Teleconnect
Verbindungen in die Zukunft

SOCRATES Series
SHDSL.EVB.1CH V1.0

User Manual

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Revision History:

Current Revision: 2.1.0, 2017-12-19

Revision	Date	Comment
1.0.0	2015-02-01	Initial revision for software release 1.0
1.2.1	2015-04-20	Update to software release 1.2
1.2.2	2015-04-27	Minor changes
1.3.1	2015-08-25	Update to software release 1.3
2.0.0	2017-07-14	Update to software release 2.0
2.1.0	2017-12-19	Update to software release 2.1

Table of Contents

List of Figures

1 Introduction

1.1 Scope of this Document

This document describes the hardware and software to get started with the SHDSL 1-Channel Evaluation Board from the Teleconnect SOCRATES series. The product code “SHDSL.EVB.1CH V1.0” used for this document.
Teleconnect (http://www.teleconnect.de/xdsl/socrates-evb) provides all necessary documentations for recreating of the hardware. This includes schematic, components layout placement, board outline, PCB layout, bill of materials and available software features. Gerber files are available upon request.

1.2 General Introduction

The new SHDSL.EVB.1CH V1.0 reference design targeting industrial designs enables customers to take advantage of Intel® SHDSL Chipset (previously known as "Lantiq SOCRATES™-1E") for long reach broadband connectivity. It is the first ever ready-to-copy reference design developed for the Intel® SHDSL Chipsets. The SHDSL/Ethernet Bridge Modem was developed by Teleconnect and measures only about 9 x 5 cm. It is available for online purchase through:

- Würth Elektronik webshop (http://www.we-online.com/socratesdemo) and
- CODICO® webshop (https://www.codico.com/shop/en/shdsl-evaluation-board.html).

Teleconnect offers dedicated support for board and software customizations. With this Evaluation Board you get an Evaluation License for the Software Package 1 (basic communication). You can request some evaluation licenses for different features at shdsl@teleconnect.de. With this, for the first time ever, even smaller companies without DSL expertise can include SHDSL and Long-Reach-Ethernet connectivity into their designs.
SHDSL’s unique rate/reach performance makes it the product of choice in an ever more diversified field of applications ranging from business broadband access to enterprise networks and industrial communications.
Known as long haul Ethernet, SHDSL was included in the Ethernet standard IEEE 802.3-2008 [1], where it is named 2BASE-TL. Standard Ethernet has a maximum reach of 100 m. SHDSL has a reach beyond 15 kilometres.
Using SHDSL enables costumer to transmit Ethernet over only one unshielded twisted wire pair or over any other cable. The general structure of SHDSL is shown at Figure 1.

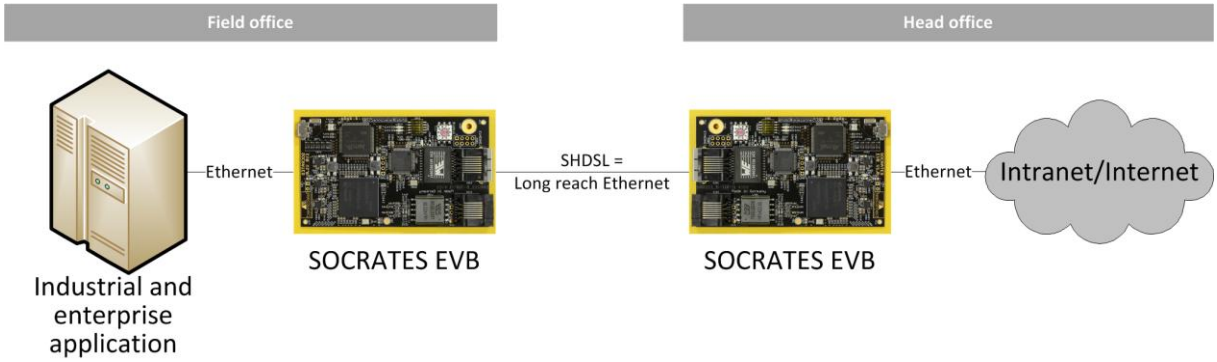

Figure 1: Structure of SHDSL Link

1.3 Content of the SHDSL.EVB.1CH V1.0 Evaluation Board Kit

The evaluation kit contains the SHDSL.EVB.1CH V1.0 Evaluation Board shown in Figure 2. Beside this you need a power source provided via micro USB cable. For Ethernet and SHDSL connection, standard Ethernet patch cables can be used.

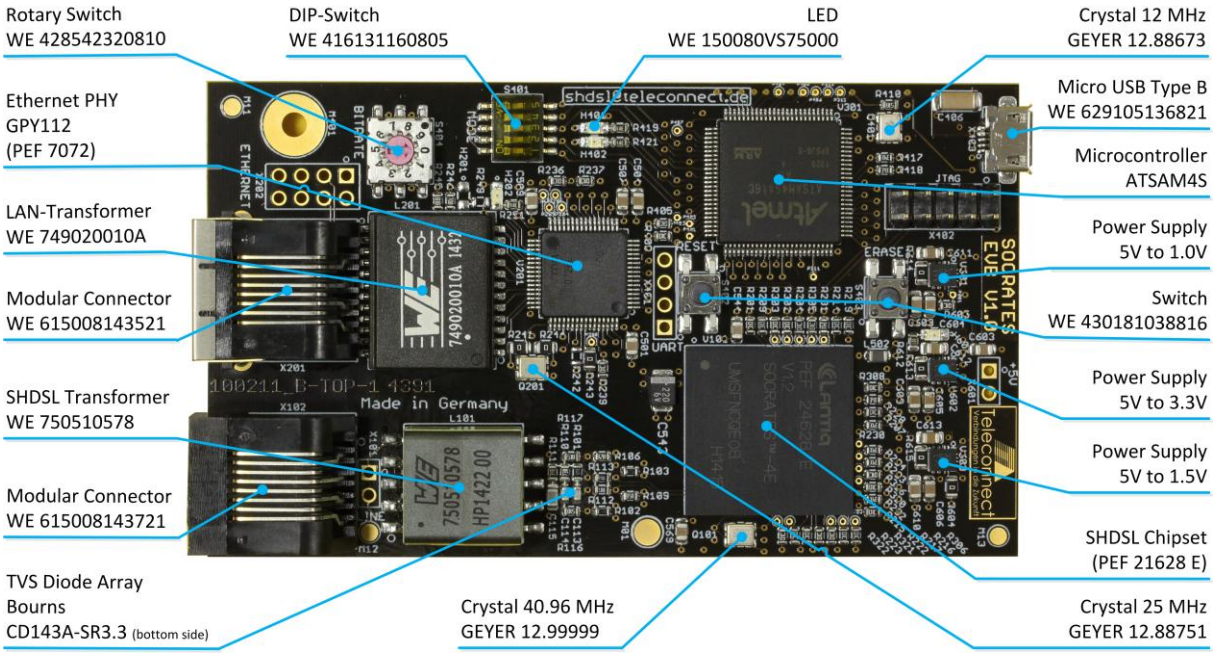

Figure 2: Components of SHDSL.EVB.1CH V1.0 Evaluation Board

Please consider the changes for the chip manufacturers (Lantiq was acquired by Intel®). In the past, the SHDSL transceiver PEF 21628 E was offered by Lantiq as SOCRATES™-1E with identical PEF number. Now the SHDSL chipset is offered by Intel® as *Intel® SHDSL Chipset*. This also applies to the Ethernet PHY. In the past, the XWAY™ PHY11G was offered by Lantiq, now the chip is called *Intel® Ethernet Network Connection GPY112* and offered by Intel®.
In 2016, Microchip agreed to buy Atmel®. That´s the reason why the Atmel® microcontroller ATSAM4S is now part of Microchip product spectrum.

2 Block Diagram

Figure 3 shows the block diagram of the SHDSL.EVB.1CH V1.0 Evaluation Board.

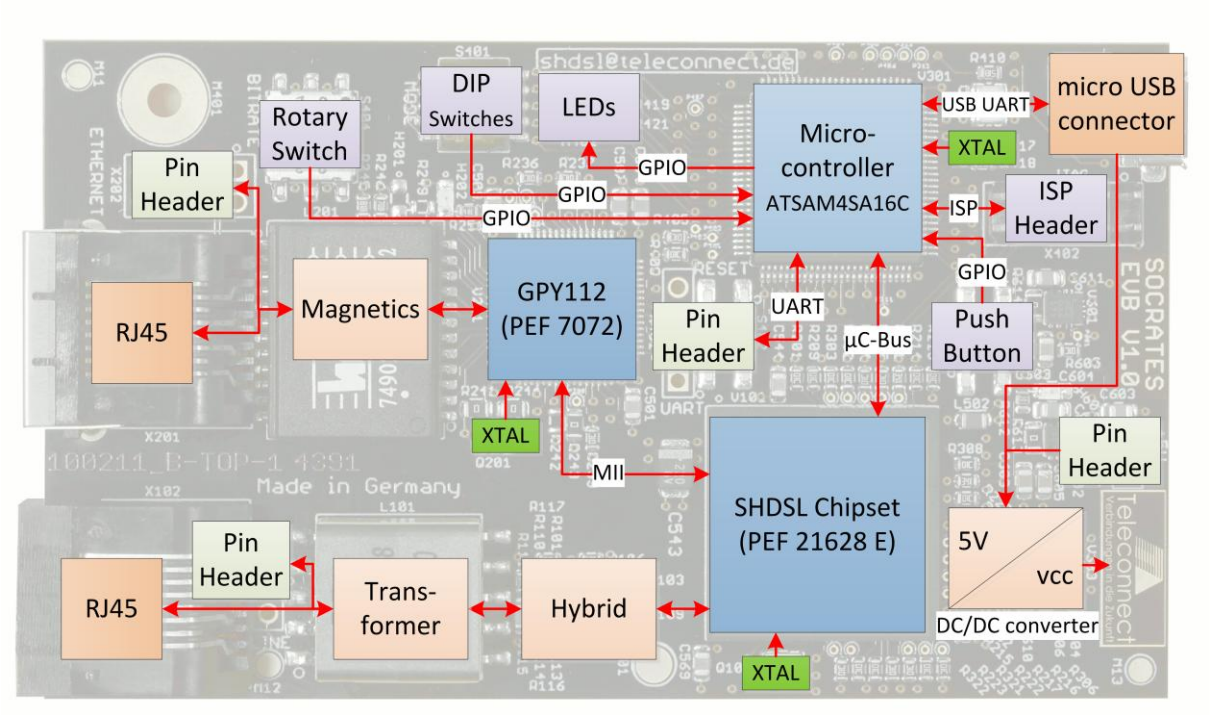

Figure 3: Block Diagram of the SHDSL.EVB.1CH V1.0 Evaluation Board

The SHDSL.EVB.1CH V1.0 Evaluation Board consists of the following blocks:

