraunhofer IISB Schottkystr. 10 91058 Erlangen Germany	www.iisb.fraunhofer.de	Project: BMS-Slave 12-Cell	Description: External Power Supply
			Author: foxBMS Team	License: Creative Commons Attribution 4.0

File	Version	Release Date	Sheet
ext_supply.SchDoc	2.1.7	2019-03-28	6 / 21

External Power Supply





www.foxbms.org	developed by: Fraunhofer IISB Schottkystr. 10 91058 Erlangen Germany	www.iisb.fraunhofer.de	Project: BMS-Slave 12-Cell	Description: Passive Balancing Feedback	File: feedback.SchDoc		
			Author: foxBMS Team	License: Creative Commons Attribution 4.0	Version: 2.1.7	Release Date: 2019-03-28	Sheet: 8 / 21

CELL_VOLTAGES

FUSED_CELL

CELL_11+ FUSED_CELL_11+
CELL_10+ FUSED_CELL_10+
CELL_9+ FUSED_CELL_9+
CELL_8+ FUSED_CELL_8+
CELL_7+ FUSED_CELL_7+
CELL_6+ FUSED_CELL_6+
CELL_5+ FUSED_CELL_5+
CELL_4+ FUSED_CELL_4+
CELL_3+ FUSED_CELL_3+
CELL_2+ FUSED_CELL_2+
CELL_1+ FUSED_CELL_1+
CELL_0+ FUSED_CELL_0+
CELL_0- FUSED_CELL_0-

S[0..12] S[0..18]

CELL_FEEDBACK

CELL_FEEDBACK

CELL11_FEEDBACK+ CELL11_FEEDBACK+
CELL10_FEEDBACK+ CELL10_FEEDBACK+
CELL9_FEEDBACK+ CELL9_FEEDBACK+
CELL8_FEEDBACK+ CELL8_FEEDBACK+
CELL7_FEEDBACK+ CELL7_FEEDBACK+
CELL6_FEEDBACK+ CELL6_FEEDBACK+
CELL5_FEEDBACK+ CELL5_FEEDBACK+
CELL4_FEEDBACK+ CELL4_FEEDBACK+
CELL3_FEEDBACK+ CELL3_FEEDBACK+
CELL2_FEEDBACK+ CELL2_FEEDBACK+
CELL1_FEEDBACK+ CELL1_FEEDBACK+
CELL0_FEEDBACK+ CELL0_FEEDBACK+

FUSED_CELL_5+
T1501 NX2301P,215
R1501 3k3
S6
CELL5_FEEDBACK+
R1504 68R
R1505 68R
147mA @ 5.0V
123mA @ 4.2V
118mA @ 4.0V
112mA @ 3.8V
106mA @ 3.6V
FUSED_CELL_4+

T1503 NX2301P,215
R1507 3k3
S5
CELL4_FEEDBACK+
R1510 68R
R1511 68R
FUSED_CELL_3+

T1505 NX2301P,215
R1513 3k3
S4
CELL3_FEEDBACK+
R1516 68R
R1517 68R
FUSED_CELL_2+

T1507 NX2301P,215
R1519 3k3
S3
CELL2_FEEDBACK+
R1522 68R
R1523 68R
FUSED_CELL_1+

T1509 NX2301P,215
R1525 3k3
S2
CELL1_FEEDBACK+
R1526 68R
R1527 68R
FUSED_CELL_0+

T1510 NX2301P,215
R1530 3k3
S1
CELL0_FEEDBACK+
R1534 68R
R1535 68R
FUSED_CELL_0-

FUSED_CELL_11+
T1500 NX2301P,215
R1500 3k3
S12
CELL11_FEEDBACK+
R1502 68R
R1503 68R
FUSED_CELL_10+

T1502 NX2301P,215
R1506 3k3
S11
CELL10_FEEDBACK+
R1508 68R
R1509 68R
FUSED_CELL_9+

T1504 NX2301P,215
R1512 3k3
S10
CELL9_FEEDBACK+
R1514 68R
R1515 68R
FUSED_CELL_8+

T1506 NX2301P,215
R1518 3k3
S9
CELL8_FEEDBACK+
R1520 68R
R1521 68R
FUSED_CELL_7+

T1508 NX2301P,215
R1524 3k3
S8
CELL7_FEEDBACK+
R1528 68R
R1529 68R
FUSED_CELL_6+

T1511 NX2301P,215
R1531 3k3
S7
CELL6_FEEDBACK+
R1532 68R
R1533 68R
FUSED_CELL_5+

fox BMS
www.foxbms.org

developed by:
Fraunhofer IISB
Schottkystr. 10
91058 Erlangen
Germany

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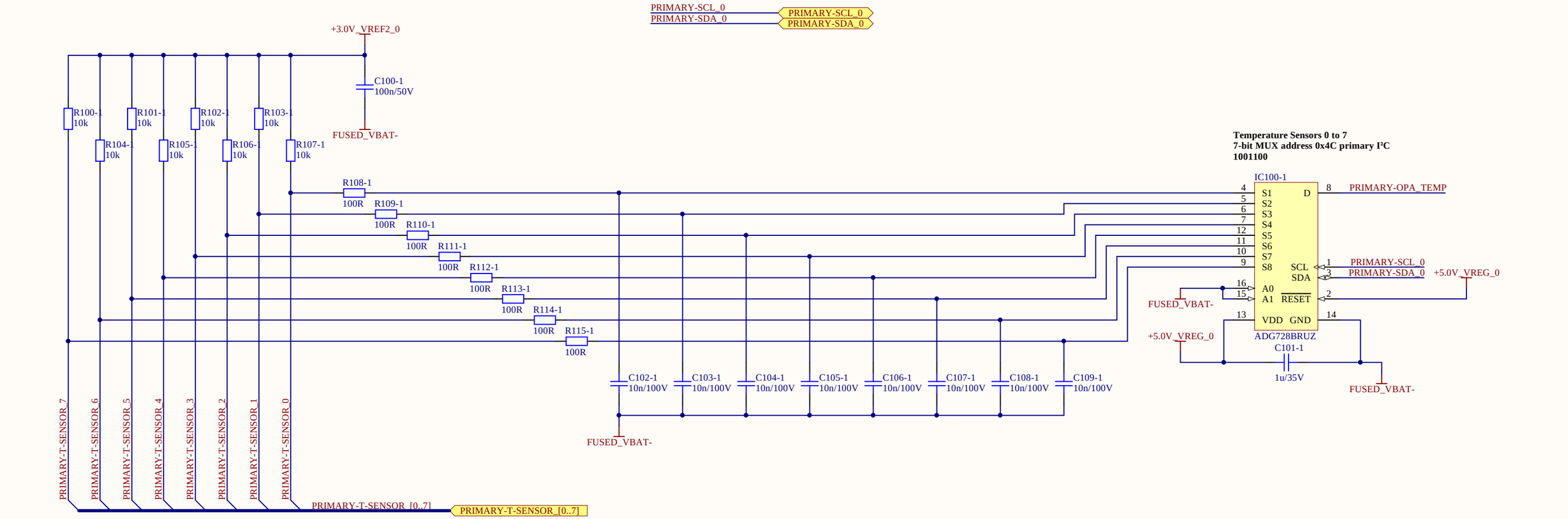
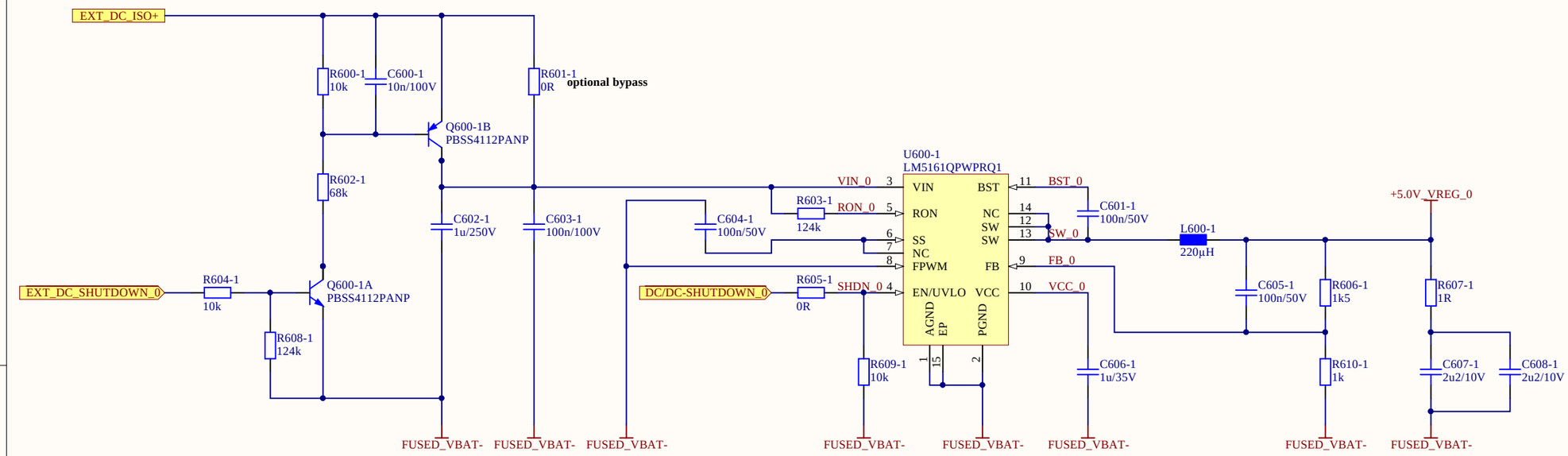
www.iisb.fraunhofer.de

