UM11657

Ringo TEA2017 development software with GUI

Rev. 1 — 1 April 2022 User manual

Document information

Information	Content
Keywords	TEA2017, LLC, PFC, controller, I^2C, USB, parameters, programming, MTP, GUI, Ringo, software, interface
Abstract	The Ringo TEA2017 development software with GUI is a development tool that enables working with the TEA2017 settings using a computer and the RDK01DB1563 USB I^2C interface kit. The software and interface are intended for engineering work in a lab environment as part of power supply development.

Revision history

Rev	Date	Description
v.1	20220401	Initial version

1 Introduction

This user manual describes how the TEA2017 development software Ringo GUI is set up and what functions it provides.

The impact of parameter settings, as part of designing a power supply with the TEA2017, is discussed in the TEA2017 data sheet (Ref. 1) and the application note (Ref. 4). The info buttons in the GUI also provide information on the effect of the parameter in a pop-up window.

Note: *Some screenshots of the Ringo GUI may deviate from the version that you are currently using. The reason is that the tool is updated regularly during its development. This document is based on the Ringo v1.10 (June 2021).*

1.1 Using the Ringo GUI for the first time

Before the Ringo GUI can be used, the FTDI drivers for the RDK01DB1563 USB-I^2C interface must be installed. When the Ringo GUI is run for the first time, the RDK01DB1563 USB-I^2C interface must be connected to a USB port of the computer.

When the Ringo GUI does not start anymore after a Windows update, the I^2C interface must also be connected.

1.2 Software license agreement

When the Ringo software is started up, the license agreement, which appears on the screen as a pop-up window, must be accepted.

1.3 Appearance

Because the Ringo GUI uses functions of the operating system, some (personal) settings in the operating system can influence colors and character appearances. The screenshots in this document may be different from the screens on the computer of the user.

1.4 Fixed window pixel size GUI window

To avoid issues on showing all functions in an orderly manner, the Ringo GUI uses a fixed pixel size window.

When the GUI is shown on a display (automatically) set on a low resolution, the GUI window may not fit completely on the display. In this case, to show the complete window, do one of two things:

- Set the display to a higher resolution
- Select a resolution on the computer that the display can handle

The pop-up windows are not fixed and scalable.

2 Setup and functions of Ringo

2.1 Chapters and tabs

The parameters and settings are organized in related sections.

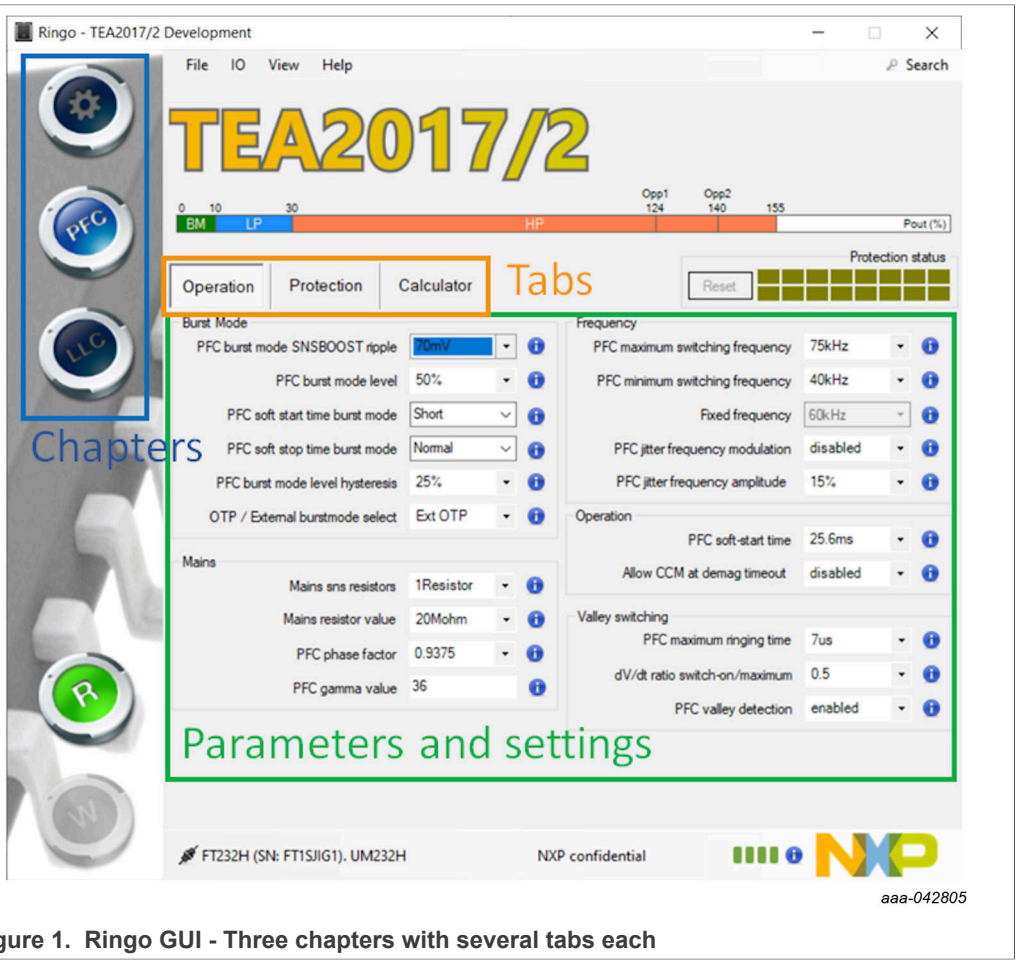


Figure 1. Ringo GUI - Three chapters with several tabs each

Clicking three large blue buttons gives the option to select three chapters. Each chapter includes tabs.

General

- Info sheet

PFC

- Operation
- Protection
- Calculator

LLC

- Operation
- Burst mode
- Protection
- Power good

Each tab shows parameters and settings. They are grouped in blocks with similar functions.

For example, Figure 1 shows the PFC operation tab that contains five blocks:

- Burst Mode
- Mains
- Frequency
- Operation
- Valley switching

2.2 Selecting a parameter value

Clicking the drop-down button, selects a parameter for modification.

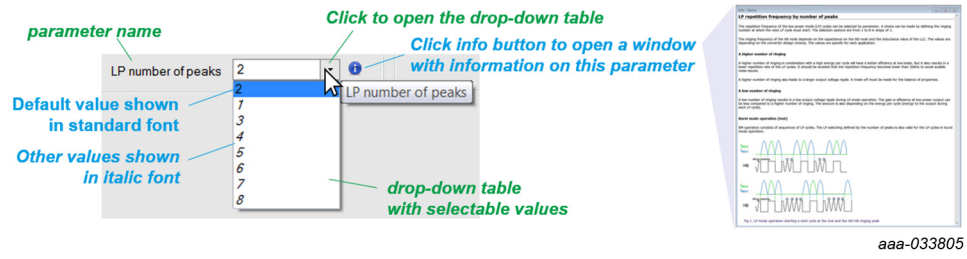


Figure 2. Example of parameter elements

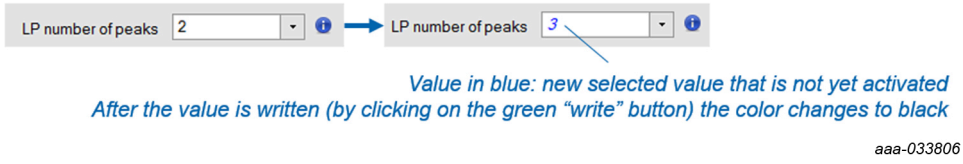


Figure 3. Selected new value in blue becomes black again after it is written (activated)

2.3 Reading parameter bit setting

When the drop-down button is clicked while the Ctrl button on the keyboard is held down, then a window pops up. It shows the parameter name, MTP location, and the bit setting of the corresponding parameter.

