

ST7580 power line modem demonstration kit graphical user interface (GUI)

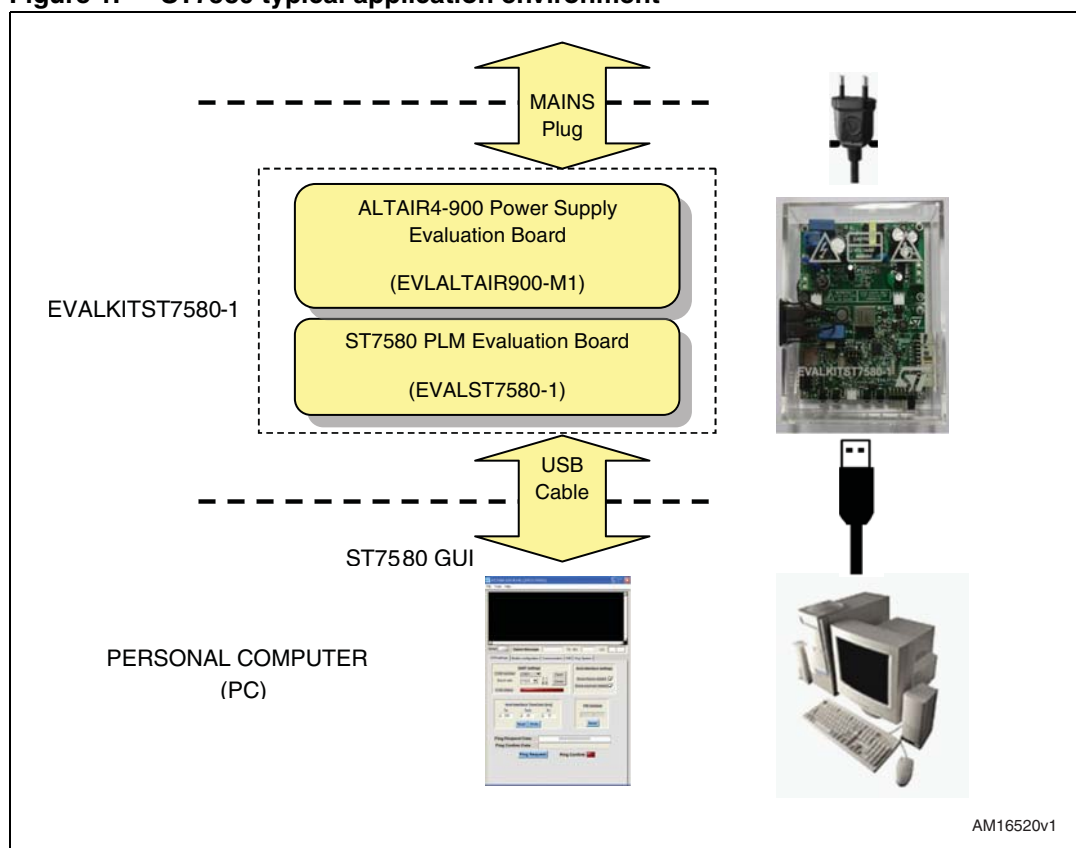
Introduction

The “ST7580 GUI” is a software tool that allows one or more ST power line modem (PLM) demonstration boards to be interfaced with a personal computer (PC). Only PLM demonstration boards equipped with the ST7580 device are supported.

When using the ST7580 GUI the user has complete control of the ST7580 device, having access to all its registers and functions described in [2].

The typical application environment (shown in [Figure 1](#)) consists of an ST7580 GUI running on a PC and communicating through a USB connection with a PLM demonstration kit equipped with the ST7580 product, such as the EVALKITST7580-1 (consisting of an EVALST7580-1 modem board and an EVLALTAIR900-M1 power supply board).

Figure 1. ST7580 typical application environment



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1 Document conventions

1.1 List of abbreviations

The following abbreviations are used:

Table 1. Abbreviations

Abbreviation	Description
PRE	Preamble
UW	Unique word
MIB	Management information base
ZC	Zero-crossing
PHY	Physical layer
DL	Data link layer

2 Connection procedure

In order to connect the EVALKITST7580-1 to the PC, the user must follow the instructions below:

1. Connect the board to the PC using a mini-USB cable.
2. Plug a power cable into the board AC power plug.
3. Plug the power cable into the power socket.

As soon as the board is powered, the LEDs DL1, DL2 on EVALST7580-1 switch on.

USB/UART adapter driver installation

The USB communication between the EVALKITST7580-1 and the PC is managed through the onboard STM32 microcontroller, whose embedded default code acts as a USB to UART bridge.

In order to allow the PC to properly recognize this microcontroller application, the installation of a proper software driver is necessary.

Assuming that the device drivers are not yet installed, the user must:

1. Download the latest available virtual COM port (VCP) drivers from the ST website (at www.st.com) and unzip them to a location on the host PC.
2. Launch the setup file "VCP_V1.3.1_Setup.exe" to install the virtual COM port driver on the PC.
3. When the screen shown in [Figure 2](#) is displayed, click "Next" to proceed with the installation.

Figure 2. Hardware update wizard screen



- The setup is completed and the screen shown in [Figure 3](#) is displayed.

Figure 3. Completing the found new hardware update wizard



- Connect the EVALKITST7580-1 to a spare USB port on the host PC: an "STMicroelectronics virtual COM port" is recognized by the PC device manager and the EVALST7580-1 is installed and ready to use.

3 GUI installation

3.1 Software license agreement

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3.2 System requirements

A personal computer (PC) including:

1. Operating system Windows NT/2000/XP/7.
2. A hard disk with at least 15 MBytes of free space to install the GUI.
3. One or more USB 1.1 ports.

3.3 Installing the software

Follow the instructions below to install the ST7580 GUI software.

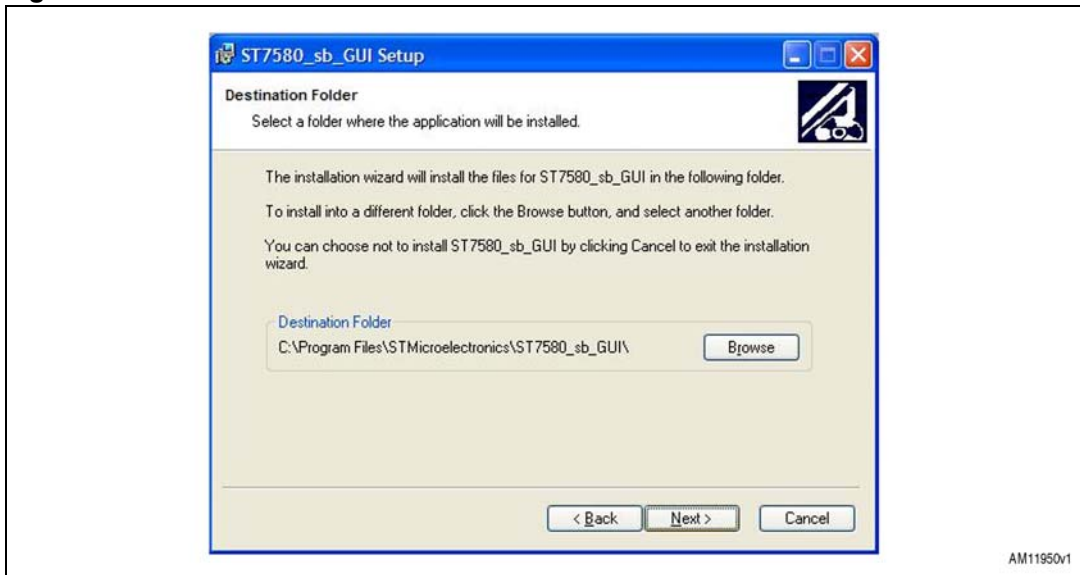
1. Extract the contents of the archive in a new directory.
2. Launch “setup.exe” to start the install procedure.
3. Press “Next” button (*Figure 4*):

Figure 4. ST7580 GUI installation wizard



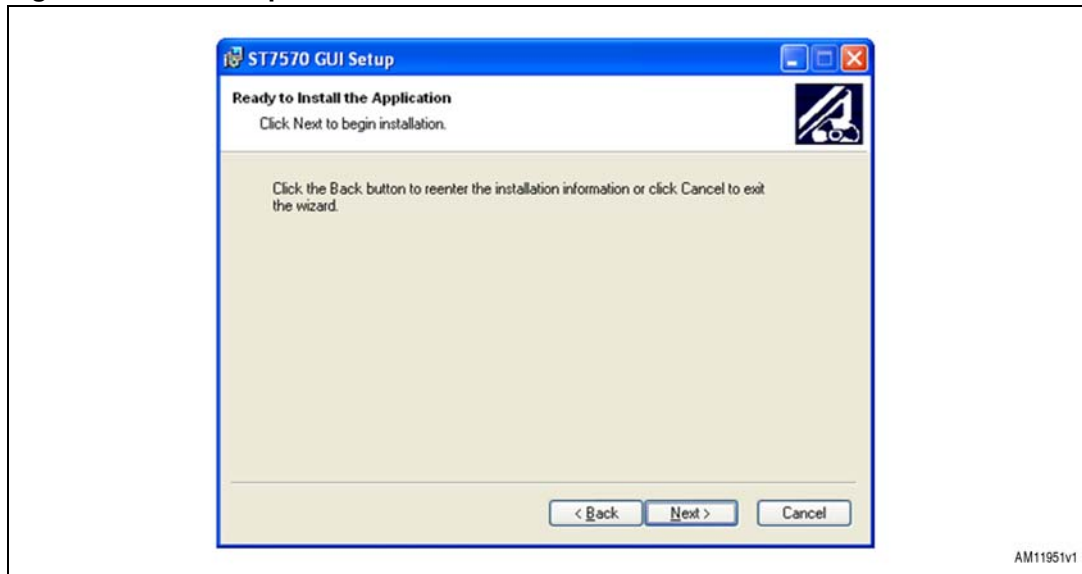
4. Choose an installation path (the default path is suggested) and press the “Next” button, (*Figure 5*).