- SHDSL transceiver Intel® SHDSL Chipset (PEF 21628 E) (previously known as "Lantiq SOCRATES-1E" with same PEF number).
  The functionality of the Evaluation Board could also be realized with the 2ch or 4ch versions of the Intel® SHDSL Chipsets (PEF 22628 E and PEF 24628 E). Teleconnect provides 4ch SHDSL Evaluation Board also (product code: SHDSL.4CH.EVB V1.0).
  In any case only one channel is used by SHDSL.EVB.1CH V1.0.
- Intel® Ethernet Network Connection GPY112 (PEF 7072), Version 1.6 (previously known as "Lantiq PHY11G").
  The GPY112 is a Gigabit Ethernet PHY. However, in this application only 10/100BaseTX is available.
- Microcontroller Microchip ATSAM4SA16C (previously known as "Atmel ATSAM4SA16C").
  The microcontroller is used for configuration, controlling and monitoring. The requirements of the microcontroller are very low, e.g. an 8 bit controller has enough performance for SHDSL. We use the ARM® based microcontroller to provide a highly flexible evaluation platform.
- RJ45 connectors (shielded for Ethernet and unshielded for SHDSL), both from Würth Elektronik eiSos GmbH
- Micro USB connector Type B (Würth Elektronik eiSos GmbH),
- SHDSL Hybrid including SHDSL transformer (Würth Elektronik eiSos GmbH),
- Ethernet magnetics (Würth Elektronik eiSos GmbH),

- DC/DC converter from 5 V to 3.3 V, 1.5 V and 1.0 V. Three voltage regulators from MPS (Mini-Module Family) are used.
- XTAL for SHDSL-transceiver, Ethernet-PHY and Microcontroller (Geyer Quarz),
- Input and Output components (Würth Elektronik eiSos GmbH):
    - Rotary switch and DIP switches,
    - Push buttons,
    - ISP pin header for debugging of the microcontroller,
    - LEDs.

3 Interfaces

This chapter describes the interfaces and header pinouts of the SHDSL.EVB.1CH V1.0 Evaluation Board.

3.1 Design Overview

The design with its main function blocks and important components are shown in Figure 4. The description for it is given in the following section.

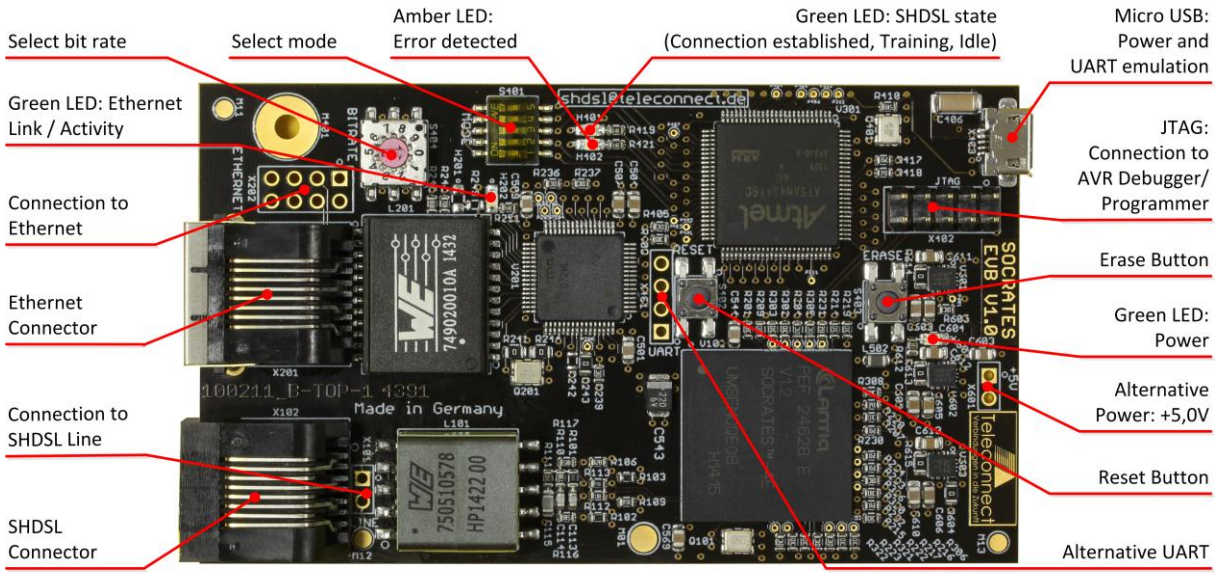

Figure 4: Design of the SHDSL.EVB.1CH V1.0 Evaluation Board

3.2 SHDSL Interface

The SHDSL interface is divided in SHDSL connector, SHDSL Transformer, Protection, Hybrid and SHDSL data pump (see Figure 5).

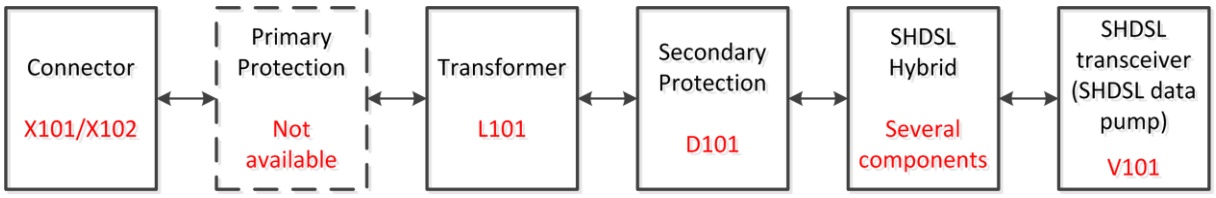

Figure 5: SHDSL Interface

Additional primary protection is necessary depending on requirements. There is no primary protection on the evaluation board available.
The connector X102 is an unshielded RJ45 connector. It is used for connecting the SHDSL.EVB.1CH V1.0 to one SHDSL line (according ITU-T G.991.2 [2]). Table 1 shows the pin definition of X102.

Table 1: Pin Definition of X102

Pin Number	Pin Name / Function
1 … 3	Not connected
4	SHDSL line – Tip
5	SHDSL line – Ring
6 … 8	Not connected

Typical lines are unshielded twisted pair cables. Any standard Ethernet cable is also usable. Beside the RJ45 connector X102 SHDSL.EVB.1CH V1.0 provides the possibility to use the pin header X101 spaced 2.54 millimetres (0.1 in). Table 2 gives the pin definition.

Table 2: Pin Definition of X101

Pin Number	Pin Name / Function
1	SHDSL line – Tip
2	SHDSL line – Ring

The pin header X101 is not mounted by default. It is possible to mount it on both PCB sides to get an easy test adapter for evaluation or to use the SHDSL.EVB.1CH V1.0 as a module. Figure 6 shows the schematic of the SHDSL hybrid with line transformer L101 and SHDSL data pump V101 (PEF 21628 E).

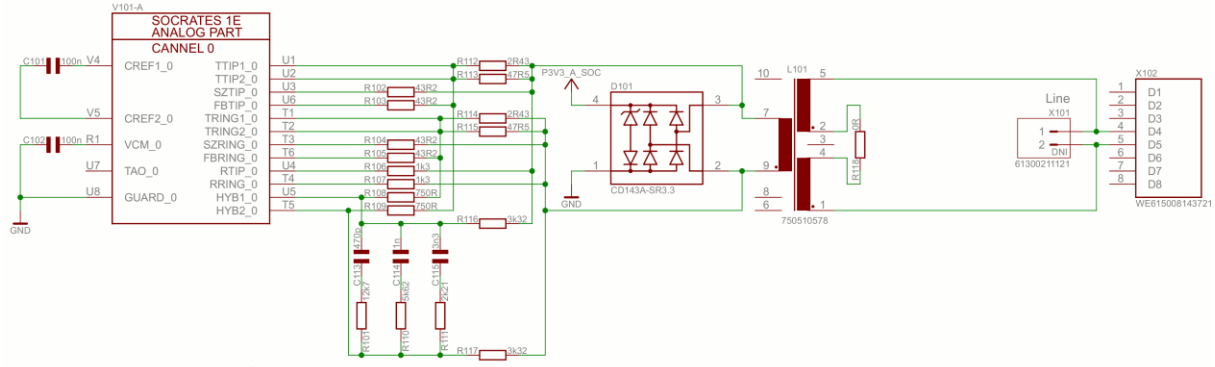

Figure 6: (Extract from) Schematic of SHDSL Hybrid

Components and layout are influencing the SHDSL performance. Teleconnect can assist you with the selection of additional line protection at raw ambient conditions.
There are pin compatible 2 and 4 channel SHDSL chips available. However, SHDSL.EVB.1CH V1.0 provides only one SHDSL channel.
Please note, depending on serial number your SHDSL.EVB.1CH V1.0 may be mounted PEF 21628 E or PEF 24628 E.

3.3 Ethernet Interface

The Ethernet interface is divided in connector, transformer (magnetics) and Ethernet PHY (see Figure 7).

