MTX-BC48-DB
Development Board

User Guide

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1. Overview

The MTX-BC48-DB is an easy-to-use platform to develop and demonstrate various features of the iCE40 UltraPlus for Bluetooth Low Energy communication and Image processing.

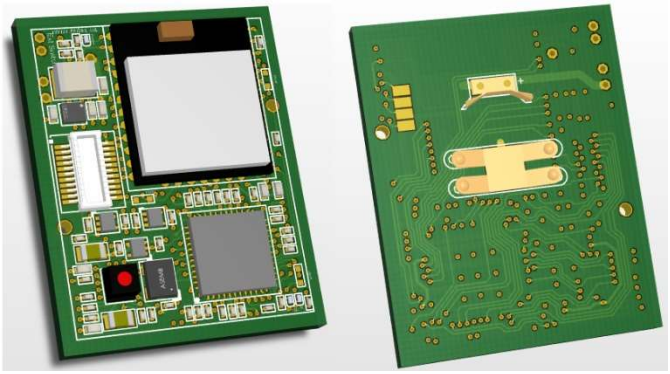


Figure 1.1. MTX-BC48-DB board

2. Features

Features that can be demonstrated using this board include:

- iCE40 UltraPlus (iCE40UP5K-SG48) device in a 48-PIN QFN package.
- Bluetooth Low Energy module BGX13P22GA-V31R
- CameraCube Image Sensor OVM7690-R20A
- Coin Cell Battery contacts
- External mechanical switch input
- Size: 31mm x 25mm x 3mm
- Wight: 5gram

Figure 2.1 shows the front side of the MTX-BC48 board and Figure 2.2 (on the next page) shows its back side, including specific features and the mechanisms behind them.

