



TEF1001 TRM

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4 Overview

The Trenz Electronic TEF1001 FPGA board is a PCI Express form factor card integrating the Xilinx Kintex-7 XC7K160T, XC7K325T or XC7K410T FPGA SoC. The FPGA-board is designed for high system resources and intended for use in applications with high demands on system performance and throughput. To extend the board with standard DDR3 SDRAM memory module, there is a 204-pin SODIMM socket with 64bit databus width on the board present. Highspeed data transmission is enabled by the 4 lane PCIe Gen 2 interface.

The board offers a HPC (High Pin Count) ANSI/VITA 57.1 compatible FMC interface connector for standard FPGA Mezzanine cards and modules. Other interface connectors found on-board include JTAG for accessing FPGA and on-board System Controller CPLD.

The TEF1001 FPGA board is intended to be used as add-on card in a PCIe 2.0 or higher capable host system to meet the power supply requirements.

Refer to <http://trenz.org/tef1001-info> for the current online version of this manual and other available documentation.

4.1 Key Features

- Xilinx Kintex-7 XC7K160T, XC7K325T or XC7K410T FPGA SoC
- Large number of configurable I/Os are provided via HPC FMC connector
 - 4 GTX high-performance transceiver
 - 2x MGT transceiver clock inputs
 - 160 FPGA I/O's (80 LVDS pairs)
- On-board high-efficiency switch-mode DC-DC converters
- Lattice MachXO2 LCMXO2-1200HC System Controller CPLD
- 10x User LEDs
- PCI Express x8 connector with 4 lane PCIe Gen 2 interface
- ANSI Vita 57.1 FMC High Pin Count (HPC) connector
- DDR3 SODIMM SDRAM with ECC socket with 64bit databus width
- 256Mbit (32MByte) Quad SPI Flash memory (for configuration and operation) accessible through:
 - FPGA
 - JTAG port (SPI indirect, bus width x4)
- FPGA configuration through:
 - JTAG connector
 - Quad SPI Flash memory
- Clocking
 - Si5338 programmable quad PLL clock generator - 4 outputs for MGT and PL clocks
 - 200MHz oscillator for DDR3 bank
- System management and power sequencing

Additional assembly options are available for cost or performance optimization upon request.