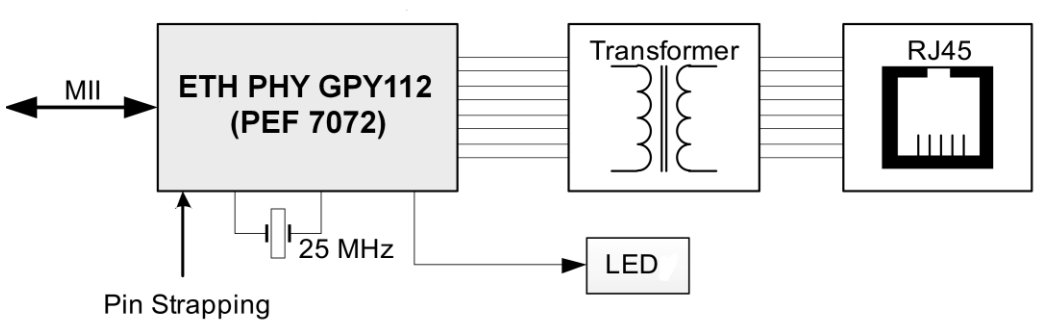

Figure 7: Ethernet interface

The shielded RJ45 connector X201 is a standard Ethernet interface. It is compatible with 10BASE-T and 100BASE-TX Ethernet according to IEEE 802.3 [3] and can be connected to a twisted pair medium such as CAT5 cable infrastructure.

Beside the RJ45 connector, SHDSL.EVB.1CH V1.0 provides the possibility to use the pin header X202 spaced 2.54 millimetres (0.1 in). Figure 8 and Table 3 gives the pin definition.

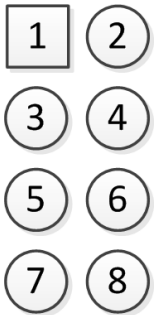

Figure 8: Pin Definition of X202

Table 3: Pin Definition of X202

Pin Number	Pin Name / Function
1	TX/RX1 +
2	TX/RX1 -
3	TX/RX2 +
4	TX/RX2 -
5	Not used for 10/100BASE-TX
6	Not used for 10/100BASE-TX
7	Not used for 10/100BASE-TX
8	Not used for 10/100BASE-TX

The pin header X202 is not mounted by default. It is possible to mount it on both PCB sides to get an easy test adapter for evaluation or to use the SHDSL.EVB.1CH V1.0 as module (see chapter 7).
The transformer L201 connects the connector to the Ethernet PHY GPY112 V201 (PEF7072). The connection to the SHDSL data pump Intel® SHDSL Chipset V101 is realized via standard MII interface.
Figure 9 shows the schematic of the Ethernet interface.

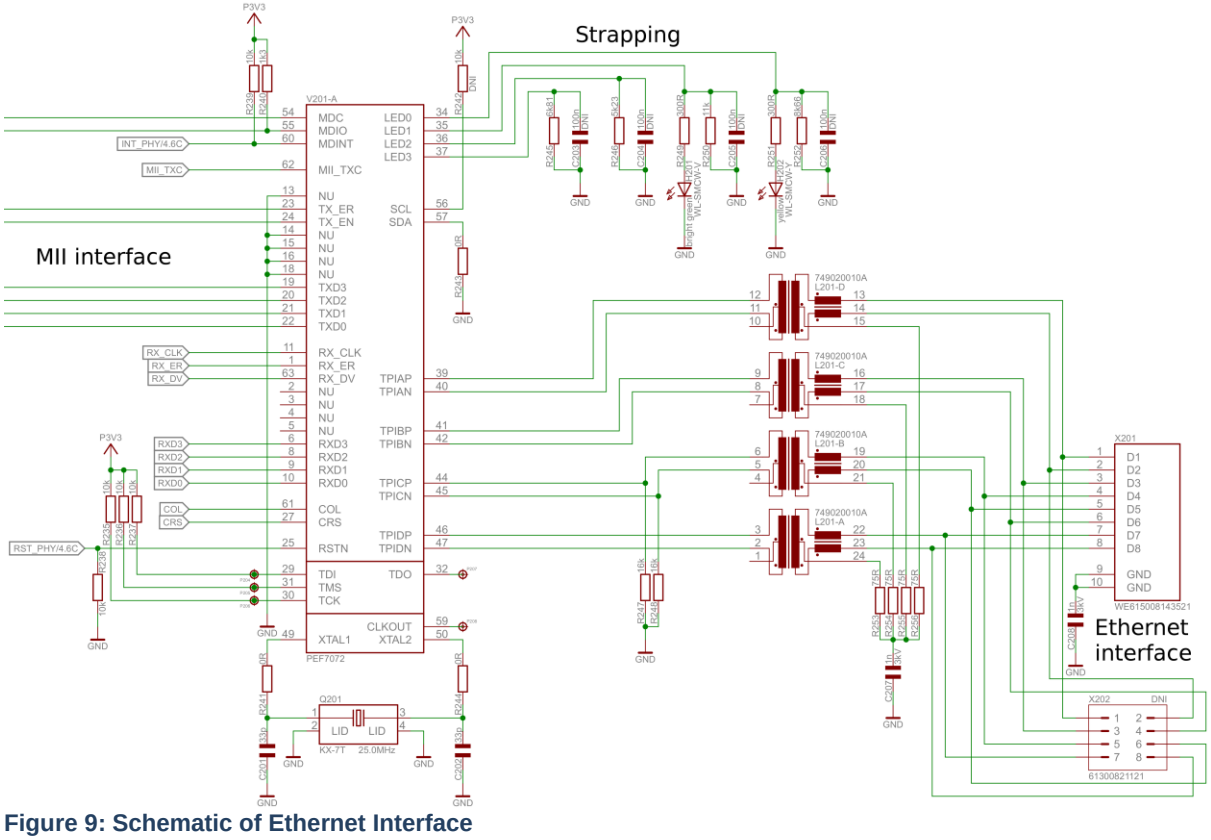

Figure 9: Schematic of Ethernet Interface

3.4 Power Supply Input

For the power supply a Micro USB connector Type B with standard pin assignment (according to USB specification) is used. This enables the EVB to utilize a standard 5V USB plug-in power supply as power source. We recommend using power supply with at least 500 mA output current (which is commonly given). Please note the power consumption of the

SHDSL.EVB.1CH V1.0 with PEF 24628 E is similar to EVB with PEF 21628 E mounted (Firmware working in 1 channel operation mode).
It is also possible to connect the Micro USB connector to any self-powered USB host interface with the standard USB cable. Please note that SHDSL.EVB.1CH V1.0 has no standard USB conform interface because of missing power management. However, commonly it works.
Beside the Micro USB connector SHDSL.EVB.1CH V1.0 provides the possibility to use the pin header X601 spaced 2.54 millimetres (0.1 in) for power supply. Table 4 gives the pin definition.

Table 4: Pin Definition of X601

Pin Number	Pin Name / Function
1	+ 5 V (4.0 … 6.0 V)
2	- (Ground)

The pin header X601 is not mounted by default. It is possible to mount it on both PCB sides getting an adapter or using the SHDSL.EVB.1CH V1.0 as module.
The Micro USB connector is also usable for data transmission to the processor. In that case UART emulation provides a serial interface.

3.5 Power Consumption

The power consumption of the SHDSL.EVB.1CH V1.0 Evaluation Board is nearly independent from the traffic on the line. It is maximum 1,5 W.

Boundary conditions:

- Intel® SHDSL Chipsets (PEF 24628 E)
- Firmware: app20-dbg-R1964 (Jan 27 2017, 09:49:45)
- Function: CO
- Cable length: 1 m
- Power Back Off inactive
- Power 5 V

Table 5: Power Consumption of the SHDSL.EVB.1CH Evaluation Board without traffic

Bitrate [Kbps]	Power [mA]	Power Consumption [W]	TCPAM	Ethernet active
no connection	204	1,02	16	no
512	254	1,27	16	yes
1024	258	1,29	16	yes
2032	261	1,31	32	yes
5192	280	1,40	32	yes
15288	272	1,36	128	yes

Table 6: Power Consumption of the SHDSL.EVB.1CH Evaluation Board with full traffic

Bitrate [Kbps]	Power [mA]	Power Consumption [W]	TCPAM	Ethernet active
512	253	1,27	16	yes
1024	256	1,28	16	yes
2032	259	1,30	32	yes
5192	279	1,40	32	yes
15288	271	1,36	128	yes

3.6 Serial Interface (UART)

SHDSL.EVB.1CH V1.0 features a serial interface (UART) for controlling and monitoring purposes. The interface is usable in two ways: UART emulation via USB interface and TTL-compatible interface via connector X401. Both interfaces have the same function and can work simultaneously.
The pin header X401, also named “UART”, is not mounted by default. It is possible to mount any 2.54 millimetres (0.1 in) spaced pin header at both sides of the PCB. So the soldering pads are usable as an easy test adapter for evaluation or as a module placed on a host board.
Table 7 shows the pin definition of X401.

Table 7: Pin Definition of X401

Pin Number	Pin Name / Function
1	+ 3.3V
2	TX (sending data from SAM4S)
3	RX (receiving data by SAM4S)
4	Ground

3.7 Debug interface

The controlling processor of SHDSL.EVB.1CH V1.0 is Microchip ATSAM4SA16C. Based on the powerful ARM® Cortex®-M4 core, the SAM4S series gives improved performance, low power consumption and an easy to use processor. The processor gives much more performance and periphery than SHDSL chipset needs. This offers a good basis for the development of own software.
With the connector X402 (“JTAG”) SHDSL.EVB.1CH V1.0 provides a compatible interface to Microchips development and debugging tools. For example the SAM-ICE™, Microchips JTAG Emulator for ARM® core-based microcontrollers is usable.

X402 is a 2.54 millimetres (0.1 in) spaced pin header. The pin definition is given at Table 8.

