XMC4000

32-bit Microcontroller Series for Industrial Applications

XMC4200 Digital Power Control Card User Manual

UG_201511_PL30_003

Board User Manual

Scope and purpose

This document describes the features and hardware details of XMC4200 Digital Power Control Card, designed to provide an evaluation platform for digital control applications with XMC ARM® Cortex™M4F based microcontroller. This board is part of Infineon's Digital Power Explorer Application Kit.

Applicable Products

- XMC4200 Microcontroller
- XMC Digital Power Explorer Kit
- DAVE™

References (optional, may be shifted to Appendix)

Infineon: DAVE™, http://www.infineon.com/DAVE

Infineon: XMC Family, http://www.infineon.com/XMC

XMC Digital Power Explorer, http://www.infineon.com/xmc_dp_exp

Example codes for this board, www.infineon.com/DAVE

Table of Contents

1 Overview 3
1.1 Key Features 3
1.2 Block Diagram 3

2 Hardware Description 5
2.1 Power Supply 5
2.2 Clock Generation 6
2.3 Debug Interface 6
2.3.1 Debug Connector Options 7
2.3.2 Removing the On-Board Debugger 8
2.4 User LEDs and test points 8
2.5 EEPROM 9
2.6 Power Board Connector 9
2.7 Analog to Digital Converter (ADC) inputs filter 12

3 Production Data 14
3.1 Schematics 14
3.2 Component Placement 19
3.3 Bill Material (BOM) 19

4 Revision History 22

1 Overview

The XMC4200 Digital Power Control Card is an evaluation board with the goal to help engineers in the learning and testing of digital power control applications. The board features a XMC4200 microcontroller based on ARM® Cortex™M4F core.
The dimensions of the board (50 mm height, 45 mm width to connector) allow the usage of this evaluation card into designs with high requirements on power density. In particular dimensions of XMC4200 Digital Power Control Card are suitable for 1U rack designs. The control card integrates an isolated on board debugger for plug and play experience. The isolated debugger part can be detached once the code is finalized.
This board has been developed with the collaboration of Würth Elektronik whose passive components and mechanical components are used.

1.1 Key Features

The XMC4200 Digital Power Control Card is equipped with the following features

- Infineon XMC4200 (ARM® Cortex™-M4F-based) Microcontroller, 256 kByte on-chip Flash, LQFP64
- Connection to power board like Digital Power Explorer, via the power board connector including analog signals, PWM or serial interfaces
- 5 LEDs
  - 1 Power indicating LED - “Power OK” from power board side
  - 2 User LEDs (P2.2, P2.6)
  - 2 Debugger controller LEDs (DEBUG, COM)
- Isolated Debug options
  - On-Board Debugger (SEGGER J-Link LITE) via USB connector
  - ARM® Cortex™ 9 pin connector (1.27 mm pitch - double row) on non-isolated section. Isolation needs to be built between this connector and the computer side to avoid overvoltage in computer.
- Isolated Connectivity
  - UART channel of On-Board Debugger (SEGGER J-Link LITE) via USB connector
- Power supply of MCU domain
  - Via power board connector (12V). Converted to 3.3V with Infineon supply parts
- Power supply of isolated debug domain
  - Via Debug USB connector

1.2 Block Diagram

Figure 1 shows the functional block diagram of the XMC4200 Digital Power Control Card. For more information about the power supply domains please refer to chapter 2.1.

The control card has got the following building blocks:

- 1 Power Board Connector
- 1 I2C controlled EEPROM for optional data storage
- 2 User LED connected to GPIOs (P2.2 and P2.6)
- 2 user test points
- USIC0 interface connector (P0.10, P0.14, P1.4, P1.5)
  Isolated On-board Debugger via Debug USB connector (Micro-USB) with UART channel (USIC0, channel 0)

- Optional ARM® Cortex™-Debug interface connector

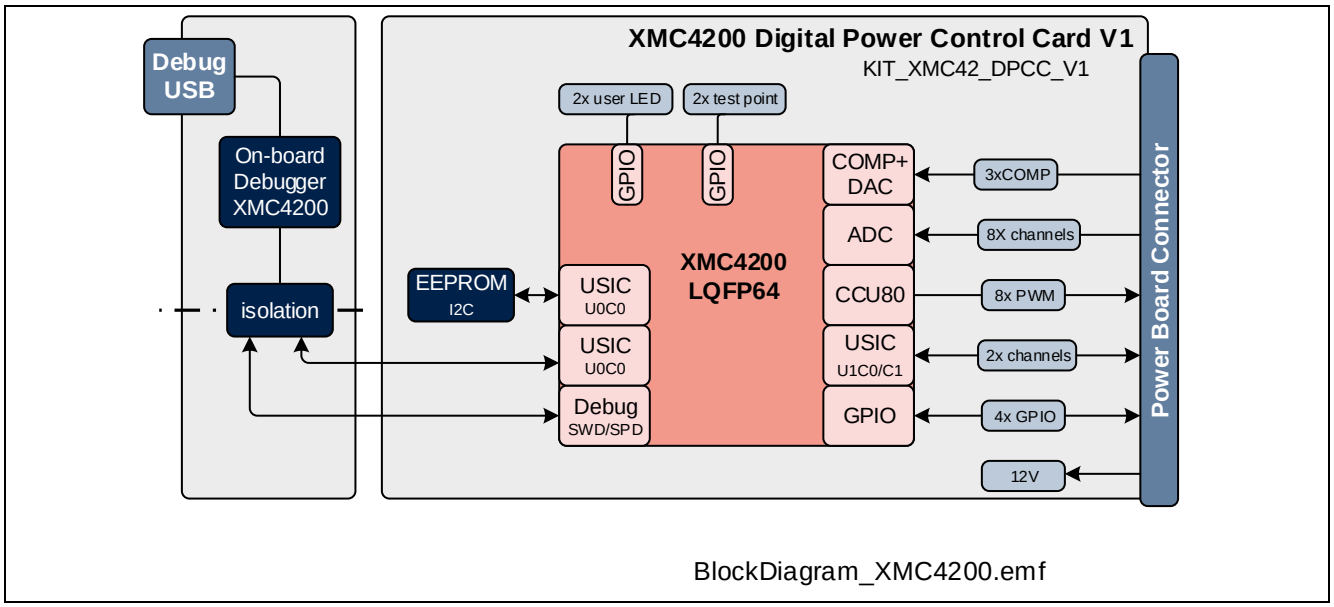

Figure 1 Block Diagram of XMC4200 Digital Power Control Card

2 Hardware Description

The following sections give a detailed description of the hardware and how it can be used.