4.2 Block Diagram

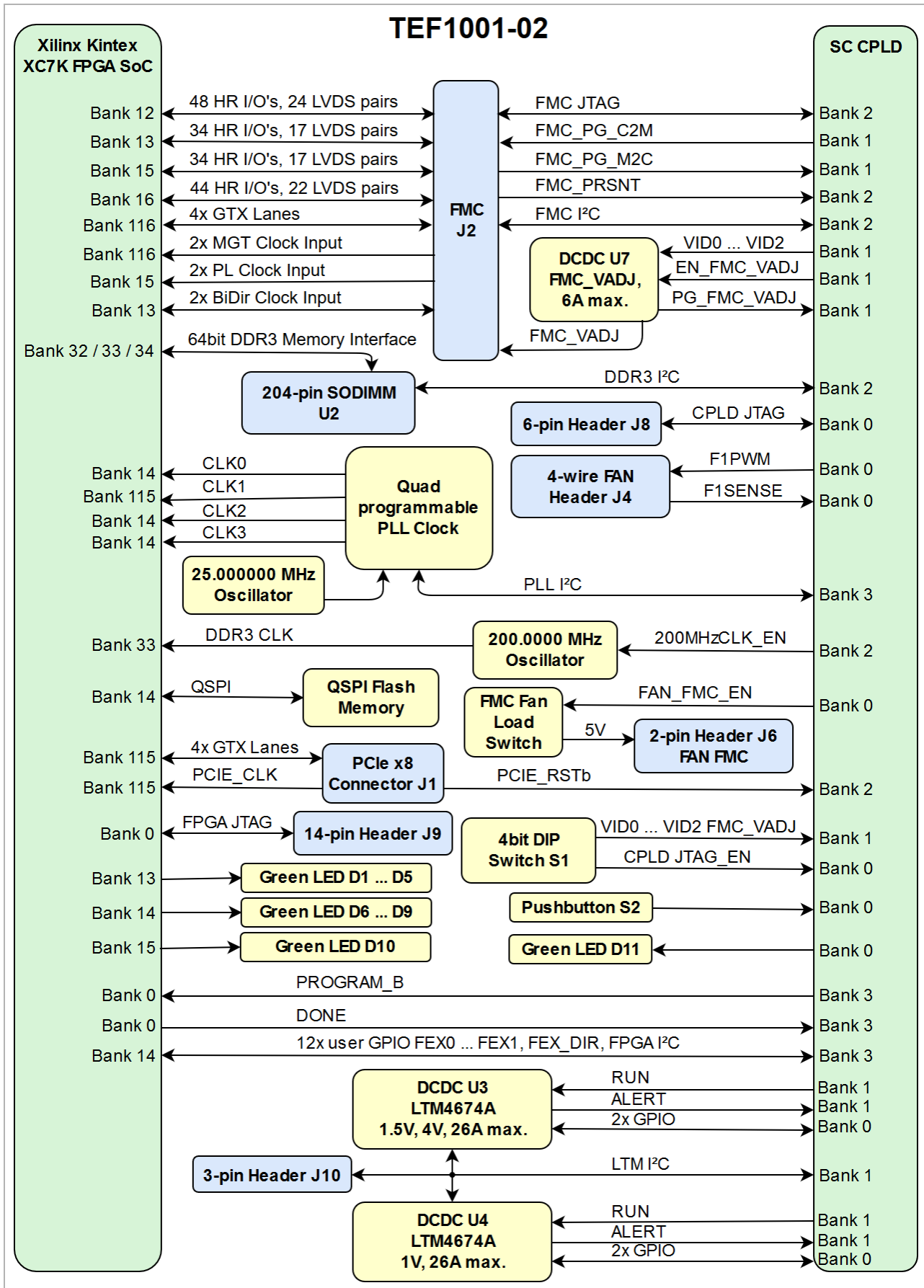


Figure 1: TEF1001-02 block diagram

4.3 Main Components

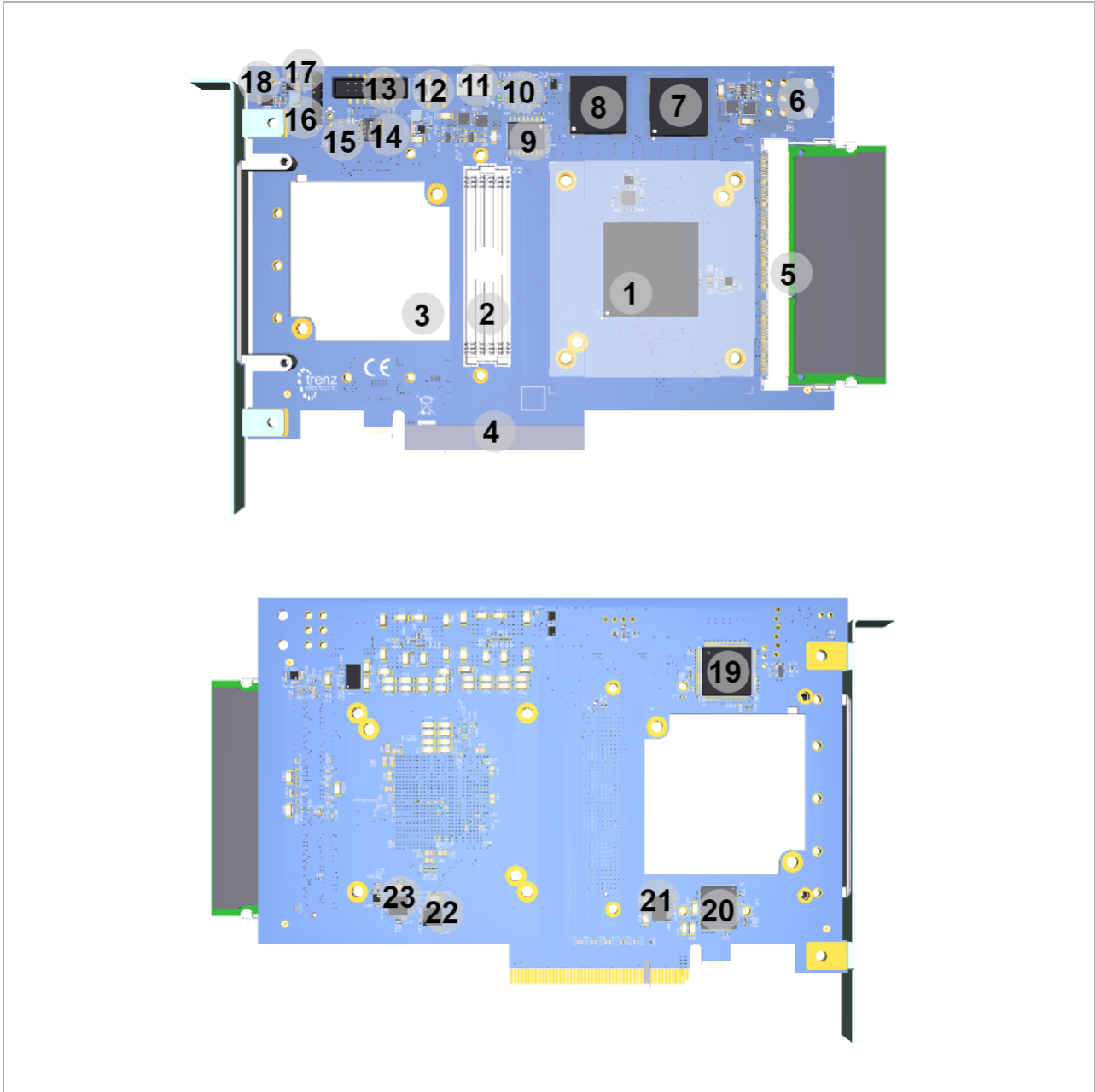


Figure 2: TEF1001-02 main components

1. Xilinx Kintex XC7K-2FBG676I FPGA SoC, U6
2. ANSI/VITA 57.1 compliant FMC HPC connector, J2
3. Cooling fan 5VDC M1 (45X5MM, 0.7W, 1.06CFM), M1
4. PCIe x8 connector, J1
5. DDR3 SODIMM 204-pin socket, U2
6. 6-pin 12V power connector, J5
7. Step-down DC-DC converter @1.5V and @4V (LT LTM4676A), U3

8. Step-down DC-DC converter @1.0V (LT LTM4676A), U4
9. 256 Mbit Quad SPI Flash Memory (Micron N25Q256A), U12
10. 10x Green user LEDs connected to FPGA, D1 ... D10
11. 4-wire PWM fan connector, J4
12. User button, S2
13. FPGA JTAG connector, J9
14. 4bit DIP switch, S1
15. I²C header for LTM4676A DC-DC converter, J10
16. System Controller CPLD JTAG header, J8
17. 1x Green LED connected to SC CPLD, D11
18. 2-pin 5V FAN header, J6
19. System Controller CPLD (Lattice Semiconductor LCMXO2-1200HC), U5
20. 6A PowerSoC DC-DC converter @FMC_VADJ (Altera EN5365QI), U7
21. 4A PowerSoC DC-DC converter @3.3V (3V3FMC) (Altera EN6347QI), U15
22. LDO converter @1.2V (MGTAVTT_FPGA) (TI TPS74401RGW), U17
23. LDO converter @1.0V (MGTAVCC_FPGA) (TI TPS74401RGW), U18
24. 4A PowerSoC DC-DC converter @1.8V (Altera EN6347QI), U7

4.4 Initial Delivery State

| Storage device name | Content | Notes |
|---------------------------|-----------------------|---|
| Si5338A OTP Area | not programmed | - |
| SPI Flash OTP Area | Empty, not programmed | Except serial number programmed by flash vendor |
| SPI Flash Quad Enable bit | Programmed | - |
| SPI Flash main array | demo design | - |
| HyperFlash Memory | not programmed | - |
| eFUSE USER | Not programmed | - |
| eFUSE Security | Not programmed | - |

Table 1: Initial delivery state of programmable on-board devices

4.5 Control Signals

To get started with TEF1001 board, some basic control signals are essential and are described in the following table:

| Control signal | Switch / Button / LED / Pin | Signal Schematic Names | Connect ed to | Functionality | Notes |
|----------------------------|-------------------------------|--|--|--|--|
| SC CPLD JTAG Enable | DIP switch S1-1 | JTAG_EN | SC CPLD U5, pin 82 | ON-position: SC CPLD U5 JTAG interface enabled | - |
| BOOT Mode | FPGA bank 0, pins T5, T2, P5 | - | Pin T5 (M0): 1V8 Pin T2 (M1): GND Pin P5 (M2): GND | Hard-wired Boot Mode | By default the configuration mode pins M[2:0] of the FPGA are set to QSPI mode (Master SPI) |
| Global Reset input | Push Button S2 | S2 | SC CPLD U5, pin 77 | Manual reset from user | - |
| FMC_VADJ voltage selection | DIP switches S1-2, S1-3, S1-4 | VID0_FMC_V ADJ_CTRL .. . VID2_FMC_V ADJ_CTRL | SC CPLD U5, pins 71, 63, 62 | sets adjustable voltage 'FMC_VADJ' for FMC connector | DIP-switch states forwarded by SC CPLD U5 to DC-DC U7. Refer to section Configuration DIP-switch for more details. |

Table 2: TEF1001 Control Signals

5 Signals, Interfaces and Pins

5.1 FMC HPC Connector

I/O signals and interfaces connected to the FPGA SoCs I/O bank and FMC connector J2:

| Interfaces | I/O Signal Count | LVDS-pairs count | Connected to | VCCO bank Voltage | Notes |
|------------------|------------------|------------------|---|-------------------|--|
| I/O | 48 | 24 | FPGA Bank 12 HR | FMC_VADJ | Bank voltage FMC_VADJ is supplied by DC-DC converter U7 |
| | 34 | 17 | FPGA Bank 13 HR | FMC_VADJ | |
| | 34 | 17 | FPGA Bank 15 HR | FMC_VADJ | |
| | 44 | 44 | FPGA Bank 16 HR | VIO_B_FMC C | Bank voltage VIO_B_FMC is supplied by FMC connector J2 |
| I ² C | 2 | - | SC CPLD U5, Bank 2, pin 48, 49 | - | FMC connector J2 is hardware programmed to I ² C address 0x50 |
| JTAG | 5 | - | SC CPLD U5, Bank 2, pin 27, 28, 331, 32, 36 | 3.3V | 4 JTAG pins with additional signal 'TRST' |
| MGT | - | 8 (4 x RX/ TX) | Bank 116 GTX | - | 4x MGT lanes |
| Clock Input | - | 2 | Bank 116 GTX | - | 2x Reference clock input to MGT bank |
| Control Signals | 3 | - | SC CPLD U5, Bank 1, pin 68, 69, 70 | 3.3V | 'FMC_PG_C2M', 'FMC_PG_M2C', 'FMC_PRSNT_M2C_L' |

Table 3: FMC connector J2 interfaces

For detailed information about the pin out, please refer to the [Pin-out Tables](#)¹.