Figure 5. ST7580 GUI destination folder



5. Press the “Next” button to start the installation (*Figure 6*).

Figure 6. GUI setup start



6. Once the installation has completed, press the “Finish” button to conclude the process, (*Figure 7*).

Figure 7. GUI setup finish



4 Getting started

4.1 Introduction

The ST7580 GUI gives the user complete control of the ST7580 device, with full access to all the settings and functions described in [2]. The GUI can be used to:

- Establish a connection to the ST7580 modem
- Configure the ST7580 and manage all its settings
- Perform any transmission and reception of data over the power line
- Open a Ping session, where at least two modems (a Master device and one or more Slave devices) can communicate exchanging data.

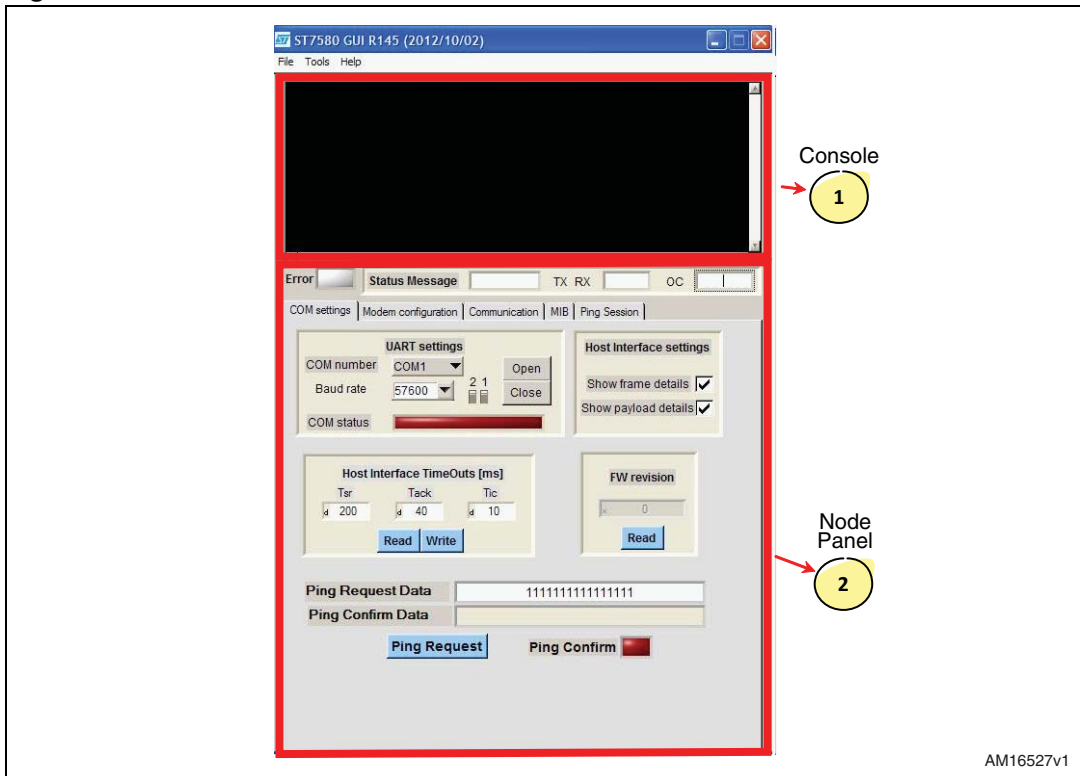
A single instance of the ST7580 GUI can handle only one EVALST7580-1 board at a time.

Figure 8 shows the main window of the ST7580 GUI. The panel is divided into two sections:

1. Console: box displaying all the messages exchanged with the node. The messages can be cleared or saved in a .txt file through options on the “Tools” menu bar;
2. Node panel: used to control an ST7580 node; it is divided into five tabs to easily change between the main service blocks of the node:
 - The properties and services of the connection to the PC;
 - The device's basic configuration, related to MIB objects 00h (modem configuration) and 01h (PHY configuration);
 - The characteristics of the exchanged power line frames (for both transmitted and received frames);
 - The access (writing, reading, erasing) to the MIB objects.
 - The settings to open a Ping session (selecting Master or Slave role) and display the communication results.

A point in the top part of this window always displays the composition of the status message returned by the modem and the occurrence of error during the last requested command:

Figure 8. ST7580 GUI

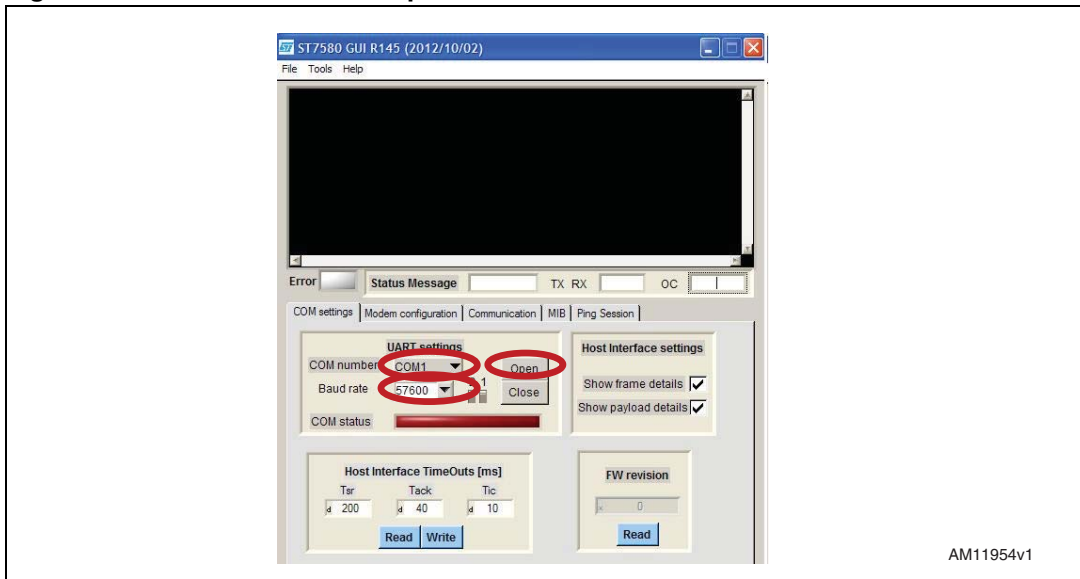


4.2 Opening the COM

To establish communication with the EVALST7580-1 demonstration board:

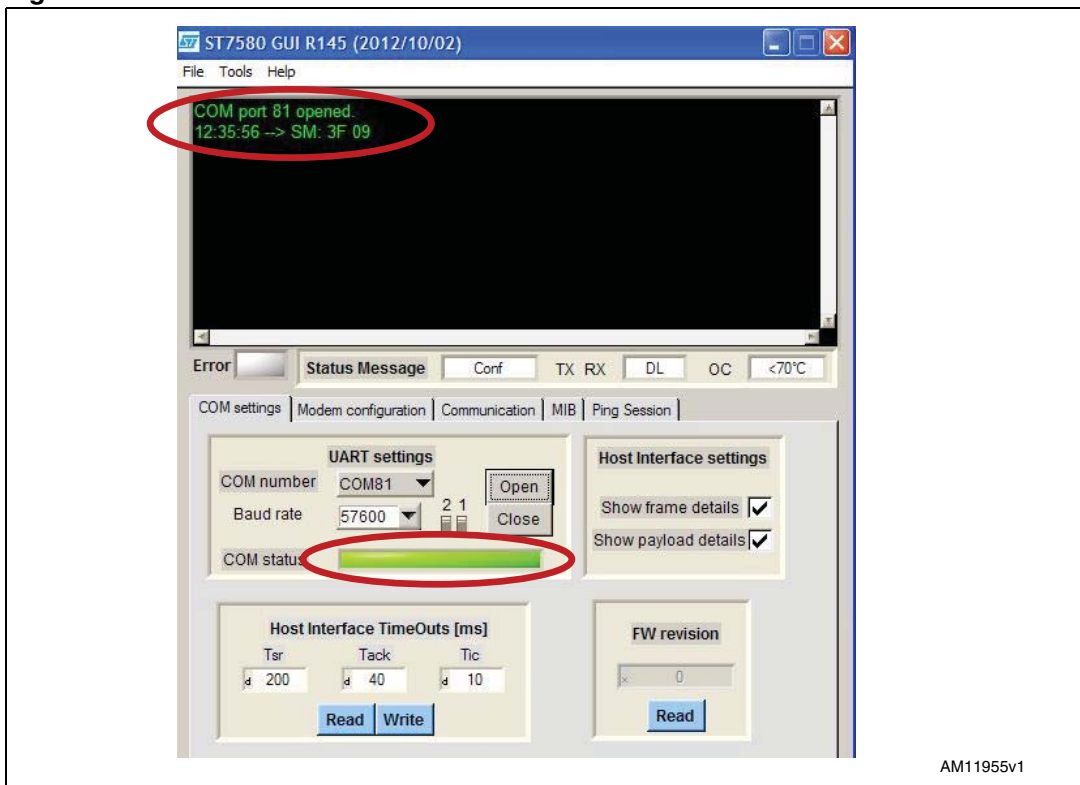
1. Manually select the COM port number associated to the board.
2. Select the desired baud rate. Note that the EVALST7580-1 board has a factory default baud rate equal to 57600 bps.