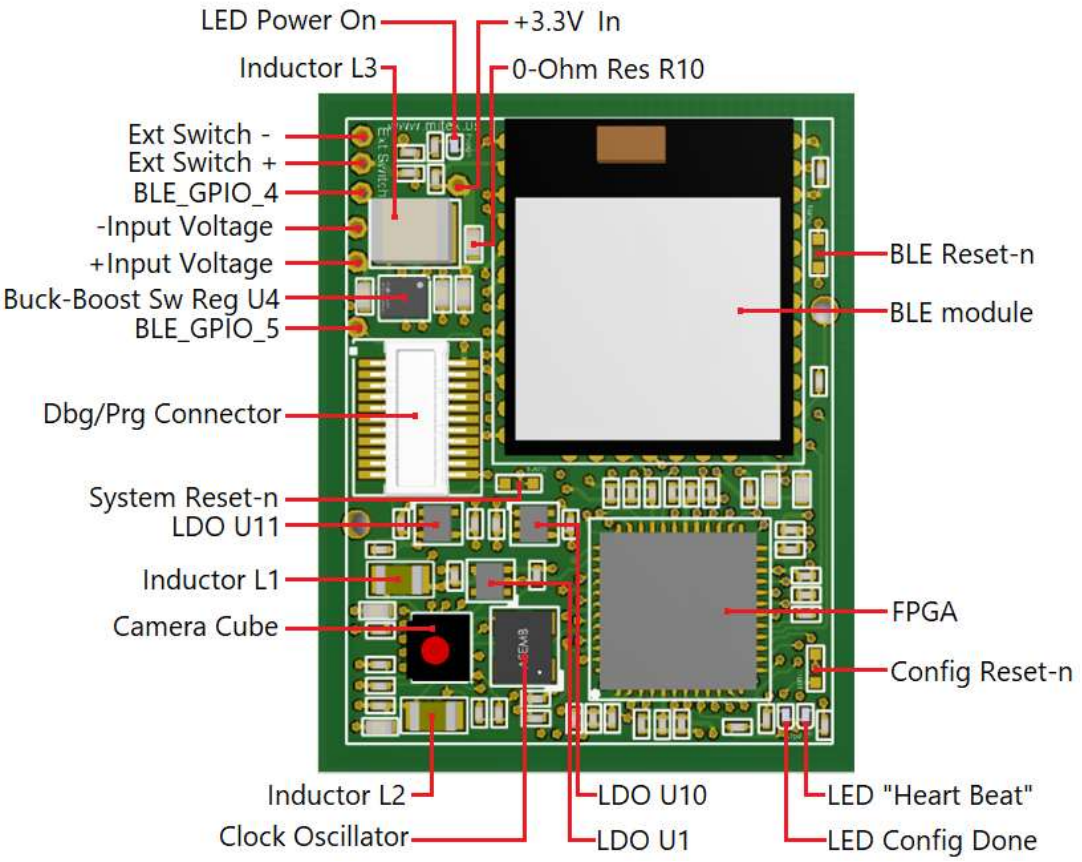


Figure 2.1. MTX-BC48-DB board Top Side

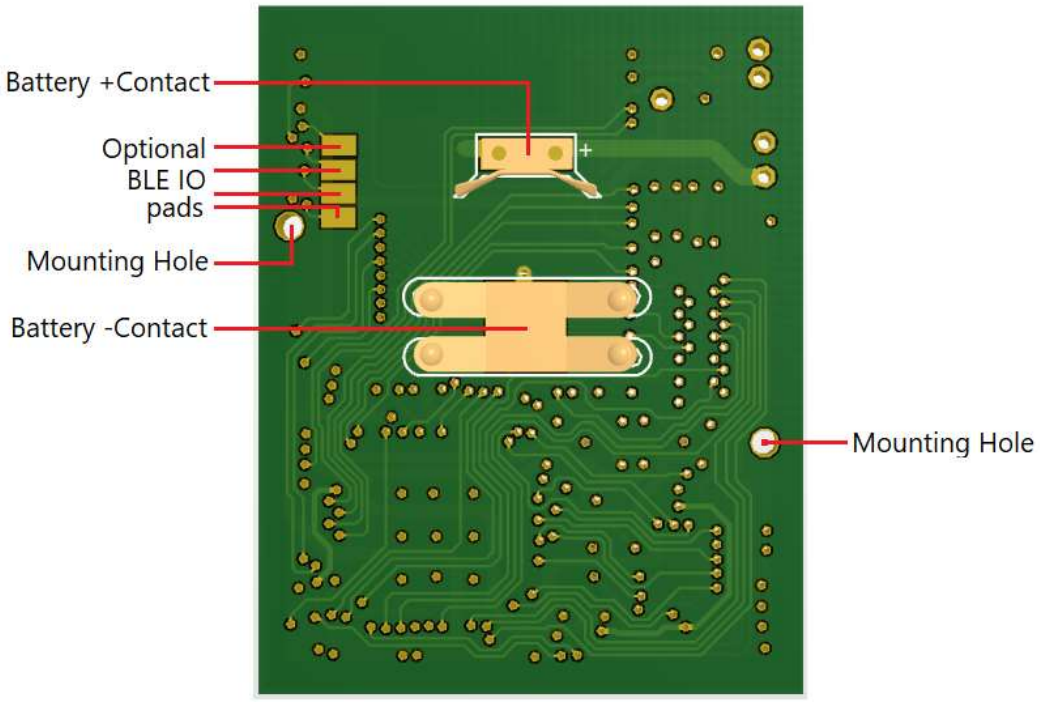


Figure 2.1. MTX-BC48-DB Bottom Side

3. Board Resets

BLE Reset-n is the Manual reset of the BLE through the shorting (by touching) of contacts 1 and 2.

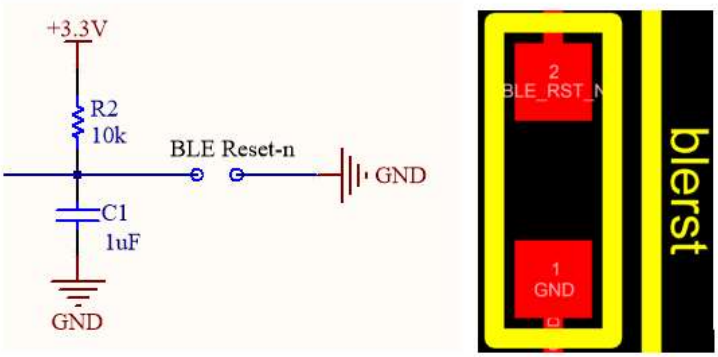


Figure 3.1. BLE Reset-n Contacts

Config Reset-n is the Manual reset of the FPGA configuration through the shorting (by touching) of contacts 1 and 2.

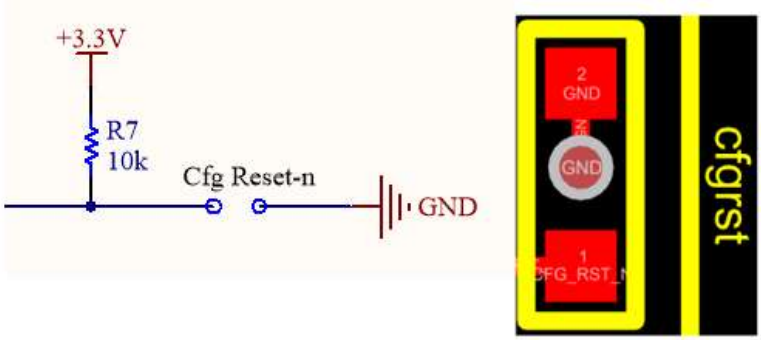


Figure 3.2. Config Reset-n Contacts

System Reset-n is the Manual reset of the System through the shorting (by touching) contacts 1 and 2.

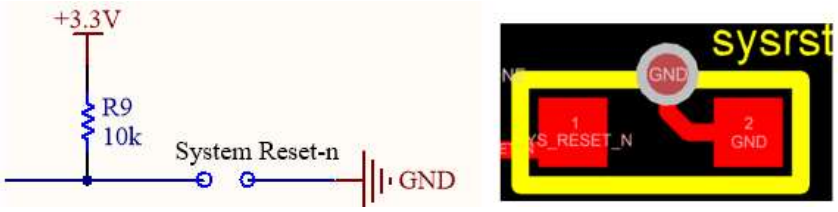


Figure 3.3. System Reset-n Contacts

4. Board LEDs

LED Power On flashes after the application of power supply to the Board.