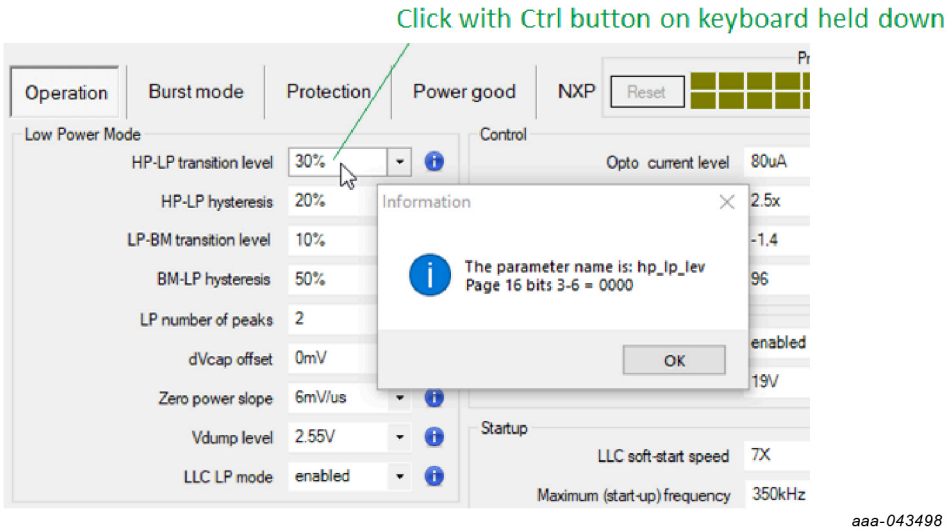


Figure 4. Reading parameter bit setting

2.4 Protection registers and LEDs

Protections that are triggered are stored in the MTP. An LED turning from green to orange shows the protections in the GUI. Selecting the LED using the mouse shows the protection name. When the LED is orange, clicking provides extra information.

The reset button clears all protections.

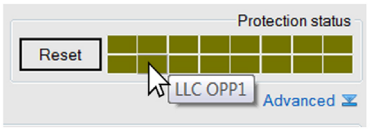


Figure 5. Protection LEDs

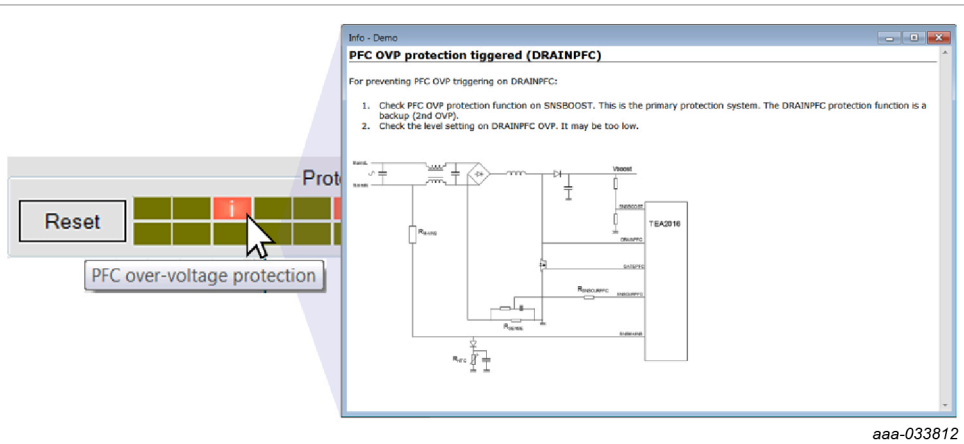


Figure 6. A triggered protection (orange LED) provides extra information

At start-up, the status of the protection registers is read. These registers are constantly updated during operation.

If a protection is triggered, it is stored in the MTP, unless it was already set earlier. It avoids that MTP writes when it is not necessary.

Table 1. Protections registers shown in the GUI

	Protections
1	OPP via SUPIC UVP
2	PFC overcurrent protection
3	PFC overvoltage protection (DRAINPFC)
4	PFC overvoltage protection (SNSBOOST)
5	LLC maximum optocoupler current in burst
6	LLC capacitive mode
7	LLC maximum on-time exceeded
8	LLC maximum start-up time exceeded
9	LLC OPP2
10	LLC OPP1
11	LLC overcurrent protection
12	LLC overvoltage protection
13	MTP read failure
14	Fast disable
15	External overtemperature protection
16	Internal overtemperature protection

If the IC is not locked, the protection registers can be reset using the GUI (RESET button). After resetting, the LEDs becomes orange again when the protection is triggered.

If a protection is triggered and showing an orange LED, it does not always mean that the system has stopped operating (and restarted). A timing filter may prevent that the system stops or the protection does not lead to stopping but to just limiting a condition. The triggering indicates that this function may be critical and attention is necessary.

2.5 Info buttons

Settings and protection LEDs provide extra information. When clicking the info button, a window with information pops up. The window can be scrolled through and its size can be adjusted. Opening multiple windows at the same time is also possible.