Table 8: Pin Definition of X202

Pin Number	Pin Name / Function
1	TCK
2	Ground
3	TDO
4	+ 3.3V
5	TMS
6	Reset (NRST)
7	Not used
8	Not used
9	TDI
10	Ground

3.8 Control and Monitoring Interface

SHDSL.EVB.1CH V1.0 provides on board software usable for many standard applications. For configuration and status information, several buttons, switches and LEDs are available. The following section gives more information.

3.8.1 Buttons

There are two buttons available. The first is the button S402 called “RESET”. Pressing this button triggers hardware reset of the processor and the SHDSL interface. The software restarts and makes new initialisation of SHDSL.EVB.1CH V1.0.
The second button is the button S403 called “ERASE” with two functions. During reset (Reset button is also pressed) the whole flash memory will be cleared. This is necessary to reload a new Firmware version via processor’s SAM-BA interface. During runtime, additional information about software, SHDSL firmware version and SHDSL configuration will be printed to serial interfaces (UART and USB) if the button “ERASE” is pressed.
Please see Figure 4 for the location of the buttons.

3.8.2 DIP switches

The dual in-line package switch S401 is used for selection of operation mode. If the switch position is stable for more than four seconds the software will accept the new setting and reconfigure the SHDSL chipset.
There are five switches available. Table 9 describes the function of the DIP switch called “MODE”.

Table 9: Function of “MODE” Switch S401

Switch number	Description	Switch function
1	Device Mode	On: STU-C (Master, CO mode) Off: STU-R (Slave, CPE mode)
2	Extended Rates	On: Enables extended bitrates (64..15336kbps) Off: ITU-T standard bitrates (192..5696kbps)
3	User Interface Mode	On: CLI is active (only with SW Packages P3) Off: BSI is active
4	Test mode (TM1)	Both off: no test mode (normal function) TM1 on, TM2 off: PSD test TM1 off, TM2 on: idle (Silent State) Both on: Loopback
5	Test mode (TM2)	

SHDSL is a point to point connection. SHDSL interconnections need two different device modes, called SHDSL Termination Unit Central Office (STU-C) and SHDSL Termination Unit Remote (STU-R). Switch 1 is usable for device mode selection. Please ensure to switch one modem to STU-C and the other to STU-R. Otherwise no data transmission will be established.
Beside the standard data rates according to ITU-T G.991.2 [4] Intel® SHDSL Chipset provides higher (and lower) data rates. Intel® SHDSL Chipset is capable to use about three times higher transmission speed compared to high speed standard SHDSL connections. The lower bitrates, for example, match better to ISDN-BRI. Switch 2 selects full performance or compatibility to other SHDSL equipment. For SHDSL systems with Intel® SHDSL Chipset on both sides Intel® recommend to use the extended bitrates (switch 2 on). For highest interoperability let switch 2 off.
SHDSL.EVB.1CH V1.0 provides helpful features for the evaluation of the SHDSL equipment. Therefore two switches for test mode selection are available. Three test modes provide PSD test, idle and loopback functions. PSD test initiates the SHDSL transmitter sending data without a counterpart station. This function supports the transmit spectrum measurement.

For this feature a fixed bitrate has to be selected (rotary switch position other than 0, see section 3.8.3 also) because the spectrum is depending on bit rate. In idle mode (also called Silent State), the transceiver does not send any data. This test mode is useful for Idle Noise Measurement.
The loopback mode activates a loopback inside the Intel® SHDSL Chipset. Data from the SHDSL interface goes back to the SHDSL interface. This loop back simplifies the analysis of an established data connection.
There is a protective tab on top of DIP switch. Please remove it from the DIP switch before first use.

3.8.3 Rotary switch

The rotary switch S404 (named “BITRATE”) is used for selection of the bitrates. Table 10 shows choice of bitrates.
If the switch position is stable for more than 4 seconds the software will accept the new setting and reconfigure the SHDSL chipset. An established data transmission will be interrupted during reconfiguration.

Table 10: Selectable Bitrates of SHDSL.EVB.1CH V1.0

Switch position	Extended Rates (DIP switch 2)	Line probing	Bitrate [Kbps]	PAM
0 (default)	Off	Enabled	192…5696	Auto
1	Off	Disabled	192	16
2	Off	Disabled	384	16
3	Off	Disabled	512	16
4	Off	Disabled	768	16
5	Off	Disabled	1536	16
6	Off	Disabled	2048	16
7	Off	Disabled	2304	32
8	Off	Disabled	3072	32
9	Off	Disabled	5696	32

Switch position	Extended Rates (DIP switch 2)	Line probing	Bitrate [Kbps]	PAM
0 (default)	On	Enabled	64…15336	Auto
1*	On	Disabled	64*	4
2*	On	Disabled	192*	4
3*	On	Disabled	192*	8
4*	On	Disabled	2496*	4
5*	On	Disabled	5056*	8
6*	On	Disabled	7616*	16
7*	On	Disabled	10176*	32
8*	On	Disabled	12736*	64
9*	On	Disabled	15288*	128

The best choice for most applications is switch position 0 which enables the Power Measurement Modulation Session (PMMS), also called “Line Probing”. PMMS works like an automatic mode, in that case SHDSL chipset selects the highest given bitrate for actual noise floor and loop length. The bitrate differs depending on extended rates that are enabled or not (see Table 9). The target SNR margin is always set to 6 dB.

* The configuration of fixed bitrates in extended rates mode is only possible by SHDSL Master (CO mode, STU-C). The SHDSL Slave (CPE mode, STU-R) ignores the switch position and always uses line probing (switch position 0).

3.8.4 LEDs

Five LEDs indicate the current state of SHDSL.EVB.1CH V1.0.
The green LED H601 “POWER” indicates that power is connected. This LED is on if the board is active and off if the SHDSL.EVB.1CH V1.0 is not powered up.
The next green LED is H401 (“SHDSL STATE”). This LED is off if SHDSL is not active (e.g. during initialization). If the SHDSL chipset is initialized, the LED blinks slowly (approximately 1 Hz). The SHDSL chipset is ready to work and waits for detecting counterpart station. Once the counterpart station is detected, the training process starts and the LED blinks faster (approximately 3 Hz). This process takes some seconds and if the SHDSL chipset can establish a SHDSL link the “SHDSL STATE”-LED goes on.
The state of the Ethernet port is indicated by the green LED H202 (“ETHERNET LINK/ACTIVITY”). This LED is off if the Ethernet PHY hasn’t detect any Ethernet counterpart. The LED goes on if an Ethernet link is established and starts blinking if data transmission is active.
Beside the green LEDs there is amber LED H402 (“ERROR”). For normal operation this LED is off. The LED is on or starts blinking if an error has occurred. The error type will also print to the serial interface (USB UART emulation and hardware UART). Pressing the “ERASE”-button repeats output of error message to serial interface.
For the location of the LEDs please look at Figure 4.

4 Software

4.1 Updating Firmware

The control and monitor processor ATSAM4SA16 supports Microchip SAM Boot Assistance (SAM-BA), an open set of tools for programming the Microchip ARM® core-based microcontrollers. SHDSL.EVB.1CH V1.0 uses this tool for an easy way to update the processors firmware (including SHDSL firmware).
The following section provides a guide on how to install the in-system programmer and how to use it.

4.1.1 Preparation

If you have already installed the SAM-BA programmer, please go to the next section.

Please regard, that **only** SAM-BA revision **2.16** works correctly with the microcontroller device SAM4S at SHDSL.EVB.1CH. Subject to change without notice.

This is a guide on how to install the in-system programmer on your PC.

1. Download the version 2.16 of SAM-BA in-system programmer from Microchip web page (http://www.microchip.com). (regard comment above)
2. Install the downloaded software on your PC. Follow the instruction of the installer of user interface (more infos: see "sam-ba user guide.pdf" or "usb_notice.html")
3. Download at91sam4s16-ek.tcl from Teleconnect Website http://www.teleconnect.de/xdsl/socrates-evb
4. Store the newly downloaded file at91sam4s16-ek.tcl into your installation directory "<your SAM-BA installation directory>\tcl_lib\at91sam4s16-ek". You have to overwrite the existing file.
5. Connect the SHDSL.EVB.1CH V1.0 with a Micro-USB 2.0 cable (USB-Micro-B connector to USB-A connector) to your PC and clear the whole memory including the firmware of EVB by pressing "RESET" and "ERASE" button at the same time.
6. Install the driver for the unknown device.
   (For Microsoft Windows 10 users this step is not necessary.)
   Please select "search for driver software at local computer". The driver is located in your installation directory "<your SAM-BA installation directory>\drv".
   Attention: do not select "automatic search for driver software" (search in the internet).
   Select "Install from ATMEL Rousset" trust. After a while the driver software "AT91 USB to Serial Converter" is installed successfully and assigned to a COM port.
   For more information please have a look at "<your SAM-BA installation directory>\doc\usb_notice.html"

If you have installed another revision than 2.16, you may experience errors with the driver.
Or if Windows version loads another driver version via Windows Update called "Bossa Program Port" please do not hesitate to contact us by E-mail: shdsl@teleconnect.de .

4.1.2 Using the in-system programmer

Before starting, prepare the new firmware image. You can generate it by yourself (including your application software) or use the latest firmware image provided by Teleconnect Website (http://www.teleconnect.de/xdsl/socrates-evb). You need the firmware image in *.bin file format.

1. Connect the SHDSL.EVB.1CH V1.0 to your PC using the micro USB cable.

2. Press both buttons of the EVB (“RESET” and “ERASE”) at the same time. This clears the whole memory including the firmware of EVB.
3. Disconnect and reconnect the USB connection of EVB. After reconnection, the LEDs “SHDSL STATE” and “ERROR” will not light up/flash. This indicates that no firmware is present.
4. Call the SAM-BA programmer
5. Select the connection, e.g. COM1 or \USBserial\COM8, select your board and choose at91sam4s16-ek as board type.