LED "Heart Beat" blinks after starting the MTX BLE application. This LED could be used for other purpose as well.

LED Config Done flashes successfully as a result of FPGA configuration.

5. Clock Source

The board has a single 12 MHz clock source Y1. The 12 MHz clock drives the CameraCube Image sensor U2 (Figure 5.1). FPGA U5 iCE40UP5K-SG48 gets a clock from the Image Sensor as the Pixel Clock.

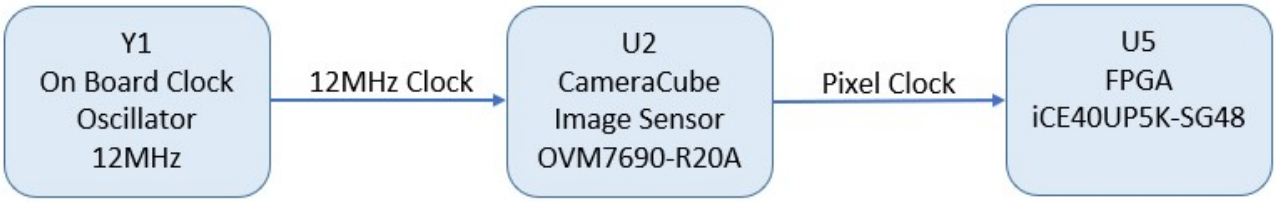


Figure 5.1. MTX-BC48 board Clock Sources

6. Power Source

The MTX-BC48-DB board is powered by three sources:

1. External +2.3V to +5.5V Input voltage, which represents External Battery or other DC power supply.
2. Internal Coin Cell Battery connected to Plus and Negative contacts. Internal Coin Cell Battery and External supply cannot be used at same time.
3. External +3.3V supply through +3.3V input. In this case, the 0-Ohm resistor R10 should be removed from the board.

Power sourcing block diagram is shown in Figure 6.1.

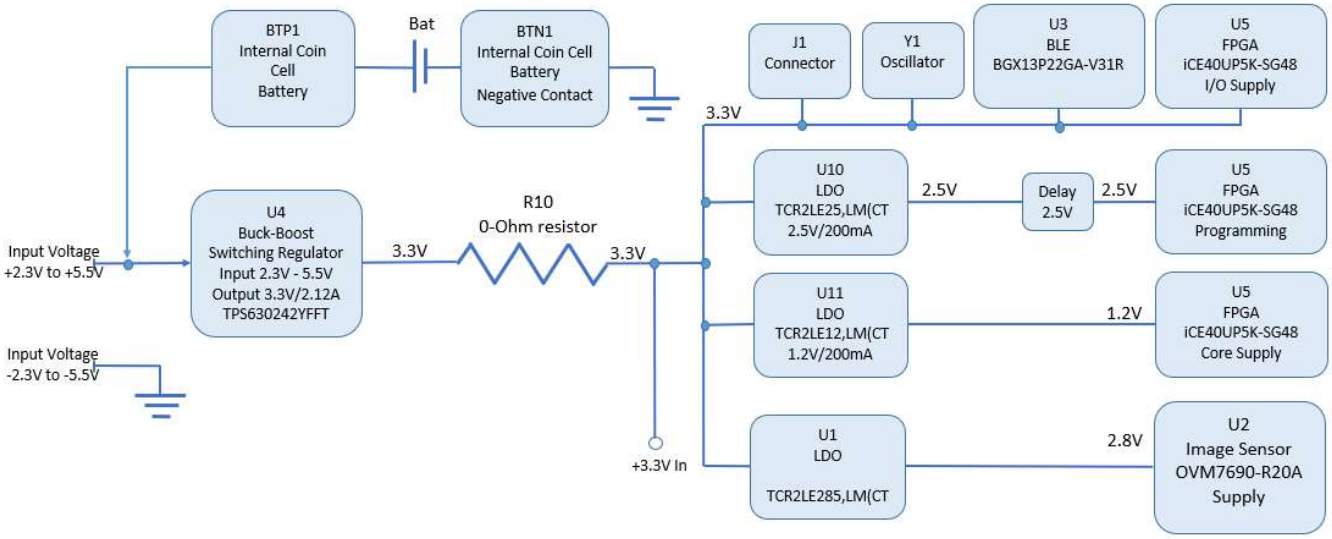


Figure 6.1. MTX-BC48-DB board Power sourcing block diagram

FPGA iCE40UP5K-SG48 requires Power-up Supply Sequencing. The programming of +2.5V should be applied after Core, PLL and I/O supplies because its programming is delayed through extra output capacitance. Refer to the board schematics for further understanding.