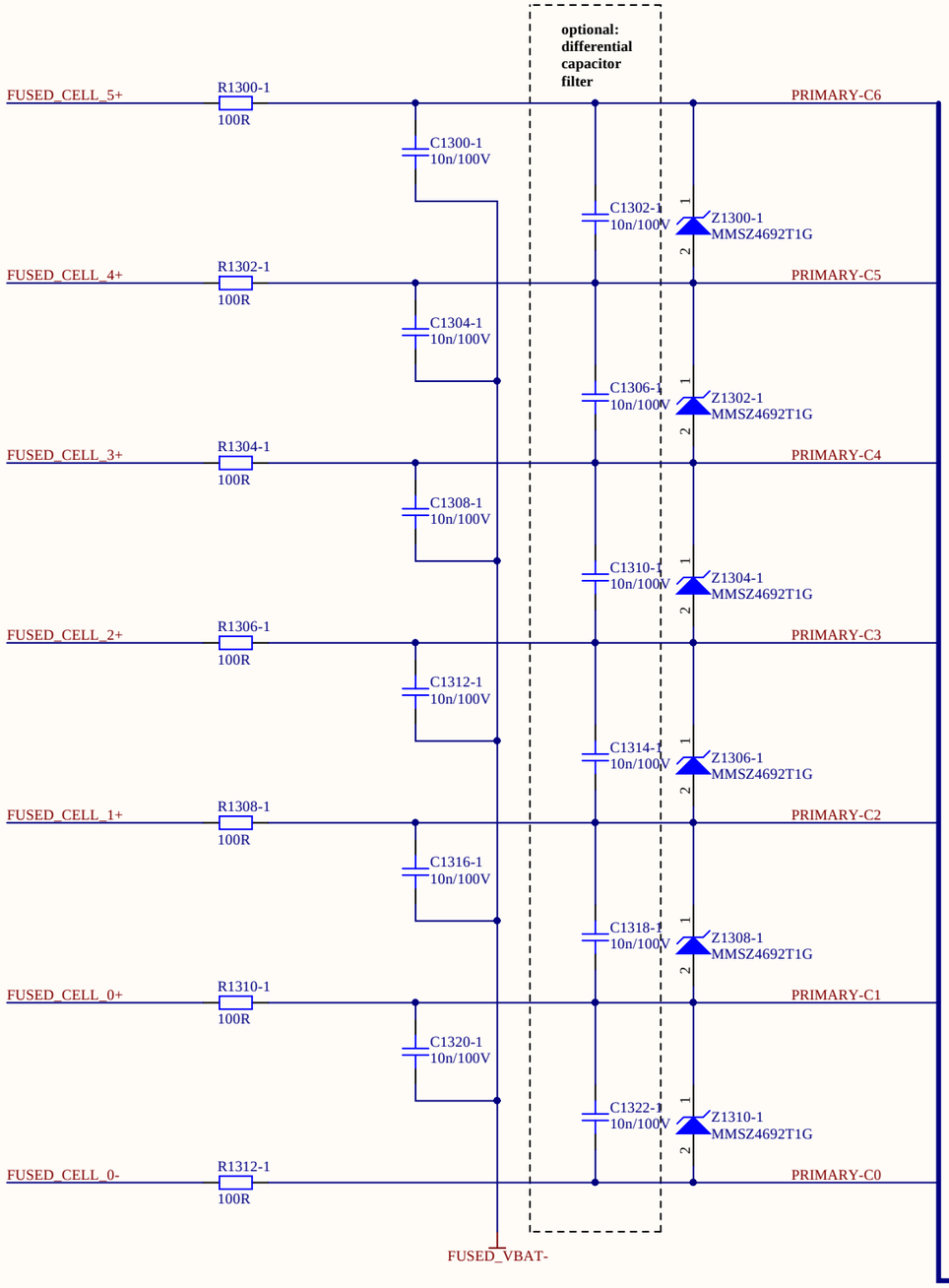
Project: BMS-Slave 12-Cell	Description: Passive Cell Balancing	File: passive_balancing.SchDoc	
Author: foxBMS Team	License: Creative Commons Attribution 4.0	Version: 2.1.7	Release Date: 2019-03-28
			Sheet: 9 / 21

