

USER MANUAL

Evaluation Kit

Single Pair Ethernet with Power over Data Line System

WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

CAUTIONS AND WARNINGS



For safe and correct usage, please follow these instructions. Keep them for future reference.





CAUTION
PCB Surfaces may become hot during operation! Wait at least 2 minutes following power-down before handling the board again.



CAUTION
This product contains parts that are ESD sensitive. Follow appropriate ESD procedures and guidelines when handling the evaluation board.

NOTE
Use only input supply voltage and output load current levels within the range stated in the Specification section of this document for each configuration of the evaluation board. Operation above these limits may cause erratic behavior and irreversible damage to the evaluation board.

Recommended ambient temperature range: 5 °C to 30 °C. To reduce the likelihood of short circuits, keep away from paper clips, screws or any other electrically conductive materials. Place the boards on a stable flat surface. Keep away from dust and humidity.

Dispose these boards separately from unsorted municipal waste at special collection and return points.

CE conformity declaration
Würth Elektronik herewith declares that the product fully complies with the relevant guidelines for CE conformity. The complete text of the CE conformity declaration together with the listed relevant guidelines can be viewed at the following website:
https://www.we-online.com/doc

Before getting started with the 749951 SPE with PoDL Evaluation Kit read the Terms of Use for Evaluation Boards, Kits or Modules carefully. These 749951 SPE with PoDL Evaluation Kit boards are not intended for resale and/or use in final customer applications or products.



WARNING: ONLY qualified* personnel should operate this board!

* Qualified personnel (skilled persons) is defined as an individual with relevant technical education, training, or experience to enable perceiving risks and avoiding hazards occurring during use of this product (Source: IEEE 82079-1 3.36).

ABBREVIATIONS

Abbreviation	Name	Description
10BASE-T1L	Ethernet Standard	Provides 10 Mbps full-duplex communication over a single twisted-pair cable, designed for long-reach applications up to 1,000 meters, commonly used in industrial automation and building management systems.
SPE	Single Pair Ethernet	New standard that enables data transmission over a single pair of twisted copper wires.
PoDL	Power over Data Lines	Power from PSE to PD via same wires as the signal/data.
SPoE	Single Pair Power over Ethernet	Single Pair Ethernet with Power over Data Line and Single Pair Power over Ethernet essentially refer to the same concept.
PSE	Power Source Equipment	Station from which the supply voltage is fed into the signal line.
PD	Powered Device	Station that is supplied with the supply voltage via the signal line.
PHY	Physical Layer	The component in networking devices responsible for handling the physical transmission and reception of data over a network medium, such as electrical signals over copper cables or light pulses in fiber optics. It converts digital data from the MAC layer into signals suitable for transmission and vice versa.
MDIO	Management Data Input/Output	Serial bus defined by the IEEE 802.3 Ethernet standard for communication between a MAC (Media Access Control) device and a PHY (Physical Layer) device, used to configure and monitor the PHY
IEEE 802.3.cg	Institute of Electrical and Electronics Engineers	IEEE Standard for Ethernet – Amendment 5: Physical Layer Specifications and Management Parameters for 10 Mb/s Operation and Associated Power Delivery over a Single Balanced Pair of Conductors
SCCP	Signalling Connection Control Part	Mode which refers to the operational mode used in telecommunications networks, primarily within the SS7 (Signaling System 7) protocol suite, to route signaling messages between different network nodes.
MAC	Media Access Control	Interface which is the communication layer in networking devices that manages the transmission and reception of data packets to and from the physical layer (PHY), controlling access to the shared network medium.

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1. INTRODUCTION

SPE with PoDL also called SPoE offers a suitable solution in all those applications where space and weight are constrained like Industrial and building automation, automotive, Internet of Things (IoT), and where wiring reduction is a must and/or an installation advantage.

This 749951 Evaluation Kit shows a fully functional SPE with PoDL electronic design with a data transmission rate of 10 Mbit/s integrating WE passive and active components and specifically a transformer designed for this application: WE-SPE.

It is provided to help designers to understand the different components and architecture of the system. At the same time, this setup allows for real-time testing of the hardware, including signaling and functional performance.

2. INTENDED USE

This reference design HW demonstrates a system that transmits data between two points via a two-wire line, where the main unit (PSE) also supplies power to the peripheral unit (PD) over the same line. This method is known as "Single Pair Ethernet" (SPE) with "Power over Data Lines" (PoDL), combining data transmission and power delivery over a single twisted pair cable. The system is powered by an external power supply connected to the PSE. The power supply system is not galvanically isolated, so if isolation is needed, it must be ensured by the external 24 V supply.

