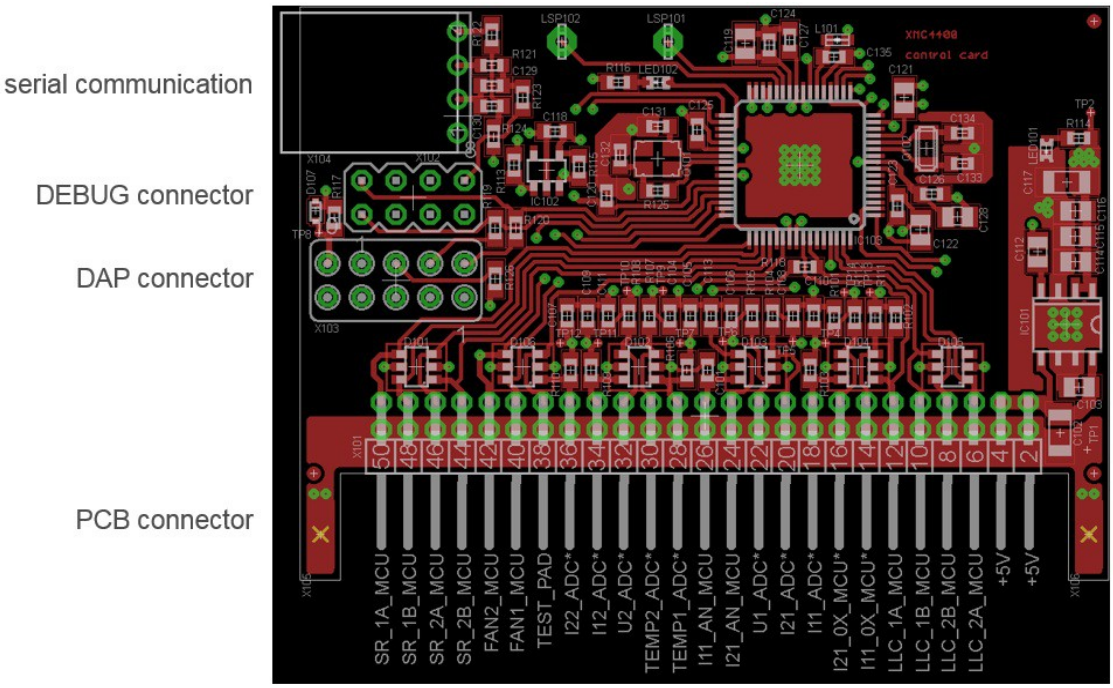
LLC3kW GUI Manual

Graphical User Interphase for LLC3kw inverter was designed for UART communication between PC and LLC power inverter. The communication protocol is defined in "LLCk3W_ComProtocol.h" file.

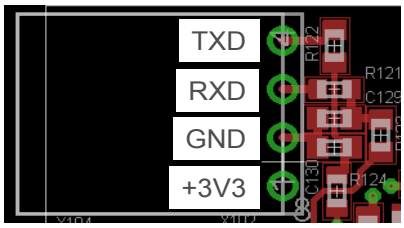
1 Control board



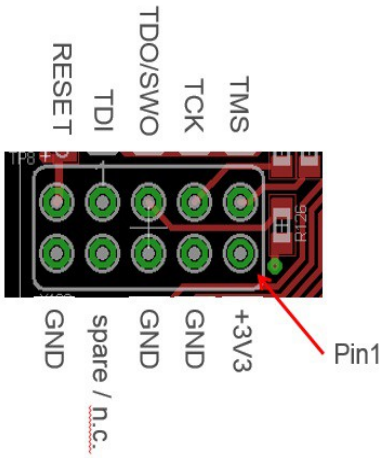
2 Connections

2.1 Serial communication connector

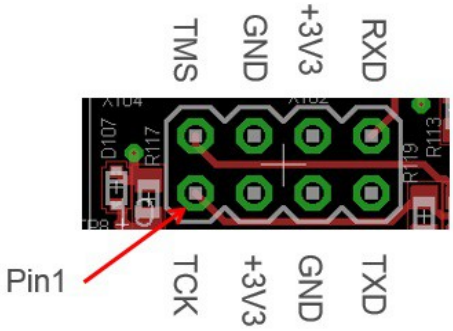
Graphical User Interphase software controls the MCU by serial bus (UART) with TTL logic (3.3V). The connector part number is Wurth 619 004 110 21.