7. External Switch

The MTX-BC48-DB board has an external switch connection (Figure 7.1). A reed relay could be used as a switch as well.

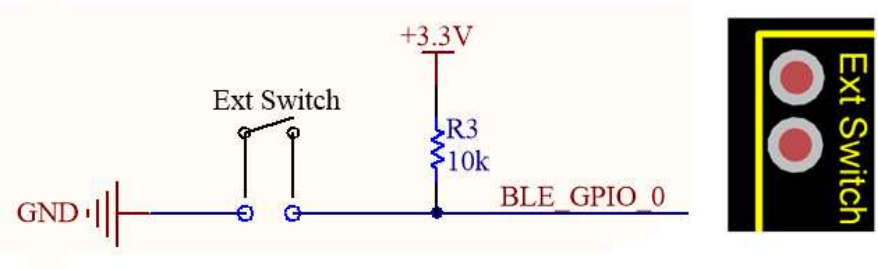


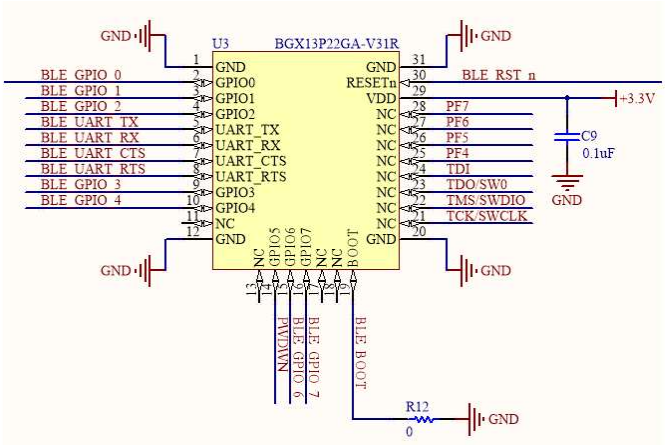
Figure 7.1. MTX-BC48-DB board external switch connection

8. BLE

The MTX-BC48-DB board has a Silicon Labs BLE Xpress module BGX13P22GA-V31R:

- Out-of-the-box BLE5 to UART cable replacement
  - No firmware development needed
  - Built-in Xpress streaming service for data transfer

BLE Xpress module connection information (on the MTX-BC48 board) is shown in Table 8.1. It also includes BGM13P series modules pins connection information as well.



BGX13Pxxx

BGM13Pxxx

Figure 8.1. BLE modules

Table 8.1. BLE module connection

BLE Xpress module Pins	BLE Xpress module Pin Name	MTX-BC48 board Signals Name	Connected To	BGM13P series modules Pins
1	Gnd	-	Gnd	Gnd
2	GPIO 0	BLE_GPIO_0	External Switch	PD13
3	GPIO 1	BLE_GPIO_1	FPGA U5 pin 23	PD14
4	GPIO 2	BLE_GPIO_2	FPGA U5 pin 21	PD15
5	UART TX	BLE_UART_TX	FPGA U5 pin 20	PA0
6	UART RX	BLE_UART_RX	FPGA U5 pin 19	PA1
7	UART CTS	BLE_UART_CTS	FPGA U5 pin 18	PA2

8	UART RTS	BLE_UART_RTS	FPGA U5 pin 25	PA3
9	GPIO 3	BLE_GPIO_3	FPGA U5 pin 26	PA4
10	GPIO 4	BLE_GPIO_4	FPGA U5 pin 46	PA5
11	Not Connect	-	-	PB11
12	Gnd	-	Gnd	Gnd
13	Not Connect	-	-	PB13
14	GPIO 5	PWDWN	Image Sensor U2 pin A1	PC6
15	GPIO 6	BLE_GPIO_6	FPGA U5 pin 31	PC7
16	GPIO 7	BLE_GPIO_7	FPGA U5 pin 28	PC8
17	Not Connect	-	-	PC9
18	Not Connect	-	-	PC10
19	BOOT	BLE_BOOT	See schematics	PC11
20	Gnd	-	Gnd	Gnd
21	Not Connect	TCK/SWCLK	Connector J1 pin 20	PF0
22	Not Connect	TMS/SWDIO	Connector J1 pin 19	PF1
23	Not Connect	TDO/SWO	Connector J1 pin 18	PF2
24	Not Connect	TDI	Connector J1 pin 17	PF3
25	Not Connect	-	-	PF4
26	Not Connect	-	-	PF5
27	Not Connect	-	-	PF6
28	Not Connect	-	-	PF7
29	VDD	-	3.3V	VDD
30	RESETn	BLE_RST_n	See schematics	RESETn
31	Gnd	-	Gnd	Gnd

Some options of MTX-BC48-DB board include the BGM13P series module. MTX-BC48 board has PCB pads (on bottom surface) for development purposes through the use of BGM13P pins (Figure 8.2).