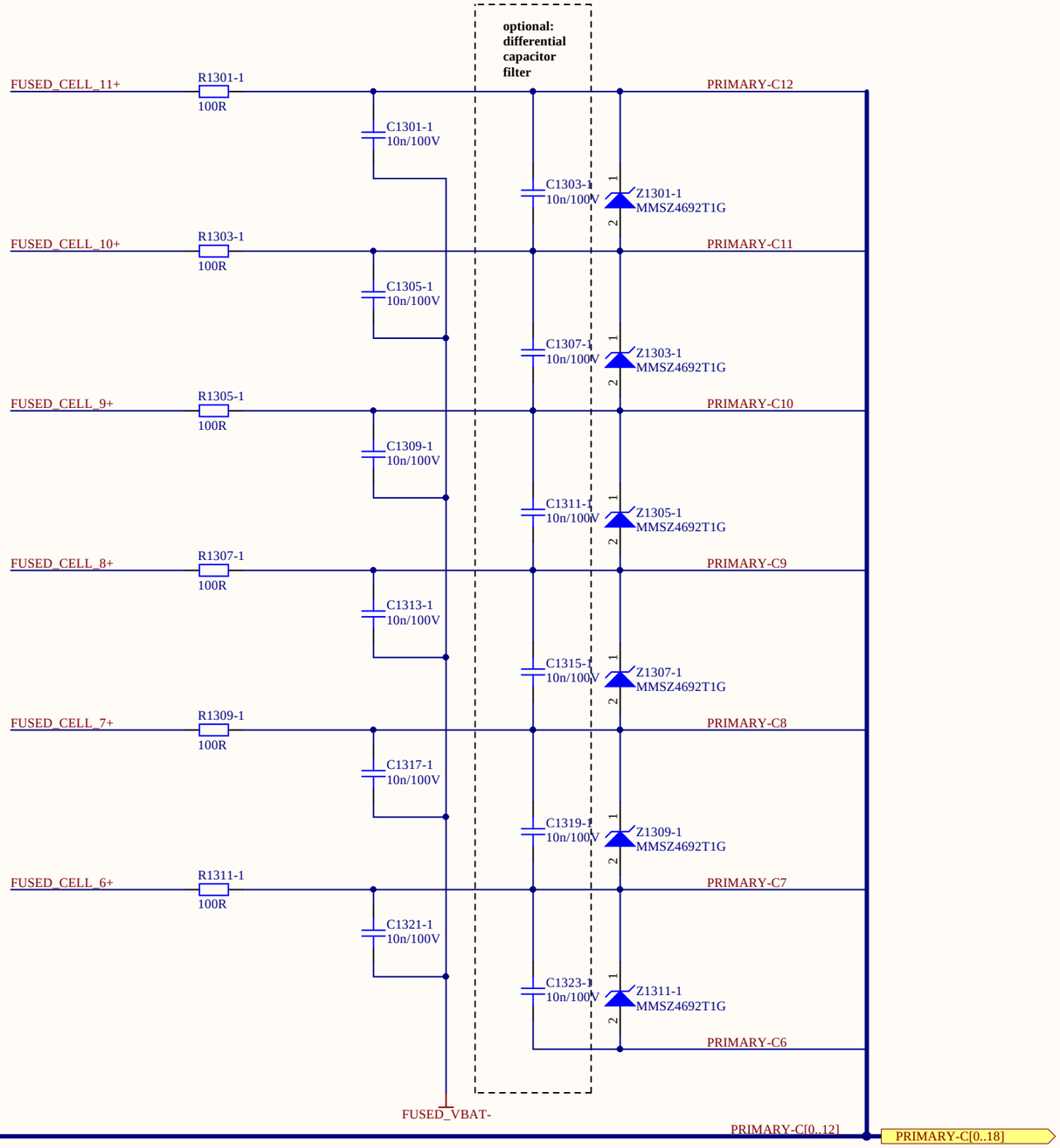


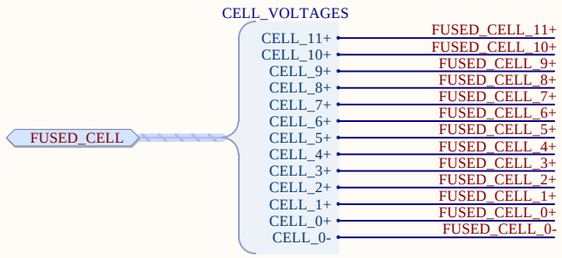
www.foxbms.org	developed by: Fraunhofer IISB Schottkystr. 10 91058 Erlangen Germany	www.iisb.fraunhofer.de	Project: BMS-Slave 12-Cell	Description: Primary Analog Inputs	File: prim_analog_in.SchDoc
			Author: foxBMS Team	License: Creative Commons Attribution 4.0	Version: 2.1.7 / Release Date: 2019-03-28 / Sheet: 10 / 21



www.foxbms.org	developed by: Fraunhofer IISB Schottkystr. 10 91058 Erlangen Germany	www.iisb.fraunhofer.de	Project: BMS-Slave 12-Cell	Description: DC/DC Converter	File: primary_dcdc_converter.SchDoc		
			Author: foxBMS Team	License: Creative Commons Attribution 4.0	Version: 2.1.7	Release Date: 2019-03-28	Sheet: 11 / 21







-3dB corner frequency of LTC6811 internal digital low-pass filter:
fast mode: 27kHz
normal mode: 6.8kHz
filtered mode: 26Hz

Grounded capacitor low-pass filter:
C = 100nF -> fg = 16kHz
C = 22nF -> fg = 72kHz
C = 10nF -> fg = 160kHz (recommended)

Differential capacitor low-pass filter (lower cost):
C = 100nF -> fg = 11kHz
C = 22nF -> fg = 50kHz
C = 10nF -> fg = 112kHz

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Fraunhofer IISB
Schottkystr. 10
91058 Erlangen
Germany

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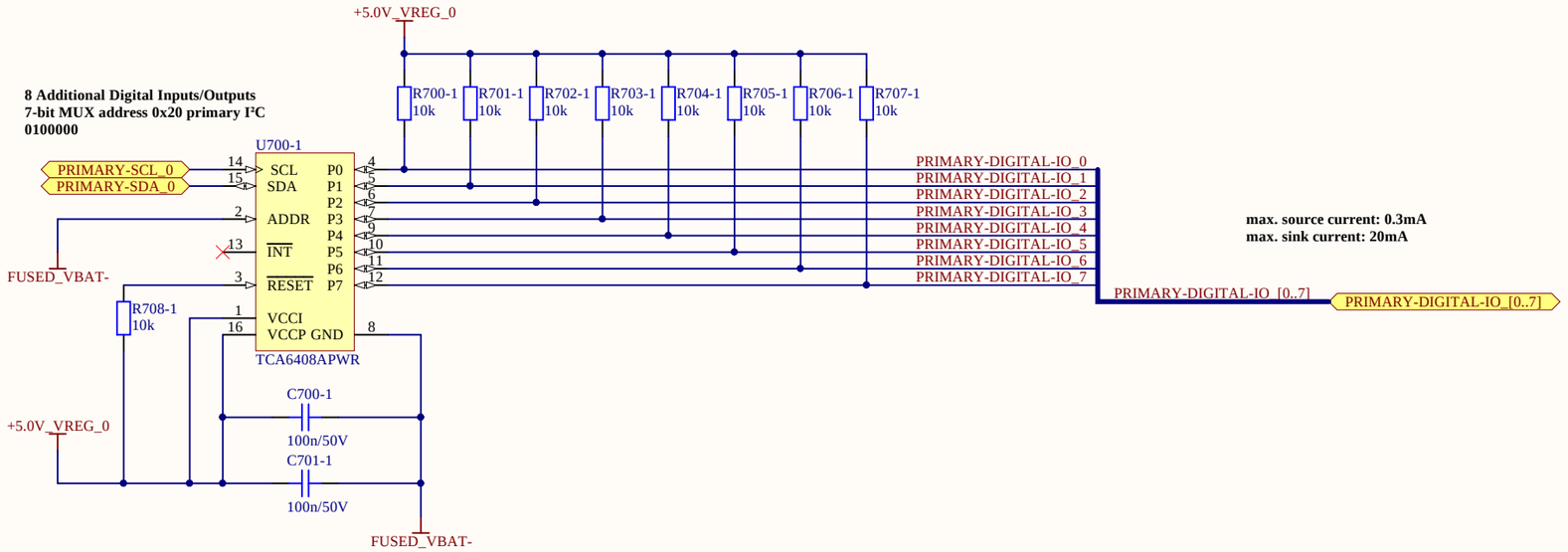
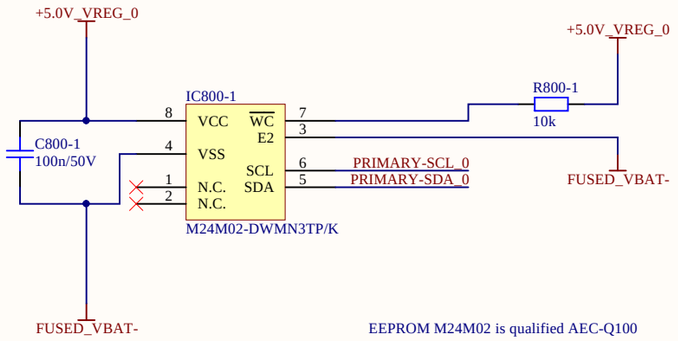
Project	Description	File		
BMS-Slave 12-Cell	Primary Voltage Measurement	primary_decoupling.SchDoc		
Author	License	Version	Release Date	Sheet
foxBMS Team	Creative Commons Attribution 4.0	2.1.7	2019-03-28	12 / 21



www.foxbms.org	developed by: Fraunhofer IISB Schottkystr. 10 91058 Erlangen Germany	www.iisb.fraunhofer.de	Project: BMS-Slave 12-Cell	Description: Primary Digital Inputs/Outputs	File: primary_DIO.SchDoc		
			Author: foxBMS Team	License: Creative Commons Attribution 4.0	Version: 2.1.7	Release Date: 2019-03-28	Sheet: 13 / 21