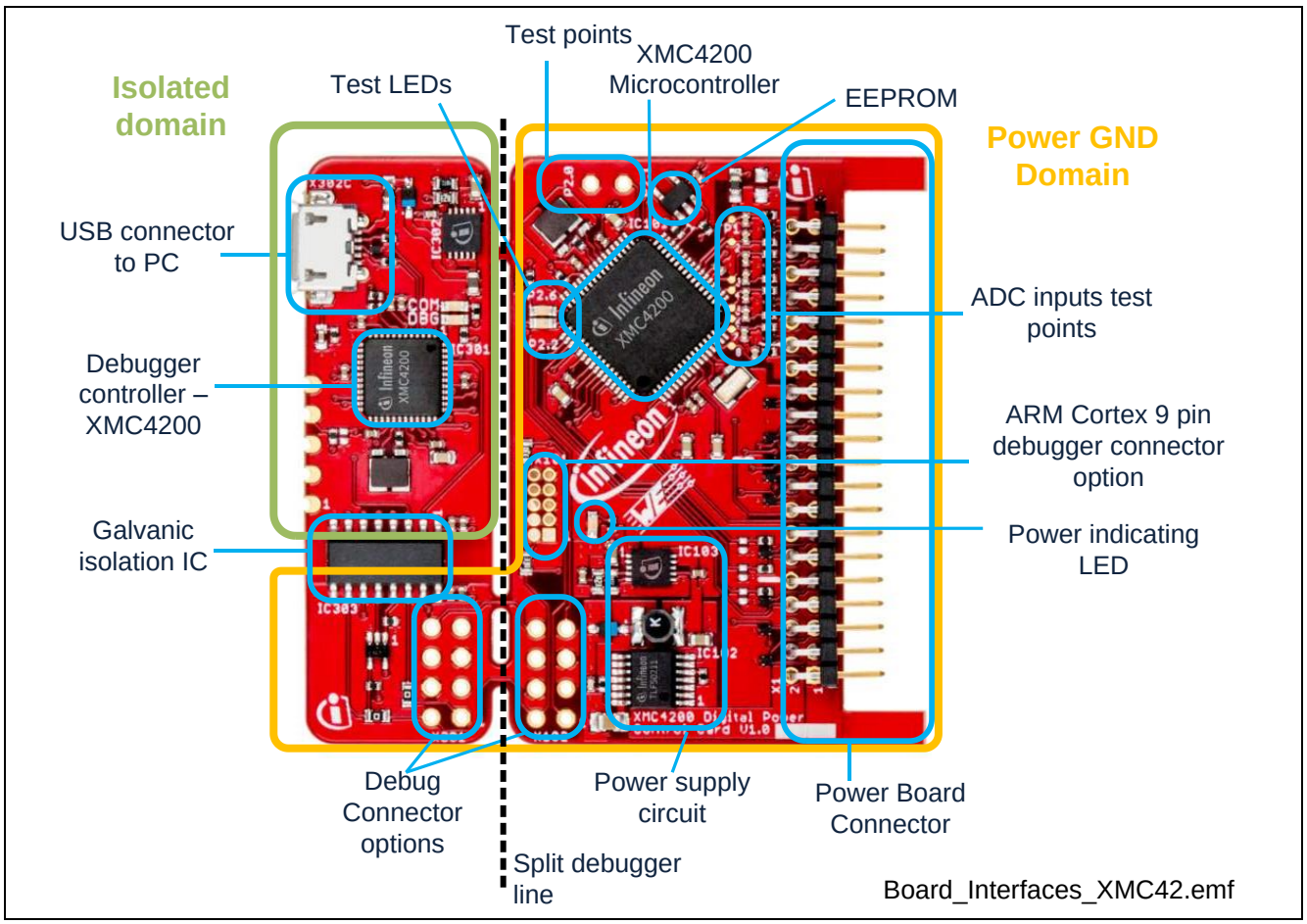

Figure 2 XMC4200 Digital Power Control Card hardware description

2.1 Power Supply

The XMC4200 Digital Power Control Cardboard is designed with two galvanically isolated supply domains. On the left side, there is the debug domain or isolated domain, which contains a XMC4200 MCU as on-board debug controller (OBD). The isolated domain is powered via the USB plug (5V)
The rest of the control card is called power GND supply domain. This part is supplied from the power board connector and the control card will step down the input voltage to the 3.3V that XMC4200 requires. This supply domain is usually powered from the power board connector. The typical current drawn by the drive card at the power GND domain is about 65 mA at 12 V input voltage.

To indicate the power status of the power GND domain, one power indicating LED is provided on board (see Figure 2). The LED will be “ON” when the corresponding power rail is powered.

LED Reference	Power Rail	Voltage
LED102	VDD3.3	3.3 V

Figure 3 shows details of the power supply concept of the control card. More detailed circuitry can be found in section 3.1.

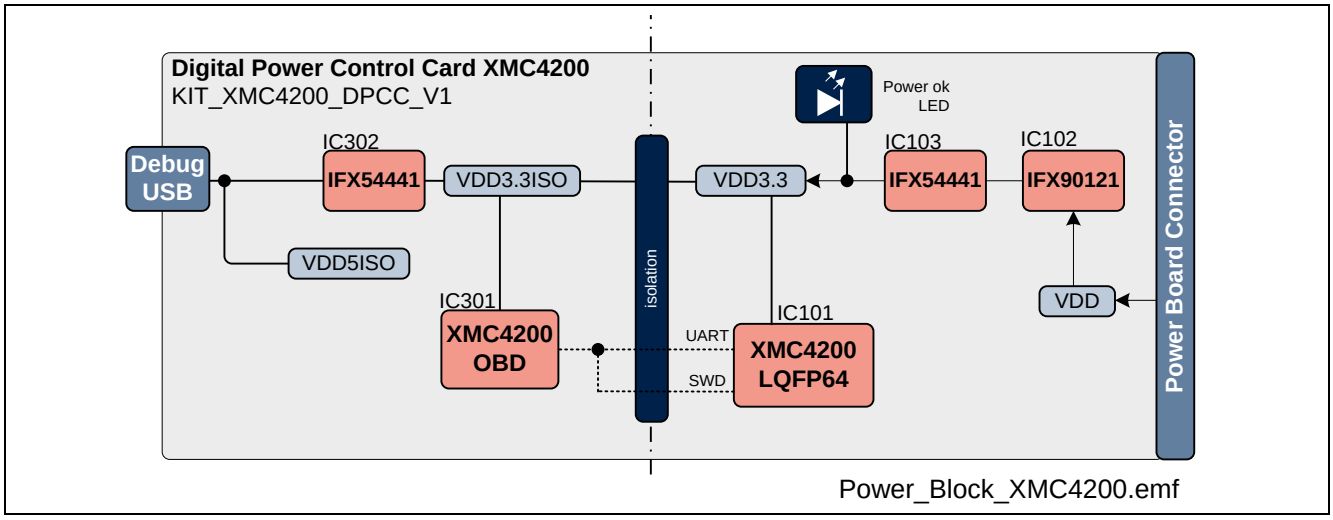

Figure 3 Block Diagram of Power Supply Concept

2.2 Clock Generation

An external oscillator circuit is provided in the control card to provide a crystal signal. The internal PLL of XMC4200 will trace care to generate all internal clocks needed in the microcontroller.

2.3 Debug Interface

The XMC4200 Digital Power Control Card supports 2 different debug interfaces:

- Isolated On-Board Debugger (OBD). This is the default connection.

  Connect to computer with an USB cable. The control card includes a debugger controller and isolation up to 1kV to protect the computer. This is the easiest way and is supported by DAVE™ and other debuggers

  The On-Board Debugger [1] supports
  - Serial Wire Debug (SWD)
  - UART communication via a Virtual COM port
    - PC_RXD_DEV P1.5 USIC0CH0.DOUT0
    - PC_TXD_DEV P1.4 USIC0CH0.DX0B

[1] Attention: The firmware of the on-board debugger requires the latest J-Link driver (V5.00 or higher) and a Serial Port Driver (CDC driver) installed on your computer. Please check “Install J-Link Serial Port Driver” when installing the latest J-Link driver (see Figure 4)

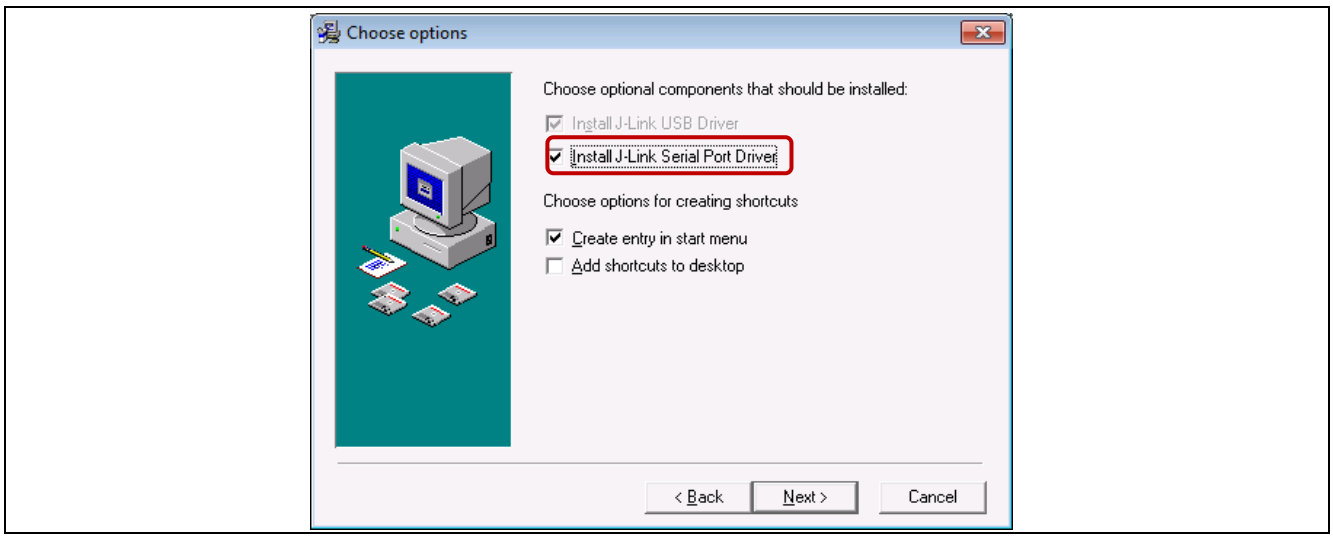

Figure 4 Installation of J-Link Serial Port Driver

- 9 pin ARM® Cortex™ connector and an external galvanically isolated debugger hardware or “box”. This option allows the user to utilize any ARM® Cortex™ debugger in the market. The user must make sure that the debugger box used provides galvanic isolation (typically 1kV) to avoid damage due to high voltages in the computer.