Figure 9. Modem connection procedure



If the connection is properly established, the light switches to green, and the console displays a positive notification and the status message returned by the modem:

Figure 10. Modem connection success



5 Services

5.1 Basic modem configuration

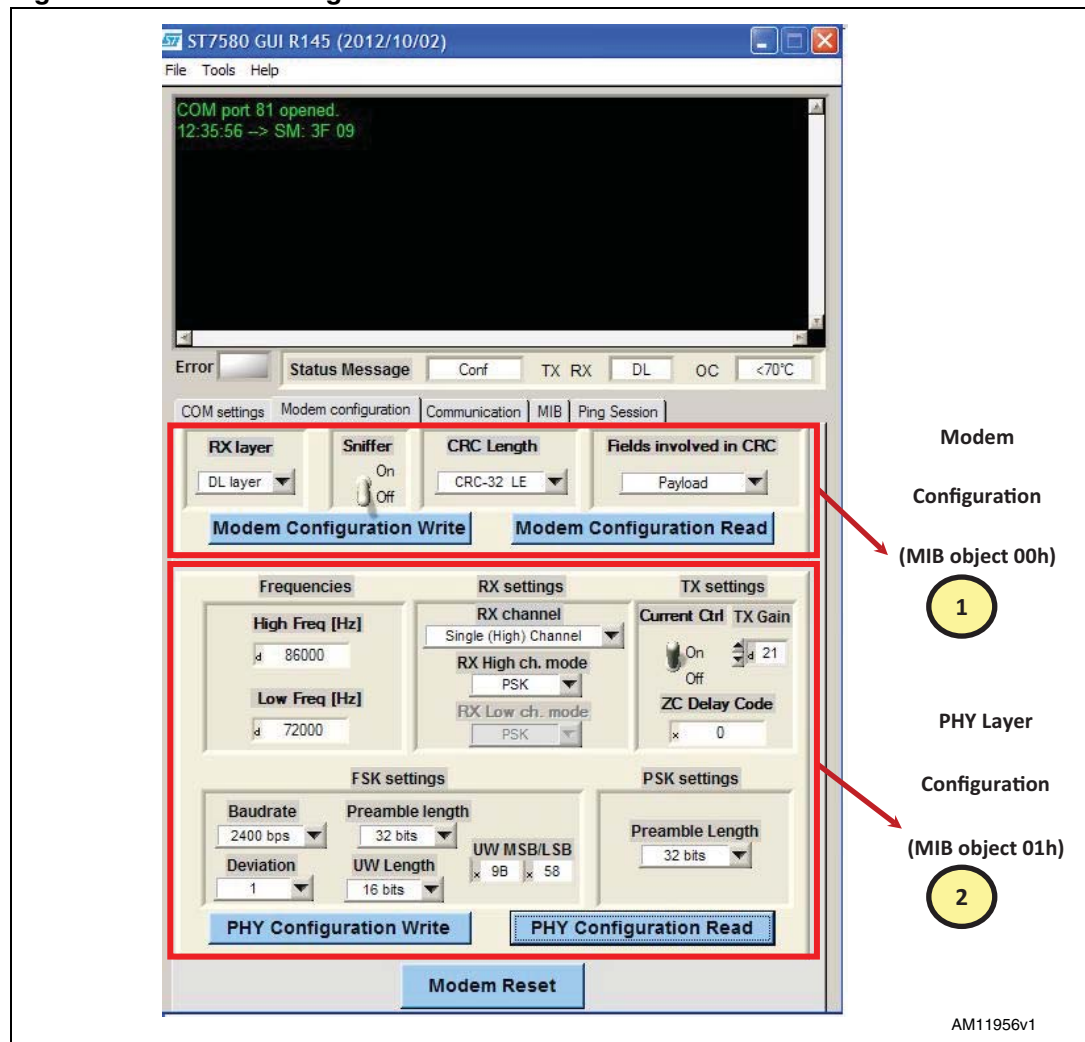
At power-on, the default values stored in the MIB objects are reported in [2]. From a power line communication point of view, it is already set to properly received frames (in compliance with values stored in MIB objects Modem configuration 00h and PHY layer configuration 01h) and to accept transmission requests.

If the user wants to change, at any moment, the two first MIB values:

1. Modem configuration 00h;
2. PHY configuration 01h.

All their parameters are selectable in the Modem configuration tab:

Figure 11. Modem configuration



The four buttons in the Modem configuration tab, highlighted by the red squares, execute correspondingly:

- Modem configuration write: it performs an “MIB Write Request” command automatically built with MIB index 00h and data as selected in the objects above;
- Modem configuration read: it performs an “MIB Read Request” command automatically built with MIB index 00h; if the command is properly executed, the data contained in the expected “MIB Read Confirm” (sent by the ST7580) is extracted and displayed in the objects above;
- PHY configuration write: as the previous “Modem Configuration Write”, it performs an MIB Write Request on the MIB object 01h (PHY layer configuration);
- PHY configuration read: as the previous “Modem Configuration Read”, it performs an MIB Read Request on the MIB object 01h (PHY layer configuration).

5.2 Power line communication: transmission and reception

In order to put into place a proper power line communication through the GUI, it is enough to power on the EVALST7580-1 and to open the USB port as explained in [Section 4.2](#).

The “Communication” tab contains all the parameters for ST7580 commands related to power line communication:

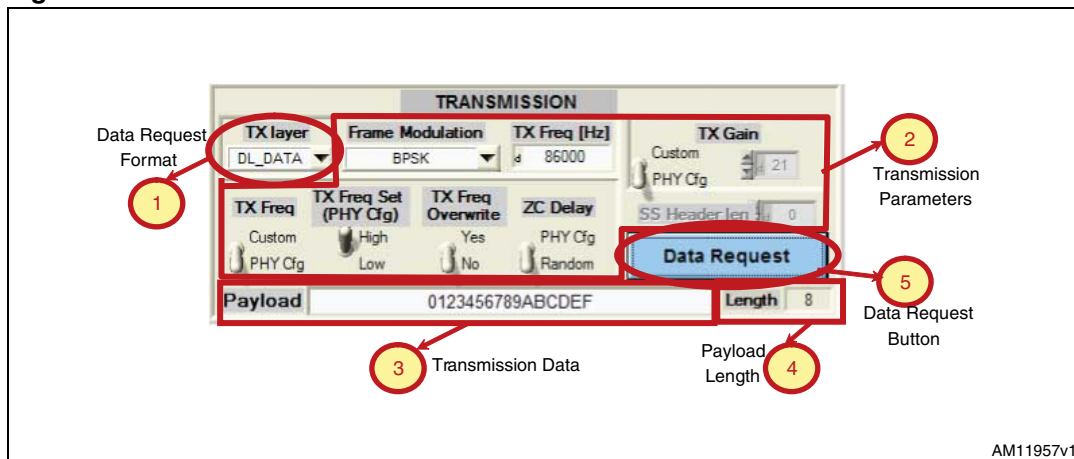
- “Transmission” box: refers to three “Data Request” commands and contains all their parameters and data to allow the user to choose the transmission settings;
- “Confirm” box: displays the parameters of the last “Data Confirm” received from the ST7580 device;
- “Reception” box: shows the parameters and the data of the last “Data Indication” received.

5.2.1 Power line transmission command

As shown in [Figure 12](#), the transmission box contains:

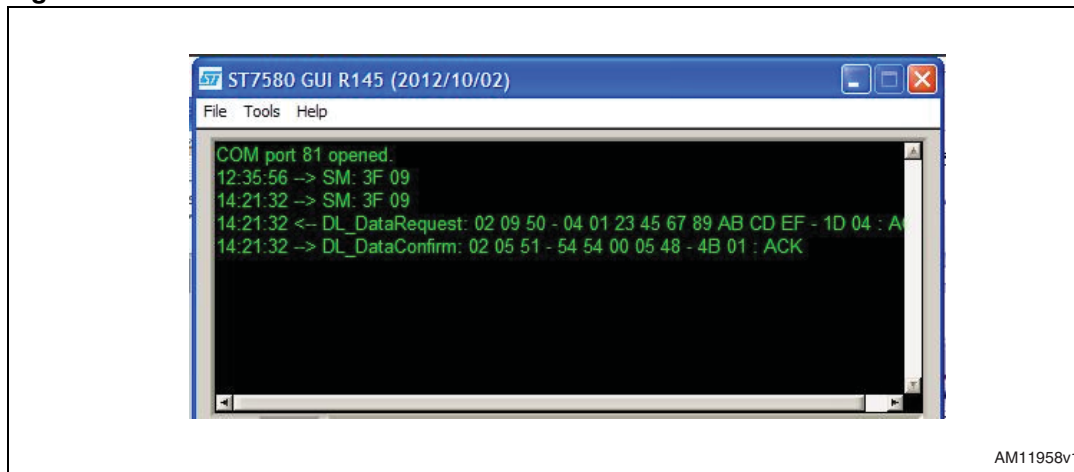
1. The “TX Layer” drop-down menu: through this parameter it is possible to choose which kind of Data Request command the GUI addresses to the ST7580.
 - The PHY_Data selection determines a “PHY Data Request” command;
 - The DL_Data selection determines a “DL Data Request” command;
 - The SS_Data selection determines a “SS Data Request” command.
2. All transmission parameters to be filled in a data request command; note that:
 - “TX Gain” value is accessible if “Gain Selector” bit is equal to “Custom” value only;
 - “SS Header Length” value is accessible if selected “TX Layer” value is equal to “SS_Data” only.
3. The Payload box where the data to be transmitted must be expressed in hexadecimal characters;
4. The length (in bytes) of the inserted Payload data, automatically calculated and displayed.
5. The Data Request button that builds a Data Request command and transmits it to the ST7580 connected device.