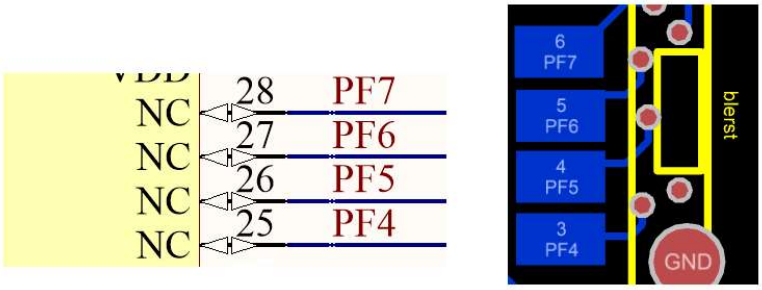


Figure 8.2. MTX-BC48-DB **board PCB pads for BGM13P series module**

9. Debug/Programming Connector

For programming and debugging of the application of FPGA U5 and BLE BGM13P series, the MTX-BC48-DB board has connector J1 (Figure 9.1).

Figure 9.1. MTX-BC48-DB **board J1 connector**

Connector J1 connection information (on the MTX-BC48 board) shown in Table 9.1.

Table 9.1. J1 connection

J1 connector Pins	J1 connector Signals Name	Connected To	Comments
1	IO_DATA_J_1	FPGA U5 pin 2	FPGA IO port
2	IO_DATA_J_3	FPGA U5 pin 3	FPGA IO port
3	IO_DATA_J_5	FPGA U5 pin 4	FPGA IO port
4	IO_DATA_GATE	FPGA U5 pin 6	FPGA IO port
5	IO_DATA_ENB	FPGA U5 pin 9	FPGA IO port
6	IO_DATA_J_4	FPGA U5 pin 32	FPGA IO port
7	IO_DATA_J_6	FPGA U5 pin 11	FPGA IO port
8	IO_DATA_J_2	FPGA U5 pin 13	FPGA IO port
9	IO_DATA_J_0	FPGA U5 pin 12	FPGA IO port
10	IO_DATA_J_7	FPGA U5 pin 10	FPGA IO port
11	Gnd	Gnd	Power
12	+3.3V	+3.3V	Power
13	SS_IO	FPGA U5 pin 16	FPGA SPI interface port
14	MISO_IO	FPGA U5 pin 14	FPGA SPI interface port
15	SCK_IO	FPGA U5 pin 15	FPGA SPI interface port
16	MOSI_IO	FPGA U5 pin 17	FPGA SPI interface port
17	TDI	BLE U3 pin 24	BLE BGM13P series Prg/Dbg port
18	TDO/SWO	BLE U3 pin 23	BLE BGM13P series Prg/Dbg port
19	TMS/SWDIO	BLE U3 pin 22	BLE BGM13P series Prg/Dbg port
20	TCK/SWCLK	BLE U3 pin 21	BLE BGM13P series Prg/Dbg port
21	CFG_RST_n	FPGA U5 pin 8	FPGA config reset input
22	O_CFG_DONE	FPGA U5 pin 7	FPGA config done output

For the easy connection with the connector J1, a mezzanine connector adapter board, shown on Figure 9.2 could be used.

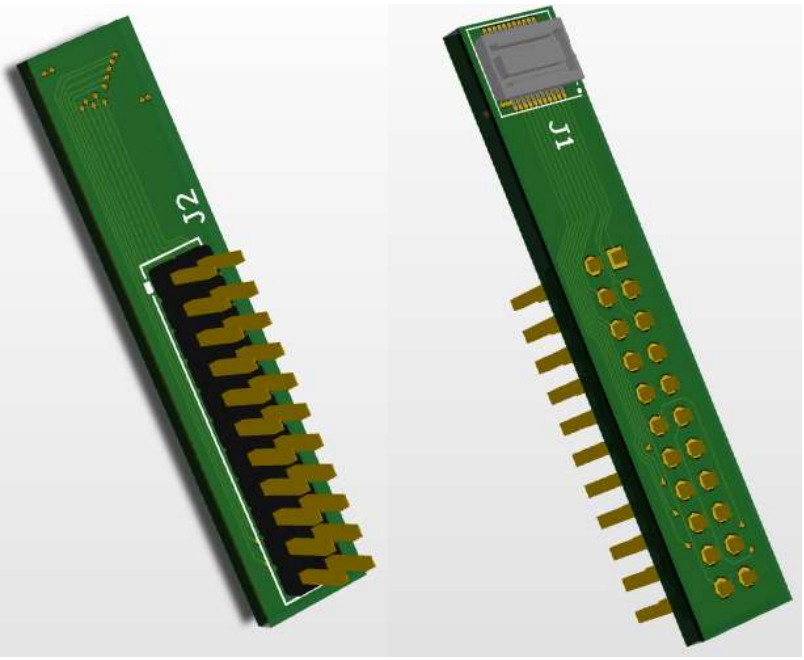


Figure 9.2. Mezzanine connector adapter board

Mezzanine adapter board connection information shown in Table 9.2.