¹ https://shop.trenz-electronic.de/de/Download/?path=Trenz_Electronic/Pinout

FMC connector J2 MGT Lanes:

| MGT Lane | Bank | Type | Signal Schematic Name | FMC Connector Pin | FPGA Pin |
|----------|------|------|--|--|--|
| 0 | 116 | GTX | <ul style="list-style-type: none"> DP3_M2C_P DP3_M2C_N DP3_C2M_P DP3_C2M_N | <ul style="list-style-type: none"> J2-A10 J2-A11 J2-A30 J2-A31 | <ul style="list-style-type: none"> MGTXRX0_116, G4 MGTXRXN0_116, G3 MGTTXP0_116, F2 MGTXTXN0_116, F1 |
| 1 | 116 | GTX | <ul style="list-style-type: none"> DP2_M2C_P DP2_M2C_N DP2_C2M_P DP2_C2M_N | <ul style="list-style-type: none"> J2-A6 J2-A7 J2-A26 J2-A27 | <ul style="list-style-type: none"> MGTXRX1_116, E4 MGTXRXN1_116, E3 MGTTXP1_116, D2 MGTXTXN1_116, D1 |
| 2 | 116 | GTX | <ul style="list-style-type: none"> DP1_M2C_P DP1_M2C_N DP1_C2M_P DP1_C2M_N | <ul style="list-style-type: none"> J2-A2 J2-A3 J2-A22 J2-A23 | <ul style="list-style-type: none"> MGTXRX2_116, C4 MGTXRXN2_116, C3 MGTTXP2_116, B2 MGTXTXN2_116, B1 |
| 3 | 116 | GTX | <ul style="list-style-type: none"> DP0_M2C_P DP0_M2C_N DP0_C2M_P DP0_C2M_N | <ul style="list-style-type: none"> J2-C6 J2-C7 J2-C2 J2-C3 | <ul style="list-style-type: none"> MGTXRX3_116, B6 MGTXRXN3_116, B5 MGTTXP3_116, A4 MGTXTXN3_116, A3 |

Table 4: FMC connector J2 MGT lanes

FMC connector J2 reference clock sources:

| Signal Schematic Name | Connected to | FMC Connector Pin | FPGA Pin | Notes |
|--|--------------|-------------------|--|---------------------------------|
| <ul style="list-style-type: none"> GBTCLK0_M2C_P GBTCLK0_M2C_N | MGT bank 116 | J2-D4 J2-D5 | MGTREFCLK0 P_116, D6 MGTREFCLK0 N_116, D5 | Supplied by attached FMC module |
| <ul style="list-style-type: none"> GBTCLK1_M2C_P GBTCLK1_M2C_N | MGT bank 116 | J2-B20 J2-B21 | MGTREFCLK1 P_116, F6 MGTREFCLK1 N_116, F5 | Supplied by attached FMC module |

Table 5: FMC connector J2 clock signal input

FMC connector J2 VCC/VCCIO:

| Available VCC/ VCCIO | FMC Connector Pin | Source | Notes |
|----------------------|--------------------------------------|--|--|
| 3V3FMC | J2-D36 J2-D38 J2-D40 J2-C39 | DCDC U15, max. current: 4A | Enable by SC CPLD U5, bank 1, pin 60 Signal: 'EN_3V3FMC' |
| 3V3 | J2-D32 | LDO U9, max. current: 0.5A | not dedicated for FMC connector |
| 12V | J2-C35 J2-C37 | external source through ATX main power connector | - |
| FMC_VADJ | J2-H40 J2-G39 J2-F40 J2-E39 | DCDC U7, max. current: 6A | Enable by SC CPLD U5, bank 1, pin 51 Signal: 'EN_FMC_VADJ' set voltage FMC_VADJ by DIP switch S1 |

Table 6: FMC connector J2 available VCC/VCCIO

FMC connector J2 Cooling Fan:

| Fan Designator | Enable Signal | Notes |
|----------------|--|-------|
| M1 | Enable by SC CPLD U5, bank 0, pin 78 Signal: 'FAN_FMC_EN' | - |

Table 7: FMC connector J2 cooling fan

5.2 PCI Express Interface

The TEF1001 FPGA board is a PCI Express card designed to fit into systems with PCI Express x8 slots and has a data transmission capability which meets PCIe Gen. 2 with 4 GTX lanes routed to the PCIe interface.

Following table lists lane number, MGT bank number, transceiver type, signal schematic name, connector and FPGA pins connection:

| Lane | Bank | Type | Signal Name | PCIe Connector Pin | FPGA Pin |
|------|------|------|--|--|--|
| 0 | 115 | GTX | <ul style="list-style-type: none"> • PER3_P • PER3_N • PET3_P • PET3_N | <ul style="list-style-type: none"> • J1-A29 • J1-A30 • J1-B27 • J1-B28 | <ul style="list-style-type: none"> • MGTTXP0_115, P2 • MGTTXN0_115, P1 • MGTXRP0_115, R4 • MGTXRN0_115, R3 |
| 1 | 115 | GTX | <ul style="list-style-type: none"> • PER2_P • PER2_N • PET2_P • PET2_N | <ul style="list-style-type: none"> • J1-A25 • J1-A26 • J1-B23 • J1-B24 | <ul style="list-style-type: none"> • MGTTXP1_115, M2 • MGTTXN1_115, M1 • MGTXRP1_115, N4 • MGTXRN1_115, N3 |
| 2 | 115 | GTX | <ul style="list-style-type: none"> • PER1_P • PER1_N • PET1_P • PET1_N | <ul style="list-style-type: none"> • J1-A21 • J1-A22 • J1-B19 • J1-B20 | <ul style="list-style-type: none"> • MGTTXP2_115, K2 • MGTTXN2_115, K1 • MGTXRP2_115, L4 • MGTXRN2_115, L3 |
| 3 | 115 | GTX | <ul style="list-style-type: none"> • PER0_P • PER0_N • PET0_P • PET0_N | <ul style="list-style-type: none"> • J1-A16 • J1-A17 • J1-B14 • J1-B15 | <ul style="list-style-type: none"> • MGTTXP3_115, H2 • MGTTXN3_115, H1 • MGTXRP3_115, J4 • MGTXRN3_115, J3 |

Table 8: GTX lanes routed to the PCIe interface

| PCI e | Signal Schematic Name | Connected to | PCIe connector pin | FPGA Pin | Notes |
|-------|--|--------------|------------------------------------|--|---|
| J1 | <ul style="list-style-type: none"> PCIE_CLK_P PCIE_CLK_N | MGT bank 115 | J1-A13, REFCLK+ J1-A14, REFCLK- | MGTREFCLK 1P_115, K6 MGTREFCLK 1N_115, K5 | External clock supplied by PCIe interface |

Table 9: PCIe reference clock sources

5.3 JTAG Connectors

There are two JTAG connectors J8 and J9 available on the TEF1001 board:

| JTAG Interface | Signal Schematic Name | JTAG Connector Pin | Connected to |
|---|-----------------------|--------------------|-------------------------|
| CPLD JTAG VCCIO: 3.3V Connector: J8 | CPLD_JTAG_TMS | J8-1 | SC CPLD, bank 0, pin 90 |
| | CPLD_JTAG_TDI | J8-2 | SC CPLD, bank 0, pin 94 |
| | CPLD_JTAG_TDO | J8-3 | SC CPLD, bank 0, pin 95 |
| | CPLD_JTAG_TCK | J8-4 | SC CPLD, bank 0, pin 91 |
| FPGA JTAG VCCIO: 1.8V Connector: J9 | FPGA_JTAG_TMS | J9-4 | FPGA, bank 0, pin N9 |
| | FPGA_JTAG_TCK | J9-6 | FPGA, bank 0, pin M8 |
| | FPGA_JTAG_TDO | J9-8 | FPGA, bank 0, pin N8 |
| | FPGA_JTAG_TDI | J9-10 | FPGA, bank 0, pin L8 |

Table 10: JTAG interface signals

5.4 FAN Connectors

The TEF1001 board offers one FAN connector for cooling the FPGA device and one built-in FAN for the FMC modules.

| Connector | Signal Schematic Names | Connected to | Notes |
|--|---|--|---|
| 4-Wire PWM FAN connector J4, 12V power supply | 'F1SENSE', pin J4-3 'F1PWM', pin J4-4 | SC CPLD U5, pin 99 SC CPLD U5, pin 98 | FPGA cooling FAN can be controlled via I ² C interface from FPGA, see current SC CPLD firmware |
| 2-pin FAN connector J6, 5V power supply with TPS2051 Load Switch U25 | 'FAN_FMC_EN', (Load Switch U25, pin 4) | SC CPLD U5, pin 78 | FMC cooling FAN |

Table 11: FAN connectors

6 On-board Peripherals

6.1 System Controller CPLD

The System Controller CPLD (U5) is provided by Lattice Semiconductor LCMXO2-256HC (MachXO2 Product Family). The SC-CPLD is the central system management unit where essential control signals are logically linked by the implemented logic in CPLD firmware, which generates output signals to control the system, the on-board peripherals and the interfaces. Interfaces like JTAG and I²C between the on-board peripherals and to the FPGA module are by-passed, forwarded and controlled by the System Controller CPLD.