2.2 Debug connection



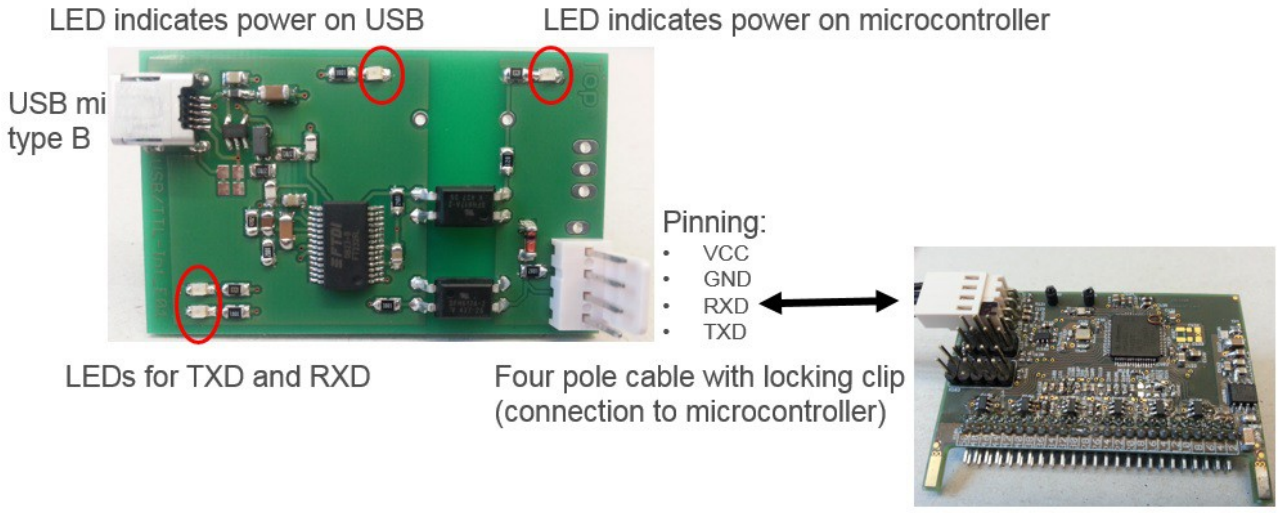
DAP connector



Debug connector

2.3 Serial communication interphase

The communication between MCU and controller can be established via RS232/TTL or USB/TTL interphase. TTL voltage levels must not exceed 3.3V. The communication ground is referenced to LLC output ground. It is strongly recommended to use an interphase with sufficient galvanic insulation.



Interphase PCB

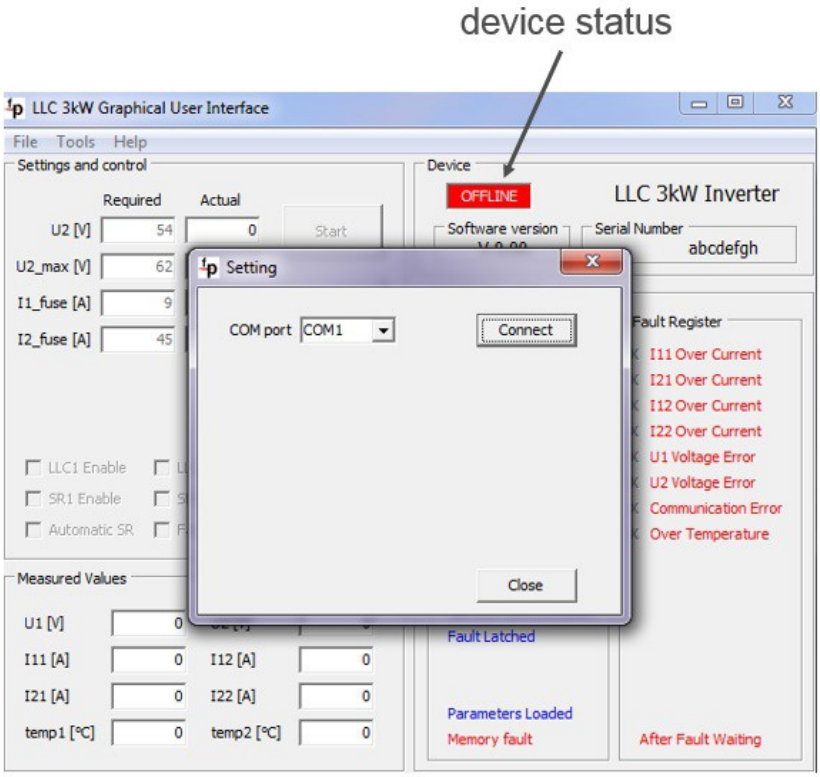
- the interphase PCB includes FTDI USB to UART converter module
- the PC driver has to be installed before first plug-in
- the drive is downloadable online (http://www.ftdichip.com/Drivers/VCP.htm)
- the virtual comport number should be between 1 and 9