2.3.1 Debug Connector Options

XMC4200 Digital Power Control Card includes 3 connector options for debugging. The default configuration of the control card is prepared for OBD debug and therefore, none for the 3 connector options are assembled. If required, user has to mount the corresponding pin headers. The 3 connector options are:

- Two 8 pins connector: OBD Debug Connector (X301) and Debug Connector (X102)– 2.54 mm header pitch
- 9pin ARM® Cortex™ (X101)– 1.27mm header pitch

Connectors are described in Figure 5

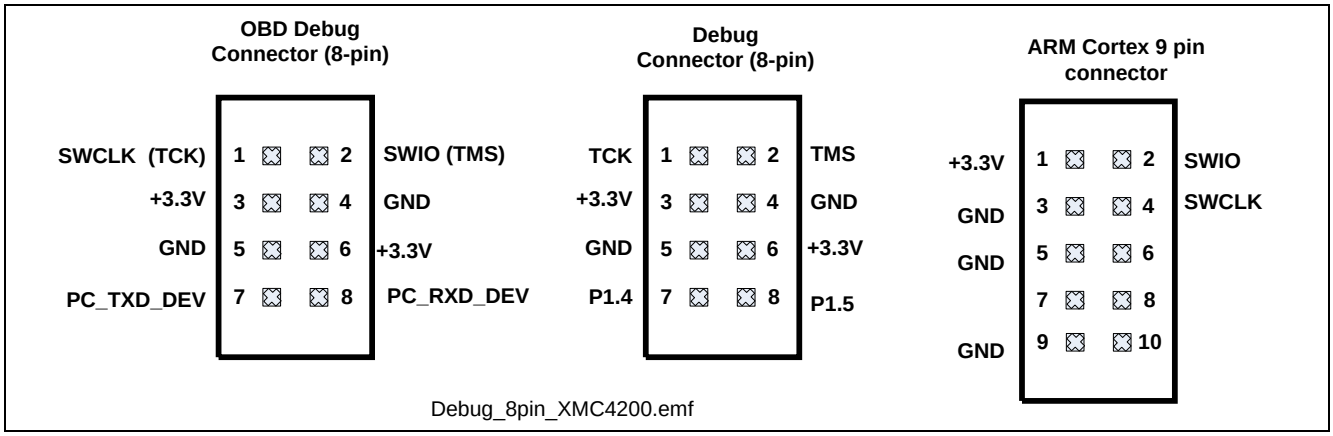

Figure 5 Pin assignment of Debug Connector (8-pin)

2.3.2 Removing the On-Board Debugger

XMC4200 Digital Power Control Card can be broken off into 2 parts by breaking the PCB as shown in Figure 6. This will reduce the size of the main controller part so that it can fit into 1U standard sized rack systems once programmed. The control card can still be debugged in 2 different ways if debugger part is removed (see Figure 6):

1. connecting a ribbon cable to both 8 pin connectors (main controller part and debugger part) or,
2. using the 9 pin connector option with an external debugger box. If the board is not broken, this connection cannot work.

*Attention: **when using external debuggers, make sure that the debugger box includes a galvanic isolation to the computer. If the control card is exposed to high voltages, this could produce damage to the computer***

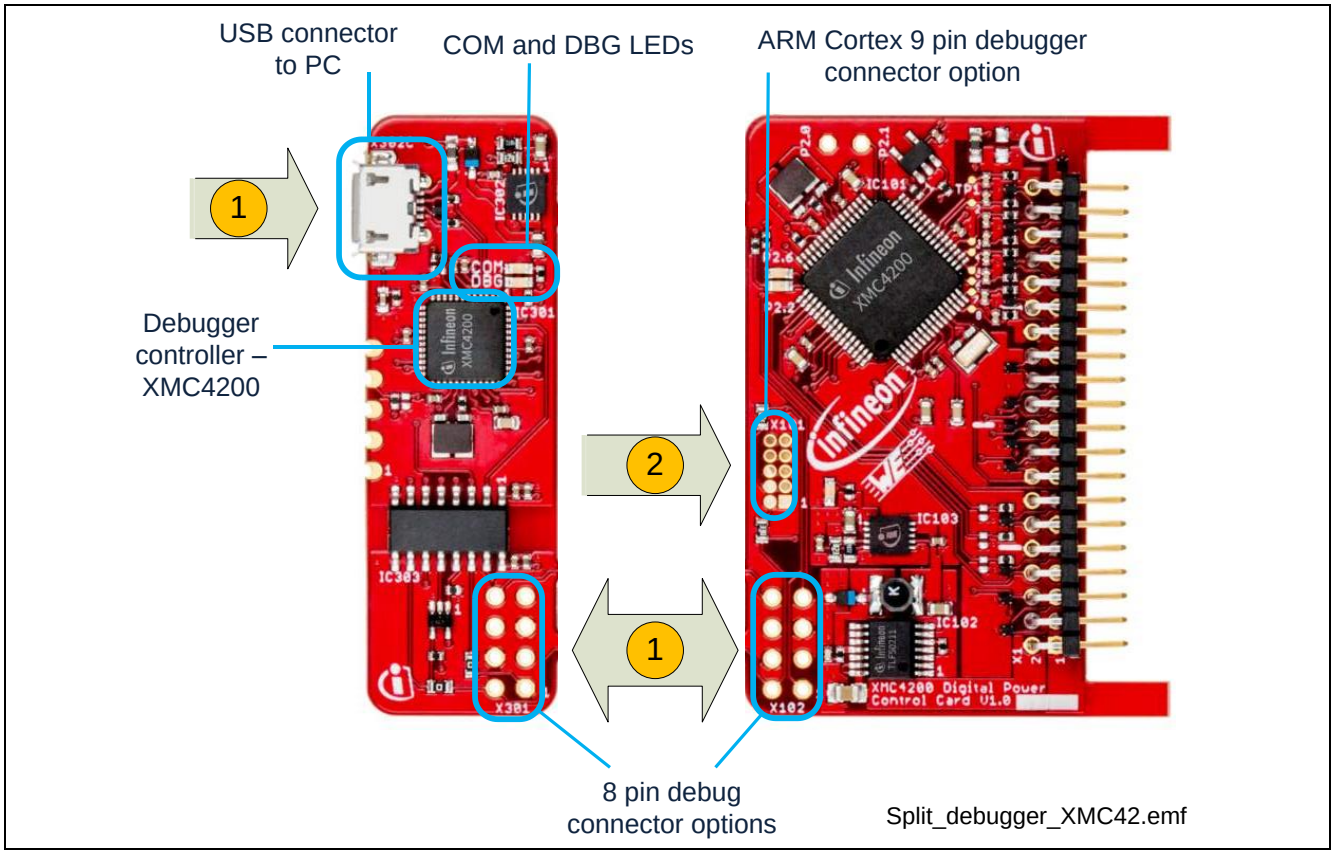

Figure 6 Debug options when removing debugger part of control card

2.4 User LEDs and test points

The XMC4200 Digital Power Control Card provides a two user LEDs (P2.2 and P2.6). Next to the LEDs, two **test points (P2.0 and P2.1)** are available in order to easily connect an oscilloscope's probe for controlled trigger signals.

Table 1 User LEDs

Table 1 User LEDs

User LEDs	Connected to Port Pin
LED100	P2.2
LED101	P2.6

Attention: The test points are referenced to power GND supply domain. Hence they may carry hazardous voltages.

2.5 EEPROM

XMC4200 Digital Power Control Card includes as well an external 4kB EEPROM for different purpose. This EEPROM communicates with XMC4200 through I2C communication. XMC4200 can be configured as master I2C for that purpose. This can be used for storing parameters for example.

Both data and clock lines are pulled up with 10 kohm resistors to 3.3V.