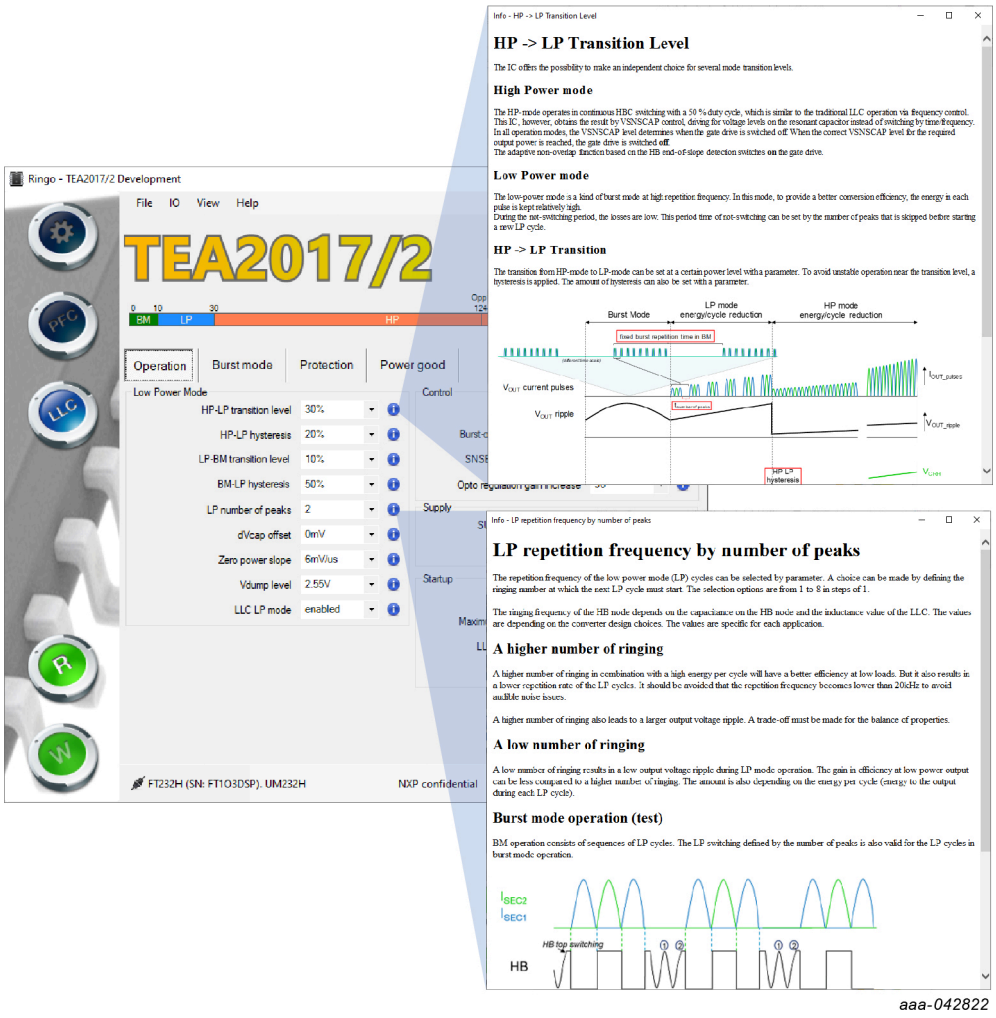


Figure 7. Info buttons provide extra information

2.6 Mode transitions and protection levels on a power scale

Mode transitions levels between the operating modes HP, LP, and BM can be set independently using parameters. Protection levels related to output power can also be set. These levels are always shown as a reference for parameter design choices that were made.

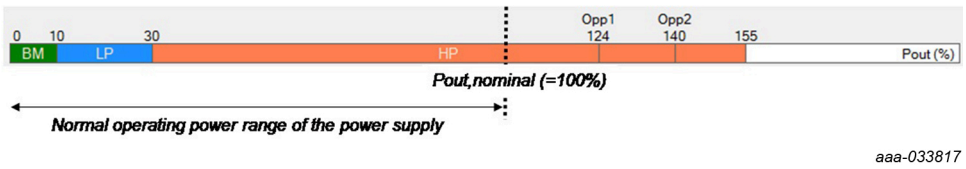


Figure 8. Mode transitions and protection levels on a power scale

2.7 Warnings

When a combination of settings is chosen that may be conflicting or runs the risk of creating a problem, a warning is provided to check if the choice is correct. When clicking the general warning box, a pop-up window shows which parameters can be checked.

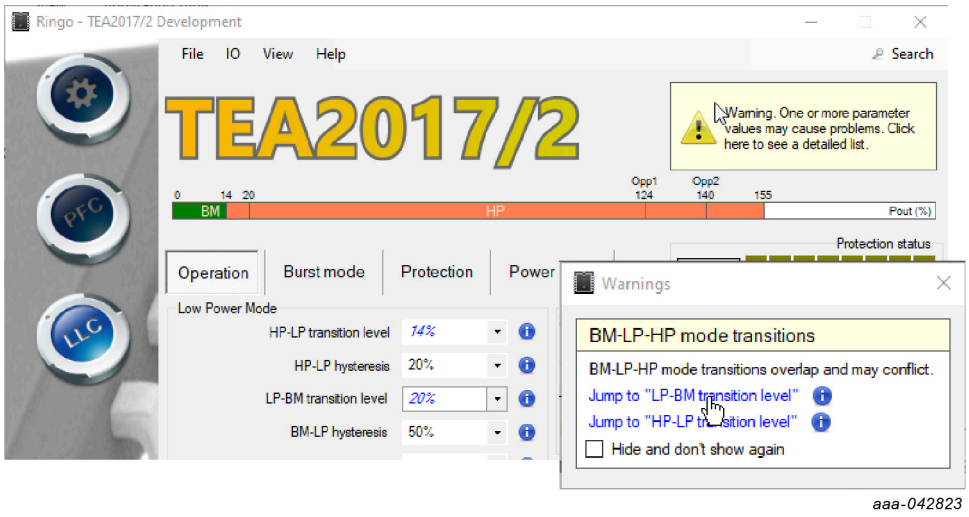


Figure 9. Warning example with pop-up information and link to related parameters

The warning system is a help function for the user. It does not provide a full coverage of all possible conflicts.

There is no limit to combinations. The user has freedom of choice.

2.8 Search function

Ringo includes a search function to find the location of a setting or related settings. The search function can be activated:

- View menu: select search
- Ctrl+F
- Click the search field in top right corner

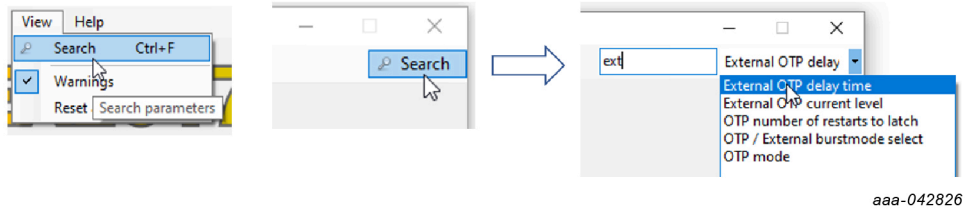


Figure 10. Ringo search function

By clicking one of the search results, the view shows the correct tab and highlights the parameter.

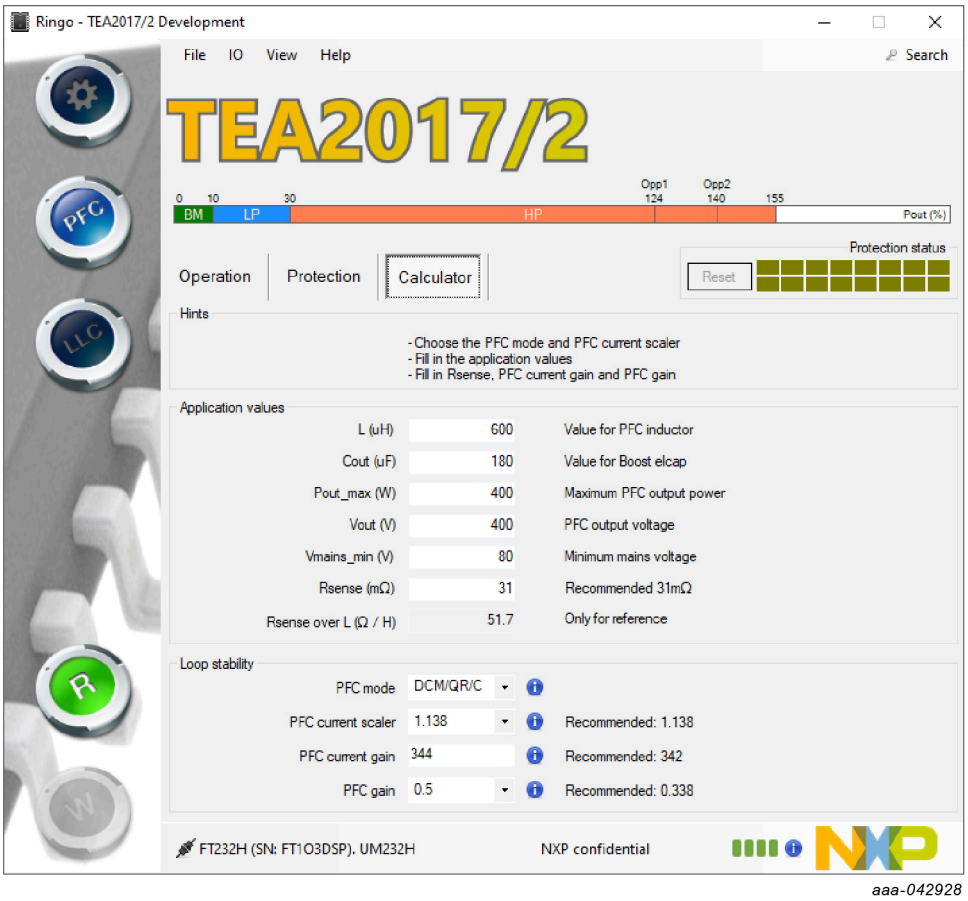
2.9 PFC calculator

The PFC calculator tab can be used to determine correct values for the control loop parameters. The values that are filled in in the "Application values" block are used for calculating recommended values for the PFC sense resistor and the MTP parameters in the "Loop stability" block. The way of working is as follows:

Steps to take:

1. Select the correct PFC mode.
2. A recommended value for the PFC current scaler is calculated. Select this value.
3. Fill in the value for L, C_{out}, P_{out_max}, V_{out}, V_{mains_min}.
4. A value for R_{sense} is recommended. Copy that value in the R_{sense} field.
5. Select the PFC gain closest to the recommended value.
6. Fill in the recommended value for PFC current gain.

After these steps, the MTP control loop parameters have a good value, which acts as a starting point for further fine-tuning.



aaa-042928

Figure 11. PFC calculator tab

PFC mode:
0 = DCM/QR
1 = DCM/QR/CCM
2 = Fixed frequency
3 = Off

$$PFC\_current\_scaler := \begin{cases} 2.013 & \text{if } PFC\_mode = 0 \\ 1.138 & \text{if } PFC\_mode = 1 \\ 1.138 & \text{if } PFC\_mode = 2 \\ 1.138 & \text{otherwise} \end{cases}$$

$$R_{Recommended} := \frac{1000 V_{mains\_min}}{P_{out\_max} \cdot 4 \cdot \sqrt{2} \cdot PFC\_current\_scaler}$$

$$RsenseoverL := \frac{1000 R_{sense}}{L}$$

$$PFC\_current\_gain := \frac{20100 \cdot L \cdot 10^{-6}}{R_{sense} \cdot 10^{-3} \cdot PFC\_current\_scaler}$$

$$PFC\_gain := \frac{PFC\_current\_scaler \cdot 30.63 \cdot R_{sense} \cdot 10^{-3} \cdot C_{out} \cdot 10^{-6} \cdot V_{out}^{2}}{1.15 \cdot V_{mains\_min}}$$

aaa-042929

Figure 12. PFC calculator equations

2.10 Adding modification restrictions

To block the modification of one or more parameters, the ParamEdit tool can be used. The ParamEdit.exe tool is included in the Ringo software package. Double-clicking it, starts the editor.

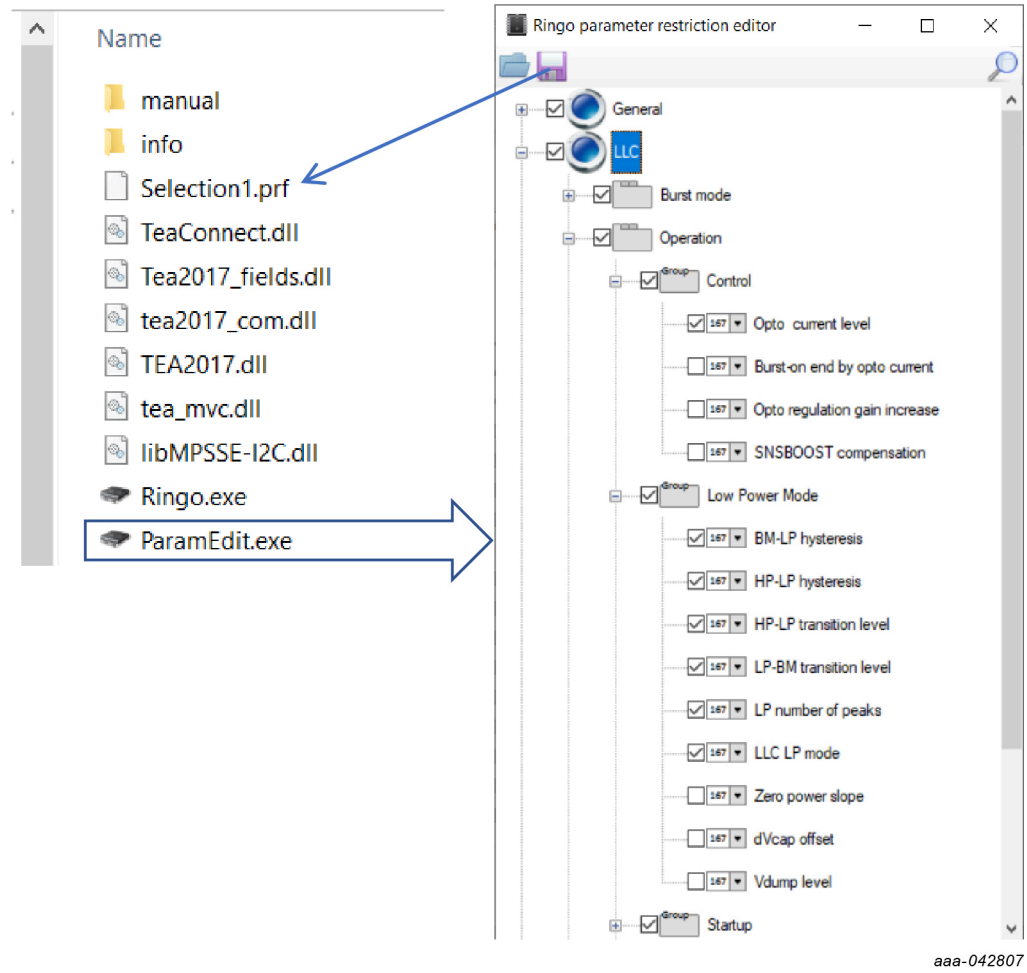


Figure 13. ParamEdit

The right side of Figure 13) shows the window that opens when the program ParamEdit.exe is started.

Initially, all parameters are marked with a “v”. Removing the mark by clicking it blocks that parameter in the TEA2017/2 GUI. After the editing of the list is finished, it must be saved in a file with ".prf" extension.

After the ".prf" file is saved, the settings must be imported in the TEA2017/2 GUI, which is done by dragging and dropping the ".prf" file into the left side of the Ringo GUI (see Figure 14). When the ".prf" file is dropped, the parameters that were unchecked using ParamEdit are greyed out. The name of the GUI changes to the name of the ".prf" file.