3 Graphical User Interphase

There are two versions of GUI. First is for developers and engineers, where they can change most of setting and run the inverter in debug mode. This version is called “EXP” and it's described bellow. Second version “BASIC” is designed for regular user to test the device safely. Here, some of described settings are not available to change.

3.1 Connection to MUC

- start GIU
- File → Setting
- Select Comport
- Press connect and Close
- Device Status should change from OFFLINE to ONLINE and inverter will be connected

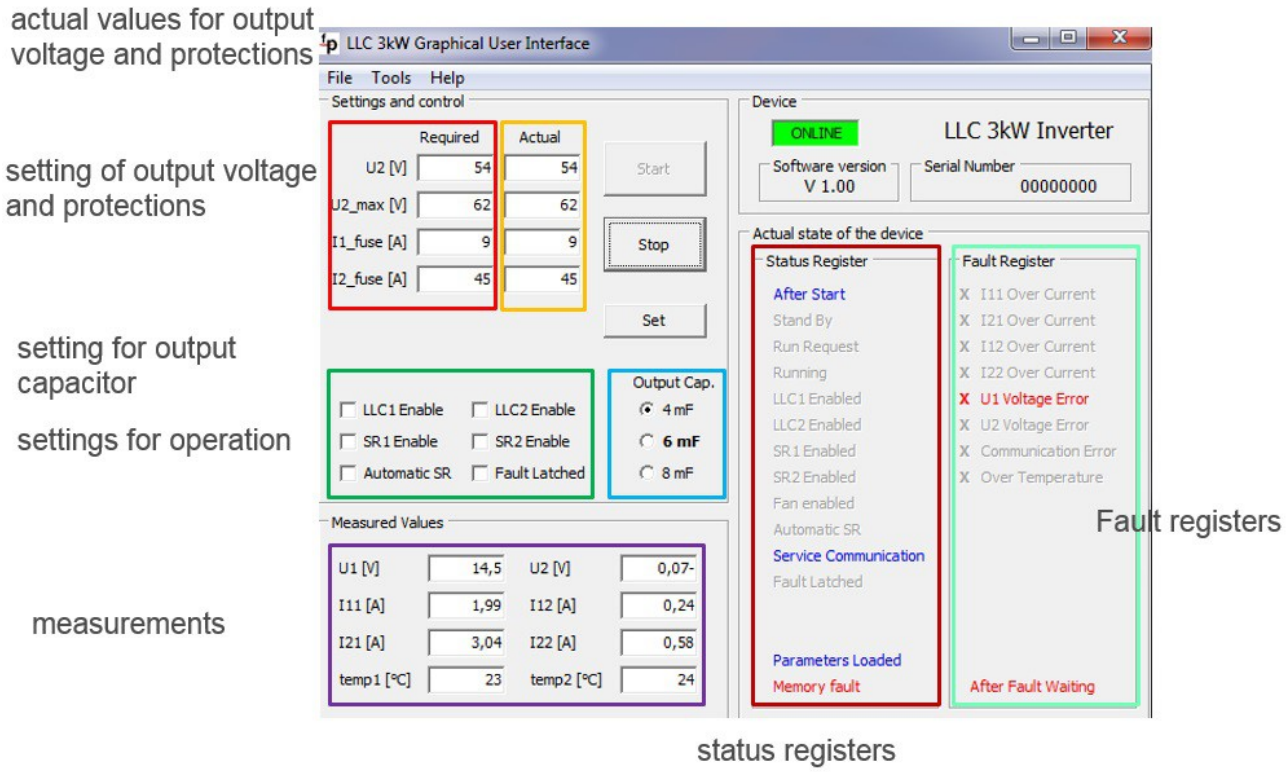


3.2 Start procedure

Standard start procedure after GUI connection is more or less intuitive. Operator has to set required output voltage, input and output limits (or keep default values), enable LLC stages and rectifiers and press “Set” button. Inverter is ready to start after this setting (“Stand By” flag is set). Now it could be controlled by buttons “Start” and “Stop”.

Special option is **automatic start**. This is a function which turns the inverter automatically on if there is no service communication in first 5s after MCU start and if configuration saved in flash memory contains flag “LLC1 Enable”. Parameters saved in flash memory are described below. The inverter can sill start only from “Stand By” state.

3.3 Functional overview



Setting:
U2 – required voltage
U2_max – output over-voltage protection value
I1_fuse – input (tank) over-current protection value
I2_fuse – output over-current protection value

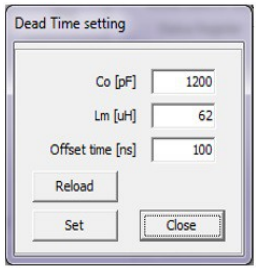
Check-boxes:
LLC2, LLC2 phases enabler – LLC2 is not allowed to work separately
SR1, SR2 enabler – LLC converters can run without synchronous rectifier, but rectifiers cannot be enabled without corresponding LLC stage
Automatic SR – synchronous rectifiers are turned on and off automatically if they are enabled
Fault Latched – faults can be latched (until MCU reset) or they are cleared after some time
Buttons:
Start/Stop – inverter run/stop commands
Set – command to transfer all values and setting into MCU

Measurement:
U1 – input voltage
U2 – output voltage
I11 – rectified input (tank) current phase 1
I21 – rectified input (tank) current phase 2
I12 – output current phase 1
I22 – output current phase 2

temp1 – temperature phase 1
temp2 – temperature phase 2
Status and fault registers are displayed for observation and changes check of status and setting. These registers are described in Appendix A and B or in communication protocol definition file.

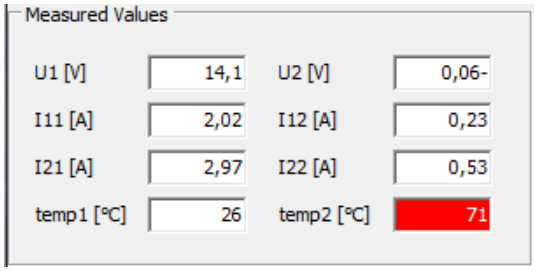
3.4 Automatic dead-time setting

- Tools → Dead-time setting
- enter $C_{O(tr)}$ of used primary side MOSFET
- enter L_m of main transformer
- enter constant dead-time offset, if needed
- pressing "Set" will transfer the values to MCU
- "Reload" will load the actual set values from MCU