Other tasks of the System Controller CPLD are the monitoring of the power-on sequence and to display the programming state of the FPGA module.

For detailed function of the pins and signals, the internal signal assignment and the implemented logic, look to the [Wiki reference page²](#) of the board's SC CPLD or into its bitstream file.. Table below lists the SC CPLD I/O pins with their default configuration:

| SC CPLD U5 Pins and Interfaces | Connected to | Function | Notes |
|--------------------------------|----------------------|--------------------------------------|--|
| 200MHZCLK_EN | Oscillator U1, pin 1 | Oscillator U1 control line | enables 200.0000MHz oscillator U1 |
| BUTTON | Push Button S2 | user | Reset Button |
| CPLD_JTAG_TDO | header J8, pin 3 | SC CPLD JTAG interface | SC CPLD JTAG interface enabled when DIP-switch S1-1 in ON-position |
| CPLD_JTAG_TDI | header J8, pin 2 | | |
| CPLD_JTAG_TCK | header J8, pin 4 | | |
| CPLD_JTAG_TMS | header J8, pin 1 | | |
| JTAG_EN | DIP switch S1-1 | | |
| DDR3_SCL | SO-DIMM U2. pin 202 | I ² C bus of DDR3 SO-DIMM | I ² C interface connected to FPGA |
| DDR3_SDA | SO-DIMM U2. pin 200 | | |

² <https://wiki.trenz-electronic.de/display/PD/TEF1001-REV01+CPLD>

| SC CPLD U5 Pins and Interfaces | Connected to | Function | Notes |
|--------------------------------|----------------------------|--|--|
| PLL_SCL | Si5338 U13, pin 12 | I ² C bus of SI5338 quad clock PLL | I ² C interface connected to FPGA |
| PLL_SDA | Si5338 U13, pin 19 | | |
| PCIE_RSTb | PCIe J1, pin A11 | PCIe reset input | refer to current SC CPLD firmware for functionality |
| FEX_DIR / FEX0 ... FEX11 | FPGA bank 14 | user GPIO | refer to current SC CPLD firmware for functionality |
| F1PWM | FAN connector J4, pin 4 | FPGA FAN control | refer to current SC CPLD firmware for functionality |
| F1SENSE | FAN connector J4, pin 3 | | |
| FAN_FMC_EN | Load Switch U25, pin 4 | FMC FAN enable | |
| FMC_PG_C2M | FMC J2, pin D1 | FMC control signals | refer to current SC CPLD firmware for functionality |
| FMC_PG_M2C | FMC J2, pin F1 | | |
| FMC_PRSNT_M2C_L | FMC J2, pin H2 | | |
| FMC_SCL | FMC J2, pin C30 | FMC I ² C | I ² C connected to FPGA |
| FMC_SDA | FMC J2, pin C31 | | |
| FMC_TCK | FMC J2, pin D29 | FMC JTAG | refer to current SC CPLD firmware for functionality |
| FMC_TDI | FMC J2, pin D30 | | |
| FMC_TDO | FMC J2, pin D31 | | |
| FMC_TMS | FMC J2, pin D33 | | |

| SC CPLD U5 Pins and Interfaces | Connected to | Function | Notes |
|---|--------------------------|---|---|
| FMC_TRST | FMC J2, pin D34 | | |
| DONE | FPGA bank 0, pin J7 | FPGA configuration signal | PL configuration completed |
| PROGRAM_B | FPGA bank 0, pin P6 | | PL configuration reset signal |
| LED1 | Green LED D11 | LED status signal | refer to current SC CPLD firmware for functionality |
| FPGA_IIC_OE | FPGA bank 14, pin F25 | SC CPLD works as I ² C switch with the FPGA as I ² C-Master and on-board peripherals as I ² C-Slaves | I ² C output enable |
| FPGA_IIC_SCL | FPGA bank 14, pin G26 | | I ² C clock line |
| FPGA_IIC_SDA | FPGA bank 14, pin G25 | | I ² C data line |
| EN_1V8 | DC-DC U20, pin 27 | Power control | enable signal DC-DC U20 |
| PG_1V8 | DC-DC U20, pin 28 | | power good signal DC-DC U20 |
| EN_3V3FMC | DC-DC U15, pin 27 | | enable signal DC-DC U15 |
| PG_3V3 | DC-DC U15, pin 28 | | power good signal DC-DC U15 |
| EN_FMC_VADJ | DC-DC U7, pin 52 | | enable signal DC-DC U7 |
| PG_FMC_VADJ | DC-DC U7, pin 46 | | power good DC-DC U7 |
| VID0_FMC_VADJ, VID1_FMC_VADJ, VID2_FMC_VADJ | DC-DC U7, pin 45, 44, 43 | | DCDC U7 power selection pin |

| SC CPLD U5 Pins and Interfaces | Connected to | Function | Notes |
|---|---|---|--|
| VID0_FMC_VADJ_CTL, VID1_FMC_VADJ_CTL, VID2_FMC_VADJ_CTL | DIP switch S1-2, DIP switch S1-3, DIP switch S1-4 | | Power selection of FMC_VADJ, forwarded to DCDC U7 |
| LTM_1V5_RUN | DC-DC U3, pin F5 | | enable signals of DCDC U3, U4 (LTM4676) refer to current SC CPLD firmware for functionality |
| LTM_4V_RUN | DC-DC U3, pin F5 | | |
| LTM_SCL | DC-DC U3 / U4, pin E6 | DCDC U3, U4 (LTM4676) I ² C | I ² C Address U3: 0x40 I ² C Address U4: 0x4F |
| LTM_SDA | DC-DC U3 / U4, pin D6 | | I ² C interface of LTM4676 ICs also accessible through header J10 |
| LTM1_ALERT | DC-DC U4, pin E5 | DCDC U3, U4 (LTM4676) control, active low | refer to current SC CPLD firmware for functionality |
| LTM2_ALERT | DC-DC U3, pin E5 | | |
| LTM_1V_IO0 | DC-DC U4, pin E4 | | |
| LTM_1V_IO1 | DC-DC U4, pin F5 | | |
| LTM_1V5_4V_IO0 | DC-DC U3, pin E4 | | |
| LTM_1V5_4V_IO1 | DC-DC U3, pin F4 | | |

Table 12: System Controller CPLD I/O pins

6.2 DDR3 SDRAM ECC SO-DIMM Socket

The TEF1001 board supports additional DDR3 **ECC** SO-DIMM via 204-pin socket U2. The DDR3 memory interface has a 64bit wide databus and is routed to the FPGA banks 32, 33 and 34.

The reference clock signal for the DDR3 interface is generated by the 200.0000MHz MEMS oscillator U1 and is applied to the FPGA bank 33.

There is also a I²C interface between the System Controller CPLD U5 and the DDR3 ECC SO-DIMM memory socket U2.

| I ² C Interface | Schematic net names | Connected to | I ² C Address | Notes |
|----------------------------|--|--|--------------------------|-------|
| DDR3 SODIMM, U2 | 'DDR3_SDA', pin 200 'DDR3_SCL', pin 202 | SC CPLD U5, pin 42 SC CPLD U5, pin 43 | module dependent | - |

Table 13: DDR3 SODIMM socket I²C interface

i It is important to use SO-DIMMs which provide ECC functionality. SO-DIMMs without ECC are not compatible with this board.