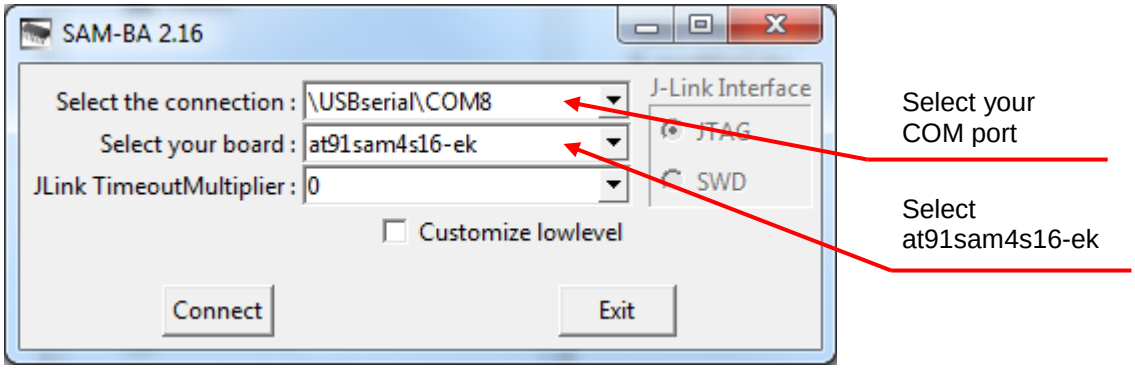

Figure 10: SAM-BA menu: select connection and board

6. Press button "Connect".
7. Select the firmware image binary and press “Send File” button.

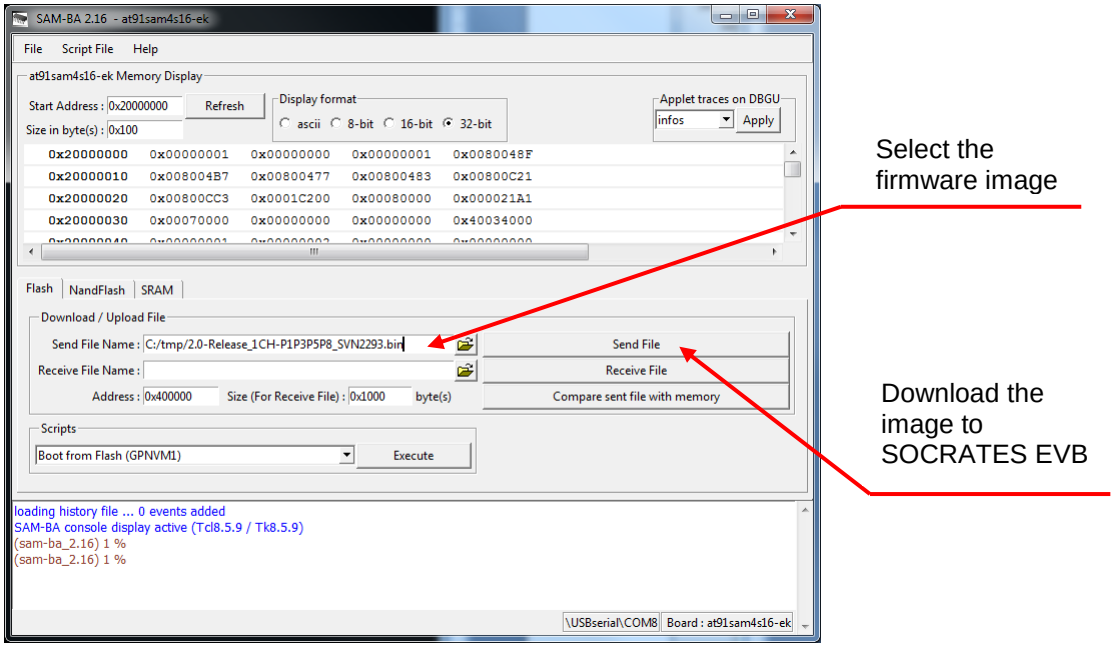

Figure 11: SAM-BA menu: select firmware image and download them

8. The file will download. After that you can lock the involved lock regions or not.

9. Press the button “Execute” and close the SAM-BA programmer.

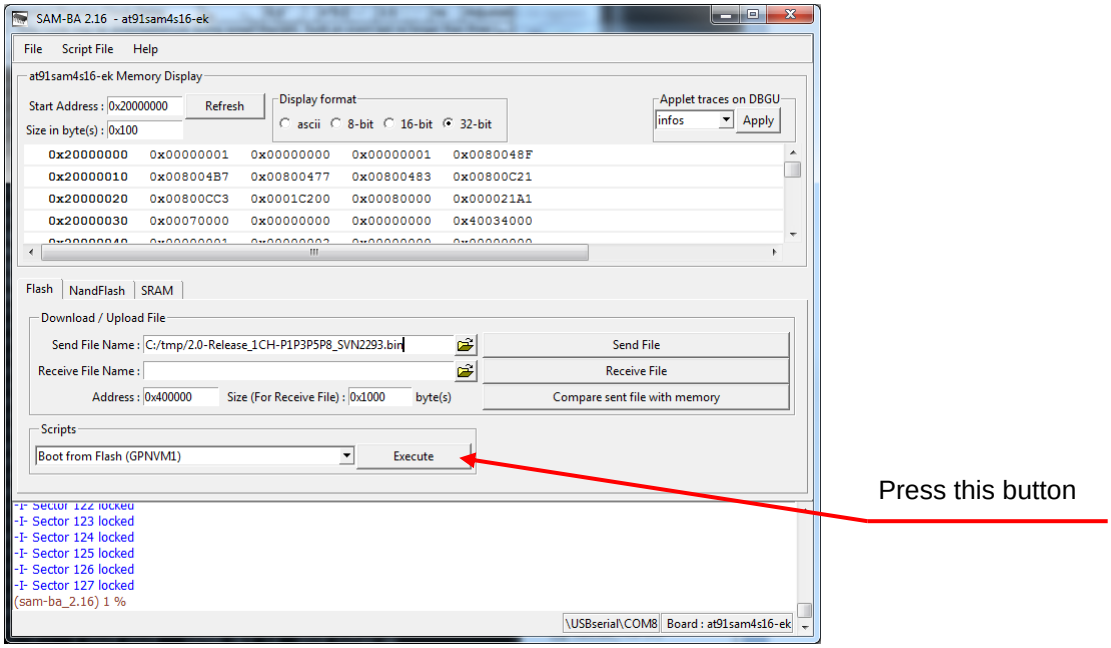

Figure 12: SAM-BA menu: press execute

Remark: With some SAM-BA versions you may get the following error sometimes:
ScriptGPNMV 2-E-Set GPNVM1 failed.

In that case you have to disconnect and reconnect the power connection. The SHDSL.EVB.1CH V1.0 should work normally.

10. Disconnect and reconnect the USB connection of SHDSL.EVB.1CH V1.0. Ready.

4.2 SHDSL.EVB.1CH V1.0 Firmware 2.1

SHDSL.EVB.1CH V1.0 comes with on-board software "Firmware 2.1" ready to use. It works autonomous without connection to host controller. The configuration is selectable by switches (see section 3.8).

The firmware includes the following main features:

- Adjust the line rate with enabled Line probing,
- Select several fixed line rates (see Quick Start Guide),
- Support for EFM-CU,
- Line coding: 16 and 32 TC-PAM according to ITU-T G.991.2 [2],
- Extended rates configuration (min rate: 64kbps, max rate: 15336kbps)
- Monitoring of basic SHDSL line parameters,
- Different test modes: PSD test, idle and loopback

Teleconnect provides this free firmware image for evaluation proposes only. You can buy software license for commercial use from Teleconnect. Beside this, Teleconnect can assist you in SHDSL software development. For further information please contact us at shdsl@teleconnect.de.
The firmware revision 2.1 of SHDSL.EVB.1CH V1.0 includes PEF24628 driver by Intel. You can use this driver for your own software development.

5 User Interfaces

5.1 Establish a Connection

SHDSL.EVB.1CH V1.0 provides user interface via serial interface (UART) and Telnet interface.

For serial interface are two equal alternatives available: TTL compatible interface and emulation via USB (see section 3.6). The baud rate is 115.2 kbaud/s with 8 data bit, 1 stop bit and none parity. With a Terminal Emulation Software like PuTTY and Minicom or other VT-100 compatible software program you can establish a connection to the evaluation board.

To establish a connection via the Telnet interface please use following settings: IPv4 address: 10.10.10.1 (default IP), Netmask: 255.255.255.0.

5.2 BSI - Basic Status/SHDSL Interface

In the software version V1.3 only a monitoring interface is provided. This interface is also available in software version V2.0 called BSI interface. The BSI provides a cyclic printout of SHDSL status to UART and / or USB.