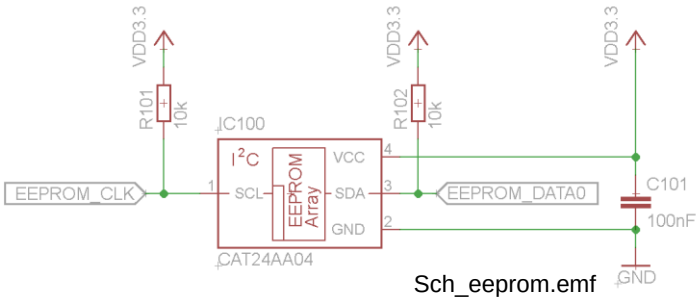

Figure 7 External EEPROM schematic

Table 2

Signal	EEPROM Chip Signal	XMC4200 port and channel
EEPROM_CLK	SCL	P2.4 - U0C1.SCLKOUT
EEPROM_DATA0	SDA	P2.5 - U0C1.DOUT0

2.6 Power Board Connector

The XMC4200 Digital Power Control Card provides a power board connector with a set of signals that can be extensively used in power supply applications, from server power supplies to UPS or lighting power supplies. Signals available in the connector are:

- 8 PWM signals
- 8 ADC analog inputs
- 3 comparator inputs
- 2 Serial channels
- 4 general purpose pins

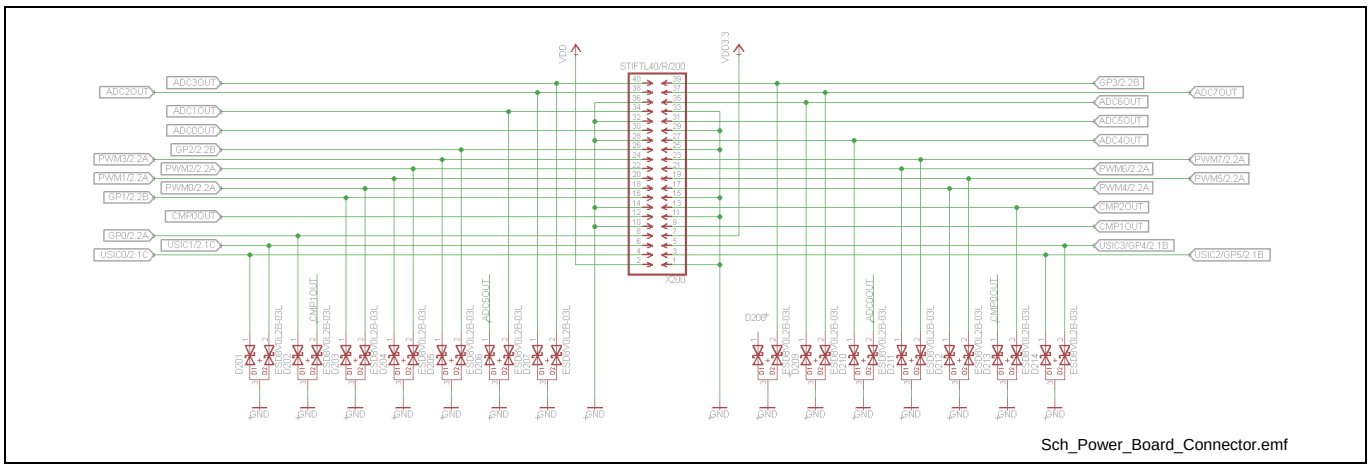

Figure 8 Control card power connector schematic

Attention: The power board connector is also providing the power supply for the power GND supply domain. Hence it may carry hazardous voltages.

As it can be seen in Figure 8, each signal entering XMC4200 Digital Power Control Card from the power board connector is additionally protected by a bidirectional n ESD protection from Infineon.

XMC4200 has internal ESD protection in each pin, however, given the general purpose characteristic of this control card, additional ESD protection is required to protect from very noisy power board environment that could eventually damage the control card or the microcontroller in it.

The pin out of the connector is described in detail in Table 3.

Table 3 Power board connector pin out

Pin number	Signal Name	Port in XMC4200	Peripheral function	Note
1	GND	-		Digital GND
2	VDD	-		12V input from power board to control card
3	USIC2/GP5	P0.1	U1C1.DOUT0	Can be used as serial port or user port pin
4	USIC0	P0.11	U1C0.DX1A or U1C0.SCLKOUT	
5	USIC3/GP4	P0.0	U1C1.DX0D	Can be used as serial port or user port pin
6	USIC1	P2.14	U1C0.DOUT0 or U1C0.DX0D	
7	VDD3.3	-		3.3 V output to power board
8	GP0	P1.3		User port pin
9	CMP1OUT	P1.1	CSG.C1INA	
10	GND	-		Digital GND
11	GND	-		Digital GND
12	CMP0OUT	P1.0	CSG.C0INA	
13	CMP2OUT	P1.2	CSG.C2INA	
14	GND	-		Digital GND
15	GND	-		Digital GND
16	GP1	P1.8		User port pin
17	PWM4	P0.8	HROUT10	

Pin number	Signal Name	Port in XMC4200	Peripheral function	Note
18	PWM0	P0.7	HROUT11	
19	PWM5	P0.6	HROUT30 or CCU80.OUT30	
20	PWM1	P0.2	HROUT01 or CCU80.OUT01	
21	PWM6	P0.4	HROUT21or CCU80.OUT10	
22	PWM2	P0.3	HROUT20 or CCU80.OUT20	
23	PWM7	P0.5	HROUT00 or CCU80.OUT00	
24	PWM3	P0.9	HROUT31or CCU80.OUT12	
25	AGND	-		Analog GND (ADC)
26	GP2	P0.10		User port pin
27	ADC4OUT	P14.14	VADC.G1CH6	
28	AGND	-		Analog GND (ADC)
29	AGND	-		Analog GND (ADC)
30	ADC0OUT	P14.6	VADC.G0CH6	
31	ADC5OUT	P14.3	VADC.G1CH3 or VADC.G0CH3	
32	AGND	-		Analog GND (ADC)
33	AGND	-		Analog GND (ADC)
34	ADC1OUT	P14.5	VADC.G0CH5	
35	ADC6OUT	P14.4	VADC.G0CH4	
36	AGND	-		Analog GND (ADC)
37	ADC7OUT	P14.0	VADC.G0CH0	
38	ADC2OUT	P14.9	VADC.G1CH1 or DAC_OUT1	
39	GP3	P2.7		User port pin
40	ADC3OUT	P14.8	VADC.G1CH0 or DAC_OUT0	

Given the flexible pin out in XMC4200, the functions above can be modified with SW configurations. In Figure 9, the PWM options are depicted. The pin out is done to fully cover High Resolution PWM (HRPWM) outputs. However, combinations of CCU8 and HRPWM are possible.

Several topologies in power supplies can be controlled with that pin out including LLC with synchronous rectification, multi-phase buck/boost converters, PFC stages and much more.

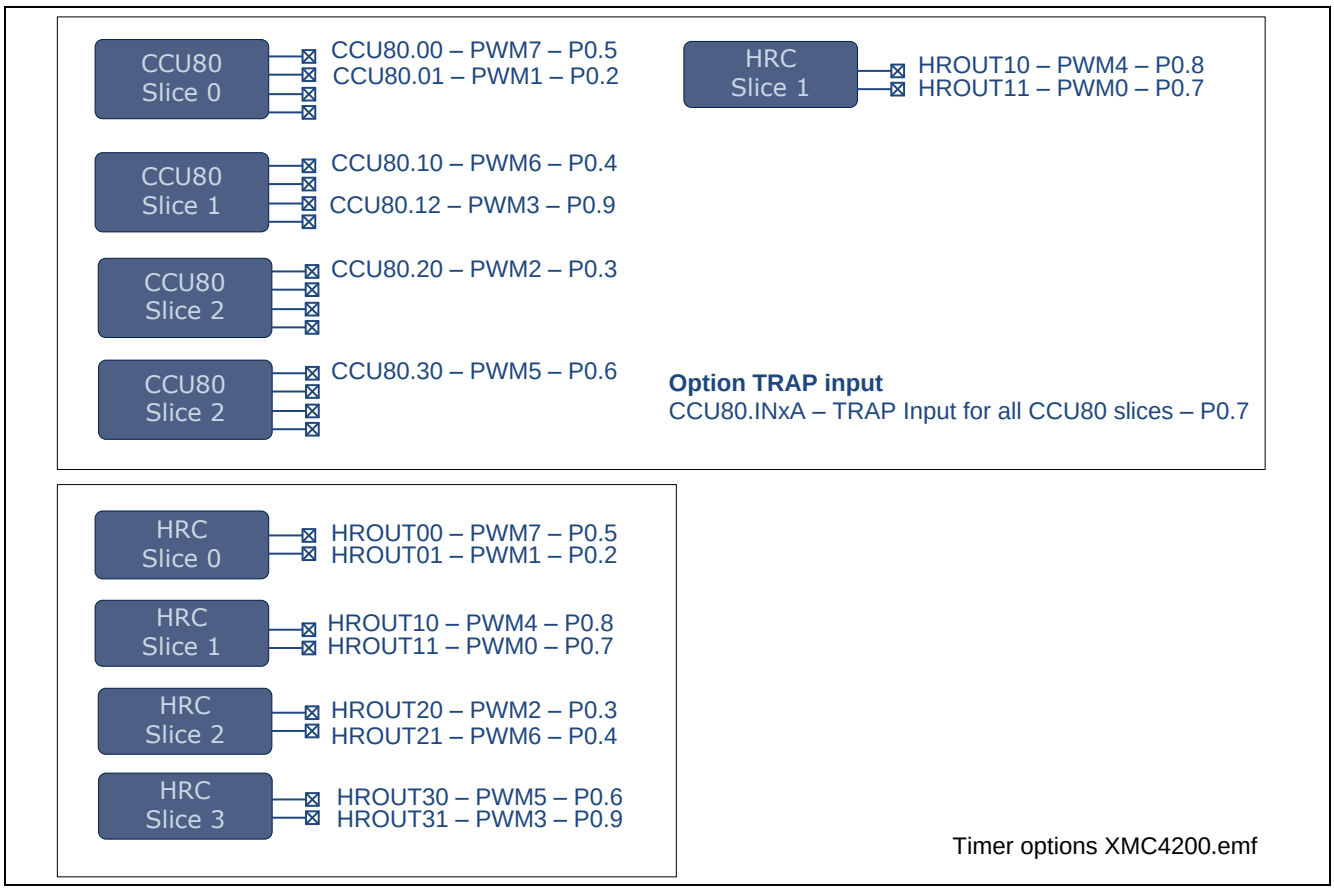

Figure 9 PWM output options- top, using CCU8 - bottom using only HRPWM

Additionally to the pins in the power board connector, the microcontroller has pins connected internally. Those are described in Table 3