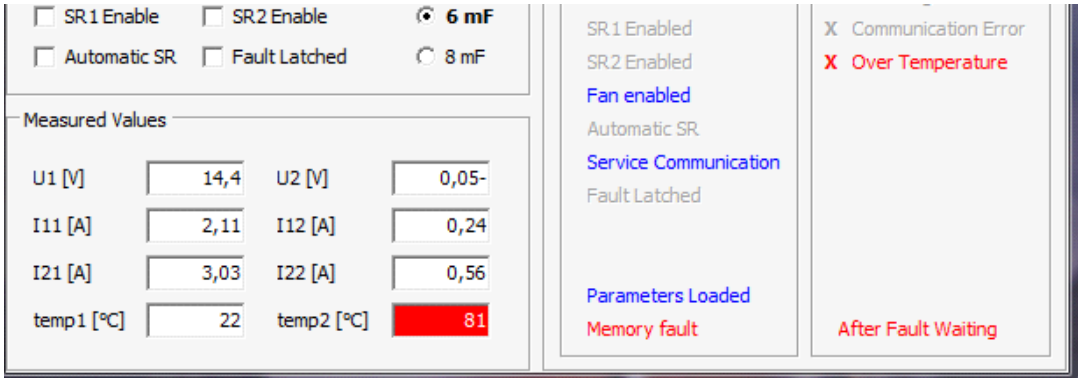


3.5 Temperature Alarm Signals

GUI displays measured temperatures with white background when corresponding temperature is below 70°C or red when it exceeds 70°C. This temperature alarm doesn't effect LLC converter operation.



In case of system over-temperature (exceeding 80°C) MCU stops all power conversion and turns to fault state. This protection function is independent to GUI.

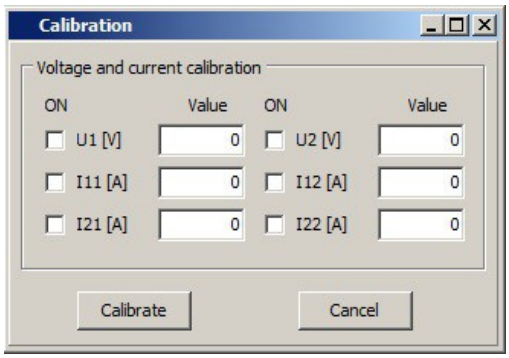


3.6 Automatic Loop Compensation

Output voltage PI-controller is optimized for specific output capacitance of the inverter. The setting could be changed according to used capacitors (sum of phase one and two). The bold values shows the current capacitance setting in the MCU. New setting is executed by button “Set”.

3.7 Calibration

- Tools → Calibration
- software provides offset calibration for currents and voltages
- operator only writes the actual correct value into the box, checks corresponding check-box and press “Calibrate” button