Table 9.1. Mezzanine adapter connection

J1 Mezzanine connector Pins	J2 Header connector Pins	Signal Name	MTX-BC48 board J1 connector Signal Name
1	1	s1	IO_DATA_J_1
2	3	s2	IO_DATA_J_3
3	5	s3	IO_DATA_J_5
4	4	s4	IO_DATA_GATE
5	6	s5	IO_DATA_ENB
6	22	s6	IO_DATA_J_4

7	13	s7	IO_DATA_J_6
8	15	s8	IO_DATA_J_2
9	17	s9	IO_DATA_J_0
10	19	s10	IO_DATA_J_7
11	21	Gnd	Gnd
12	2	+3.3V	+3.3V
13	7	s13	SS_IO
14	9	s14	MISO_IO
15	8	s15	SCK_IO
16	10	s16	MOSI_IO
17	20	s17	TDI
18	14	s18	TDO/SWO
19	16	s19	TMS/SWDIO
20	18	s20	TCK/SWCLK
21	12	s21	CFG_RST_n
22	11	s22	O_CFG_DONE

10. Image Sensor

MTX-BC48-DB board has Image Sensor OVM7690 VGA CameraCube Chip (Figure 10.1). CameraCube has some following key specifications:

- Active array size: 640 x 480
- Power supply:
  - analog: 2.6 ~ 3.0V
  - I/O: 1.7 ~ 3.0V
- output formats (8-bit): YUV 422 / YCbCr422, RGB565, CCIR656, raw RGB data
- Input clock frequency: 6 ~ 27 MHz
- Maximum image transfer rate:
  - VGA (640x480): 30 fps for VGA
  - QVGA (320x240): 60 fps for QVGA
- Package dimensions: 2.5 mm x 2.9 mm

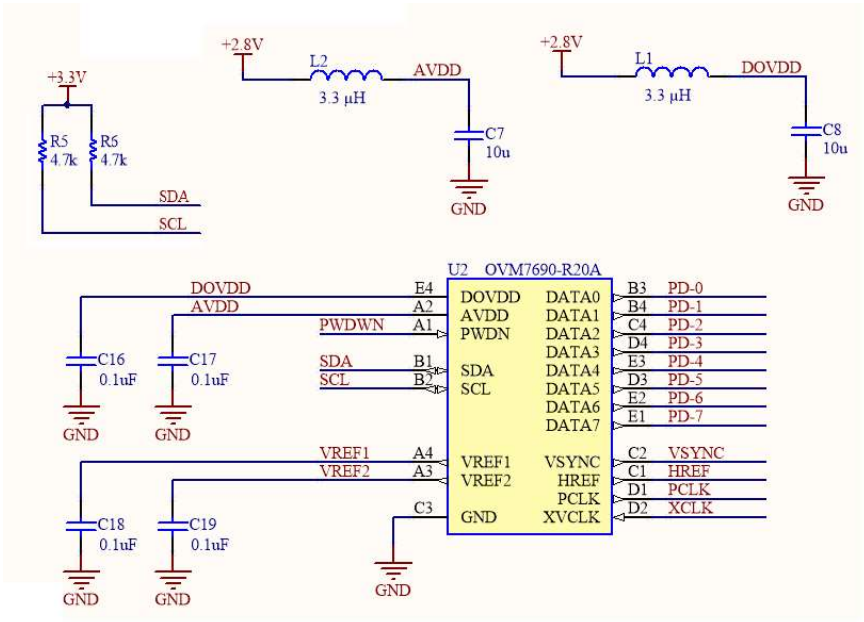
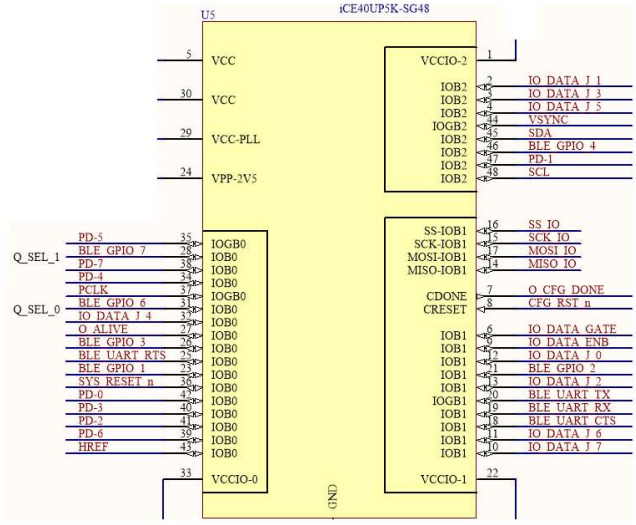


Figure 10.1. OVM7690 VGA CameraCube and its circuit

11. FPGA

MTX-BC48-DB board has FPGA iCE40UP5K-SG48 (Figure 11.1).