Figure 12. Power line transmission box



After pressing the Data Request command, the console displays it, followed by the message returned by the ST7580, i.e. either a corresponding Confirm or Error message, as displayed in [Figure 13](#).

Figure 13. Transmission notifications

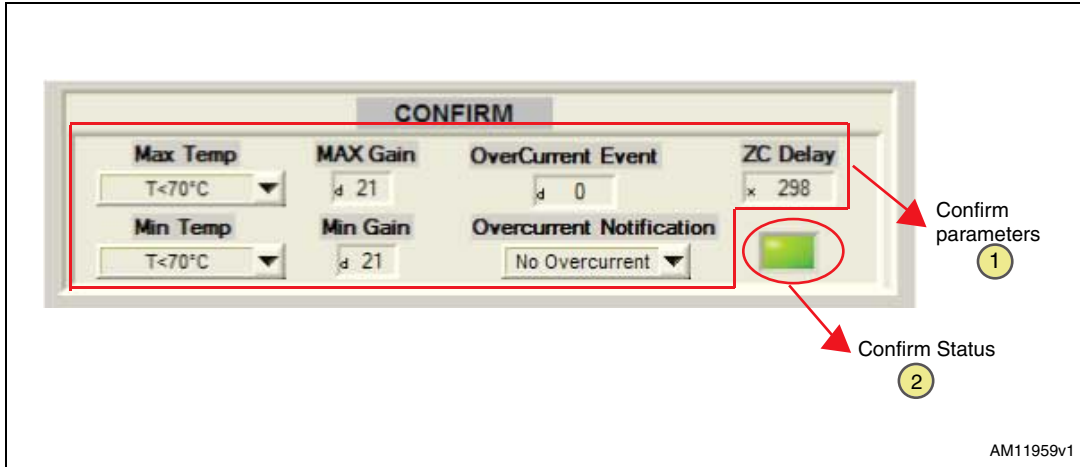


5.2.2 Power line confirm command

The confirm box, as depicted in [Figure 14](#), shows the parameters of the last Data Confirm command.

A green/red LED reports the success of the previous Data Request.

Figure 14. Power line confirm box



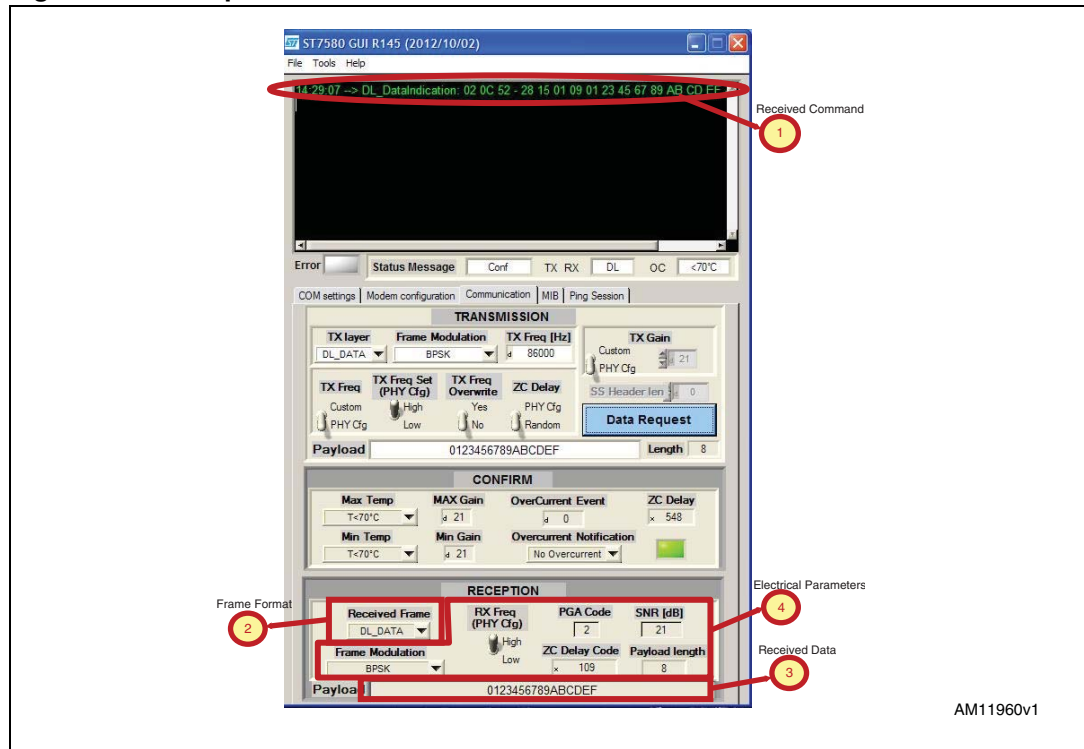
In the case of a negative result returned by the ST7580 after a previous Data Request, the confirm status LED only is refreshed to an “off” status, whereas the other parameters in the “Confirm” box are not updated.

5.2.3 Power line reception command

In the case of reception of a Data Indication (PHY, DL or SS) or a SnifferIndication (DL or SS) sent by the ST7580 after a data reception over the power line, the command type is displayed on the console, while with received data, the frame format and electrical parameters are returned in the reception box.

Figure 15 reports the GUI status after a DL_DataIndication:

Figure 15. Reception notification



5.3 MIB operations

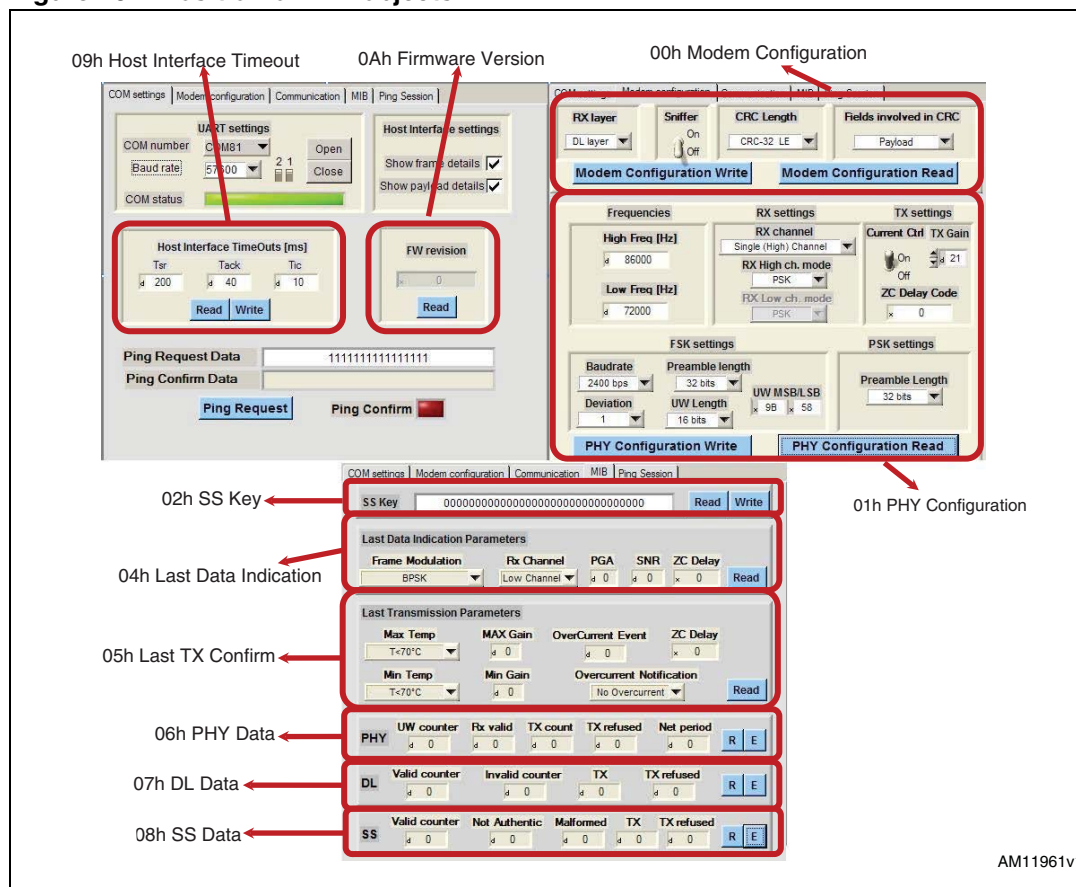
The MIB objects are all accessible through the ST7580 GUI, in accordance with the possible operations and the range of values, as presented in [2]. Table 2 lists the correspondence between MIB objects and the tab where they are accessible in the ST7580 GUI:

Table 2. MIB objects access through ST7580 GUI

MIB object index	MIB object name	ST7580 GUI tab
00h	Modem configuration	Modem configuration
01h	PHY configuration	Modem configuration
02h	SS key	MIB
04h	Last data indication	MIB
05h	Last TX confirm	MIB
06h	PHY_Data	MIB
07h	DL_Data	MIB
08h	SS_Data	MIB
09h	Host interface timeout	COM settings
0Ah	Firmware version	COM settings

The ST7580 GUI automatically handles the MIB subfields in accordance with MIB object composition. *Figure 16* shows the position of MIB objects inside the GUI tabs:

Figure 16. Position of MIB objects



The buttons present on the GUI perform the allowed operations (writing, reading, erasing) on each corresponding object.