Table 4

Signal Name	Port in XMC4200	Peripheral function	Note
LED0	P2.2		User LED
LED1	P2.6		User LED
EEPROM_CLK	P2.4	U0C1.SCLKOUT	I2C clock signal for external EEPROM
EEPROM_DATA0	P2.5	U0C1.DOUT0	I2C data signal for external EEPROM

2.7 Analog to Digital Converter (ADC) inputs filter

All ADC inputs in the control card are filtered with a high frequency cross-over frequency RC filter, as shown in Figure 10. This will help to remove undesired high frequency noise from the input signals, and therefore, will improve the measurement performance of the microcontroller

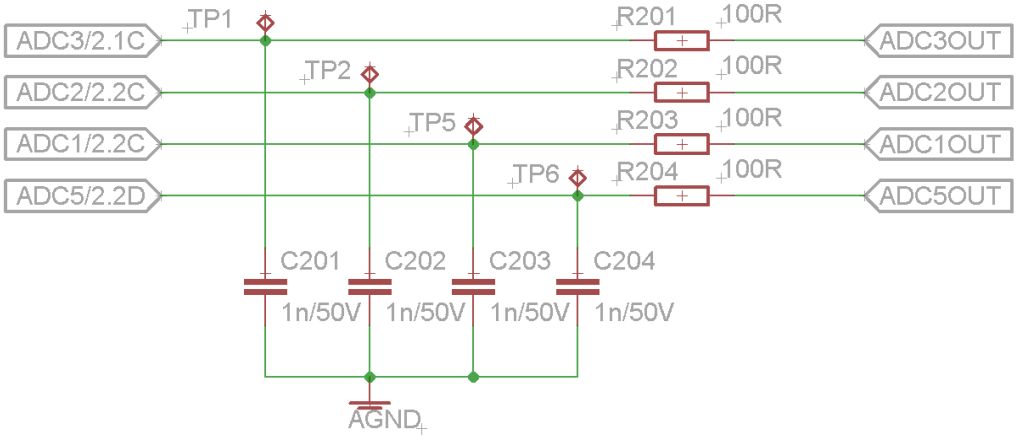

Figure 10 ADC input RC filter schematic

With respect to the analog signals routed into XMC4200 ADC, a special plane is in place for increasing signal integrity and best signal noise ratio. In Figure 11can be seen that VAGND plane has been layouted around all ADC signals in all 4 layers of the PCB.

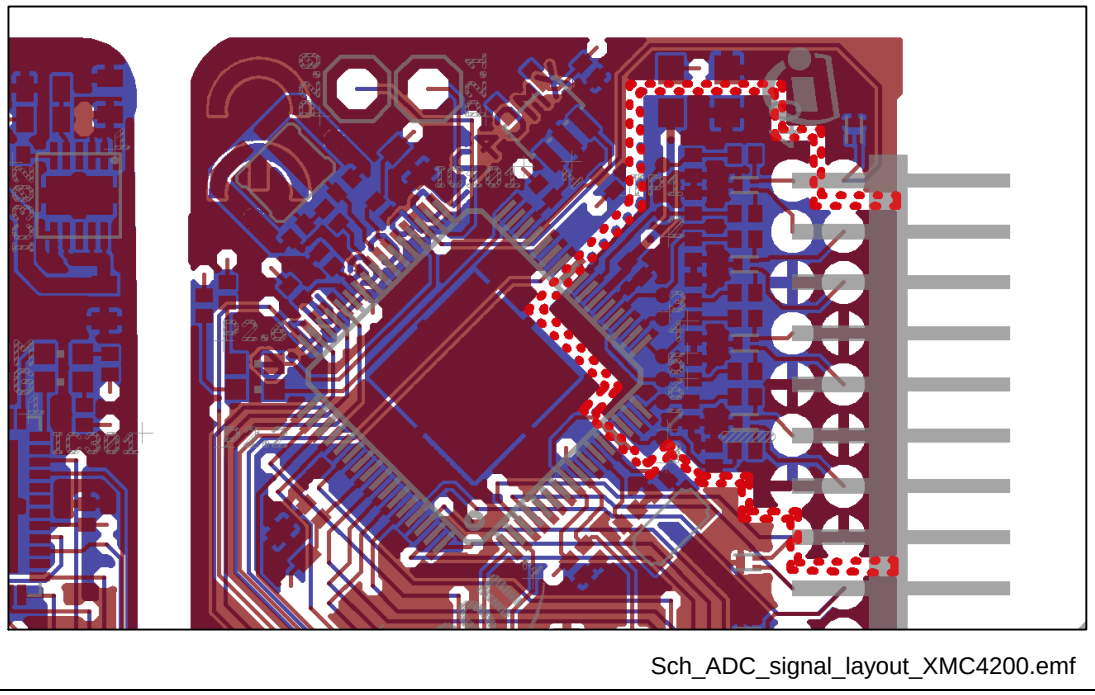

Figure 11 ADC grounding layout detail

Both GND and AGND are connected together in a single point through a ferrite bead.

3 Production Data

3.1 Schematics

This chapter contains the schematics for XMC4200 Digital Power Control Card
The board has been designed with Eagle. The full PCB design data of this board can also be downloaded from www.infineon.com/xmc-dev.