EEPROM
7-bit base address 0x50 primary I²C
10100 (A17) (A16)
A17, A16: MSB address bits



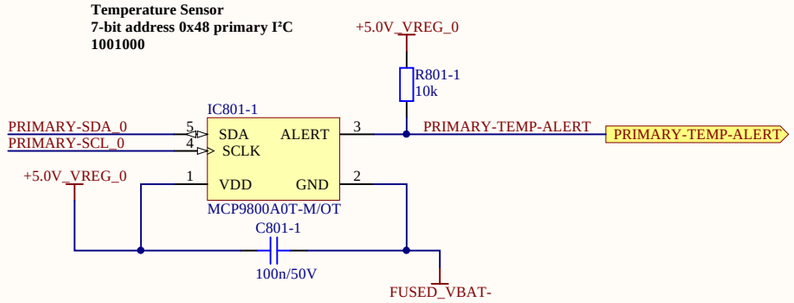
W\C\:
floating: write operation enabled
pulled high: write operations disabled

When Write Control (WC) is driven high, device select and address bytes are acknowledged,
data bytes are not acknowledged.

PRIMARY-SDA_0
PRIMARY-SCL_0
PRIMARY-SDA_0
PRIMARY-SCL_0

EEPROM M24M02 is qualified AEC-Q100

Temperature Sensor
7-bit address 0x48 primary I²C
1001000



±0.5°C (typ.) at +25°C
±1°C (max.) from -10°C to +85°C
±2°C (max.) from -10°C to +125°C
±3°C (max.) from -55°C to +125°C

Attention: use -A0T Type (I2C address conflict otherwise)!

Alert temperature can be configured via I2C

Temperature Sensor MCP9800 is qualified AEC-Q100

www.foxbms.org
developed by:
Fraunhofer IISB
Schottkystr. 10
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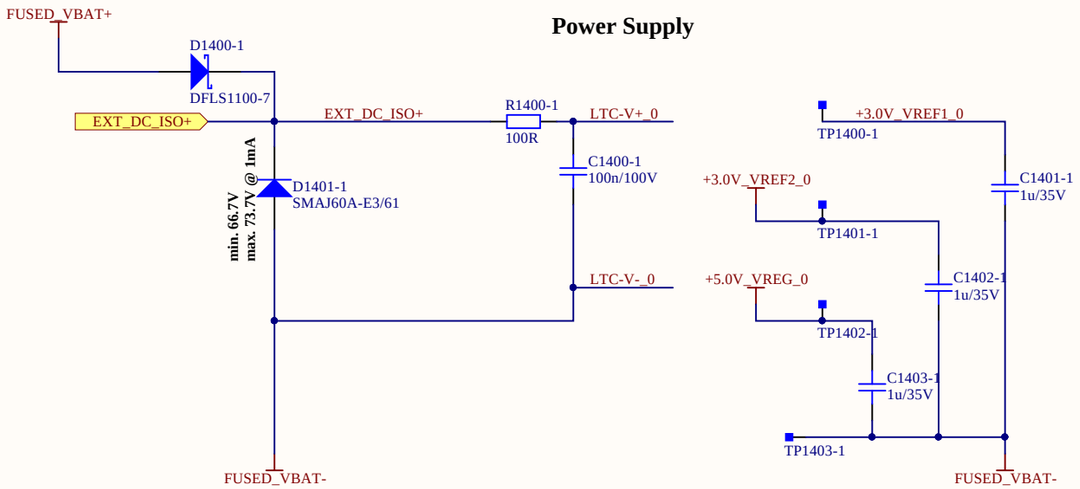
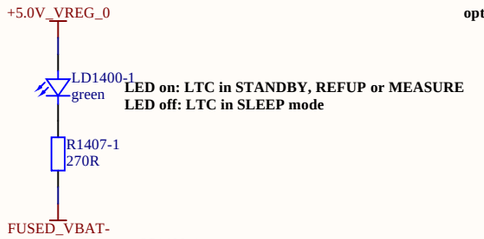
Germany
www.iisb.fraunhofer.de

Project	Description	File		
BMS-Slave 12-Cell	Primary EEPROM and Board T-Sensor	primary_EEPROM_and_T.SchDoc		
Author	License	Version	Release Date	Sheet
foxBMS Team	Creative Commons Attribution 4.0	2.1.7	2019-03-28	14 / 21

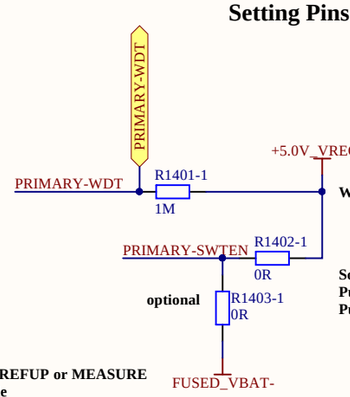
Power Supply





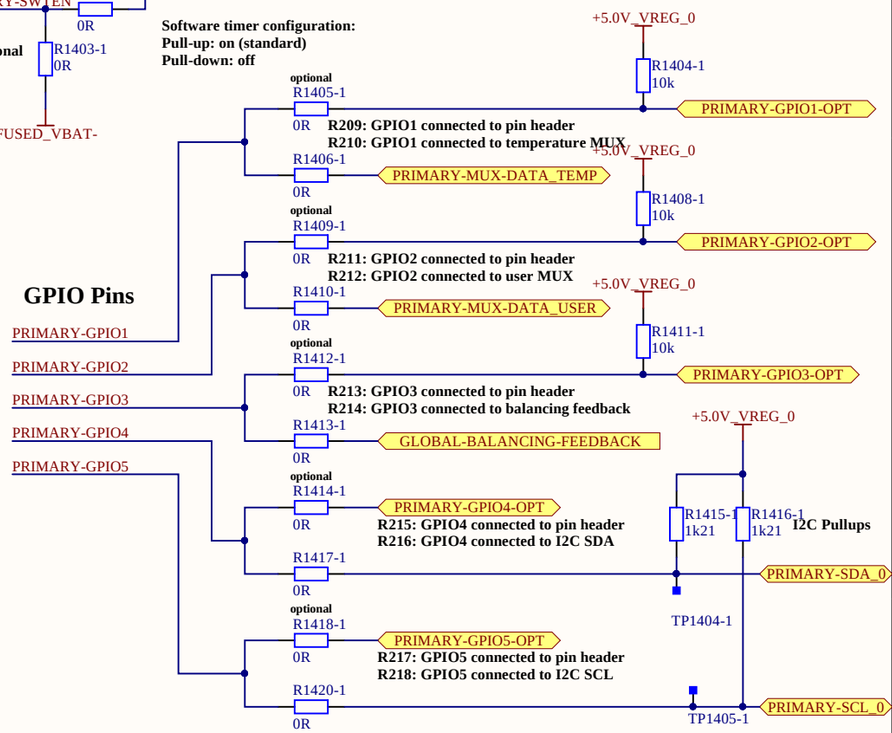
LED on: LTC in STANDBY, REFUP or MEASURE
LED off: LTC in SLEEP mode