5.4 Other ST7580 commands

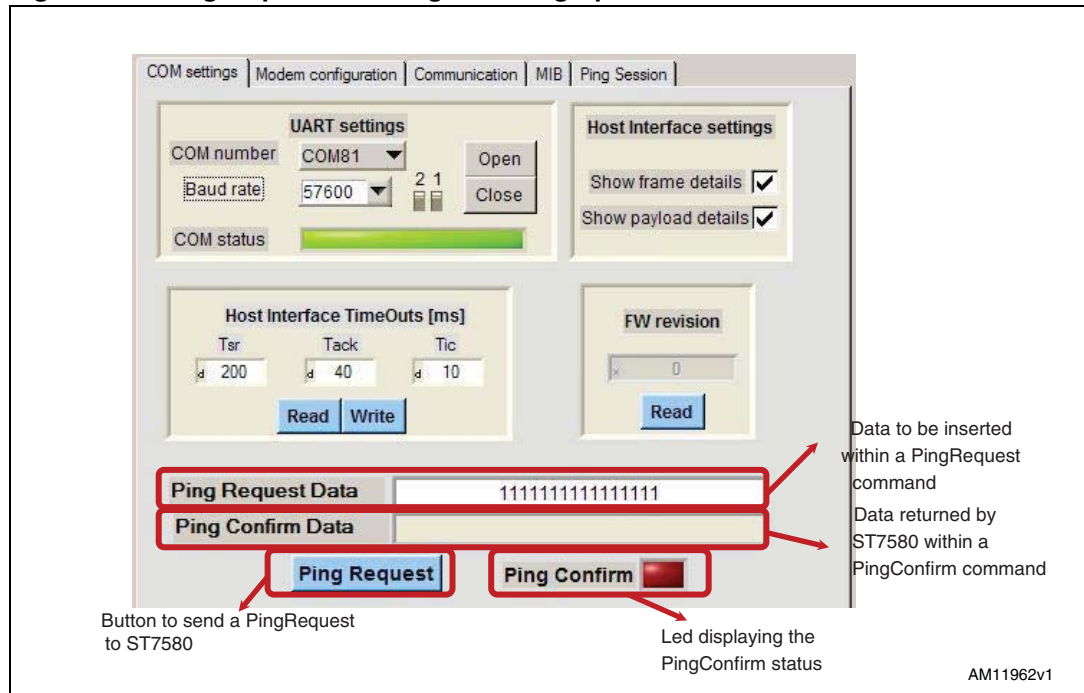
5.4.1 Ping commands

Through a dedicated button located in the COM Settings tab, it is possible to send to the ST7580 a PingRequest command with editable data Payload.

After the execution of the PingRequest command, a PingConfirm command is expected: the success of the previous request and data received are displayed through a dedicated LED and box.

Figure 17 shows all the graphical objects dedicated to the PingRequest and PingConfirm commands:

Figure 17. PingRequest and PingConfirm graphical tools

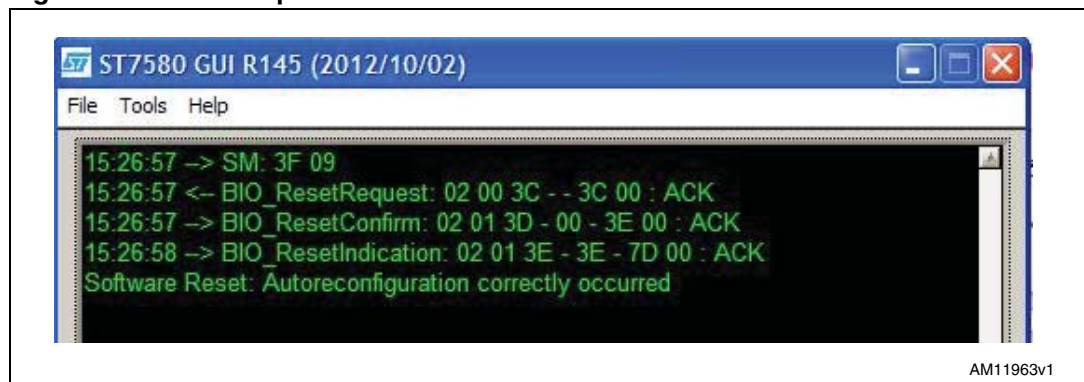


5.4.2 Reset commands

The ResetRequest command can be properly formed and sent to the modem through a dedicated button on the bottom part of the Modem Configuration tab.

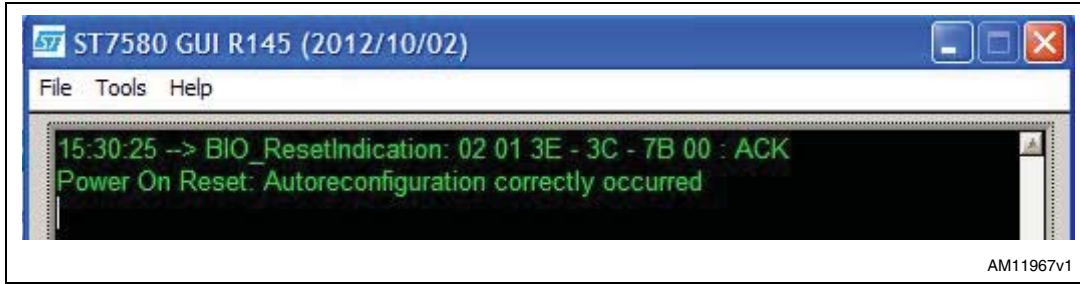
After pressing the button, the console displays the command sequence, declaring it as a “Software Reset” and returning the auto-reconfiguration feature status, as displayed in [Figure 18](#):

Figure 18. ResetRequest command: console view



In the case of a ResetIndication command (generated for example if the RESETN pin is driven at a low state), the unsolicited occurrence is directly displayed on the console and is named as a “Power On Reset” event, as shown in [Figure 19](#):

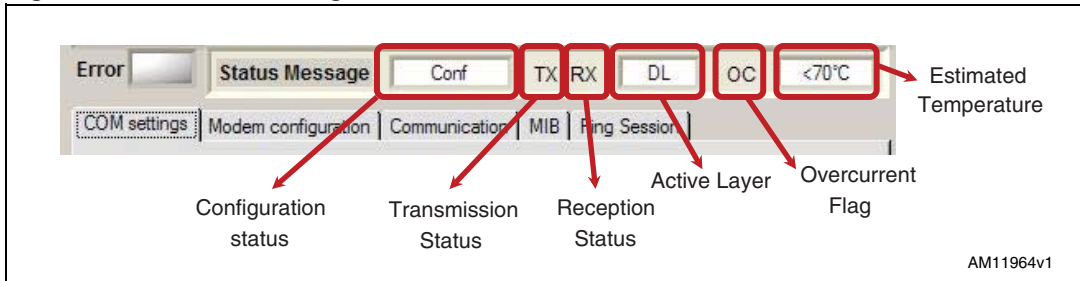
Figure 19. ResetIndication command: console view



5.4.3 Status message

The status message is automatically displayed with all its fields in the box below the GUI console. The meaning of each field is explained in [Figure 20](#):

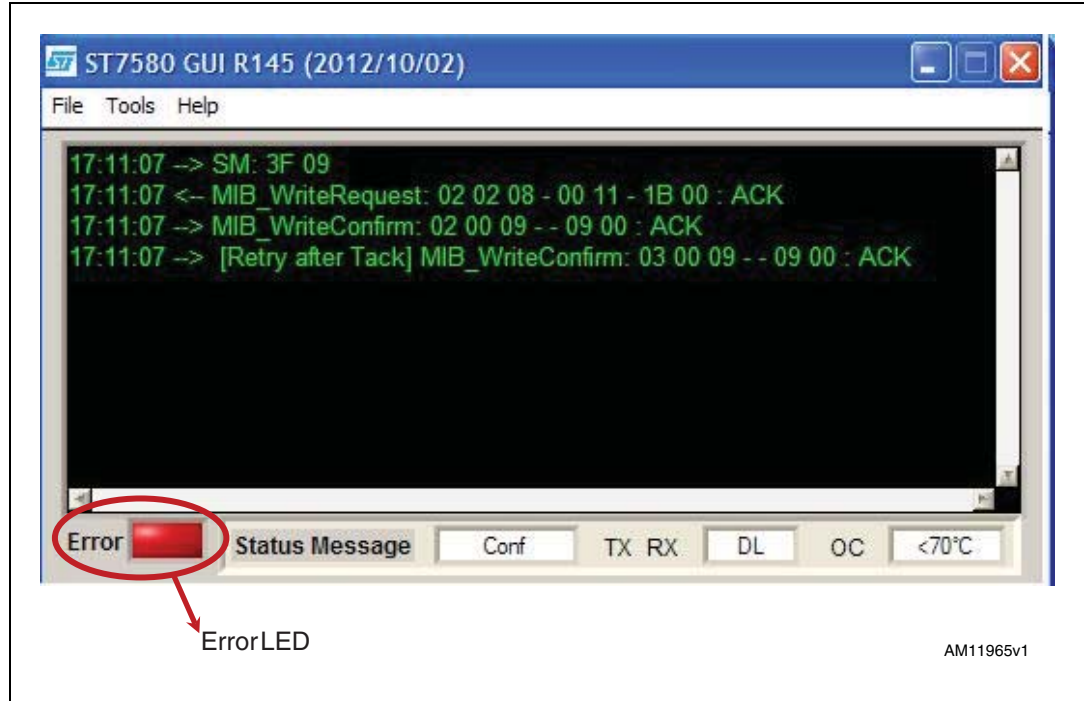
Figure 20. Status message fields



5.5 Host interface errors

The errors on a host interface communication flow (i.e. Timeout elapsed, etc.) are reported on the "Error" LED below the GUI console. [Figure 21](#) shows an occurrence of a host interface error, when the T_{ACK} timeout has elapsed:

Figure 21. Host interface error occurrence



5.6 Ping session

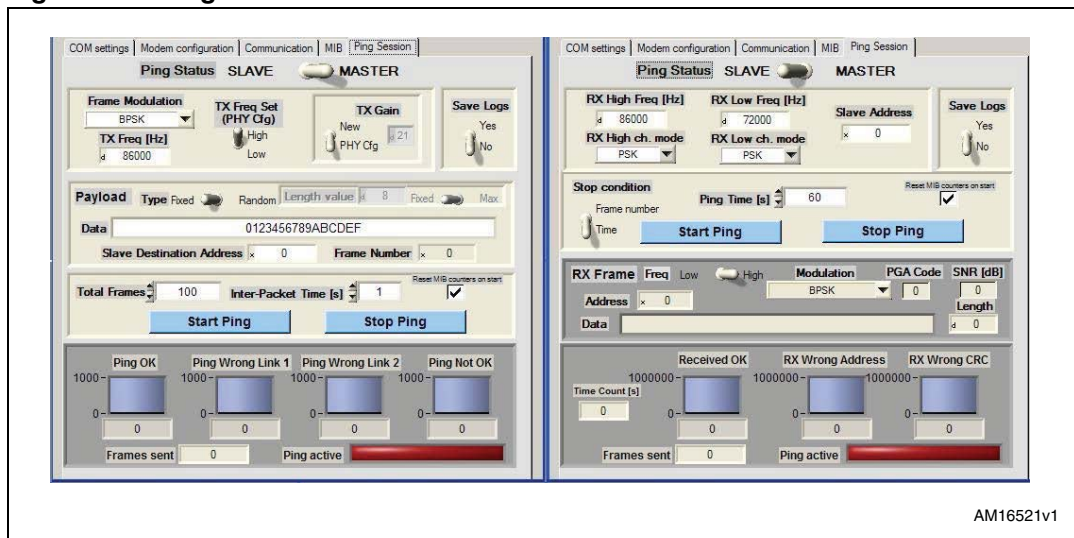
In order to evaluate the reliability of a communication between two or more devices, a Ping session can be performed. A ping session consists of a Master sending a sequence of messages to one or more Slaves. If the messages are correctly received by Slaves, they are re-sent to the Master with the same electrical parameters and Payload data, enabling the application to collect statistical data.

When a Ping session is active, the GUI adds some automatic services to the functions and commands of the ST7580 device.

The Ping tab displays different control and indicator values in accordance with the role that the EVALKITST7580 board, handled by the GUI, has during the Ping session.

Figure 22 shows both Ping tabs for Master and Slave nodes:

Figure 22. Ping session: Master and Slave tabs



The Ping session can be logged in a .txt file, selecting the "Save Logs" switch located on the right-top edge of both Master and Slave tab. The resulting file records the powerline activity (both transmitted and received frames) of the node over the Ping session.

5.6.1 Ping protocol

The Ping session consists of an exchange of DL frames between the Master node and one or more Slave nodes.

Master node

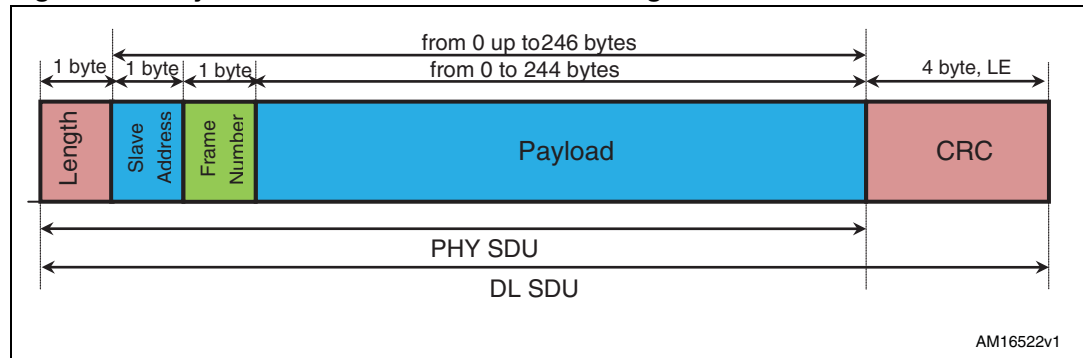
The Master node sends a powerline frame sequence with selectable electrical features:

- Carrier frequency value (it is overwritten in the MIB object 01h - PHY configuration as RX operating frequency);
- Modulation type as in ordinary DL_DataRequest command;
- TX Gain parameter (it is overwritten in the MIB object 01h - PHY configuration).

These electrical characteristics are equal to each transmitted frame in all frames sent by the Master over Ping session.

The GUI tool adds specific subfields to the Payload field of the exchanged DL frames, as shown in *Figure 23*, where the blue parts need to be specified by the user, while the green one is automatically built by the GUI tool. The red blocks refer to the fields automatically handled by the ST7580.

The Payload length selected by the user is limited to 244 bytes.

Figure 23. Payload subfields on DL frames of Ping session

The Master sends periodically, with an inter-packet time selected by the user (in seconds), a burst of DL frames built (see [Figure 23](#)) with a fixed value on Slave Address subfields (1 byte) and an increment value on Frame number subfield. The Frame number value is managed by the GUI and it is equal to 0 on the first DL frame of the Ping session, it increases on next sent frames up to value 255 hexadecimal FF. The next frame, after that with a number of frames equal to 255, is built with a subfield equal to 0.

The user chooses the number of frames to be transmitted by the Master during the Ping session, which ends after sending this number of frames.

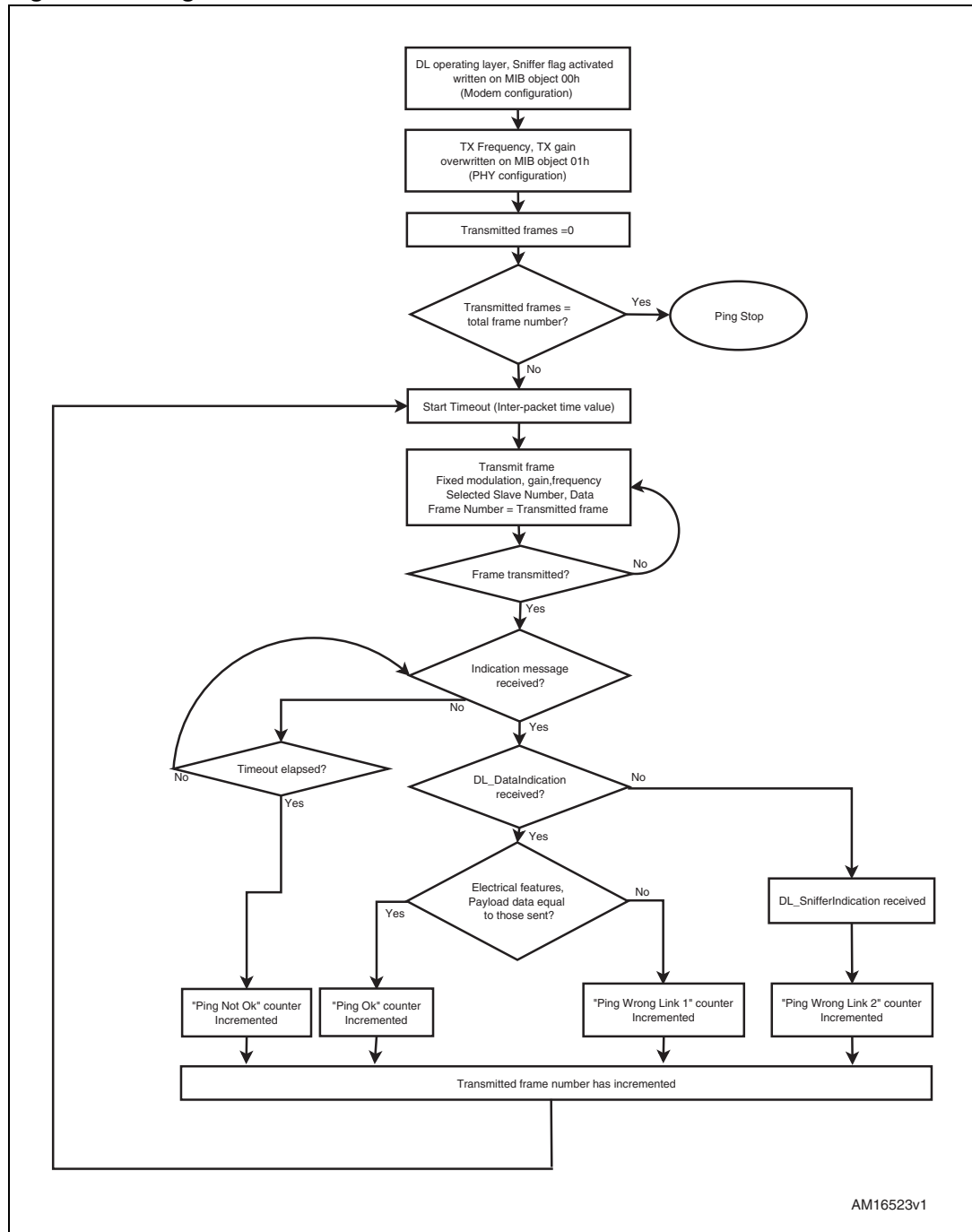
After each sent frame, a further frame is expected to be received to successfully accomplish a single Ping loopback, within an interval with length equal to inter-packet time. In case of a frame received by the Master node, the GUI compares the electrical parameters and Payload to those for transmitted frame. Three cases are taken into account by the GUI:

1. A DL_DataIndication has been notified by the modem reporting the same electrical features (modulation, carrier frequency), the Payload length and data values (over the three subfields) as the last ones to be transmitted. The single Ping loopback is reported as successful by increasing a dedicated "Ping OK" counter;
2. A DL_DataIndication has been notified by the modem reporting different electrical features or Payload data. As DL_DataIndication assumes a correct check on CRC of the powerline frames, the communication link from Slave to Master is considered as good, while the difference of frames are supposed to be due to the link from Master to Slave. Hence, the single Ping loopback is reported as failed, by increasing a dedicated "Ping Wrong Link 1" counter;
3. A DL_SnifferIndication has been notified by the modem. The communication link from Slave to Master is judged to be the cause of the wrong single Ping loopback and dedicated "Ping Wrong Link 2" counter increases.