6.3 Quad SPI Flash Memory

A 256 Mbit (32 MByte) Quad SPI Flash Memory (Micron N25Q256A, U12) is provided for FPGA configuration file storage. After configuration process completes the remaining free memory can be used for application data storage. All four SPI data lines are connected to the FPGA allowing x1, x2 or x4 data bus widths to be used. The maximum data transfer rate depends on the bus width and clock frequency. The memory can be accessed indirectly by the FPGA JTAG port (J9) by implementing the functional logic for this purpose inside the FPGA.

Quad SPI Flash memory interface is connected to the FPGA bank 14, QSPI clock is provided by FPGA config bank 0.

| Signal Name | QSPI Flash Memory U12 Pin | FPGA Pin |
|----------------|---------------------------|------------------|
| FLASH_QSPI_CS | S, Pin 7 | Bank 14, Pin C23 |
| FLASH_QSPI_D00 | DQ0, Pin 15 | Bank 14, Pin B24 |
| FLASH_QSPI_D01 | DQ1, Pin 8 | Bank 14, Pin A25 |
| FLASH_QSPI_D02 | DQ2, Pin 9 | Bank 14, Pin B22 |
| FLASH_QSPI_D03 | DQ3, Pin 1 | Bank 14, Pin A22 |
| FPGA_CFG_CCLK | C, Pin 16 | Bank 0, Pin C8 |

Table 14: Quad SPI interface signals and connections

⚠ SPI Flash QE (Quad Enable) bit must be set to high or FPGA is unable to load its configuration from flash during power-on. By default this bit is set to high at the manufacturing plant.

6.4 Programmable Clock Generator

There is a Silicon Labs I²C programmable quad PLL clock generator on-board (Si5338A, U13) to generate various reference clocks for the module.

| Si5338A Pin | Signal Name / Description | Connected to | Direction | Note |
|-------------|---------------------------|-------------------|----------------|---|
| IN1 | - | not connected | Input | not used |
| IN2 | - | GND | Input | not used |
| IN3 | Reference input clock | U3, pin 3 | Input | 25.000000 MHz oscillator U14, Si8208AI |
| IN4 | - | GND | Input | I ² C slave device address LSB |
| IN5 | - | not connected | Input | not used |
| IN6 | - | GND | Input | not used |
| SCL | PLL_SCL | SC CPLD U5, pin 8 | Input / Output | I ² C interface muxed to FPGA |
| SDA | PLL_SDA | SC CPLD U5, pin 2 | Input / Output | Slave address: 0x70. |
| CLK0A | CLK0_P | U6, G24 | Output | Clock to PL bank 14 |
| CLK0B | CLK0_N | U6, F24 | | |
| CLK1A | MGTCLK_5338_P | U6, H6 | Output | Clock to MGT bank 115, AC decoupled |
| CLK1B | MGTCLK_5338_N | U6, H5 | | |
| CLK2A | CLK1_P | U6, G22 | Output | Clock to PL bank 14 |
| CLK2B | CLK1_N | U6, F23 | | |

| Si5338A Pin | Signal Name / Description | Connected to | Direction | Note |
|-------------|---------------------------|--------------|-----------|---------------------|
| CLK3A | CLK2_P | U6, D23 | Output | Clock to PL bank 14 |
| CLK3B | CLK2_N | U6, D24 | | |

Table 15: Programmable quad PLL clock generator inputs and outputs

6.5 Oscillators

The FPGA module has following reference clocking sources provided by on-board oscillators and FMC connector J2:

| Clock Source | Frequency | Signal Schematic Name | Clock Destination | Notes |
|------------------|---------------|---------------------------|------------------------------|---------------------------------|
| U14, SiT8208AI | 25.000000 MHz | CLK | Si5338A PLL U13, pin 3 (IN3) | - |
| U1, DSC1123DL5 | 200.0000 MHz | DDR3_CLK_P | FPGA bank 33, pin AB11 | Enable by SC CPLD U5, pin 30 |
| | | DDR3_CLK_N | FPGA bank 33, pin AC11 | Signal: '200MHzCLK_EN' |
| FMC Connector J2 | - | GBTCLK0_M2C_P, Pin J2-D4 | FPGA bank 116, pin D6 | reference clock to MGT bank 116 |
| | | GBTCLK0_M2C_N, Pin J2-D5 | FPGA bank 116, pin D5 | |
| | - | GBTCLK1_M2C_P, Pin J2-B20 | FPGA bank 116, pin F6 | reference clock to MGT bank 116 |
| | | GBTCLK1_M2C_N, Pin J2-B21 | FPGA bank 116, pin F5 | |
| | - | CLK0_M2C_P, Pin J2-H4 | FPGA bank 15, pin H17 | reference clock to PL bank 15 |
| | | CLK0_M2C_N, Pin J2-H5 | FPGA bank 15, pin H18 | |
| - | - | CLK1_M2C_P, Pin J2-G2 | FPGA bank 15, pin G17 | reference clock to PL bank 15 |

| Clock Source | Frequency | Signal Schematic Name | Clock Destination | Notes |
|--------------|-----------|-------------------------|-----------------------|--|
| | | CLK1_M2C_N, Pin J2-G3 | FPGA bank 15, pin G18 | |
| | - | CLK2_BIDIR_P, Pin J2-K4 | FPGA bank 13, pin P23 | reference clock to PL bank 13 bidirectional clock line |
| | | CLK2_BIDIR_N, Pin J2-K5 | FPGA bank 13, pin N23 | |
| | - | CLK3_BIDIR_P, Pin J2-J2 | FPGA bank 13, pin R22 | reference clock to PL bank 13 bidirectional clock line |
| | | CLK3_BIDIR_N, Pin J2-J3 | FPGA bank 13, pin R23 | |

Table 16: Reference clock signals

6.6 On-board LEDs

| LED | Color | Signal Schematic name | Connected to | Description and Notes |
|-----|-------|-----------------------|-----------------------|---|
| D1 | Green | FPGA_LED1_VT | FPGA bank 13, pin K25 | LEDs D1 to D10 are available to user. LED voltages are translated from FPGA bank 13 and 14 VCCO voltage FMC_VADJ to 3V3. |
| D2 | Green | FPGA_LED2_VT | FPGA bank 13, pin K26 | |
| D3 | Green | FPGA_LED3_VT | FPGA bank 13, pin P26 | |
| D4 | Green | FPGA_LED4_VT | FPGA bank 13, pin R26 | |
| D5 | Green | FPGA_LED5_VT | FPGA bank 13, pin N16 | |
| D6 | Green | FPGA_LED6_VT | FPGA bank 14, pin J26 | |
| D7 | Green | FPGA_LED7_VT | FPGA bank 14, pin H26 | |

| LED | Color | Signal Schematic name | Connected to | Description and Notes |
|-----|-------|-----------------------|--|--|
| D8 | Green | FPGA_LED8_VT | FPGA bank 14, pin E26 | |
| D9 | Green | FPGA_LED9_VT | FPGA bank 14, pin A24 | |
| D10 | Green | FPGA_LED10_VT | FPGA bank 15, pin F19 | |
| D11 | Green | LED1 | System Controller CPLD, bank 0, pin 76 | refer to current CPLD firmware for LED functionality |

Table 17: On-board LEDs description

6.7 Configuration DIP-switch

There is one 4-bit DIP-switches S1 present on the TEB0911 board to configure options and set parameters. The following section describes the functionalities of the particular switches.