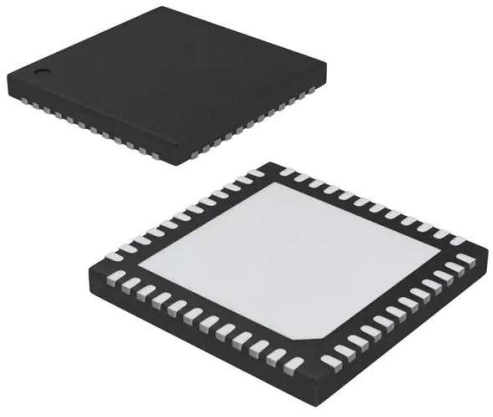


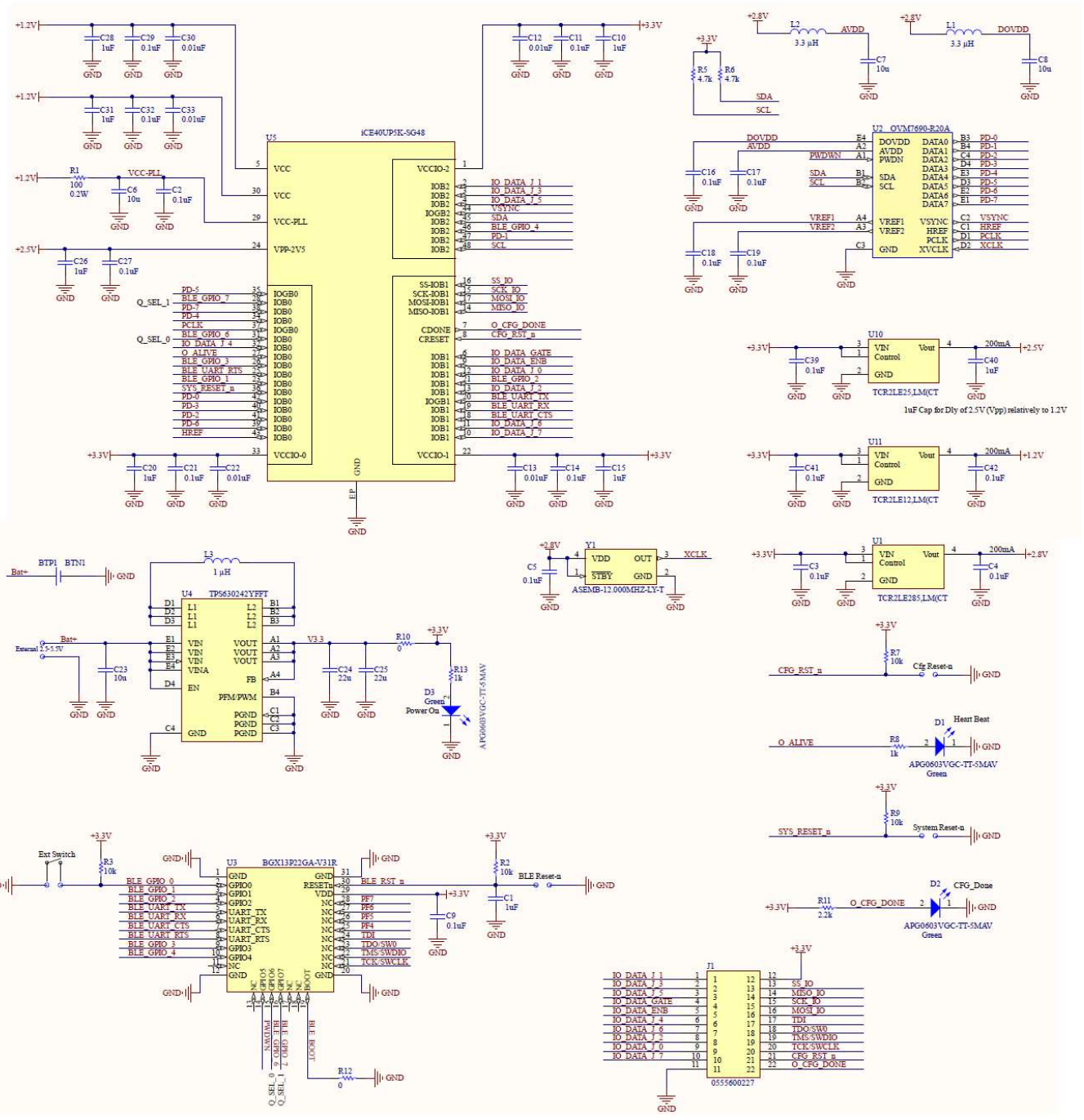
Figure 11.1. FPGA iCE40UP5K-SG48 and its circuit