In case of no Indication message notified by the ST7580 within the inter-packet time interval, the single Ping loopback is judged as failed, by increasing the corresponding "Ping Not OK" counter.

[Figure 24](#) reports the flowchart of Master node throughout Ping session:

Figure 24. Ping session: Master flowchart



Slave node

When a node is set as "Slave" for a Ping session, it automatically answers each received frame by sending a packet built with identical electrical features and Payload data.

Before starting the Ping session, the node needs to be configured with two frequency values for reception and the corresponding functional modulations. These values are overwritten to MIB object 01h (Physical configuration) and the node is set to work on a dual channel reception.

From a functional point of view, a Slave Address Number is assigned as well, as 1-byte value. The Slave node re-transmits the frames with Slave Address subfield (*Figure 23*) equal to the Slave Address Number assigned to it.

The GUI allows the user to choose between two Stop conditions:

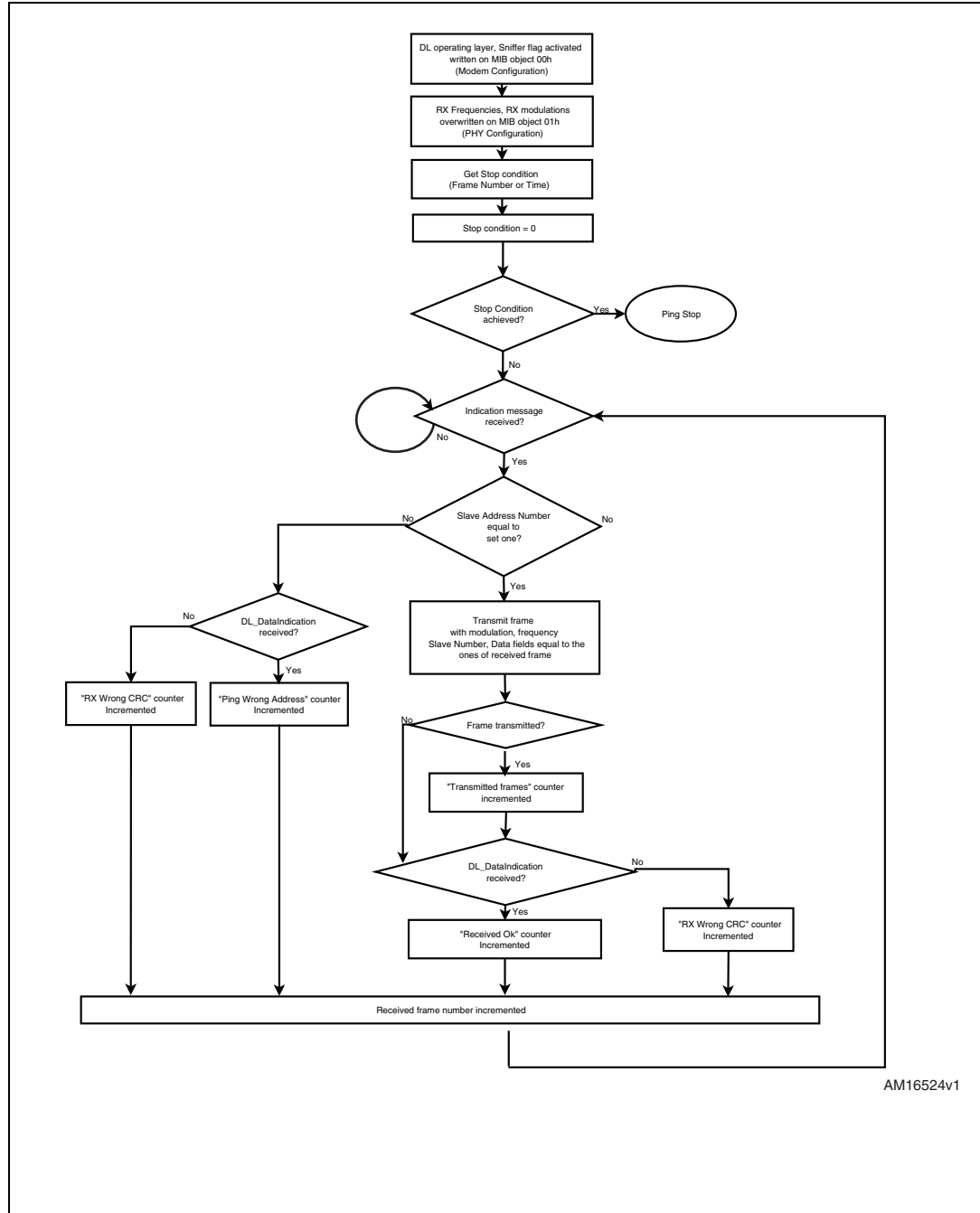
1. Frame number: the GUI stops the Ping session after the node receives a fixed number of Indication messages (DL_DataIndication and DL_SnifferIndication);
2. Time: the GUI stops the Ping session after a number of seconds selected by the user (if the number set through the GUI is equal to 0, the Ping session ends when the "Stop Ping" button is pressed).

After an Indication message, three cases are taken into account and displayed by the GUI:

1. A DL_DataIndication has been notified by the modem and the Frame Address subfield is equal to the Frame Address parameter set to the node; the Node sends a powerline frame with same electrical conditions (Frequency carrier, modulation) and data Payload (in accordance with *Figure 23* subfields). The dedicated "Received OK" counter increases.
2. A DL_DataIndication has been notified by the modem and the Frame Address subfield is not equal to the Frame Address parameter set to the node; the dedicated "RX Wrong Address" counter increases and any frame is transmitted.
3. A DL_SnifferIndication has been notified by the ST7580: the dedicated "RX Wrong CRC" counter increases. However, if the Frame Address subfield is equal to the Frame Address parameter set to the node, a powerline frame is transmitted with same electrical conditions (Frequency carrier, modulation) and data payload (in accordance with *Figure 23* subfields).

Figure 25 reports the flowchart of Master node throughout the Ping session:

Figure 25. Ping session: slave flowchart



AM16524v1

5.6.2 Ping Master session

As shown in *Figure 26*, the following parameters listed in *Table 3*, can be selected for the Ping session corresponding to Master device. "Control" parameters are the variables that can be selected by the user, while "indicators" are automatically displayed by the GUI during the Ping session.