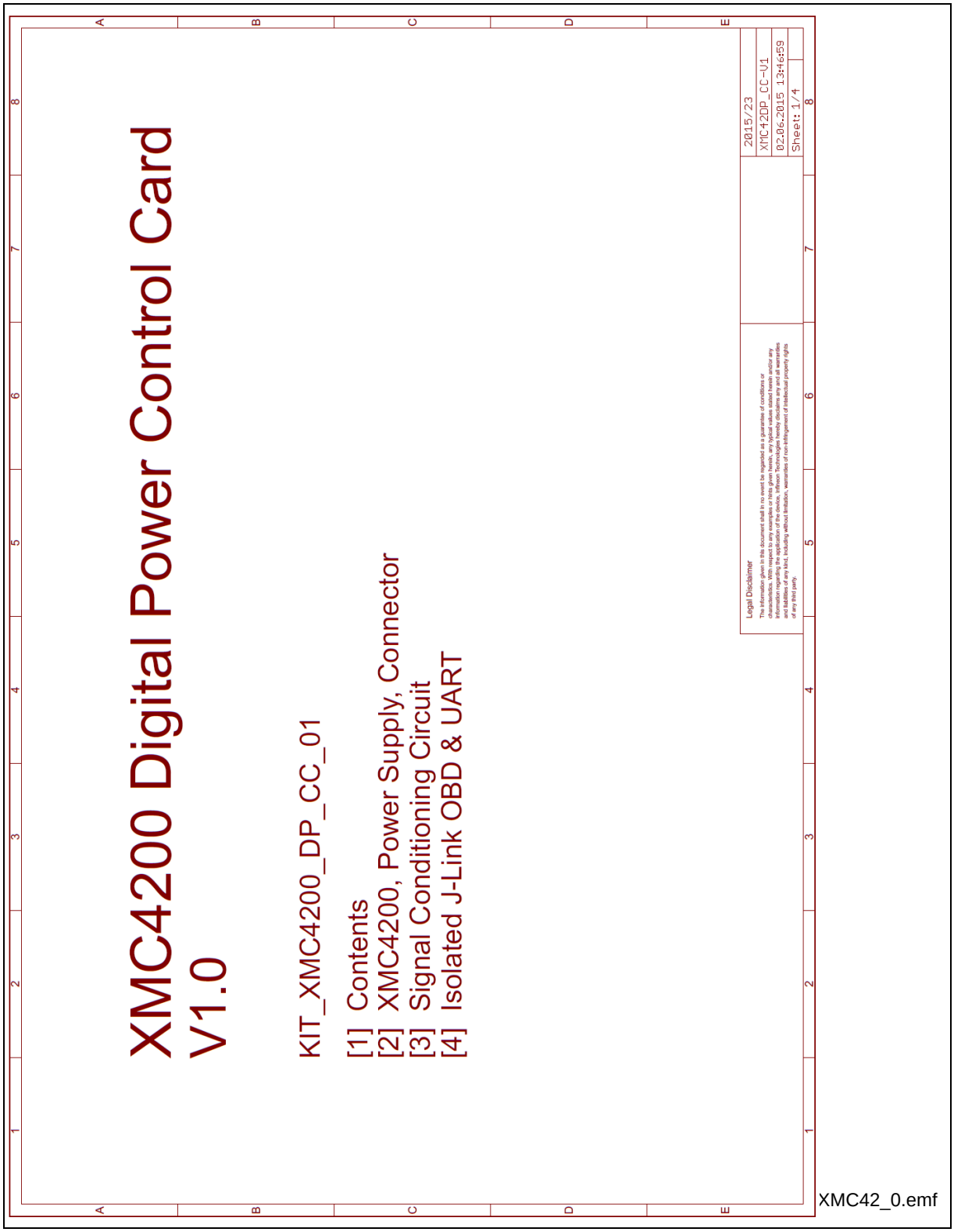

Figure 12 Schematic page 0: cover

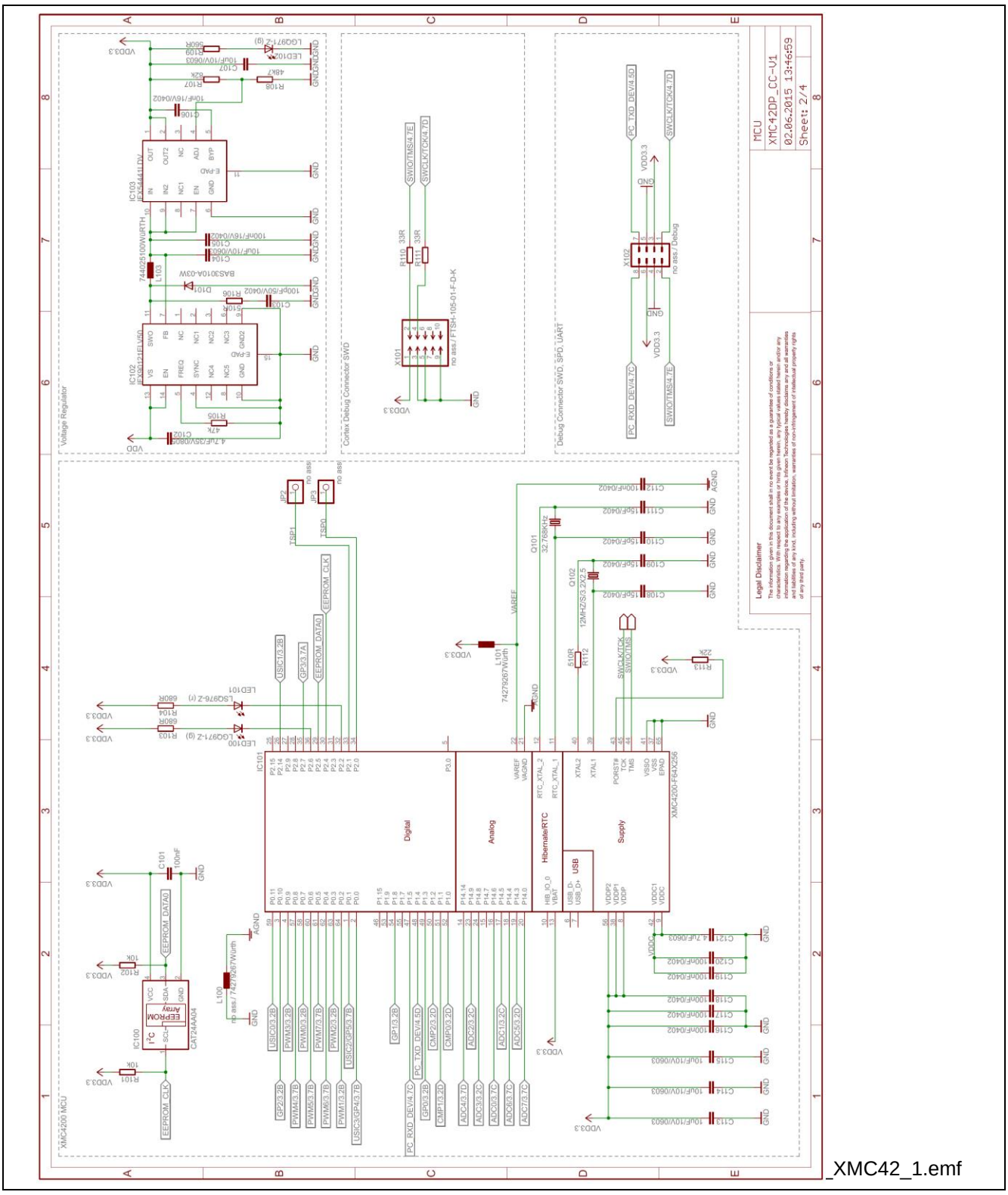

Figure 13 Schematic page1: MCU

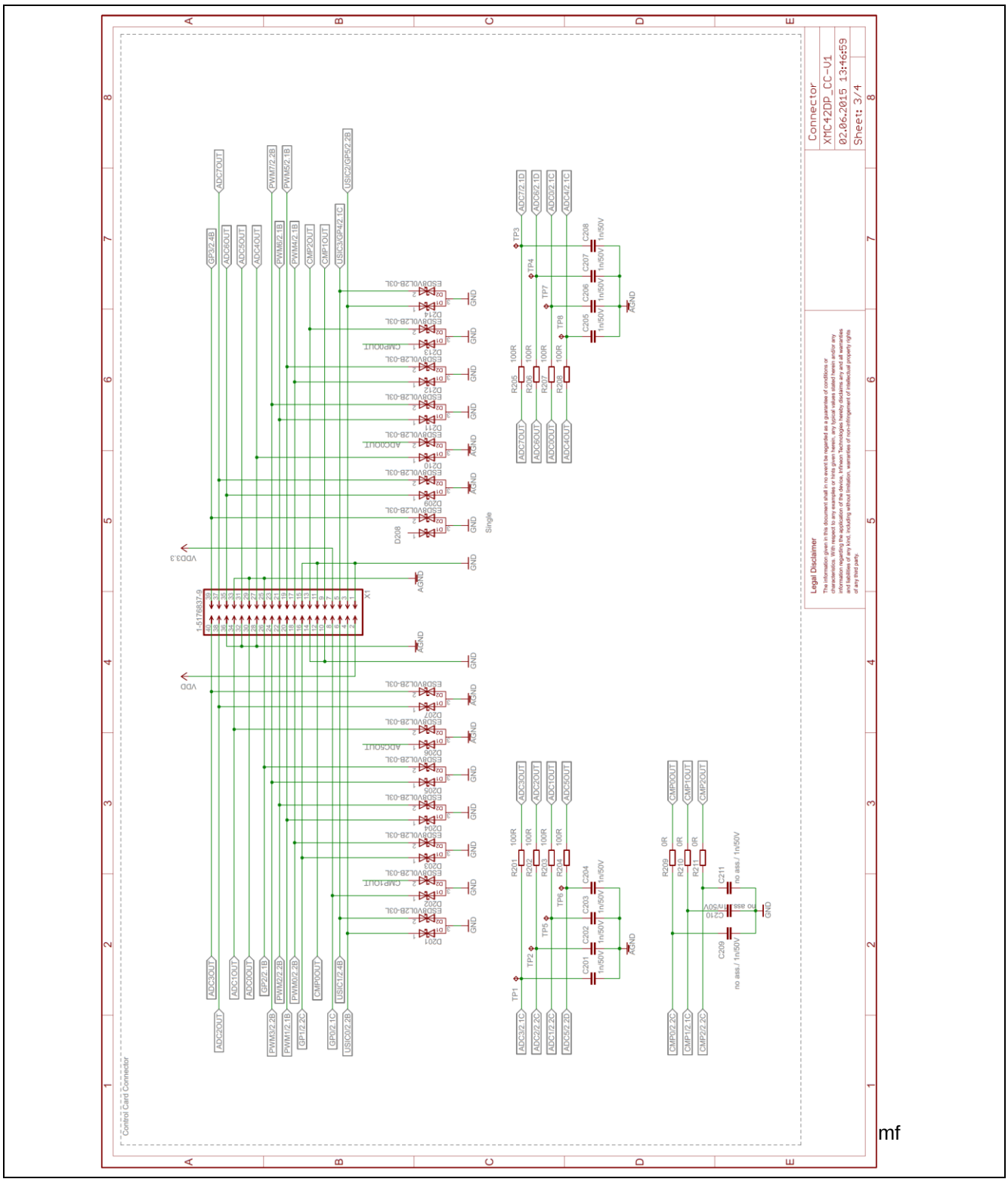

Figure 14 Schematic page 2: connector

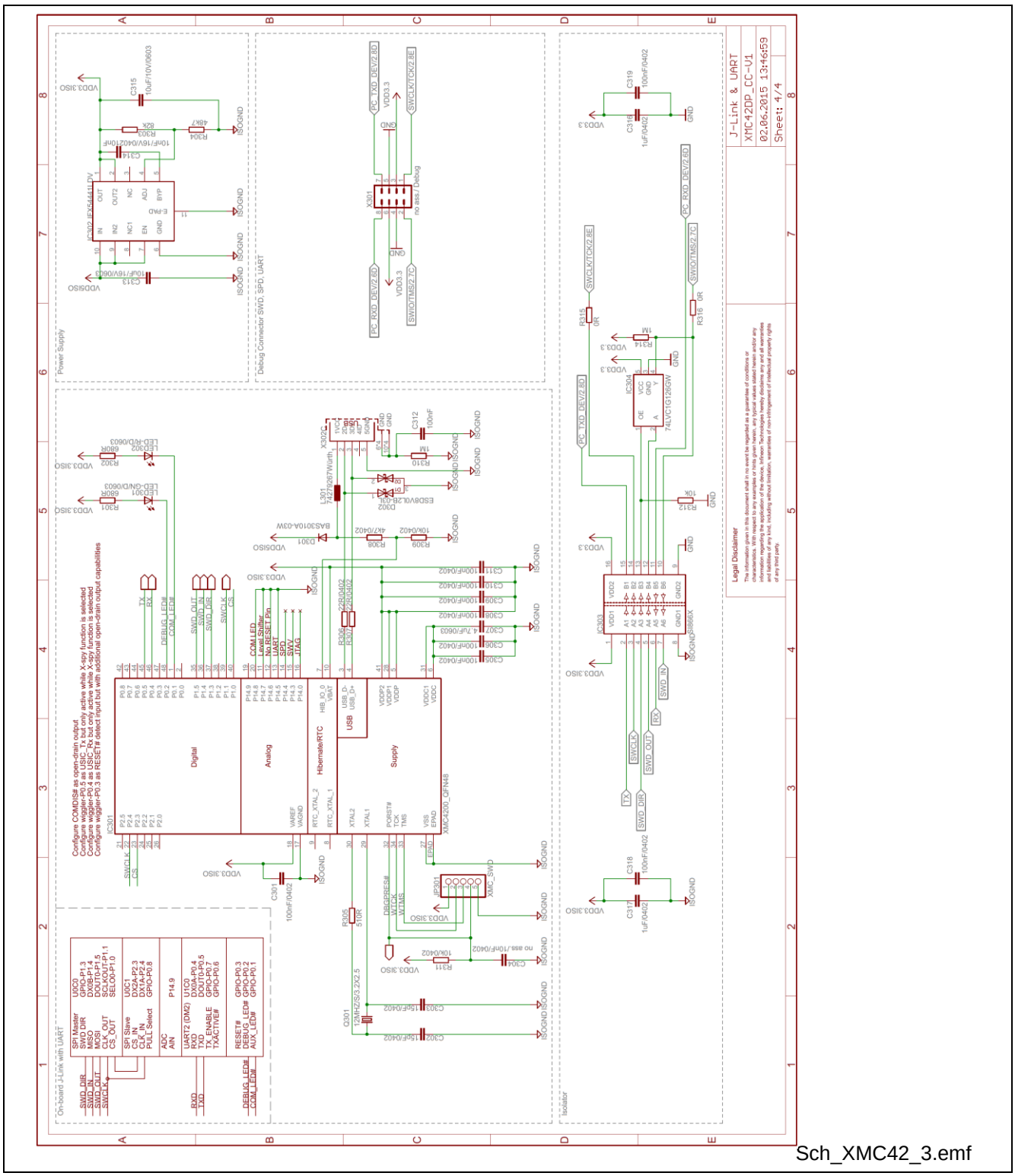

Figure 15 Schematic page 3: JLink &UART

3.2 Component Placement