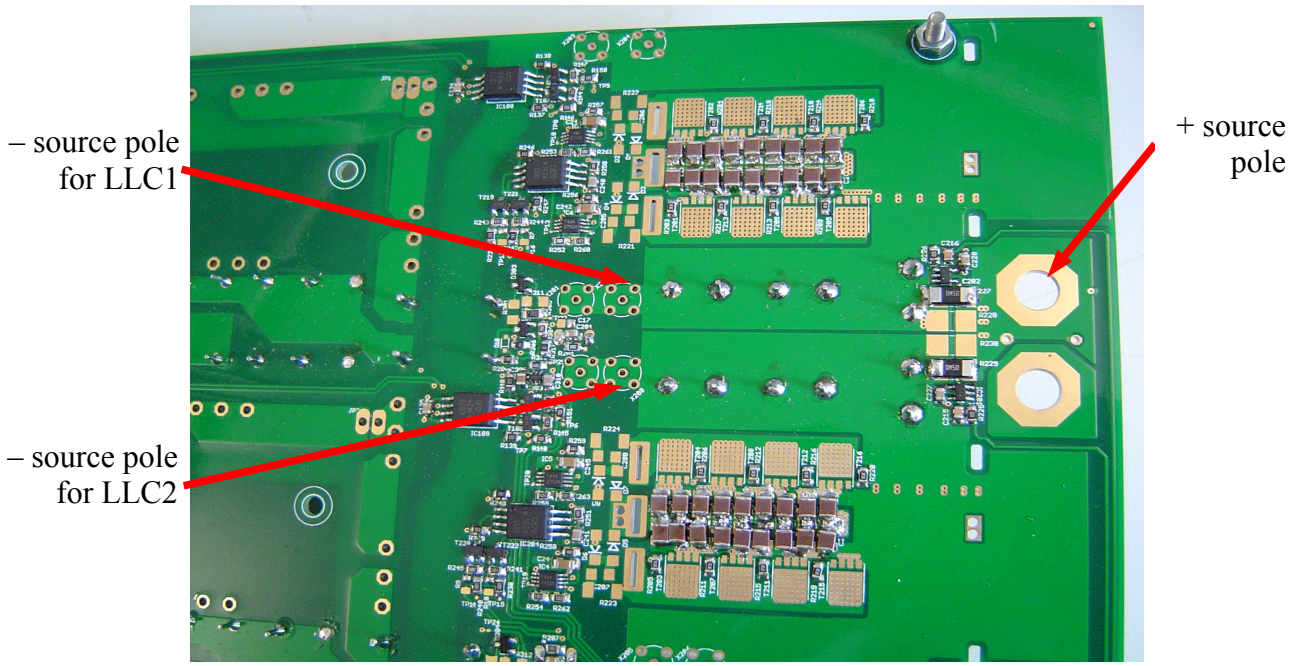
3.7.1 Voltage calibration

Voltage calibration procedure consist of connecting power supply to input or output connectors, measure the voltage by external multimeter and using this measured value for software calibration.

Voltage measurement should be calibrated to value in the middle of working range (around 380V for input voltage, 54V for output voltage). Output voltage measurement is normally accurate enough and it doesn't need a calibration.

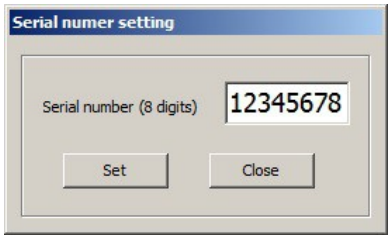
3.7.2 Current calibration

For correct operation of the inverter the output current sensors should be calibrated. Calibration procedure in this case requires injected current from external source. Plus pole of current source should be connected to output ground connector X210 and minus pole to the Net “GND_SR#1” for LLC1 stage and Net “GND_SR#2” for LLC2 stage. The GND_SR#1 is for example represented by ground of probe tip X201 and X202, GND_SR#2 ground of probe tip X207 and X208. Current around 25A should be used for calibration of each LLC stage. Correct value is measured by external probe and used for calibration similarly as in voltage calibration.



3.8 Serial Number

- Tools → Serial number
- each inverter can be signed by 8-digits serial number



3.9 Parameter Memory

Internal flash memory is used for saving important and functional values. The sting of parameters is loaded after each MCU start, but its saving is manual (Tools → Save parameters). Moreover the actual parameters could be initialized to default values by Tools → Clear parameters. The memory string is check-sum protected. If there are none or corrupted data in memory, "Memory fault" flag is set. In that case automatic start is not allowed.

String of parameters:
Serial number
Offset calibration values for voltages and currents (U1, U2, I11, I12, I21 and I22)
Required output voltage
Maximal output voltage