During startup you will see for example the following print out:

```
-- Startup --

=====================================================
SW-Ver#:       2.1-R2387
PHY-Ver#:      1.1-2.1.0__001
IDC-Ver#:      2.1.0.0
Serial#:       0123.0B60.6638.9C8F

Vendor:        Teleconnect GmbH
               Am Lehmberg 54 - 01157 Dresden - Germany
               shdsl@teleconnect.de

               Copyright (c) Teleconnect GmbH 2013-2017.
               All rights reserved.
=====================================================
SHDSL Configuration:
=====================================================
Active:         yes
Lines:          1
Masterline:     1
Testmode:       Disabled
CO/CPE:         CO
TC Layer:       EFM
Ext. rates:     Enabled
Lineprobing:    Enabled
Bitrate min:    64 kbps
Bitrate max:    15336 kbps
PAM:            Auto
Annex:          ANNEX_B
SNRM:           6 dB
=====================================================
IDC download  ... ok.
SDFE download ... ok.
IDC start     ... ok.
Linestate:      DOWN_NOT_READY
Mode:           STU-C (CO)
0=====================================================
```

If the hardware configuration is changed (e.g. new switch position of rotary switch) you get a confirmation print out like that:

```
HW Config changed (dip:0x03, rot:1)
device#1, group#1: SHDSL config activate successful
```

During operation you get a cyclic status print out like that:

```
Linestate:      UP_DATA_MODE
Mode:           STU-C (CO)
Bitrate/PAM:    15288 kbps/128-TCPAM
SNRM/LATN(NE):  10 dB/  2 dB
=====================================================0==
```

If you press the “ERASE” button, you will get a summary of state information. It looks like this:

```
#######################################################
SW-Ver#:       2.1-R2387
PHY-Ver#:      1.1-2.1.0__001
IDC-Ver#:      2.1.0.0
Serial#:       0123.0B60.6638.9C8F

Vendor:        Teleconnect GmbH
               Am Lehmberg 54 - 01157 Dresden - Germany
               shdsl@teleconnect.de

               Copyright (c) Teleconnect GmbH 2013-2017.
               All rights reserved.
=======================================================
SHDSL Configuration:
=======================================================
Active:         yes
Lines:          1
Masterline:     1
Testmode:       Disabled
CO/CPE:         CO
TC Layer:       EFM
Ext. rates:     Enabled
Lineprobing:    Enabled
Bitrate min:    64 kbps
Bitrate max:    15336 kbps
PAM:            Auto
Annex:          ANNEX_B
SNRM:           6 dB
#######################################################
```

Please note, there is a special behavior in Microsoft Windows environment. The COM port initializing happens during the connection to the USB port. During this process you get the COM port number and then you can assign a terminal program. So it is possible you miss the first notifications.
Further a reset of SHDSL.EVB.1CH V1.0 initiates a new initialization of the COM port. Your connection to the terminal program will be lost.

5.3 CLI - Command Line Interface

The command line interface (CLI) is an advanced user interface with session-management and auto-completion. The CLI has a CISCO®-like syntax. With it an advanced configuration and status management is possible. You can request an Evaluation License for CLI (Software Package 3) at shdsl@teleconnect.de.
The CLI has a VT100 emulation for UART, USB and Telnet.

The focus of the CLI was at:

- a hierarchical organization of (sub-)menus and commands,
- a command history,
- auto-completion of commands which are unique,
- password protection.

5.3.1 Login

The login to SHDSL.EVB.1CH V1.0 via CLI is password protected. In default configuration the password is "admin".
If a user was successfully authenticated his session is exclusive - Simultaneous login attempts from other interfaces will be suppressed. Unused CLI sessions will be terminated after 5 minutes of inactivity.

5.3.2 CLI commands

The CLI commands are organized hierarchical in various directories. The amount of functions and menus in the CLI depends on the enabled features during compilation. For instance it is possible to disable Networking (no package P5). As a consequence the CLI menu "iface net" is not available.

The following diagram gives an overview of the menu hierarchy.

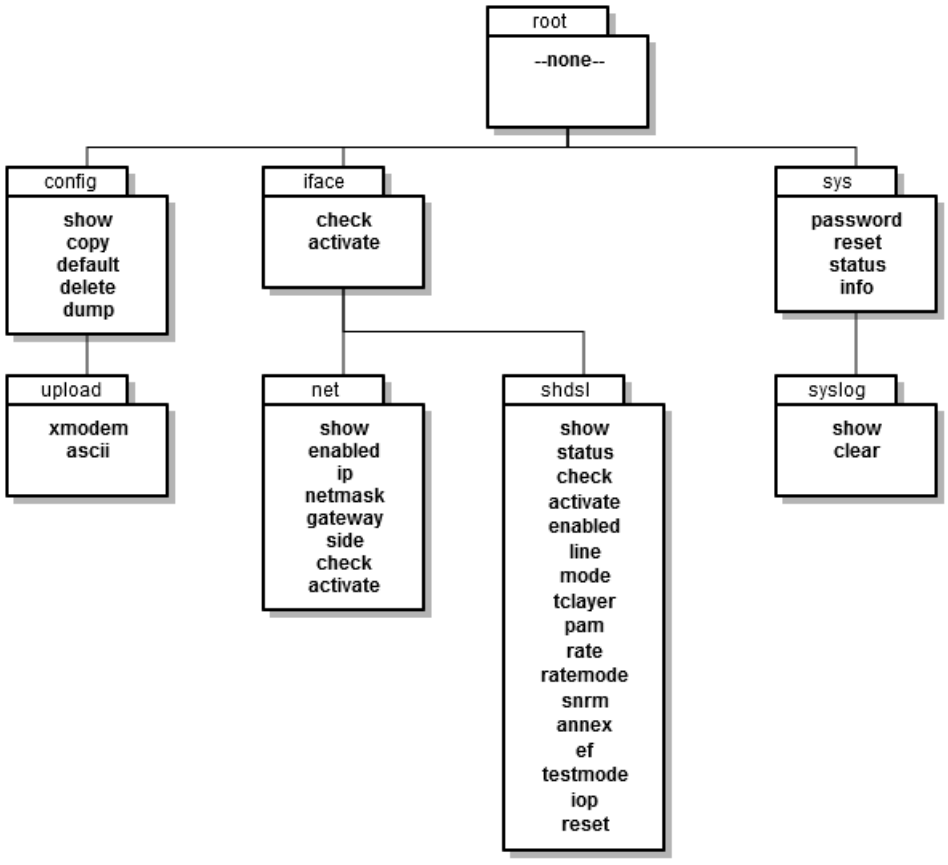

Figure 13: CLI menu tree

Table 11 gives an overview of the CLI menus and their function.

Table 11: CLI menus

Menu	Function
/config/	Manage system configuration sets
/config/upload/	Upload new configuration sets
/iface/	Manage interfaces
/iface/net/	Manage network interface
/iface/shdsl/	Manage SHDSL interface
/sys/	Get the system information
/sys/syslog/	Access the systems error log

In addition to the menu specific functions, the following navigation functions are available in every menu:

- exit (exit the current menu and move up in the menu hierarchy)
- logout (end the CLI session)

To get a list of available subdirectories and functions in the current menu enter a question mark ("?") directly following the prompt. It is also possible to get context sensitive help for your entered command. This can be achieved by pressing question mark after typing a command. Depending on whether the command refers to a directory of a function, a list of available subdirectories and functions or the function-specific help will be shown.

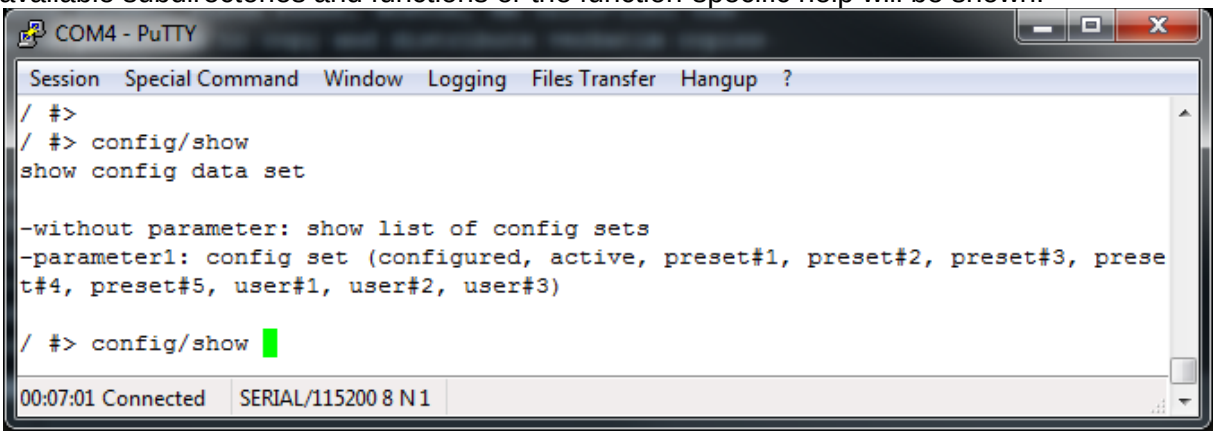

Figure 14: CLI example: config/show ?

When typing commands, it is always possible to shorten subdirectory or function names. By pressing <tab> the entered command will be completed. If a command is ambiguous CLI will provide a list of possible completions.

5.3.3 Configuring the system

Changing settings is done in two steps. First the configuration is changed and in a second step it has to be activated. The show command provided in the /iface/shdsl directory will display both, the current configured and the active (currently running) settings. Differences between them are indicated by an "#" sign.

The following example shows SHDSL parameters, after the mode has been modified from CO to CPE (with command: " iface/shdsl/mode cpe")

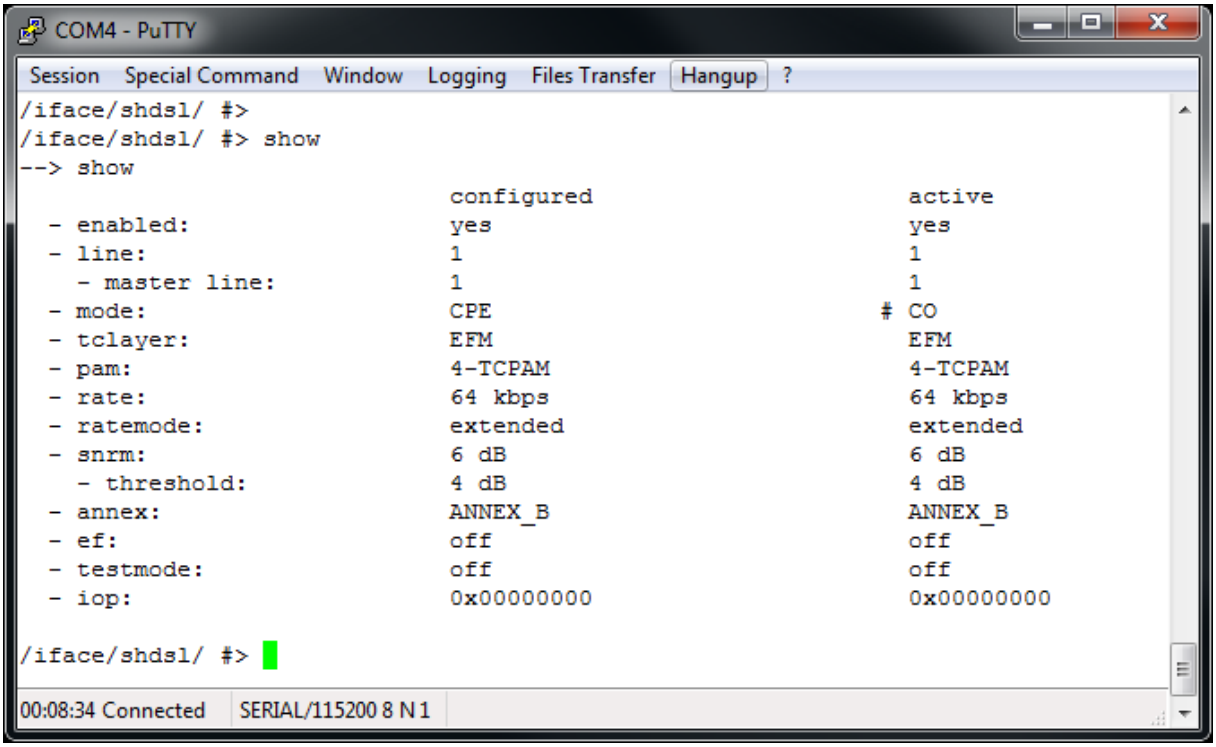

Figure 15: CLI example for show modified SHDSL configuration

All configuration options related to the IP interface can be found in the directory /iface/net. Network can either be used on SHDSL line side or system side (Ethernet port) of one SHDSL Configuration.