Table below describes the functionalities of the switches of DIP-switches S3 and S4 at their each positions:

| DIP-switch S3 | Signal Schematic Name | Connected to | Functionality | Notes |
|---------------|-----------------------|----------------------------|---|---|
| S1-1 | JTAG_EN | SC CPLD U5, bank 1, pin 82 | enables JTAG interface of SC CPLD U5 in ON-position | SC CPLD programmable through JTAG header J8 |

| DIP-switch S3 | Signal Schematic Name | Connected to | Functionality | Notes |
|---------------|------------------------|-------------------------------|--|---|
| S1-2 | VID0_FMC_VA DJ_CTRL | SC CPLD U5, bank 1, pin 71 | set 3bit code to adjust FMC_VADJ voltage | <p>The FMC_VADJ voltage is provided by DCDC U7 EN5365QI,</p> <p>the voltage can be adjusted from 0.8V to 3.3V in 7 steps:</p> <p>Set DIP-switches as bit pattern "S1-4 S1-3 S1-2: FMC_VADJ":</p> <p>0 0 0: 3.3V 0 0 1: 2.5V 0 1 0: 1.8V 0 1 1: 1.5V 1 0 0: 1.25V 1 0 1: 1.2V 1 1 0: 0.8V 1 1 1: Reserved</p> |
| S1-3 | VID1_FMC_VA DJ_CTRL | SC CPLD U5, bank 1, pin 63 | | |
| S1-4 | VID2_FMC_VA DJ_CTRL | SC CPLD U5, bank 1, pin 62 | | |

Table 18: DIP-switch S1 functionality description

6.8 Push Buttons

There is one push buttons available to the user connected to the SC CPLD U5:

| Button | Connected to | Function | Notes |
|--------|--------------------|--------------------|--|
| S2 | SC CPLD U5, pin 77 | Global board Reset | Refer to documentation of current SC CPLD firmware for more details. |

Table 19: On-board Push Button

7 Power and Power-On Sequence

7.1 Power Consumption

The maximum power consumption of a module mainly depends on the design running on the FPGA.


Xilinx provide a power estimator excel sheets to calculate power consumption. It's also possible to evaluate the power consumption of the developed design with Vivado. See also Trenz Electronic Wiki [FAQ](#)³.

| Power Input | Typical Current |
|-------------|-----------------|
| 12V VIN | TBD* |

Table 20: Typical power consumption

* TBD - To Be Determined soon with reference design setup.

It is recommended to connect the ATX connector J5 to a 12V power supply source with minimum current capability of 6A to provide a sufficient power source to the board. Only one power source is needed at the same time, the system disconnects automatically PCIe power supply from PCIe edge connector J1 if the board is powered by the ATX connector J5.

 To avoid any damage to the module, check for stabilized on-board voltages should be carried out (i.e. power good and enable signals) before powering up any FPGA's I/O bank voltages VCCO_x. All I/Os should be tri-stated during power-on sequence.

7.2 Power Distribution Dependencies

³ <https://wiki.trenz-electronic.de/display/PD/FAQ>

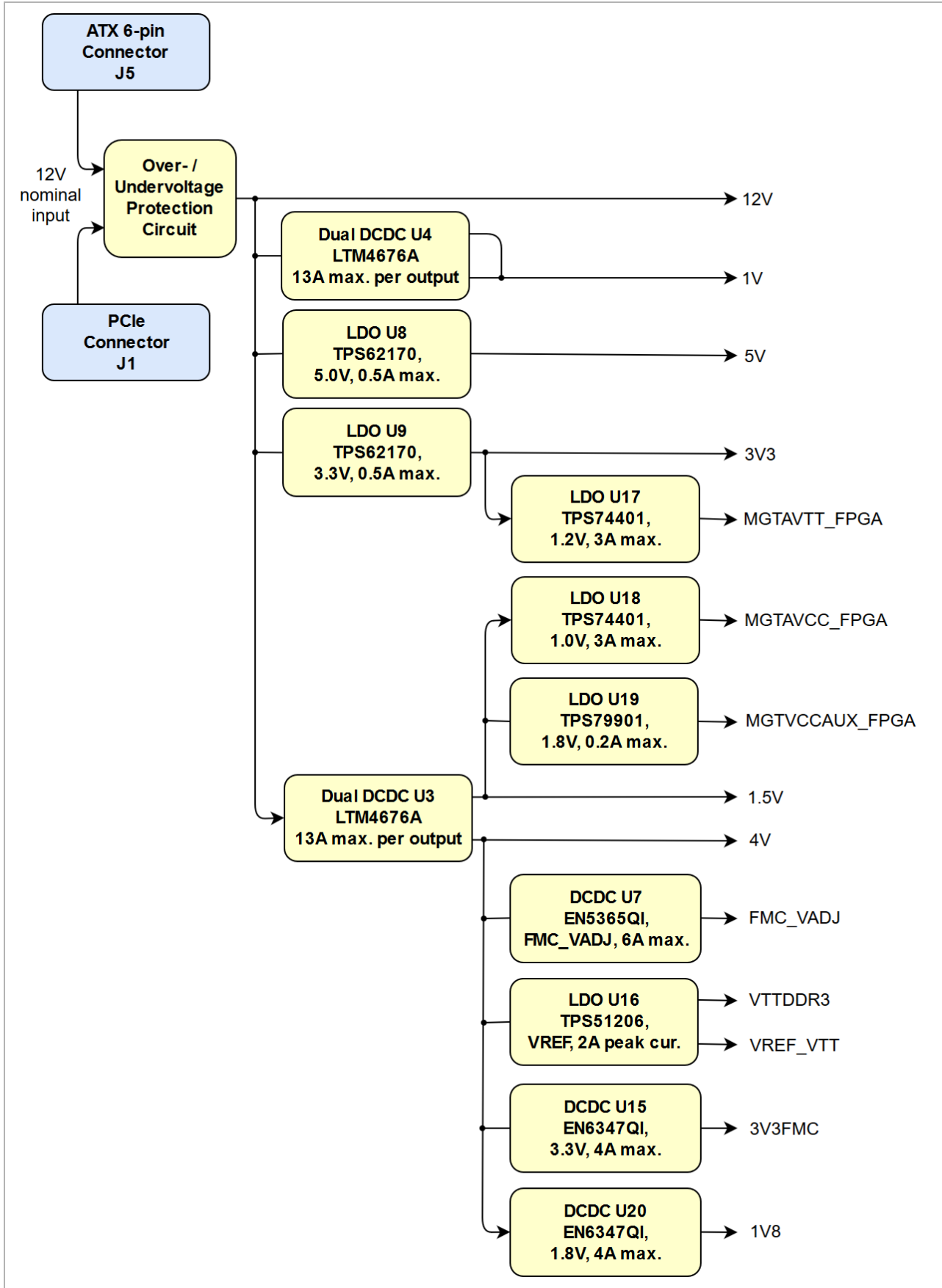


Figure 3: Power Distribution

7.3 Power-On Sequence

The TEF1001 board meets the recommended criteria to power up the Xilinx FPGA properly by keeping a specific sequence of enabling the on-board DC-DC converters dedicated to the particular functional units of the FPGA chip and powering up the on-board voltages.