In Figure 16 the placement of some components is shown in a layout snapshot of the top layer of XMC4200 Digital Power Control Card

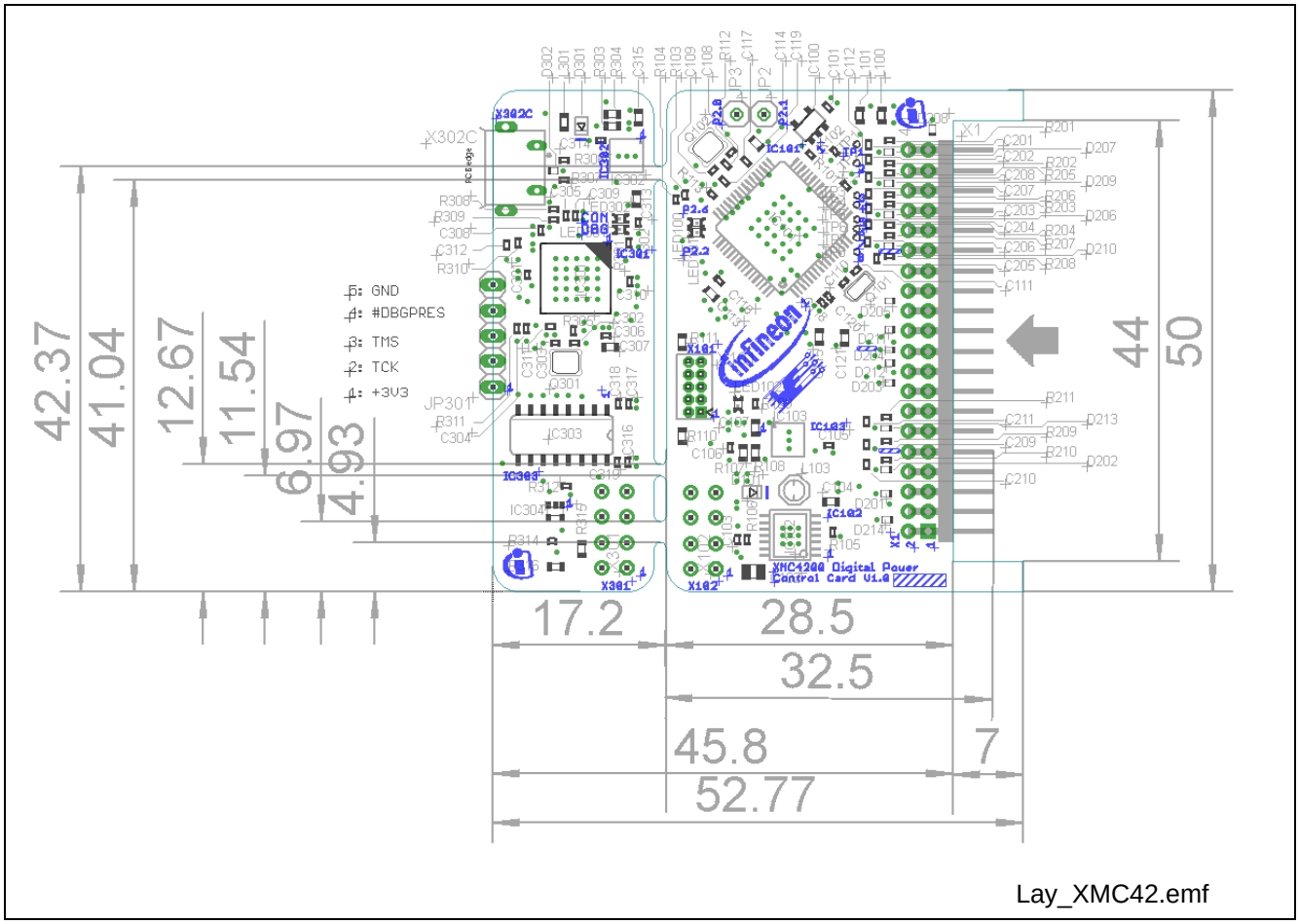

Figure 16 Layout top level view of XMC4200 Digital Power Control Card

3.3 Bill Material (BOM)

This board has been done in collaboration with Würth Elektronik. In Figure 17, the different components in the board are shown. In Table 5 a complete bill of material is given.