Primary over-current value
Secondary over-current value – fast level; the other levels are calculated automatically
Values for automatic dead-time ($C_{O(tr)}$, L_m and constant offset)
Output capacitance mode (4mF, 6mF or 8mF)
Status setting bits (LLC1, LLC2, SR1 and SR2 Enable, Automatic SR and Fault Latched)

Appendix A: Status register description

After Start – 1s time delay after start the MCU is finished
Stand By – the inverter is ready to start
Run Request – request of start was correctly received in stand by state; inverter will start
Running – inverter is on
LLC1 Enabled – first LLC stage is enabled
LLC2 Enabled – second LLC stage is enabled
SR1 Enabled – synchronous rectifier on first LLC stage is enabled
SR2 Enabled – synchronous rectifier on second LLC stage is enabled
Fan On – the fan is on; device is automatically cooling
Automatic SR – automatic synchronous rectifier control is enabled
Service Communication – UART communication is connected and active
Fault Latched – faults will be latched; MCU needs restart to clear them
Parameters Loaded – parameters were loaded from memory or filled by default values
Memory Fault – flash memory contains corrupted data; parameters were initialized by default

Appendix B: Fault register description

I11Over Current – first stage primary over-current
I21Over Current – second stage primary over-current
I12Over Current – first stage secondary over-current
I22Over Current – second stage secondary over-current
U1 Voltage Error – input voltage is out of range
U2 Voltage Error – output voltage is out of range
Communication Error – service communication problem
Over Temperature – temperature on one of sensors is out of range
Capacitive Error – capacitive mode detected on one of stages
Over Power – output power is out of range
Open Loop Error – no load is connected on the output
After Fault Waiting – inverter waits 2s after all other faults are cleared