Some of the voltages are handled by the System Controller CPLD using "Power good"-signals from the voltage regulators:

Following diagram clarifies the sequence of enabling the particular on-board voltages, which will power-up in descending order as listed in the blocks of the diagram:

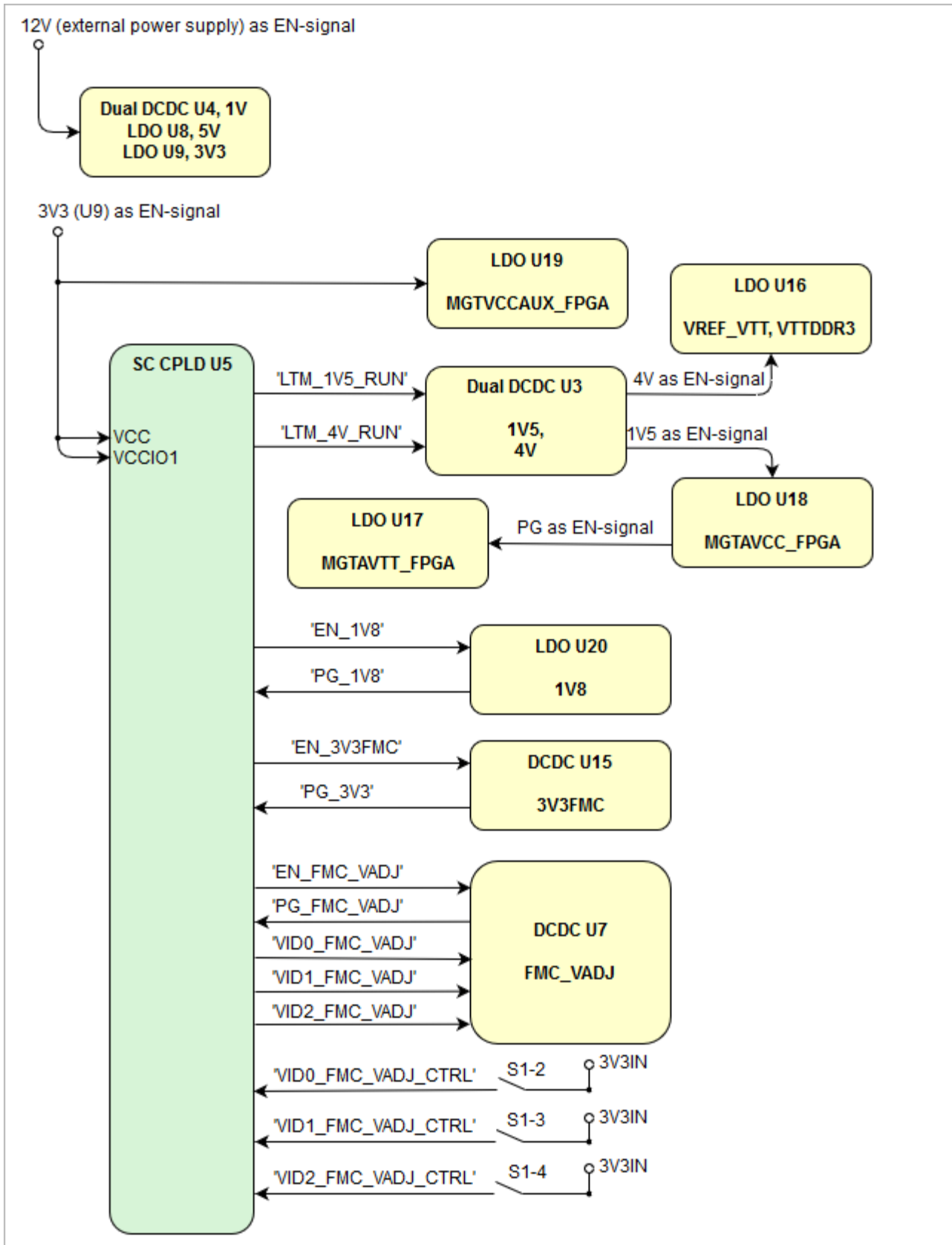


Figure 4: Power Sequence

7.4 Bank Voltages

| Bank | Schematic Name | Voltage | Range | Notes |
|------|----------------|---------|---------------------------------------|--|
| 0 | 1V8 | 1.8V | - | Config bank 0 fixed to 1.8V |
| 12 | FMC_VADJ | user | HR: 1.2V to 3.3V | FMC_VADJ voltage adjustable by DIP switch S1 |
| 13 | FMC_VADJ | user | HR: 1.2V to 3.3V | FMC_VADJ voltage adjustable by DIP switch S1 |
| 14 | 1V8 | 1.8V | HR: 1.2V to 3.3V | PL bank 14 fixed to 1.8V |
| 15 | FMC_VADJ | user | HR: 1.2V to 3.3V | FMC_VADJ voltage adjustable by DIP switch S1 |
| 16 | VIO_B_FMC | user | HR: 1.2V to 3.3V | PL bank 16 fixed to 1.8V |
| 32 | 1V5 | 1.5V | HP: 1.2V to 1.8V | DDR3 memory interface |
| 33 | 1V5 | 1.5V | HP: 1.2V to 1.8V | DDR3 memory interface |
| 34 | 1V5 | 1.5V | HP: 1.2V to 1.8V | DDR3 memory interface |
| 115 | MGTAVCC_FPGA | 1.0V | MGT bank supply voltage | MGT banks with Xilinx GTX transceiver units |
| 116 | MGTVCCAUX_FPGA | 1.8V | MGT bank auxiliary supply voltage | |
| | MGTAVTT_FPGA | 1.2V | MGT bank termination circuits voltage | |

Table 21: Board I/O bank voltages

7.5 Power Rails

| Connector / Pin | Voltage | Direction | Notes |
|-----------------|---------|-----------|---|
| J4, pin 2 | 12V | Output | 4-wire PWM fan connector supply voltage |

| Connector / Pin | Voltage | Direction | Notes |
|--------------------------------|-----------------|-----------|---|
| J6, pin 2 | 5V | Output | Cooling fan M1 supply voltage |
| J8, pin 6 | 3V3 | Output | VCCIO CPLD JTAG |
| J9, pin 2 | 1V8 | Output | VCCIO FPGA JTAG |
| J2, pin C35 / C37 | 12V | Output | FMC supply voltage |
| J2, pin D32 | 3V3 | Output | VCCIO FMC |
| J2, pin D36 / D38 / D39 / D40 | 3V3FMC | Output | VCCIO FMC |
| J2, pin H1 | VREF_A_M 2C | Input | VREF voltage for bank 13 / 15 |
| J2, pin K1 | VREF_B_M 2C | Input | VREF voltage for bank 16 |
| J2, pin J39 / J40 | VIO_B_FM C | Input | PL I/O voltage bank 16 (VCCO) |
| J2, pin H40 / G39 / F40 / E39 | FMC_VADJ | Output | PL I/O voltage bank 12 / 13 / 15 (VCCO) |
| J1, pin B1 / B2 / B3 / A2 / A3 | 12V_input _B | Input | 12V main power supply from PCIe connector |
| J5, pin 1 / 2 / 3 | 12V_input _A | Input | Main power supply connector |

Table 22: Board power rails

8 Technical Specifications

8.1 Absolute Maximum Ratings

| Parameter | Min | Max | Units | Reference Document |
|---|------------|--------------------|-------|---|
| VIN supply voltage | -0.3 | 20 | V | TPS6217 datasheet Note: voltage limitations are not valid for connected FMC module and/or FPGA FAN |
| Supply voltage for HR I/O banks (VCCO) | -0.5 00 | 3.600 | V | Xilinx datasheet DS182 |
| Supply voltage for HP I/O banks (VCCO) | -0.5 00 | 2.000 | V | Xilinx datasheet DS182 |
| I/O input voltage for HR I/O banks | -0.5 00 | VCCO + 0.500 | V | Xilinx datasheet DS182 |
| I/O input voltage for HP I/O banks | -0.5 00 | VCCO + 0.500 | V | Xilinx datasheet DS182 |
| Reference Voltage pin (VREF) | -0.5 00 | 2 | V | Xilinx datasheet DS182 |
| Differential input voltage | -0.5 | 2.625 | V | Xilinx datasheet DS182 |
| I/O input voltage for SC CPLD U5 | -0.5 | 3.75 | V | Lattice MachXO2 Family datasheet |
| GTX transceiver reference clocks absolute input voltage | -0.5 00 | 1.320 | V | Xilinx datasheet DS182 |

| Parameter | Min | Max | Units | Reference Document |
|---|--------|-------|-------|------------------------|
| GTX transceiver receiver (RXP/RXN) and transmitter (TXP/TXN) absolute input voltage | -0.500 | 1.260 | V | Xilinx datasheet DS182 |
| Voltages on LTM4676 I ² C pins (LTM_SCL, LTM_SDA), header J10 | -0.3 | 5.5 | V | LTM4676A datasheet |
| Storage temperature | -40 | +100 | °C | SML-P11 LED datasheet |

Table 23: Module absolute maximum ratings

 Assembly variants for higher storage temperature range are available on request.