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Figure 14. Dragging and dropping the ".prf" file

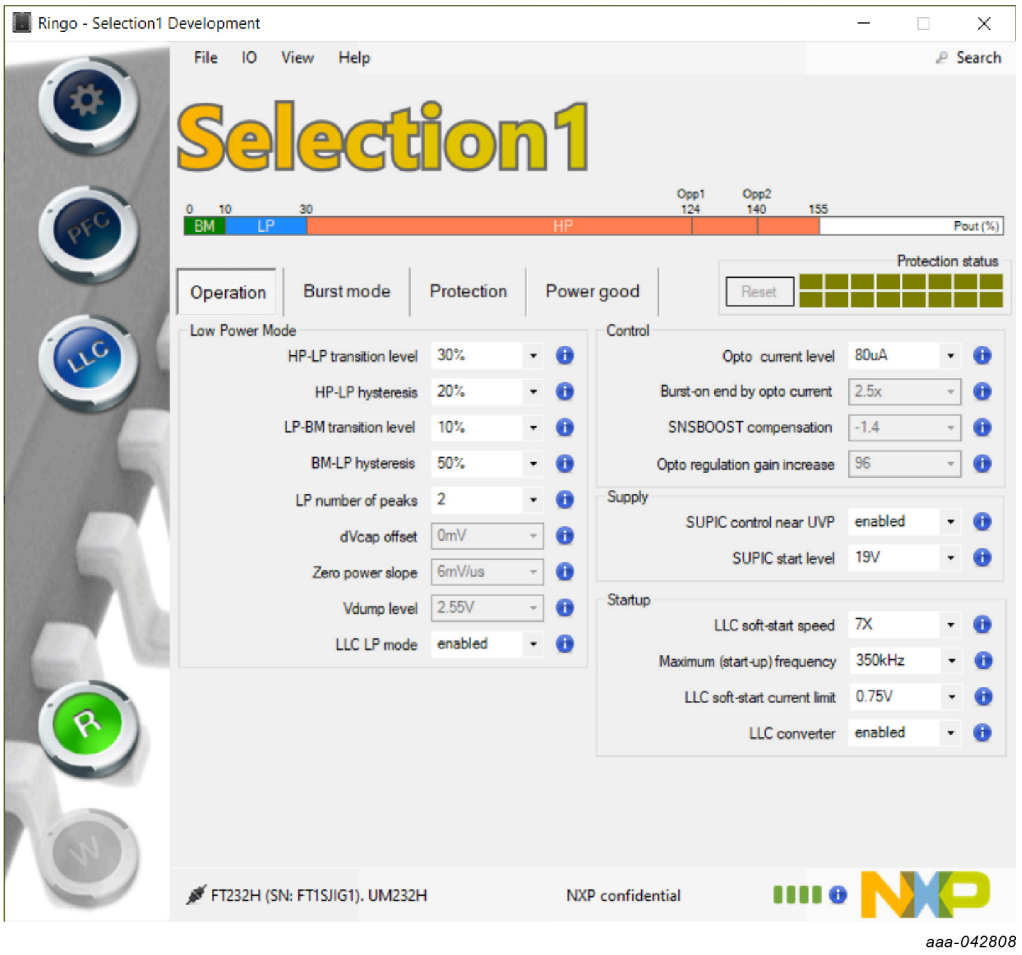


Figure 15. ParamEdit - Unchecked parameters

The parameters that are unchecked in ParamEdit.exe are greyed out. They only show the actual value. The title shown in the GUI is the name of the ".prf" file (Figure 15).

When the ".prf" file is left in the Ringo directory, the name of the file is shown as title in the GUI. When the ".prf" file is deleted, the name of the GUI changes back to TEA2017/2, but the previously selected items remain blocked.

Undoing the modification restrictions can be done by making a new ".prf" file where all parameters are marked with a “v”. After this file is saved and the settings are imported in the TEA2017/2 GUI as described above, all parameters are available again.

3 Writing and reading settings (IO)

3.1 W and R button

When a new value for a parameter is selected, this value is shown in blue to indicate that it has not yet been written into the MTP of the TEA2017. Pushing the Write button, writes the value to the MTP. The blue text changes to black to indicate that the write action was successful. To indicate that all parameter values shown in the GUI correspond with the values in the TEA2017, the Write button is greyed out.

Figure 16. Write and read buttons

The read button can be used for reading (all) device settings. Reading the device settings can be used for double checking or to compare the difference between a loaded .mif file with the actual IC settings.

The Read and Write button functions can also be activated in the IO menu or by pressing F5 and F6.

The IO menu includes the option to write all parameters instead of only the changed parameters (F7). Only use this option to double check because the number of times the MTP fields can be written is limited (guaranteed 200x, in practice 700 times).

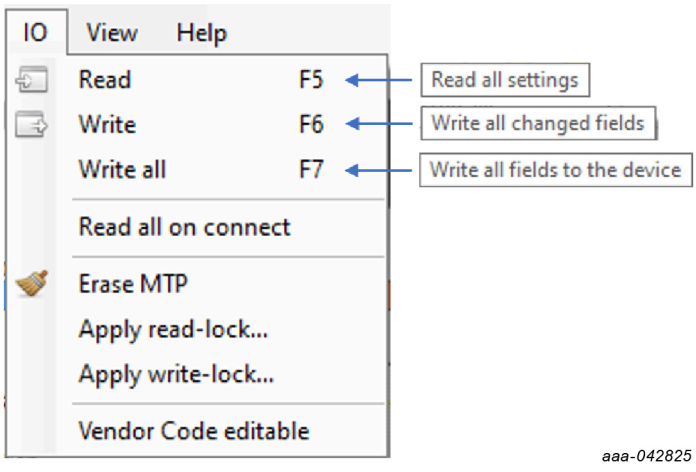


Figure 17. Read and write functions in the IO menu

3.2 Read lock and write lock

After programming, the MTP can be locked for reading and writing settings.

Only an "Erase MTP" action can unlock the IC. After erasing the MTP, the IC can be programmed again.

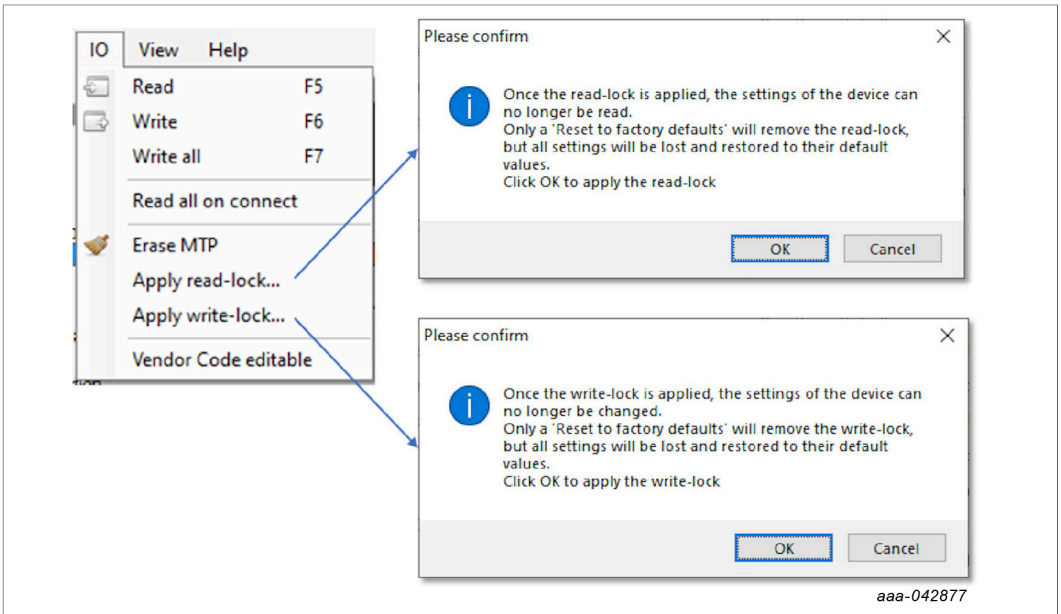


Figure 18. Read lock and write lock

If there are problems, the protection registers and the vendor code (identifier number for a specific product) can still be read for analysis after read lock and write lock.

3.3 Erase MTP

The function "Erase MTP" in the GUI fills the MTP with zeros. To recover the original MTP settings, the MTP has to be rewritten using a mif file with the original MTP settings (see Section 4.2).