The following example changes IP address, netmask, gateway and side of the network interface.

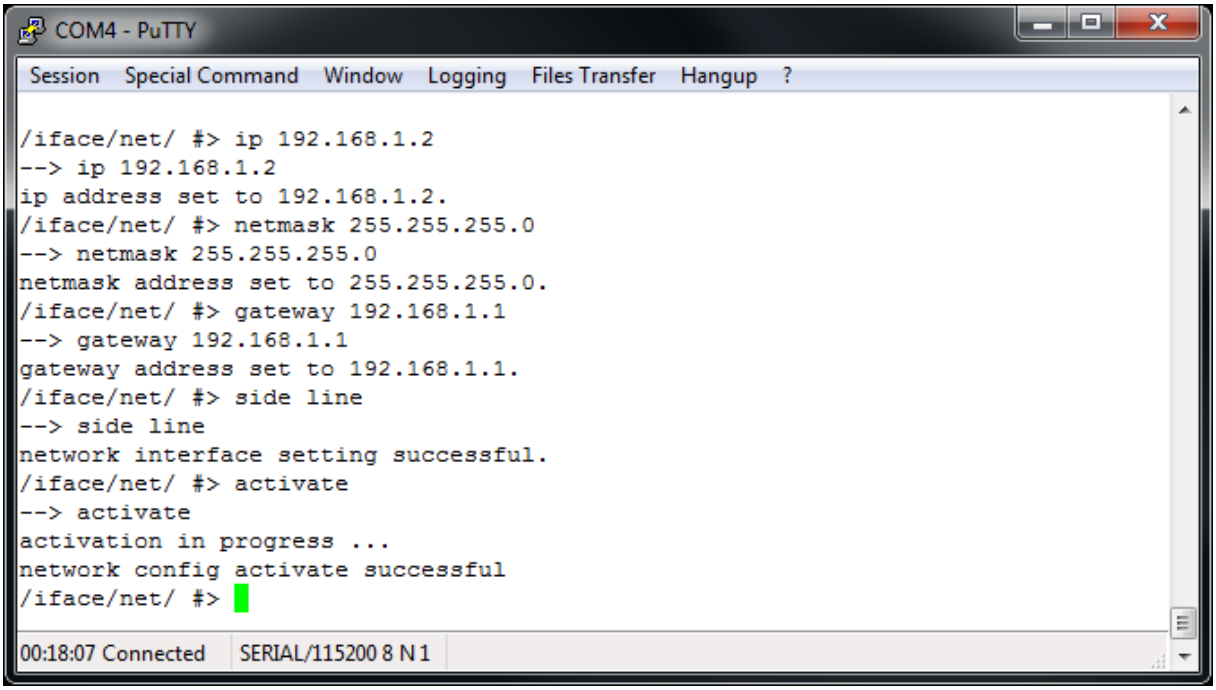

Figure 16: CLI example for net configuration

6 Operation

The following description gives an easy way to make a data connection using SHDSL. You need at least one Intel® SHDSL Chipset and one other standard compliant SHDSL modem. However, the easiest way to make a SHDSL connection is to use two SHDSL.EVB.1CH V1.0.

6.1 Start-up with two boards

1. Verify settings: DIP switch 2 on (for highest possible data rate up to 15 Mbps), all other DIP switches off, rotary switch on 0 (exempt you wish a special bit rate).
2. Switch on Device Mode (DIP switch 1) for master mode (STU-C) at one board, the other stays in slave mode (STU-R, DIP switch 1 off).
3. Connect both SHDSL connectors together. You can use a standard Ethernet patch cable.
4. Power up both boards, e.g. connect the micro USB plugs to PC.
   - The power LED, Error LED and the SHDSL LED go on.
   - After some seconds the amber Error LED and SHDSL LED go off.
   - The SHDSL LED starts blinking slowly after some seconds.
   - The SHDSL LED blinks fast during SHDSL Training.
   - The SHDSL LED is on if the SHDSL connection is established.
5. Disconnect the Ethernet cable from your computer; plug it into the Ethernet connector of the first board. Connect the wall outlet to the Ethernet connector to the second board.
   - The Ethernet LED is on if Ethernet connection was established.
   - The Ethernet LED starts blinking indicating Ethernet traffic.
6. Ready! You are using SHDSL for your data connection.

7 Using SHDSL.EVB.1CH V1.0 as Module

7.1 Scope

The main goal of SHDSL.EVB.1CH V1.0 is a simple evaluation platform of the Intel® SHDSL Chipset. Beside this it is possible to use SHDSL.EVB.1CH V1.0 as SHDSL EFM module. That is why SHDSL.EVB.1CH V1.0 is made in a small form factor, not really typical for evaluation platforms. This may be interesting for small volume applications.
This chapter covers using SHDSL.EVB.1CH V1.0 as a module.

7.2 Connection

Figure 17 shows the dimension of SHDSL.EVB.1CH V1.0 and the location of the connectors (top side view, all values are millimetres). If SHDSL.EVB.1CH V1.0 is used as module, it can power up via X601. Please connect pin 1 to + 5 V (4.0 … 6.0 V) and pin two to Ground. The SHDSL line should connect to X101 and the Ethernet interface to X202. Optionally, a control and monitor interface is available to connect at X401. If you want to use it, please connect it to serial interface of host processor. There is one mounting hole at EVB. It can be used for fixing the EVB to the host board via an M2.5 screw.
The pin header connectors X101, X202, X401 and X601 are not mounted by default and can be populated if necessary.
The connectors X102, X201 and X403 are not used and should be left open.

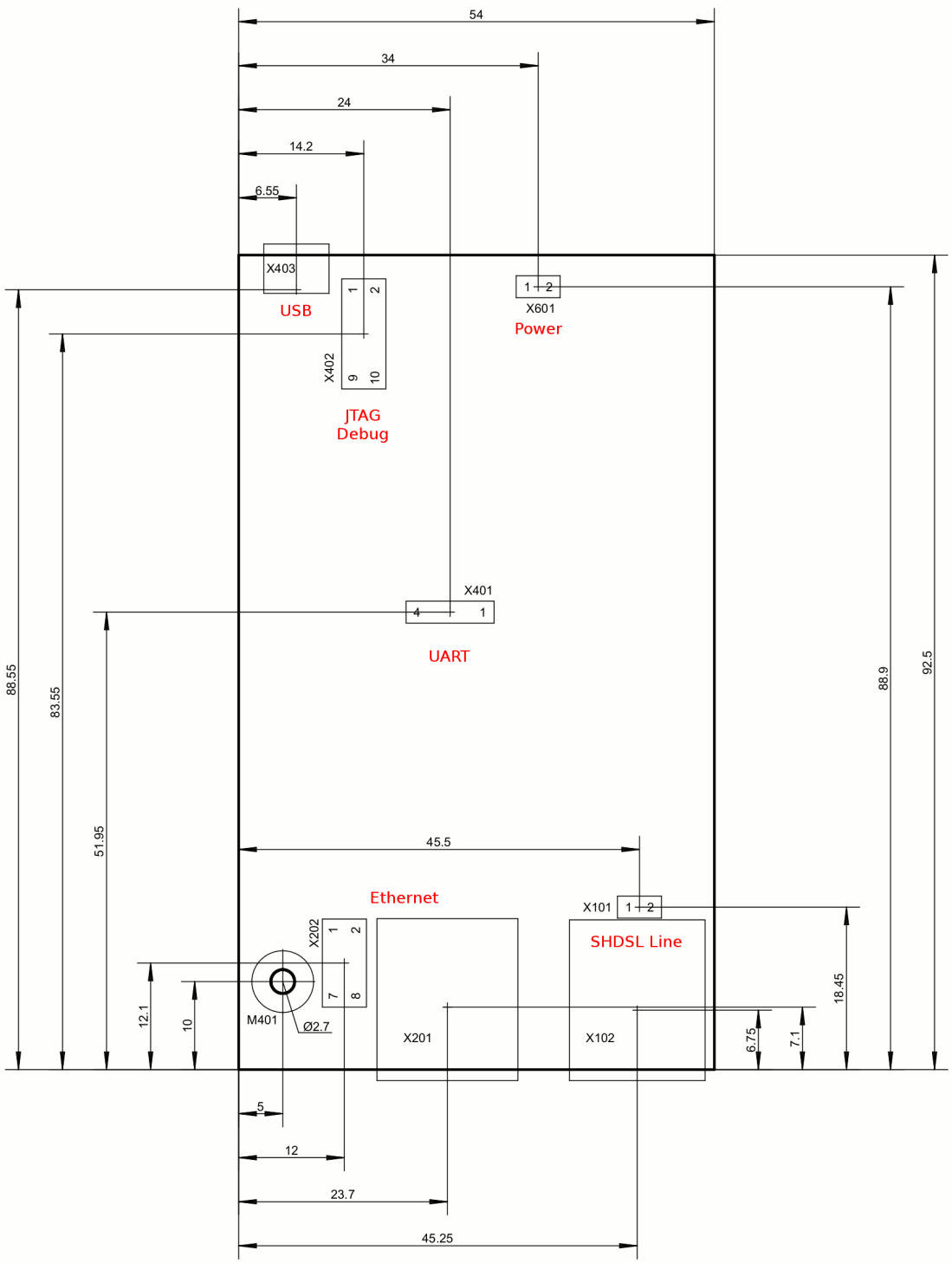

Figure 17: Dimension of SHDSL.EVB.1CH V1.0 and position of Connectors

7.3 Protection

The SHDSL.EVB.1CH V1.0 is conceptualised as an evaluation platform. For this, SHDSL.EVB.1CH V1.0 includes only basic protection. It is possible to add additional protection circuits on the host board to use SHDSL.EVB.1CH V1.0 in rough environments.
For further assistance you can contact Teleconnect at shdsl@teleconnect.de.