Setting Pins

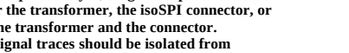


Software timer configuration:
Pull-up: on (standard)
Pull-down: off

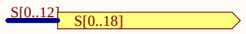
GPIO Pins

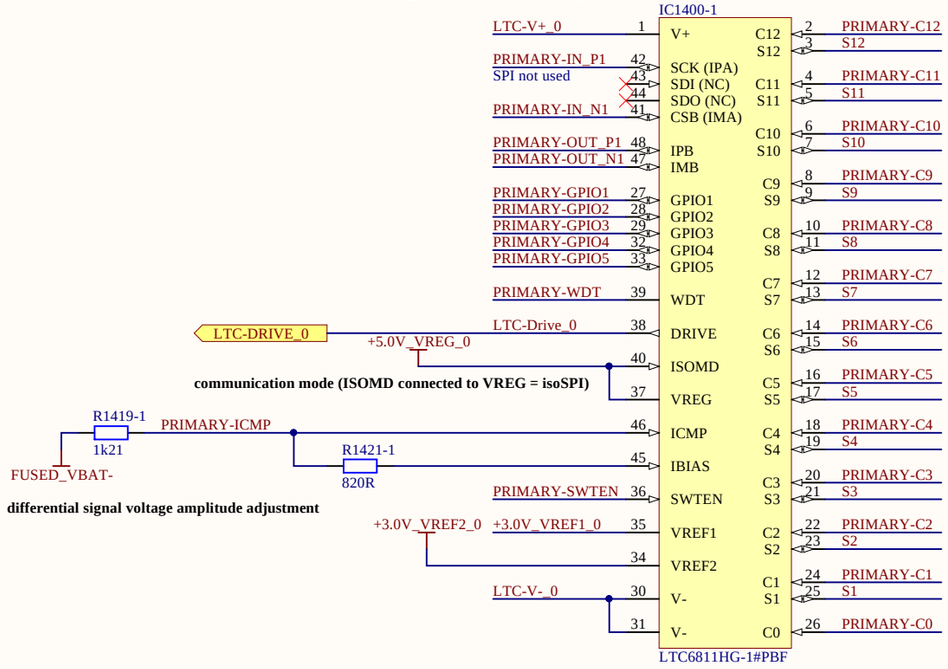


Cell voltage sense inputs

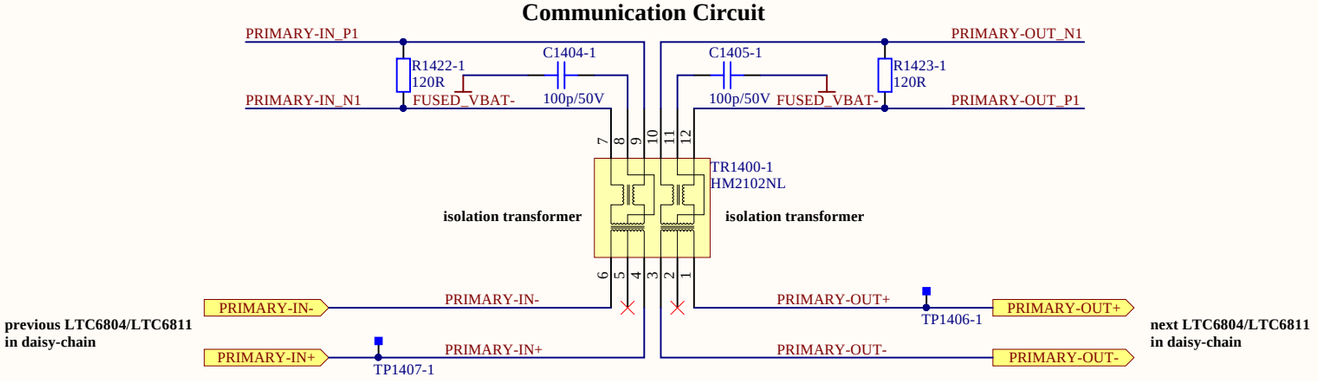


Cell balancing control





Communication Circuit



Layout:

- **The transformer should be placed as close to the isoSPI cable connector as possible. The distance should be kept less than 2cm.**
- **The LTC6811 should be placed at least 1cm to 2cm away from the transformer.**
- **On the top component layer, no ground plane should be placed under the transformer, the isoSPI connector, or in between the transformer and the connector.**
- **The isoSPI signal traces should be isolated from surrounding circuits and traces by ground metal or space. No traces should cross the isoSPI signal lines, unless separated by a ground plane on an inner layer.**

www.foxbms.org

developed by:

Fraunhofer IISB
Schottkystr. 10
91058 Erlangen
Germany

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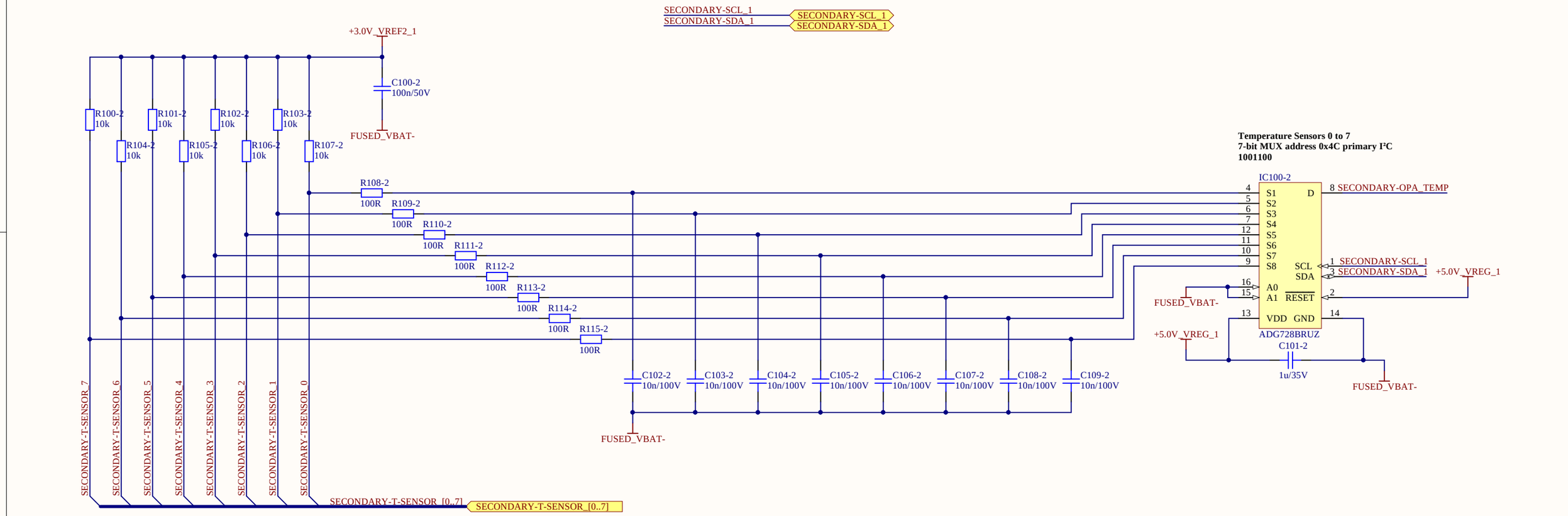
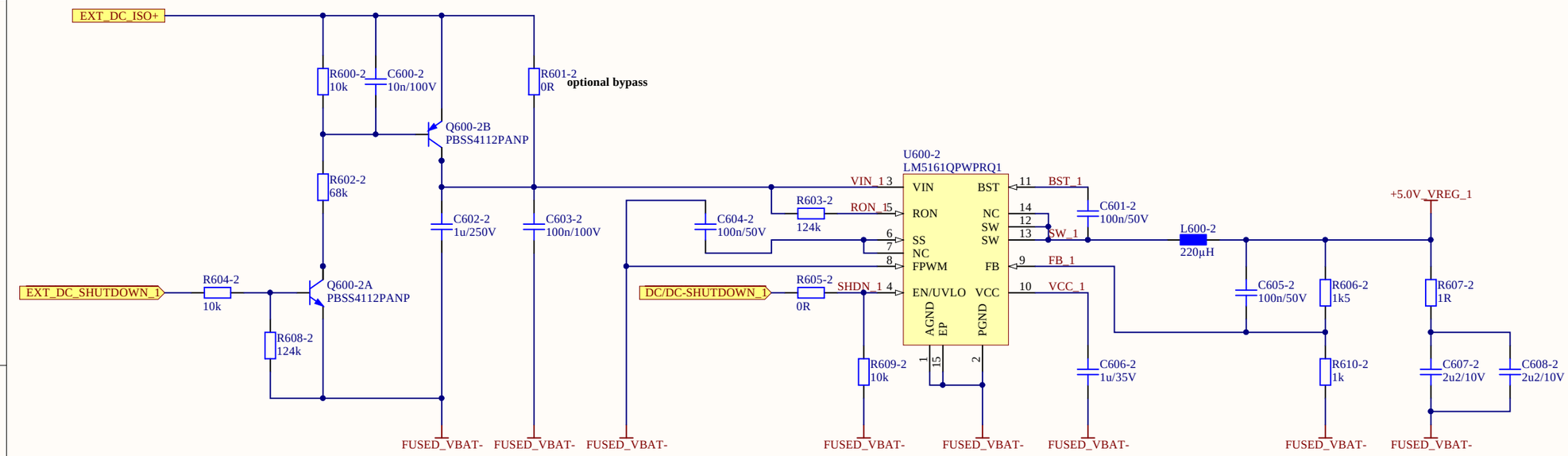
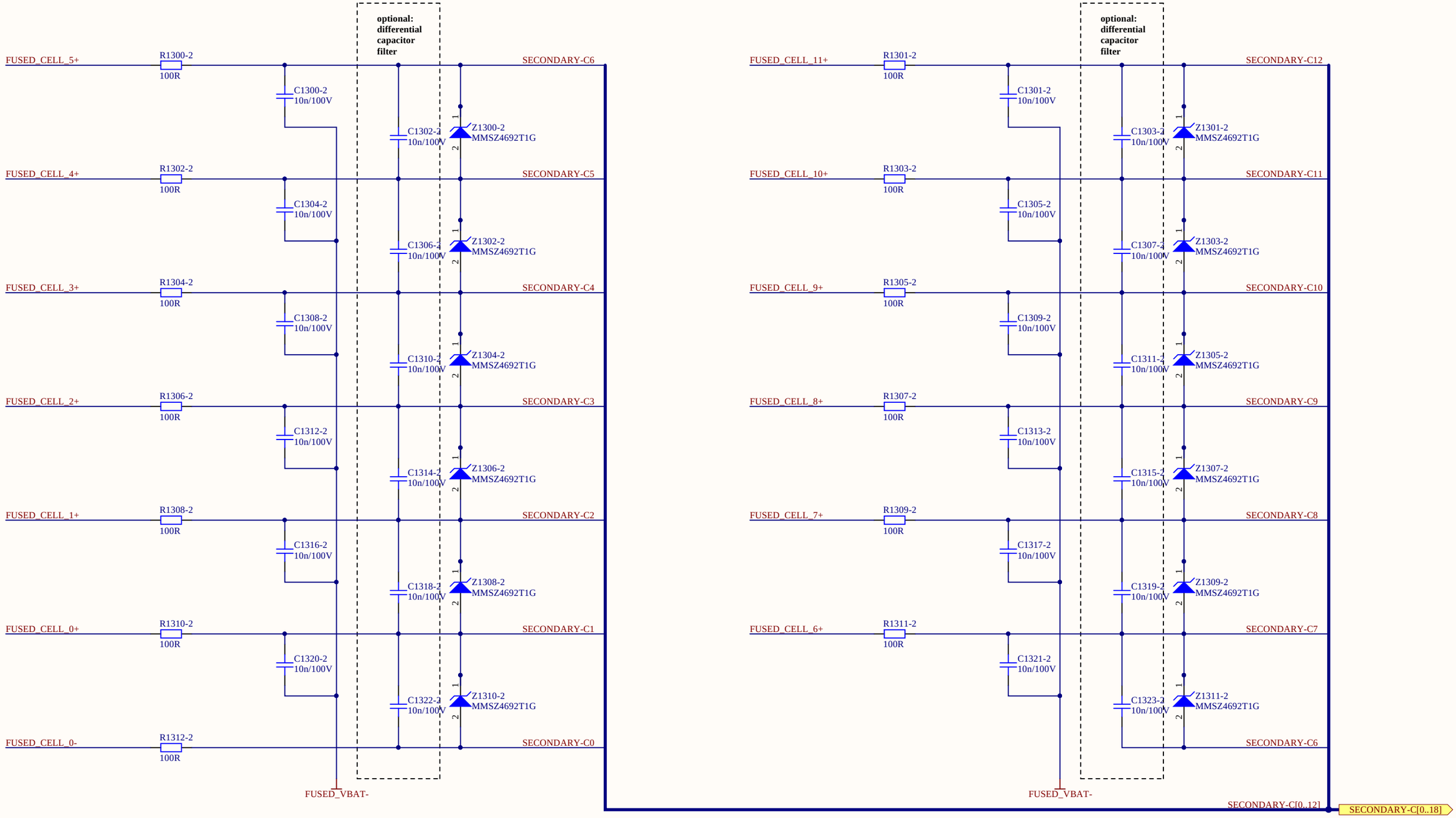
Project	Description	File		
BMS-Slave 12-Cell	Primary LTC6811	primary_LTC.SchDoc		
Author	License	Version	Release Date	Sheet
foxBMS Team	Creative Commons Attribution 4.0	2.1.7	2019-03-28	15 / 21

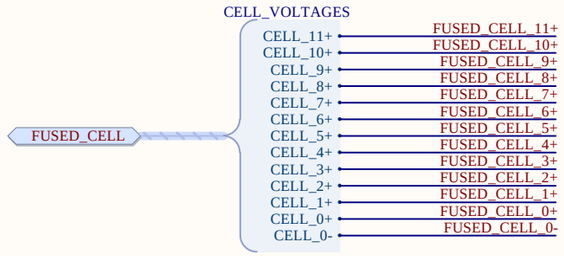


foxBMS www.foxbms.org	developed by: Fraunhofer IISB Schottkystr. 10 91058 Erlangen Germany	Fraunhofer IISB www.iisb.fraunhofer.de	Project: BMS-Slave 12-Cell	Description: Secondary Analog Inputs	File: secon_analog_in.SchDoc
			Author: foxBMS Team	License: Creative Commons Attribution 4.0	Version: 2.1.7 / Release Date: 2019-03-28 / Sheet: 16 / 21



www.foxbms.org	developed by: Fraunhofer IISB Schottkystr. 10 91058 Erlangen Germany	www.iisb.fraunhofer.de	Project: BMS-Slave 12-Cell	Description: DC/DC Converter	File: secondary_dcdc_converter.SchDoc		
			Author: foxBMS Team	License: Creative Commons Attribution 4.0	Version: 2.1.7	Release Date: 2019-03-28	Sheet: 17 / 21





-3dB corner frequency of LTC6811 internal digital low-pass filter:
fast mode: 27kHz
normal mode: 6.8kHz
filtered mode: 26Hz