3.4 Help menu

The help menu shows a list of supporting documents which are supplied with the GUI like, the TEA2017 data sheet, the application note, the user manual, and so on.

The function "About" shows the version of the GUI.

3.5 Info sheet

The info sheet tab contains information about the IC (MTP) status.

The sheet shows that the testing and calibration was completed in the NXP Semiconductors production. It also shows if the settings can be read and/or changed. It reflects the status of the read lock and write lock setting.

A function built in the TEA2017 calculates the CRC code shown. The Ringo GUI then reads out the calculated code. It can always be read, even if the read/write lock bits are set.

The CRC code is a 4-digit hexadecimal number that is calculated based on the content of MTP page 8-31. It means that the vendor code is also included in the calculation. The CRC code provides a high chance (close to 100 %) of detecting a deviation from the correct MTP content.

The vendor code is a section (MTP page 31, 16 bits) that can be used for identification of the IC (programming) version. The vendor code remains readable also after read lock.

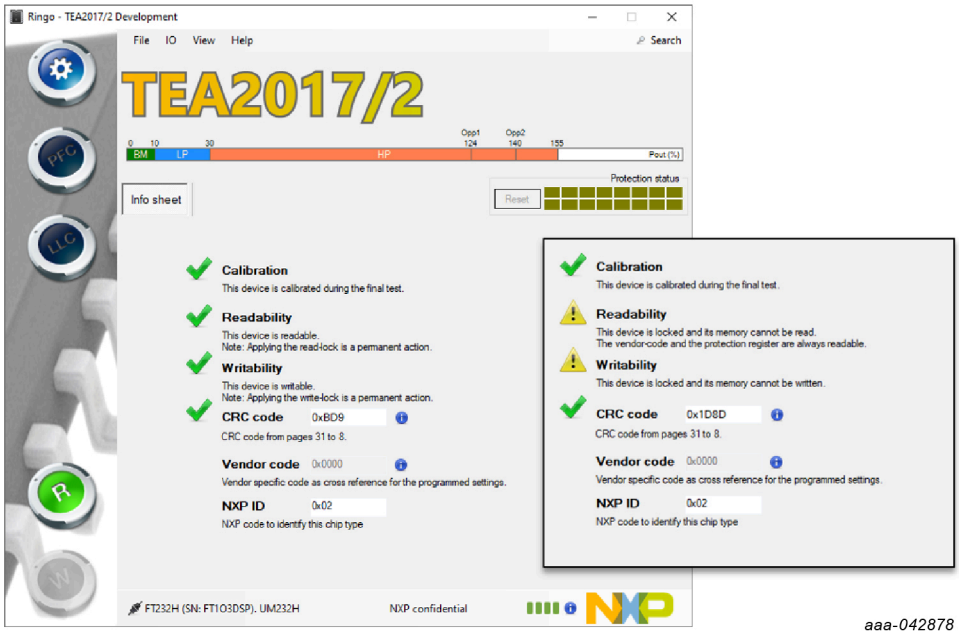


Figure 19. Info sheet

3.6 Connection

The connection is constantly checked by reading the protection status and updating the LEDs (poll protection register).

Figure 20 shows the status of communication.

Figure 20. Connection status

3.7 Connection quality

The Ringo GUI is often used in combination with the development version of the TEA2017.

In the development version, all I^2C communication runs via pins 7 and 12 (see Figure 27), which makes it possible to change the MTP on-the-fly in a working application.

When development samples are used in a working application, the high dV/dt signals (like HB and DRAINPFC) can cause spikes on the SDA and SCL lines of the I^2C-bus. These spikes can disturb the communication or, in extreme cases, damage ICs connected to the I^2C-bus.

The connection quality indicator at the bottom of the Ringo GUI screen helps to detect when something is going wrong.

Normally, the indicator provides four green bars. At this level, there may be an occasional error that the system can correct.

When the indicator shows three yellow bars, communication is showing errors often. Moving the I^2C connection cable to a better position may provide good quality again.

When the indicator shows two orange bars or one red bar, the situation is bad and changes are required.

The info button pop-up provides detailed information about what can be done to improve the connection quality. It also provides a method to avoid errors.

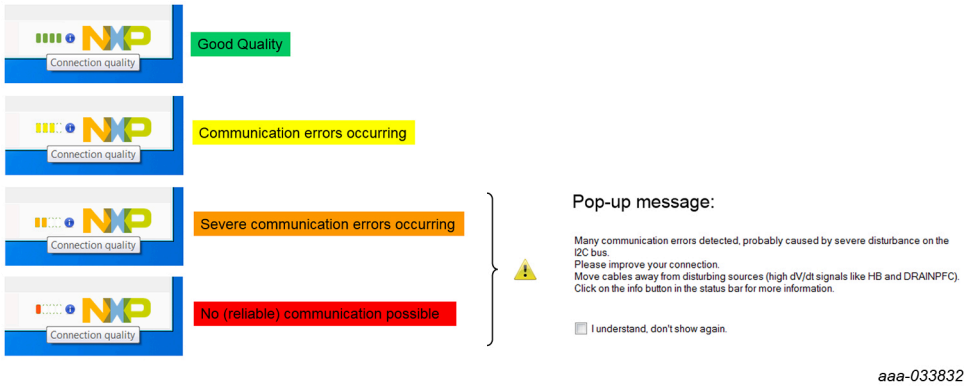


Figure 21. Connection quality indicator

4 TEA2017 MTP and registers

The MTP in the IC is a permanent (but changeable) memory like a flash memory. When the IC supply voltage goes down, the content remains.

The registers in the IC are a temporary memory. When the supply voltage goes down, the content is lost.

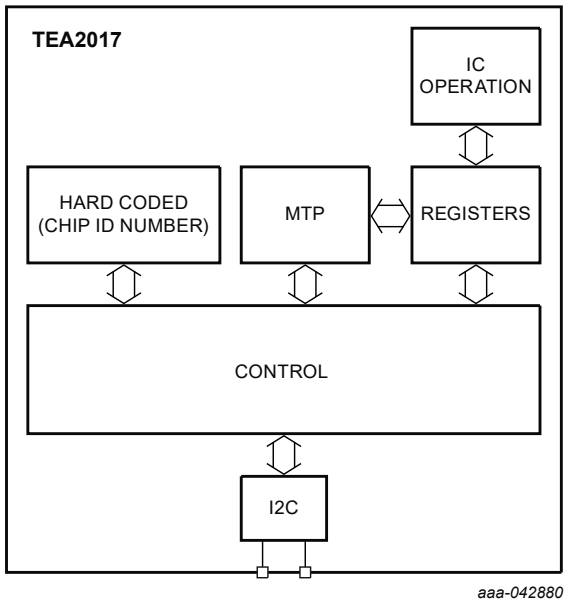


Figure 22. Communication channels with MTP and registers in the TEA2017

4.1 IC operation

For correct operation, the stored MTP setting values are copied to the registers of the IC at start-up.

During operation, the IC works with the register values. It can only store the protection registers in the MTP memory. The user or a programming unit must store or modify the remaining MTP content, if necessary.

4.2 Erase MTP

When erasing the MTP (set all values to zero), the settings are at default.

Note: *These default values are different from the settings that were programmed in the factory.*

The default values show a predefined “middle of the road” type of operation. Most applications run well, but not optimal, on default values. In some cases, the default settings conflict with the values of the converter and external component values. The result can be unintended protection triggering. To get the original MTP values again, the IC must be programmed using a .mif file with the original settings of the IC.