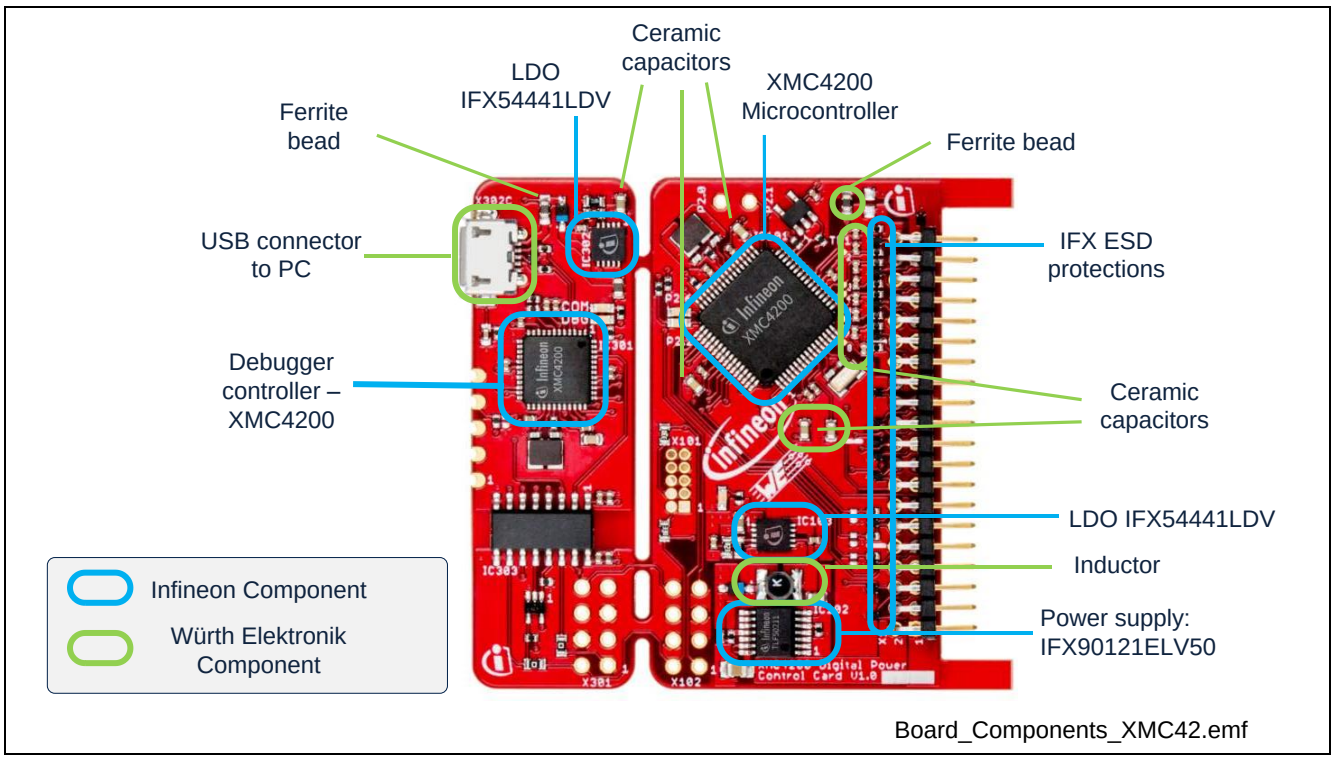

Figure 17 Components from Infineon and Würth Elektronik

Table 5 Bill of Material List

No.	Device / Description	Quantity	Position
1	SN74LVC1G126DCKR SC70 SN74LVC1G126DCKR	1	IC304
2	ESD8V0L2B-03L Protect. Diode bi-dir ESD8V0L2B-03L IFX	13	D201, D202,D203, D204,D205, D206, D207, D208, D209, D210, D211, D212, D302
3	CAT24AA04TDI-GT3 4k I2C EEPROM TSOT23-5	1	IC100
4	XMC4200 QFN-48 AB-Step XMC4200-Q48K256 AB step IFX	1	IC301
5	CPU XMC4200-F64K256 AB-Step LQFP-64	1	IC101
6	Si8662BB-B-IS1 Hex Isolator 4xIn / 2xOut 150MBit NB SOIC-16 SiLabs	1	IC303
7	SMD-LED SMD rt 0603 diffus 110mcd LSQ976-Z	2	LED101, LED302
8	SMD-LED SMD gn 0603 diffus 10mcd LGQ971-Z	3	LED100, LED102, LED301
9	Step-Down DC/DC 500mA 5.0Vout IFX90121ELV50 Infineon SSOP-14	1	IC102
10	LDO IFX54441LDV Infineon TSON10 Vadj 300mA 1,8-20Vin	2	IC103, IC302
11	SMD-Quarz 12MHz 3.2x2.5mm 2Pad NX3225GB 12MHZ SMD 2Pad	2	Q102, Q301
12	SMD Resistor 0R 1% 0603	2	R315, R316
13	SMD Resistor 33R 1% 0603	2	R110, R111
14	SMD Resistor 82K 1% 0603	2	R108, R304

15	SMD Resistor 48K7 1% 0603	2	R107, R303
16	SMD Resistor 680R 1% 0402	4	R103, R104, R301, R302
17	SMD Resistor 10K 1% 0402 TK100	5	R101, R102, R309, R311, R312
18	SMD Resistor 0R 0402	3	R209, R210, R211
19	SMD Resistor 100R 1% 0402	8	R201, R202, R203, R204, R205, R206, R207, R208
20	SMD Resistor 4K7 1% 0402	2	R308,R105
21	SMD Resistor 1M 1% 0402	2	R310, R314
22	SMD Resistor 22K 1% 0402	1	R113
23	SMD Resistor 560R 1% 0402	1	R109
24	SMD Resistor 22R 1% 0402	2	R306, R307
25	SMD Resistor 510R 0402 1%	3	R106, R112, R305
26	Quarz 32.768KHz, SMD 3.2x1.5 Cl 12,5pF NDK NX3215SA-32.768K	1	Q101
27	SMD Capacitor 100p 5% X7R 0402 50V	1	C103
28	SMD-Capacitor 10uF 10V 0603 10%	6	C104, C107, C113, C114, C115, C315
29	SMD-Capacitor 4.7UF 35V 0805 10%	1	C102
30	SMD Capacitor 15pF 10V 5% NP0 0402 Würth 885012005008	6	C108, C109, C110, C111, C302, C303
31	SMD-Capacitor 1nF 10% X7R 0402 50V Würth 885012205061	8	C201, C202, C203, C204, C205, C206, C207, C208
32	SMD Capacitor 10n 10% X7R 0402 16V Würth 885012205031	2	C106, C314
33	SMD Capacitor 100n X7R 0402 16V 10% Würth 885012205037	18	C101, C105, C112, C116, C117, C118, C119, C120, C301, C305, C306, C308, C309, C310, C311, C312, C318, C319
34	SMD Capacitor 1UF X5R 0402 10V 20% Würth 885012105012	2	C316, C317
35	SMD Capacitor 4u7F X5R 0603 10V 20% Würth 885012106012	2	C121, C307
36	SMD Capacitor 10UF X7R 0603 16V 10% Würth	1	C313
37	Ferrite Bead 0603 60R 500mA Würth 74279267	2	L101, L301
38	SMD-Ferrite 10uH 1A 2828 Würth 744025100	1	L103
39	Schottky Diode SOD323 low Vf BAS3010A-03W IFX 30V 1A	2	D101, D301
40	Pin header 2rows- 20-poles low profil 4mm	1	X1
41	USB-connector Micro USB 2.0 Type AB - Horizontal Würth 629105150921	1	X302C
Not mounted components			
42	SMD Capacitor 10n 5% X7R 0402 16V C0402C103J4R Kemet	1	C304
43	Wrap header 1-row 5-poles	1	JP301
44	Pin header, 1,27, 2*5 pol SMD Pin7 ASP-166471-01 Samtec Pin7 weg	1	X101
45	Ferrite Bead 0603 60R 500mA Würth 74279267	1	L100
46	Pin header 1-row 1-pole	2	JP2, JP3
47	Pin header 2-rows 4-poles	2	X102, X301
48	SMD-Capacitor 1nF 10% X7R 0402 50V Würth 885012205061	3	C209, C210, C211

4 Revision History

Current Version is V1.1, 2016-02

Page or Reference	Description of change
V1.0, 2015-10	
	Public version
V1.1, 2016-02	
	Table 3 corrections (USIC, PWM, ADC pins)

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Edition 2016-02
Published by
Infineon Technologies AG
81726 München, Germany

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Document reference
UG_201511_PL30_003

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