Grounded capacitor low-pass filter:
C = 100nF -> fg = 16kHz
C = 22nF -> fg = 72kHz
C = 10nF -> fg = 160kHz (recommended)

Differential capacitor low-pass filter (lower cost):
C = 100nF -> fg = 11kHz
C = 22nF -> fg = 50kHz
C = 10nF -> fg = 112kHz

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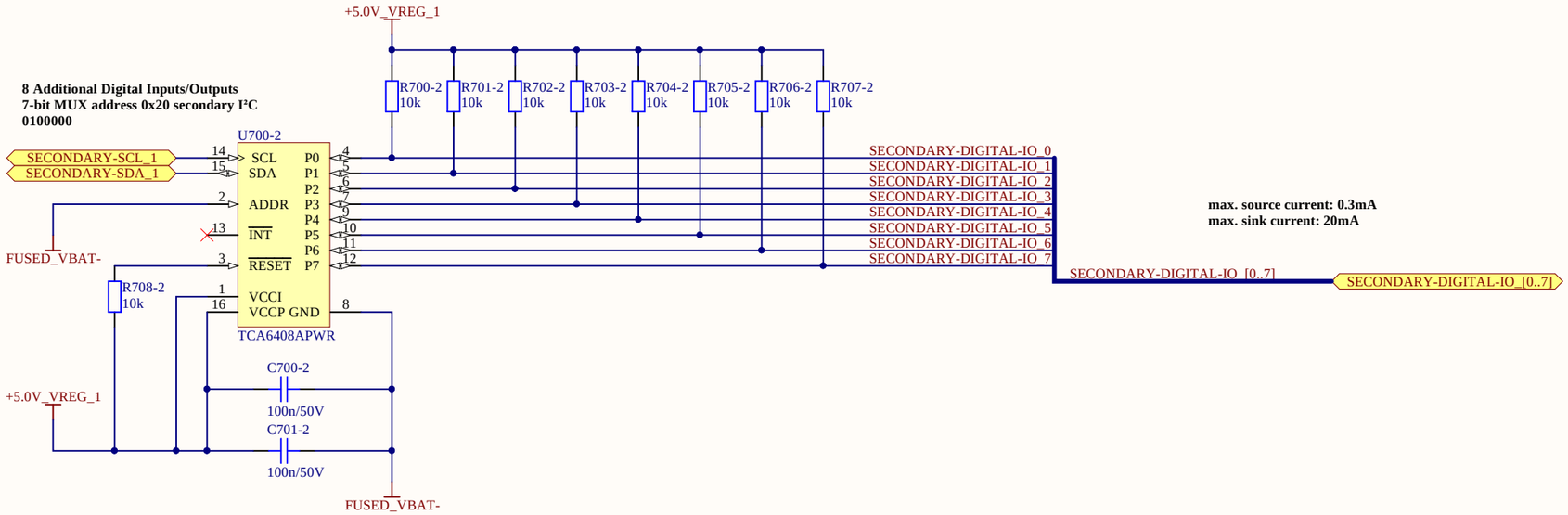
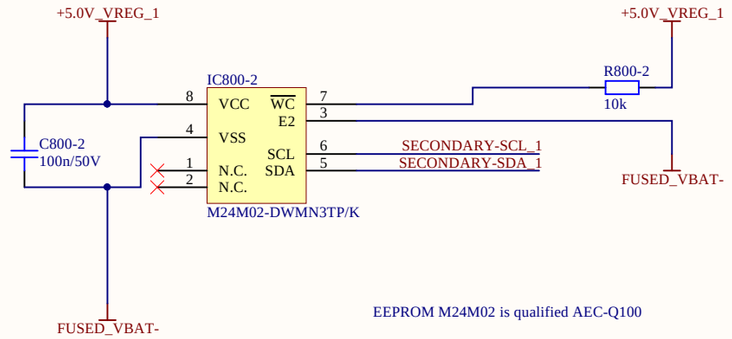
Project	Description	File		
BMS-Slave 12-Cell	Secondary Voltage Measurement	secondary_decoupling.SchDoc		
Author	License	Version	Release Date	Sheet
foxBMS Team	Creative Commons Attribution 4.0	2.1.7	2019-03-28	18 / 21



www.foxbms.org	developed by: Fraunhofer IISB Schottkystr. 10 91058 Erlangen Germany	www.iisb.fraunhofer.de	Project: BMS-Slave 12-Cell	Description: Secondary Digital Inputs/Outputs	File: secondary_DIO.SchDoc
			Author: foxBMS Team	License: Creative Commons Attribution 4.0	Version: 2.1.7 / Release Date: 2019-03-28 / Sheet: 19 / 21

EEPROM
7-bit base address 0x50 secondary I²C
10100 (A17) (A16)
A17, A16: MSB address bits



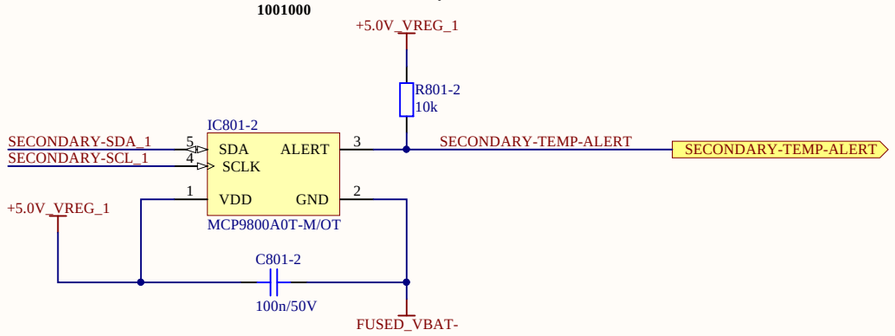
W\C\:
floating: write operation enabled
pulled high: write operations disabled

When Write Control (WC) is driven high, device select and address bytes are acknowledged,
data bytes are not acknowledged.

SECONDARY-SDA_1 SECONDARY-SDA_1
SECONDARY-SCL_1 SECONDARY-SCL_1

EEPROM M24M02 is qualified AEC-Q100

Temperature Sensor
7-bit address 0x48 secondary I²C
1001000



±0.5°C (typ.) at +25°C
±1°C (max.) from -10°C to +85°C
±2°C (max.) from -10°C to +125°C
±3°C (max.) from -55°C to +125°C

Attention: use -A0T Type (I2C address conflict otherwise)!

Alert temperature can be configured via I2C

Temperature Sensor MCP9800 is qualified AEC-Q100

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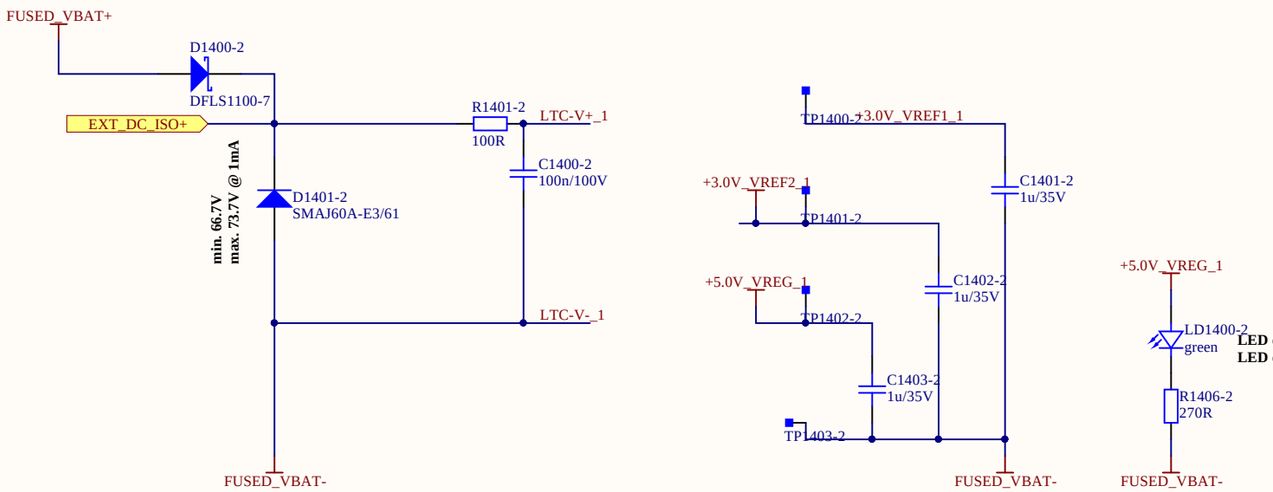
www.iisb.fraunhofer.de