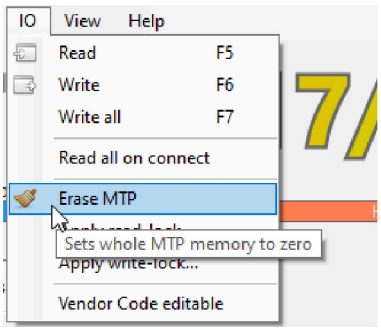


Figure 23. Erase MTP function

4.3 Saving and loading settings by .mif file

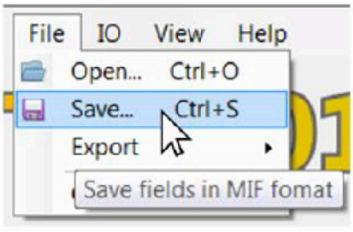
The user can read and write the MTP and the registers via I^2C. A TEA2017-specific I^2C-based protocol is required for this action.

Settings can be changed individually. A collection of settings can be saved on the computer as a .mif file. A saved .mif file can be used to program the MTP of an IC by opening it in the GUI and writing it in the IC.

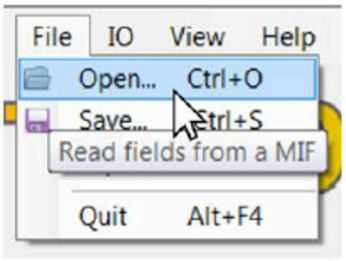
If the .mif file must contain the IC settings or MTP settings, first read the content again to be sure.

You can use the .mif file to share the settings with other engineers.

When loading settings from a .mif file, they are displayed on the screen for review. The settings must be written to modify the IC settings.



a. Saving to .mif file



b. Loading from .mif file

Figure 24. Save settings to .mif file and load settings from .mif file

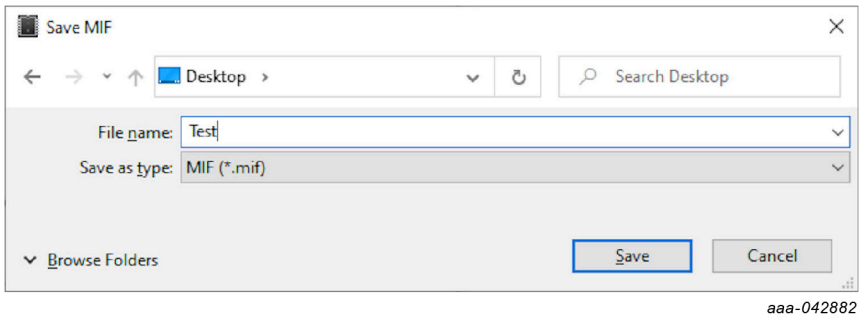
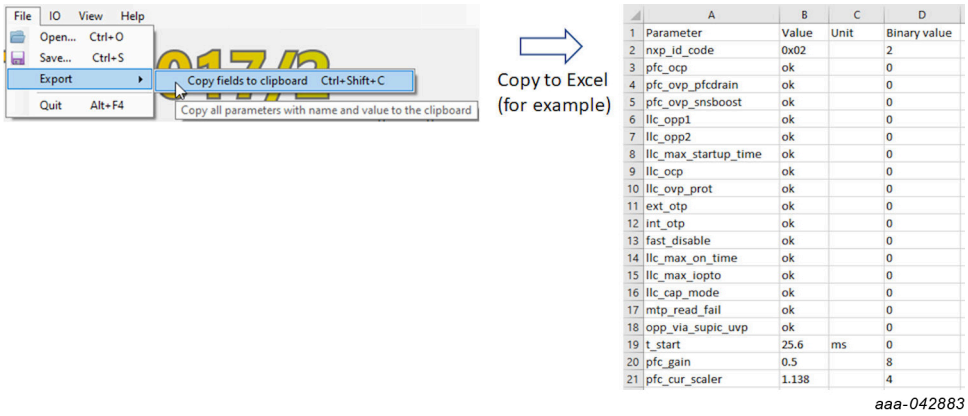


Figure 25. Saving parameter settings as Test.mif file

4.4 List of settings

All the settings shown on the GUI screen can be copied and pasted to another computer program.

Ensure that the GUI screen contains the content that you want to copy, if it must show the IC settings or MTP settings. First reread the content to be sure.



	A	B	C	D
1	Parameter	Value	Unit	Binary value
2	nxp_id_code	0x02		2
3	pfc_ocp	ok		0
4	pfc_ovp_pfcdrain	ok		0
5	pfc_ovp_snsboost	ok		0
6	llc_opp1	ok		0
7	llc_opp2	ok		0
8	llc_max_startup_time	ok		0
9	llc_ocp	ok		0
10	llc_ovp_prot	ok		0
11	ext_otp	ok		0
12	int_otp	ok		0
13	fast_disable	ok		0
14	llc_max_on_time	ok		0
15	llc_max_iopto	ok		0
16	llc_cap_mode	ok		0
17	mtp_read_fail	ok		0
18	opp_via_supic_uvp	ok		0
19	t_start	25.6	ms	0
20	pfc_gain	0.5		8
21	pfc_cur_scaler	1.138		4

Figure 26. Make a list of settings to use in another computer program

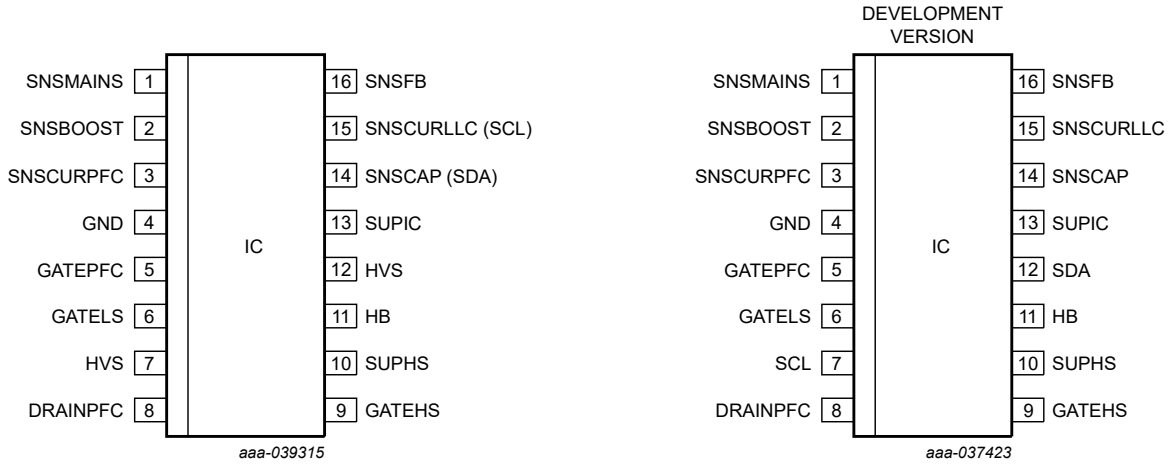
4.5 Double check changed settings

The change handling of Ringo is made to provide a reliable register and MTP modification and clear representation on the GUI screen. In some situations, it may still be unclear to the user if changes were indeed activated or stored.

To double check, the TEA2017 can be stopped (disconnect the mains voltage) and restarted to refresh the settings. At start-up, the IC copies the MTP settings to the registers. With a read action of the Ringo, the settings are copied to the GUI on your screen.