8 BoM of SHDSL.EVB.1CH V1.0

Table 12 shows the Bill of Material of SHDSL.EVB.1CH V1.0 Evaluation Board. It contains all mounted components. For further assistance please contact Teleconnect at shdsl@teleconnect.de.

Table 12: Bill of Material

Item	Quantity	Designator	Value	Manufacture
1	8	C524, C525, C534, C537, C565, C566, C567, C568	10nF	Würth Elektronik
2	58	C101, C102, C103, C104, C105, C106, C107, C108, C521, C522, C523, C528, C529, C531, C546, C547, C548, C549, C550, C551, C552, C553, C554, C555, C556, C557, C559, C561, C405, C407, C503, C505, C506, C508, C510, C511, C512, C513, C514, C515, C516, C517, C518, C519, C535, C536, C538, C539, C540, C542, C545, C558, C560, C562, C564, C601, C602, C563	100nF	Würth Elektronik
3	1	C114	1nF	Würth Elektronik
4	2	C109, C112	22pF	Würth Elektronik
5	2	C110, C111	2.2pF	Würth Elektronik
6	2	C201, C202	33pF	Würth Elektronik
7	3	C113, C403, C404	470pF	Würth Elektronik
8	2	C401, C402	4.7pF	Würth Elektronik
9	1	C115	3.3nF	Würth Elektronik
10	23	C501, C502, C504, C507, C509, C520, C526, C527, C530, C532, C544, C569, C603, C604, C605, C606, C607, C608, C609, C610, C611, C612, C613	10µF	Würth Elektronik
11	2	C533, C541	4.7µF	Würth Elektronik
12	3	C207, C208, C406	1nF	unspecified
13	1	C543	220µF	unspecified
14	2	D601, D602	BAT60B	unspecified
15	1	D101	CD143A-SR3.3	Bourns
16	3	H202, H401, H601	WL-SMCW-V	Würth Elektronik
17	1	H402	WL-SMCW-Y	Würth Elektronik
18	1	L201	749020010A	Würth Elektronik
19	2	L401, L502	300R	Würth Elektronik
20	1	L501	10µH	Würth Elektronik
21	1	L101	750510578	Würth Elektronik
22	1	L503	30Ω	Würth Elektronik
23	1	Q401	KX-7T	Geyer Electronic
24	1	Q201	KX-7T	Geyer Electronic
25	1	Q101	KX-7T	Geyer Electronic
26	73	R201, R202, R203, R204, R205, R206, R207, R208, R209, R210, R211, R212, R213, R214, R215, R216, R217, R218, R219, R220, R221, R222, R223, R224, R225, R226, R235, R236, R237, R238, R239, R301, R302, R303, R304, R305, R306, R307, R308, R309, R310, R311, R312, R313, R314, R316, R317, R318, R319, R320, R321, R322, R323, R324, R401, R402, R405, R406, R407, R408, R409, R413, R415, R416, R420, R422, R423, R424, R425, R602, R603, R605, R609	10kΩ	unspecified
27	1	R250	11kΩ	unspecified
28	1	R101	12.7kΩ	unspecified

Item	Quantity	Designator	Value	Manufacture
29	2	R247, R248	16kΩ	unspecified
30	3	R106, R107, R240	1.3kΩ	unspecified
31	14	R227, R228, R229, R230, R231, R232, R233, R234, R414, R417, R418, R426, R427, R428	22.1Ω	unspecified
32	3	R111, R403, R404	2.21kΩ	unspecified
33	3	R112, R114, R510	2.43Ω	unspecified
34	1	R611	30.1kΩ	unspecified
35	3	R116, R117, R410	3.32kΩ	unspecified
36	4	R102, R103, R104, R105	43.2Ω	unspecified
37	4	R601, R606, R608, R610	45.3kΩ	unspecified
38	2	R113, R115	47.5Ω	unspecified
39	1	R110	5.62kΩ	unspecified
40	1	R607	68.1kΩ	unspecified
41	2	R108, R109	750Ω	unspecified
42	4	R253, R254, R255, R256	75Ω	unspecified
43	1	R252	8.66kΩ	unspecified
44	1	R246	5.23kΩ	unspecified
45	2	R245, R411	6.81kΩ	unspecified
46	4	R251, R419, R421, R612	300Ω	unspecified
47	16	R118, R241, R243, R244, R501, R502, R503, R504, R505, R506, R509, R511, R604, R613, R614, R615	0Ω	unspecified
48	1	S401	WE416131160805	Würth Elektronik
49	1	S404	WS428542320810	Würth Elektronik
50	2	S402, S403	WS-TSS	Würth Elektronik
51	1	T601	BSS215P	Infineon Technologies
52	1	V301	ATSAM4SA16CA	Microchip
53	1	V401	ATSHA204	Microchip
54	3	V601, V602, V603	MPM3810GQB	Monolithic Power Systems
55	1	V101	PEF 21628 E	Intel
56	1	V201	PEF 7072	Intel
57	1	X402	61301021121	Würth Elektronik
58	1	X201	WE615008143521	Würth Elektronik
59	1	X102	WE615008143721	Würth Elektronik
60	1	X403	WE629105136821	Würth Elektronik

9 Literature

[1] IEEE, „IEEE Std. 802.3-2008, Section 5: Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) access method and physical layer specifications,“ 2008-12-26.

[2] ITU, „ITU-T G.991.2: Single-pair high-speed digital subscriber line (SHDSL) transceivers,“ 12/2003.

Appendix A. Quick Start-up guide

The following description provides an easy way to establish a data connection using SHDSL. You need at least one SHDSL.EVB.1CH V1.0 and one other standard compliant SHDSL EFM modem. However, the easiest way to make a SHDSL connection is to use two SHDSL.EVB.1CH V1.0. The following sections are describing two common use cases.

Realize Long-Reach-Ethernet Connectivity

- Check your existing application for an existing Ethernet (ETH) interface and connect to EVB.
- Select bit rate and operation mode
  - standard (192…5696 Kbps) or extended bit rate (64…15336 Kbps),
  - master mode (STU-C) or slave mode (STU-R).
- Connect 5 V power supply to the Micro USB connector.
  - The power LED, Error LED and the SHDSL LED go on.
  - After some seconds the amber Error LED and SHDSL LED go off.
  - The SHDSL LED starts blinking slowly after some seconds.
- Connect SHDSL lines.
  - The SHDSL LED blinks fast during SHDSL Training.
  - The SHDSL LED is on if the SHDSL connection is established.
- Ready! You are using SHDSL for your data connection.

Start-up using two boards

1. Verify settings: DIP switch 2 on (for highest possible data rate up to 15 Mbps), all other DIP switches off, rotary switch on 0 (exempt you wish a special bit rate).
2. Switch on Device Mode (DIP switch 1) for master mode (STU-C) at one board, the other stays in slave mode (STU-R, DIP switch 1 off).
3. Connect both SHDSL connectors together. You can use a standard ETH patch cable.
4. Power up both boards. E.g. connect the micro USB plugs to PC.
   - The power LED, Error LED and the SHDSL LED go on.
   - After some seconds the amber Error LED and SHDSL LED go off.
   - The SHDSL LED starts blinking slowly after some seconds.
   - The SHDSL LED blinks fast during SHDSL Training.
   - The SHDSL LED is on if the SHDSL connection is established.
5. Disconnect the Ethernet cable from your computer; plug it into the Ethernet connector of the first board. Connect the wall outlet to the Ethernet connector to the second board.
   - The Ethernet LED is on if Ethernet connection was established.
   - The Ethernet LED starts blinking indicating Ethernet traffic.
6. Ready! You are using SHDSL for your data connection.

Table 13: Selection of bit rates with DIP switch and rotary

Switch position	Extended Rates (DIP switch 2)	Line probing (PMMS)	Bitrate [Kbps]	PAM
0 (default)	On / Off	Enabled	64..15288 / 192…5696	Auto
1*	On / Off	Disabled	64* / 192	4 / 16
2*	On / Off	Disabled	192* / 384	4 / 16
3*	On / Off	Disabled	192* / 512	8 / 16
4*	On / Off	Disabled	2496* / 768	4 / 16
5*	On / Off	Disabled	5056* / 1536	8 / 16
6*	On / Off	Disabled	7616* / 2048	16
7*	On / Off	Disabled	10176* / 2304	32
8*	On / Off	Disabled	12736* / 3072	64 / 32
9*	On / Off	Disabled	15288* / 5696	128 / 32

***** The configuration of fixed bitrates in extended rates mode is only possible by SHDSL Master (CO mode, STU-C). The SHDSL Slave (CPE mode, STU-R) ignores the switch position and always uses line probing (switch position 0).