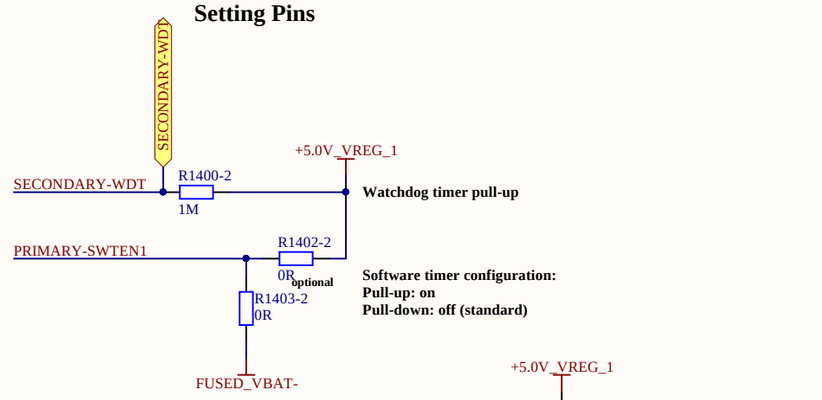
Project	Description	File		
BMS-Slave 12-Cell	Secondary EEPROM and Board T-Sensor	secondary_EEPROM_and_T.SchDoc		
Author	License	Version	Release Date	Sheet
foxBMS Team	Creative Commons Attribution 4.0	2.1.7	2019-03-28	20 / 21

Power Supply



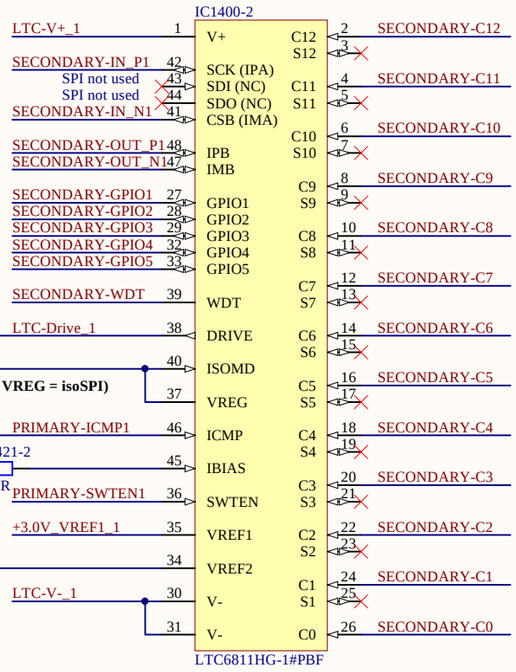
LED on: LTC in STANDBY, REFUP or MEASURE mode
LED off: LTC in SLEEP mode

Setting Pins



Cell voltage sense inputs

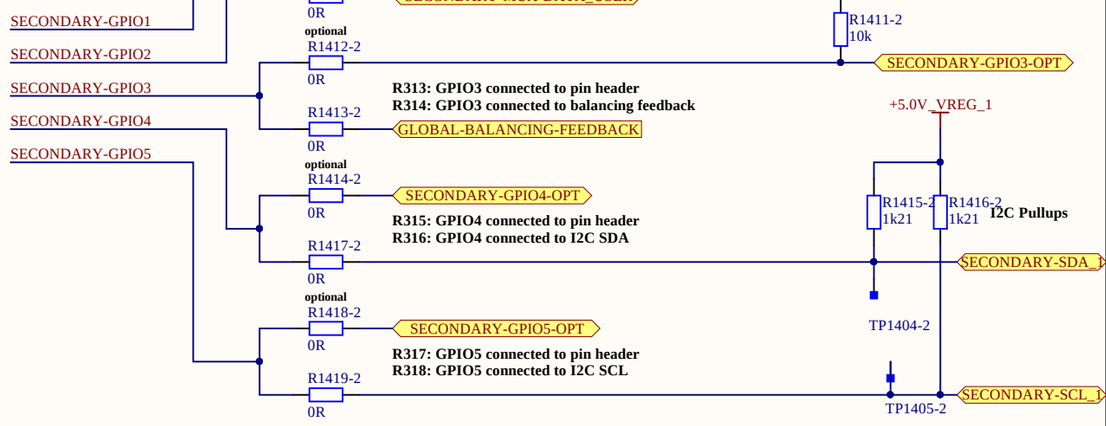
SECONDARY-C[0..12] — SECONDARY-C[0..18]



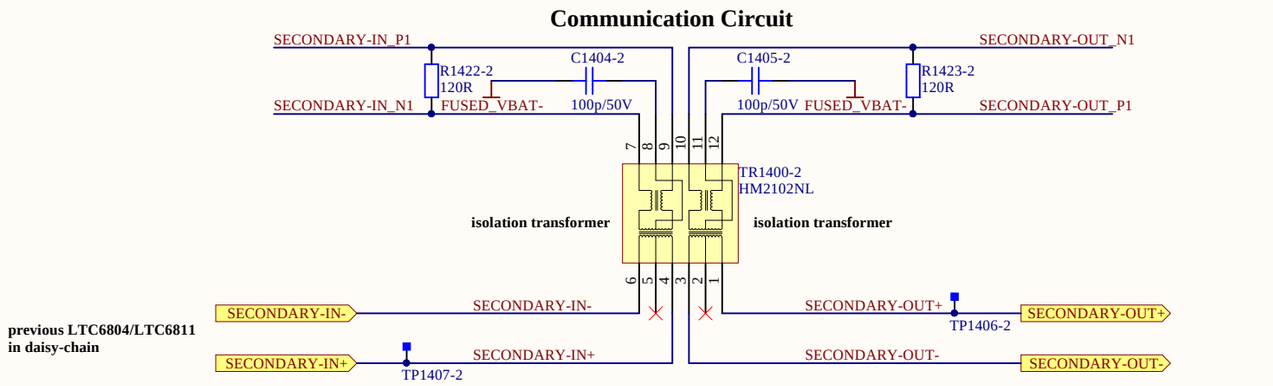
Cell balancing control

Cell balancing control
(not used on secondary)

GPIO Pins



Communication Circuit



Layout:

- **The transformer should be placed as close to the isoSPI cable connector as possible. The distance should be kept less than 2cm.**
- **The LTC6811 should be placed at least 1cm to 2cm away from the transformer.**
- **On the top component layer, no ground plane should be placed under the transformer, the isoSPI connector, or in between the transformer and the connector.**
- **The isoSPI signal traces should be isolated from surrounding circuits and traces by ground metal or space. No traces should cross the isoSPI signal lines, unless separated by a ground plane on an inner layer.**

www.foxbms.org

developed by:

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Germany

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Project	Description	File	
BMS-Slave 12-Cell	Secondary LTC6811	secondary_LTC.SchDoc	
Author	License	Version	Release Date	Sheet
foxBMS Team	Creative Commons Attribution 4.0	2.1.7	2019-03-28	21 / 21