5 I²C communication

In addition to the normal (production) TEA2017 ICs, NXP Semiconductors provides a special IC version for product development. The difference is that the development IC samples provide a second I²C interface for easy modification of settings while the IC is operating, changing operation on the fly.



a. Normal version

b. Development version

Figure 27. TEA2017 pinning diagrams

5.1 Development IC samples: SDA and SCL on spacer pins

The connection to the I²C interface of the development version is provided via the pins that are not connected in the normal version, that is, the high-voltage spacer pins 7 and 12.

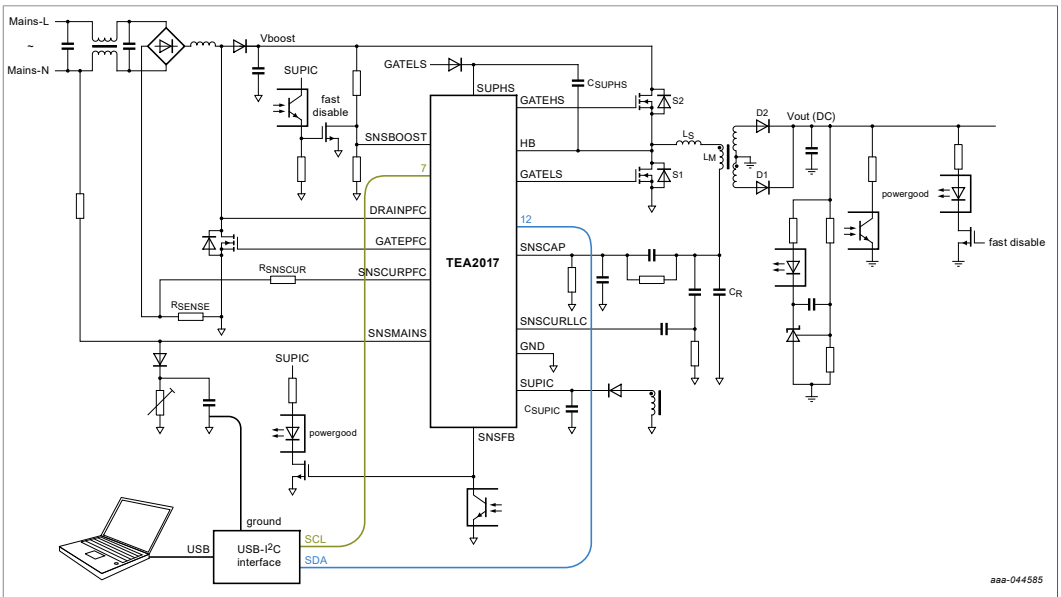


Figure 28. Development IC: I²C connections with spacer pins

5.2 Production IC samples: SDA and SCL on combined pins

The basic I^{2}C interface in the IC is available on the combined pins SNSCURLLC (SCL) and SNSCAP (SDA). To program the IC, the IC must be put in the disabled condition, pulling SNSBOOST to GND. During programming, the IC must be supplied via the SUPIC pin.

Programming can be done on a separate IC (put in an IC socket) or when the IC is mounted on the power supply PCB.

When programming is done while the IC is mounted on the power supply board, the capacitive and resistive loads on the SDA and SCL lines become much higher. The much higher capacitive and resistive loads endanger communication because rise times and fall times of the communication pulses become much slower and distorted. Depending on the application component values, the driver capability of the I^{2}C interface must be modified to ensure reliable programming.

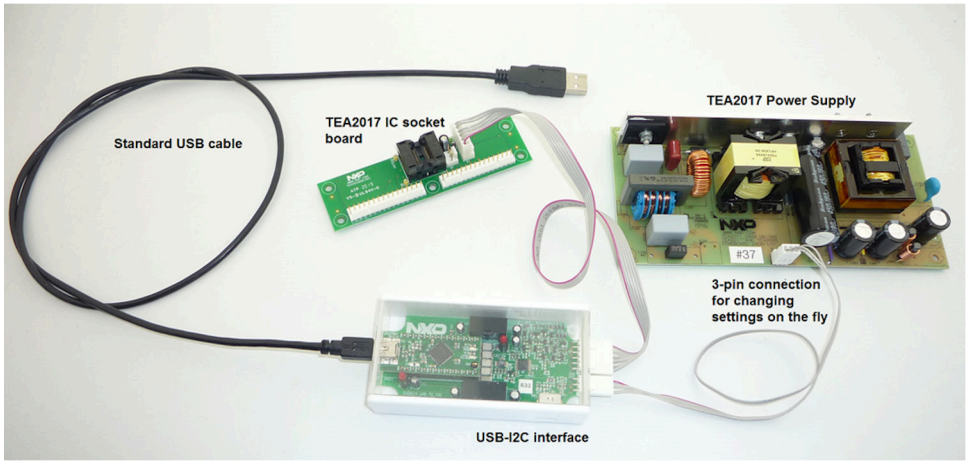


Figure 29. Two TEA2017 programming setups: On-the-fly and standalone

5.3 Graphical user interface (GUI) and USB-I^{2}C interface

The USB-I^{2}C interface board galvanically isolates the TEA2017 application from the computer. It acts as interface between the I^{2}C lines and the USB-port. It contains an FT232 module. Before using it, the appropriate driver must be installed. For more information, see the "TEA2016DB1514 USB I^{2}C interface board" user manual (Ref. 2).

The USB-I^{2}C interface and Ringo GUI are intended for engineering work in a lab environment as part of power supply development. They are not suitable for industrial purposes or use by consumers.

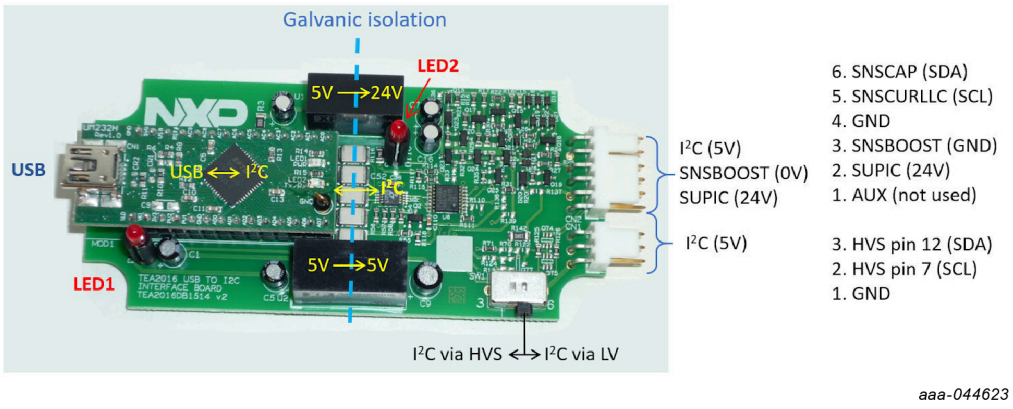


Figure 30. USB I²C interface board RDK01DB1563 connections and setup

6 References

[1] **TEA2017AAT data sheet** — Digital configurable LLC and multimode PFC controller; 2021, NXP Semiconductors

[2] **UM11235 user manual** — TEA2016DB1514 USB I2C interface board; 2019, NXP Semiconductors

[3] **UM11397 user manual** — TEA2017DB1580 240 W demo board; 2021, NXP Semiconductors

[4] **AN13140 application note** — TEA2017 CCM/DCM/QR PFC + LLC controller IC; 2021, NXP Semiconductors

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