12. Bill Of Materials

Designator	Detailed Description	Manufacturer Part Number	Quantity	Manufacturer
BTN1	Battery Contact Spring	112TR	1	Keystone Electronics
BTP1	Battery Contact Solid (Positive)	120TR	1	Keystone Electronics
C1, C10, C15, C20, C26, C28, C31, C40	Ceramic Capacitor, X5R, 1UF, 6.3V, 0201	GRM032R60J105ME05D	8	Murata
C2, C3, C4, C5, C9, C11, C14, C16, C17, C18, C19, C21, C27, C29, C32, C39, C41, C42	0.1µF 16V Ceramic Capacitor X5R	C0603X5R1C104K030BC	18	TDK
C6, C7, C8	10µF 6.3V Ceramic Capacitor X5R 0402	GRM155R60J106ME15D	3	Murata Electronics
C12, C13, C22, C30, C33	0.01µF 10V Ceramic Capacitor X5R 0201	C0603X5R1A103K030BA	5	TDK
C23	10µF 6.3V Ceramic Capacitor X5R 0402	GRM155R60J106ME15D	1	Murata
C24, C25	22µF 6.3V Ceramic Capacitor X5R 0402	CL05A226MQ5N6J8	2	Samsung
D1, D2, D3	Green LED - Discrete 3V 2-SMD, 0201	APG0603VGC-TT-5MAV	3	Kingbright
J1	Mezzanine Connector Plug 22pos SMD	0555600227	1	Molex
L1, L2	3.3µH Unshielded Wirewound Inductor 870mA 221mOhm Max 0805	BRC2012T3R3MD	2	Taiyo Yuden
L3	Shielded Wirewound Inductor 45mOhm Max 1210	DFE322512C	1	Murata
R1	Resistors - SMD 100 Ohms ±5% 0.2W, 0402	RCS0402100RJNED	1	Vishay Dale
R2, R3, R7, R9	Resistors - SMD 10 kOhms ±1% 0.05W, 0201	ERJ-1GEF1002C	4	Panasonic
R5, R6	Resistors - SMD 4.7 kOhms ±1% 0.05W, 0201	ERJ-1GEF4701C	2	Panasonic
R8, R13	Resistors - SMD 1 kOhms ±1% 0.05W, 0201	ERJ-1GEF1001C	2	Panasonic

R10	Resistors - SMD 100 Ohms ±5% 0.2W, 0402	ERJ-S020R00X	1	Panasonic
R11	Resistors - SMD 2.2 kOhms ±1% 0.05W, 0201	ERJ-1GNF2201C	1	Panasonic
R12	Resistors - SMD 0 Ohms ±1% 0.05W, 0201	ERJ-U010R00C	1	Panasonic
U1	LDO 2.8V Output 200mA	TCR2LE285,LM(CT	1	Toshiba
U2	CMOS Image Sensor 640H x 480V	OVM7690-R20A	1	OmniVision Technologies
U3	Bluetooth v5.0 Transceiver Module	BGX13P22GA-V31R	1	Silicon Labs
U4	Buck-Boost Switching Regulator IC Positive Fixed 3.3V 1 Output 2.12A (Switch) 20-UFBGA	TPS630242YFFT	1	Texas Instruments
U5	FPGA 39 I/O 48QFN	iCE40UP5K-SG48	1	Lattice Semiconductor Corporation
U10	LDO 2.5V Output 200mA	TCR2LE25,LM(CT	1	Toshiba
U11	LDO 1.2V Output 200mA	TCR2LE12,LM(CT	1	Toshiba
Y1	12MHz XO (Standard) CMOS Oscillator 4-SMD	ASEMB-12.000MHZ-LY-T	1	Abracon

13. Schematic Diagrams



14. Revision History

Date	Version	Revision
5/3/2020	0	Original revision

15. Disclaimer

We expressly disclaim any liability arising out of the application or use of the MTX-BC48-DB board. We reserve the right to make changes, at any time, to the MTX-BC48-DB board as deemed desirable in the sole discretion of ours. We assume no obligation to correct any errors contained herein or to advise you of any correction if such be made. We will not assume any liability for the accuracy or correctness of any engineering or technical support or assistance provided to you in connection with the MTX-BC48-DB board.

THE DESIGN IS PROVIDED "AS IS" WITH ALL FAULTS, AND THE ENTIRE RISK AS TO ITS FUNCTION AND IMPLEMENTATION IS WITH YOU. YOU ACKNOWLEDGE AND AGREE THAT YOU HAVE NOT RELIED ON ANY ORAL OR WRITTEN INFORMATION OR ADVICE, WHETHER GIVEN BY US, OR OUR AGENTS OR EMPLOYEES. WE MAKE NO OTHER WARRANTIES, WHETHER EXPRESS, IMPLIED, OR STATUTORY, REGARDING THE DESIGN, INCLUDING ANY WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, TITLE, AND NONINFRINGEMENT OF THIRD-PARTY RIGHTS.

The MTX-BC48-DB board is not designed or intended for use in the development of on-line control equipment in hazardous environments requiring fail-safe controls, such as in the operation of nuclear facilities, aircraft navigation or communications systems, air traffic control, life support, or weapons systems ("High-Risk Applications"). We specifically disclaim any express or implied warranties of fitness for such High-Risk Applications. You represent that use of the MTX-BC48-DB board in such High-Risk Applications is fully at your risk.