8.2 Recommended Operating Conditions


| Parameter | Min | Max | Units | Reference Document |
|--|--------|-------------|-------|---|
| VIN supply voltage | 11.4 | 12.6 | V | 12V nominal, ANSI/VITA 57.1 power specification for FMC connector |
| Supply voltage for HR I/O banks (VCCO) | 1.140 | 3.465 | V | Xilinx datasheet DS182 |
| Supply voltage for HP I/O banks (VCCO) | 1.140 | 1.890 | V | Xilinx datasheet DS182 |
| I/O input voltage for HR I/O banks | -0.500 | VCCO + 0.20 | V | Xilinx datasheet DS182 |
| I/O input voltage for HP I/O banks | -0.500 | VCCO + 0.20 | V | Xilinx datasheet DS182 |
| Differential input voltage | -0.2 | 2.625 | V | Xilinx datasheet DS182 |

| Parameter | Min | Max | Units | Reference Document |
|--|------|------|-------|--|
| I/O input voltage for SC CPLD U5 | -0.3 | 3.6 | V | Lattice MachXO2 Family datasheet |
| Voltages on LTM4676 I ² C pins (LTM_SCL, LTM_SDA), header J10 | 0 | 3.3V | V | LTM4676A datasheet |
| Board Operating Temperature Range ^{1), 2)} | -40 | 85 | °C | board operating temperature range limited by FPGA SoC and on-board peripherals |

Table 24: Recommended Operating Conditions

- 1) Temperature range may vary depending on assembly options
- 2) The operating temperature range of the FPGA soC and on-board peripherals are junction and also ambient operating temperature ranges

Board operating temperature range depends also on customer design and cooling solution. Please contact us for options.

 Please check also Xilinx datasheet [DS182⁴](#) for complete list of absolute maximum and recommended operating ratings.

8.3 Physical Dimensions

⁴ https://www.xilinx.com/support/documentation/data_sheets/ds182_Kintex_7_Data_Sheet.pdf

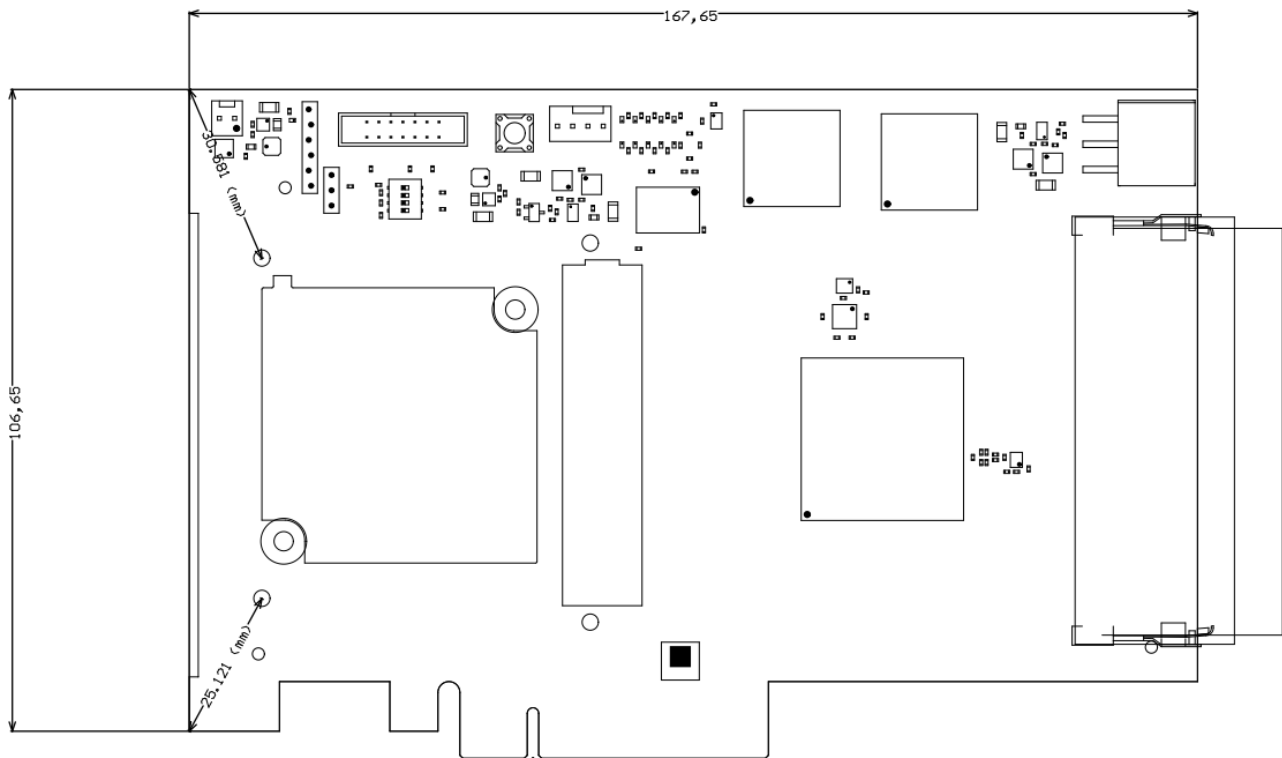


Figure 5: Physical dimensions drawing

9 Variants Currently In Production

| Trenz shop TEF1001 overview page | |
|--|---|
| English page⁵ | German page⁶ |

Table 25: Trenz Electronic Shop Overview

⁵ <https://shop.trenz-electronic.de/en/Products/Trenz-Electronic/TEF1001-Kintex-7/>

⁶ <https://shop.trenz-electronic.de/de/Produkte/Trenz-Electronic/TEF1001-Kintex-7/>

10 Revision History

10.1 Hardware Revision History

| Date | Revision | Notes | PCN | Documentation Link |
|------|----------|----------------------------------|---|-------------------------|
| - | 02 | current available board revision | - | - |
| - | 01 | First production release | PCN-20180524 TEF1001-01 ⁷ | TEF1001-01 ⁸ |

Table 26: Hardware Revision History

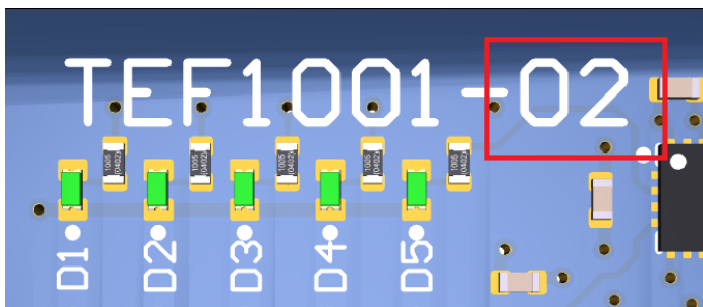


Figure 6: Hardware Revision Number

Hardware revision number can be found on the PCB board together with the module model number separated by the dash.

10.2 Document Change History

| Date | Revision | Authors | Description |
|------------|--|-------------------------------|--------------------|
| 2018-12-11 | v.42(see page 6) <small>Unknown macro: 'metadata'</small> | Pedram Babakhani ⁹ | • update picture |
| 2018-10-24 | v.41 | Guillermo Herrera | • Initial document |

Table 27: Document change history

⁷ <https://wiki.trenz-electronic.de/pages/viewpage.action?pageId=54397005>

⁸ https://shop.trenz-electronic.de/Download/?path=Trenz_Electronic/PCle_Cards/TEF1001/REV01

⁹ <https://wiki.trenz-electronic.de/display/~P.Babakhani>

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 2019-06-07

¹⁰ <http://guidance.echa.europa.eu/>

¹¹ <https://echa.europa.eu/candidate-list-table>

¹² <http://www.echa.europa.eu/>