Figure 26. Ping Master tab

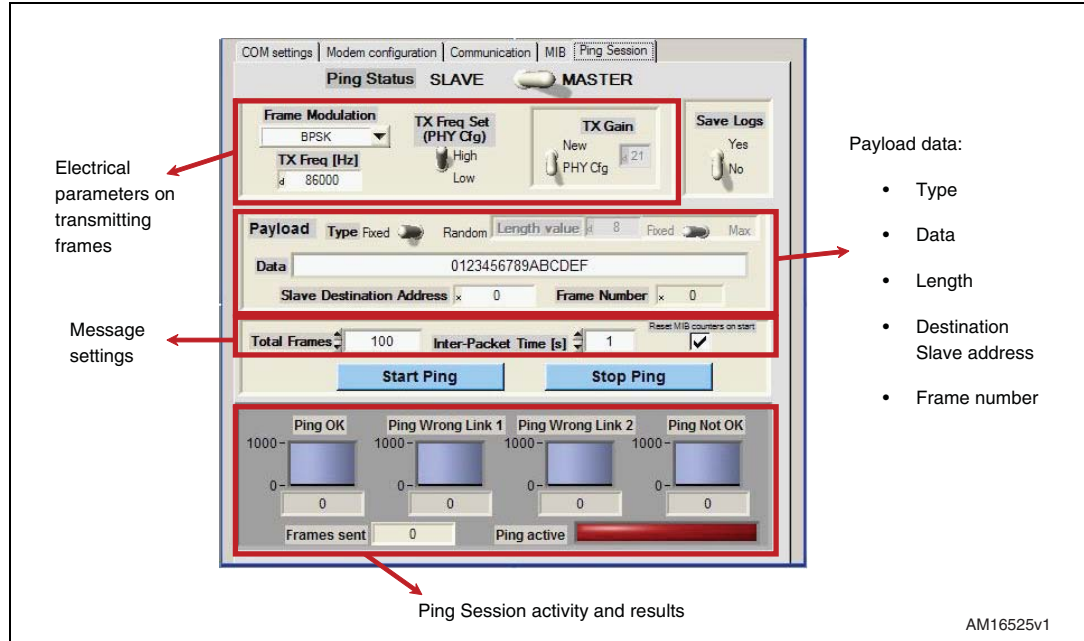


Table 3. Ping session: Master tab parameters

Parameter	Type	Description
Electrical parameters of transmitting frames		
Frame modulation	Control	Choice of modulation type for frames to be transmitted during Ping session
TX frequency [Hz]	Control	Frequency value for frames to be transmitted during Ping session.
TX frequency set (PHY configuration)	Control	Frequency value expressed in the box "TX Freq [Hz]" is written as reception frequency in MIB object 01h (PHY configuration) in accordance with the value (high or low) chosen by this switch. If a combination of these two control values is not allowed, an error is generated and Ping session doesn't start.
TX Gain	Control	Selection of the TX Gain to be set for transmitting frames: it can be used either the value stored in the MIB object 01h ("PHY Cfg" selection for this switch) or a new one ("New" selection for this switch) to be expressed in the value box which is overwritten in the same MIB object.
Payload data		
Type	Control	Selection for data composition of outgoing messages: - "Fixed" is specified by the user in the box below - "Random" is automatically generated by the GUI
Length value	Control or indicator	Length [bytes] for the transmitting Payload - automatically calculated by the GUI for Fixed Payload - selected by the user for Random Payload
Random Payload length	Control	Selection for Random Payload type only. - "Fixed" sets the parameter "Length value" expressed in the left-side box as fixed length for each transmitting frame; - "Max" sets as the maximum length of each randomly generated frame, whose length is not fixed;
Data	Control or indicator	Data of Payload of outgoing powerline frame, displayed in hexadecimal values only. - filled in by the user in case of "Fixed" frame type selection and it is a constant value for each transmitted frame; - automatically displayed for "Random" frame type selection, its value is different in each transmitting frame
Slave Destination Address	Control	1- byte field (hexadecimal value) referring to the Slave Address value. It is inserted by the GUI as the first byte of Payload field of each DL_DataRequest built throughout the Ping session.
Number of frames	Indicator	1- byte field (hexadecimal value) automatically displayed by the GUI. It displays the ordinal number of transmitted frame and it is inserted by the GUI as second byte of Payload field of each DL_DataRequest built throughout the Ping session.
Message settings		
Total frames	Control	Number of powerline frames that the Ping session sends throughout the Ping session

Table 3. Ping session: Master tab parameters (continued)

Parameter	Type	Description
Inter-packet time [s]	Control	Interval which the GUI sets during two consecutive transmitted frames within Ping Session. Minimum value is 1 second.
Reset MIB counters on start	Control	Selection to erase MIB objects 06h (PHY Data) and 07h (DL Data) before Ping session starts.
Start and Stop buttons		
Start Ping	Control	Button to start the Ping session
Stop Ping	Control	Button to force the Ping session when the transmitted frames are less than the selected total frame number.
Ping session activity and results		
Ping OK	Indicator	Number of Ping loop (transmitted and received) performed without any wrong received bit.
Ping Wrong Link 1	Indicator	Number of Ping loop (transmitted and received) performed with wrong received bit during the communication from Master to Slave
Ping Wrong Link 2	Indicator	Number of Ping loop (transmitted and received) performed with wrong received bit during the communication from Slave to Master
Ping Not OK	Indicator	Number of Ping loop (transmitted and received) performed with no loopback frame reception by the Master
Frame sent	Indicator	Number of frames successfully transmitted by the Master, updated by the GUI during the Ping session execution.
Ping active	Indicator	LED displaying the Ping session activity: -Green when Ping session is active; -Red when Ping session is not active.

5.6.3 Ping Slave session

As shown in [Figure 27](#), the following parameters, listed in [Table 4](#), can be selected for the Ping session corresponding to Slave device.

Figure 27. Ping Slave tab

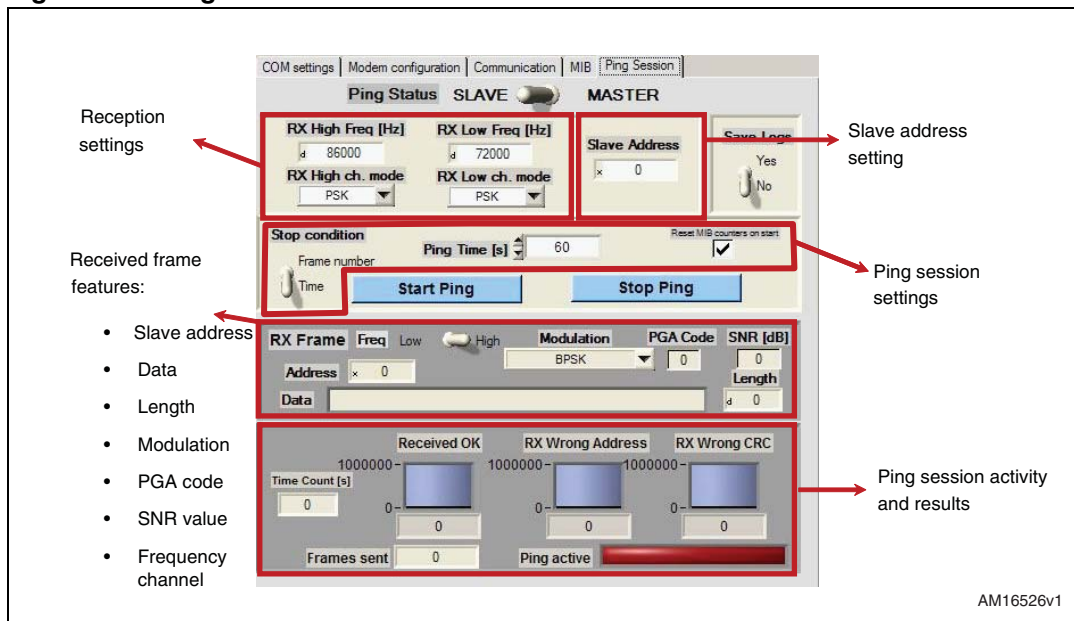


Table 4. Ping session: Slave tab parameters

Parameter	Type	Description
Reception settings		
RX high freq [Hz]	Control	Frequency channel to be set for reception. It is overwritten before starting Ping session as “High Frequency” value in MIB object 01h (PHY configuration)
RX high channel mode	Control	Functional modulation (between PSK and FSK families) on high channel. It is overwritten before starting Ping session as “RX high channel modulation” value in MIB object 01h (PHY configuration)
RX low freq [Hz]	Control	Frequency channel to be set for reception. It is overwritten before starting Ping session as “Low Frequency” value in MIB object 01h (PHY configuration)
RX low channel mode	Control	Functional modulation (between PSK and FSK families) on high channel. It is overwritten before starting Ping session as “RX low channel modulation” in MIB object 01h (PHY configuration)
Slave address settings		
Slave address	Control	1-byte value (hexadecimal value) that sets the address value of the Slave throughout the Ping session. The Slave retransmits the received frames with the address field equal to this value.
Ping session settings		
Stop condition	Control	Selection on stop event for Ping session - Time: the Ping session ends after a selected time interval (in seconds) - Frame numbers: the Ping session ends after reception of a selected frame number (not necessarily re-transmitted)

Table 4. Ping session: Slave tab parameters (continued)

Parameter	Type	Description
Ping time[s] or Frame numbers	Control	Occurrence number of Stop condition selection. The variable is displayed in accordance with "Stop condition" value. If Ping Time is set to 0, the Ping session continues until "Stop Ping" button is pressed.
Reset MIB counters on start	Control	Selection to erase MIB objects 06h (PHY Data) and 07h (DL Data) before starting the Ping session.
Start and Stop buttons		
Start Ping	Control	Button to start the Ping session
Stop Ping	Control	Button to force the Ping session before the Stop condition is achieved.
Received frame features		
Slave address	Indicator	Slave address field of the last received frame (i.e., first byte of the DL_DataIndication or DL_SnifferIndication received by the ST7580)
Data	Indicator	Payload data (without Slave address field) of the received frame
Length	Indicator	Length (in bytes) of the Payload data, calculated by the GUI
Modulation	Indicator	Signal modulation of the received frame
PGA code	Indicator	PGA value on the received frame
SNR value	Indicator	SNR estimation (over UW reception) performed by ST7580
Frequency channel	Indicator	RX channel (high or low) on the received frame
Ping session activity and results		
Time count [s]	Indicator	Number of seconds elapsed during Ping session. Active if "Stop condition" is equal to time only, hidden otherwise.
Received OK	Indicator	Number of received frames with correct CRC (i.e. DL_DataIndication notified by the ST7580) and Slave address field equal to the value set in "Slave Address" control. These frames are re-transmitted, in accordance with Ping session rules.
RX Wrong Address	Indicator	Number of received frames with correct CRC (i.e. DL_DataIndication notified by the ST7580) and Slave address field not equal to the value set in "Slave Address" control.
RX Wrong CRC	Indicator	Number of received frames with wrong CRC (i.e. DL_SnifferIndication notified by the ST7580).
Frames sent	Indicator	Number of frames successfully transmitted by the Slave, updated by the GUI during Ping session execution
Ping active	Indicator	LED displaying the Ping session activity: -Green when Ping session is active; -Red when Ping session is not active.

5.6.4 Starting and stopping a Ping session

For both Master and Slave nodes, the Ping session manually starts by pressing "Start Ping" button, while the session stops either automatically (if Stop condition is achieved) or manually, pressing "Stop Ping" button.

6 References

1. ST7580 datasheet: FSK, PSK multi-mode power line networking system-on-chip;
www.st.com/powerline
2. UM0932: ST7580 - FSK, PSK multi-mode power line networking system-on-chip; Rev 2
www.st.com/powerline

7 Revision history

Table 5. Document revision history

Date	Revision	Changes
11-Apr-2012	1	Initial release.
05-Dec-2012	2	Changed: <i>Figure 1, Figure 8, Figure 9, Figure 10, Figure 11, Figure 12, Figure 13, Figure 15, Figure 16, Figure 17, Figure 18, Figure 19, Figure 20, Figure 21.</i> Added <i>Section 5.6.</i>

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