The following devices can be connected for data communication:

- PSE: X2 or X3, PD X2 or X3
  which is the single pair Ethernet channel

The interfaces can be used in mixed or cross configurations and operated simultaneously. From USB to Ethernet and to SPE. Both on one board and across boards via SPE.

Examples are:

- PSE/X7: 10 Mbit/s Ethernet,
  PD/X1: USB 3.1
- PSE/X1: 10 Mbit/s Ethernet,
  PD/X7: 10 Mbit/s Ethernet
- PD/X7: 10 Mbit/s Ethernet,
  PSE/X1: USB 3.1

3. EVALUATION KIT CONTENTS

The WE-PoDL Evaluation kit includes the following:

- PSE Board (Power Source Equipment), product number: 749949
- PD Board (Powered Device), product number: 749950
- Connectors and wire to easily build an unshielded connection twisted pair cable between the boards

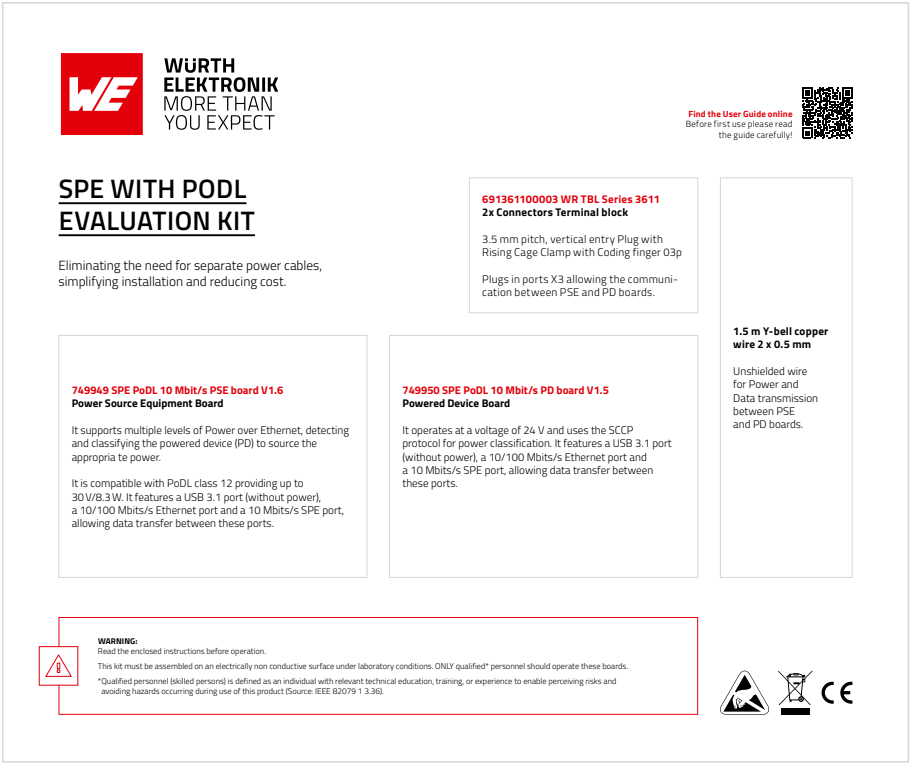


Figure 1: *WE-PoDL Development kit content*

For a detailed description of the PoDL system, the electronic boards and the installation, please refer to the reference note RD041 at the following link:

Design of a Single Pair Ethernet System with Power over Data Lines (SPoE)

The document can be downloaded there free of charge.

3. EVALUATION KIT CONTENTS

Short specification:
The absolute maximum values of the design are given in Table 1&2

Input voltage range at PSE	20 V – 30 V	Reverse polarity protected; transient voltage protected
Input current at PSE	< 700 mA	Overcurrent protected
Output voltage at PSE data line on Single Pair Ethernet	30 Vmax.	Nominal voltage: 24 V, voltage level controlled
Output current at PSE data line on Single Pair Ethernet (SPE)	350 mA	Overcurrent protected
Operating ambient temperature	+10 … +30 °C	
Data rates at interfaces PSE/PD	SPE: 10 Mbit/s	Data rates limited by hardware and firmware

Table 1: *Short specification (absolut max. values)*

3. EVALUATION KIT CONTENTS

Data Protocol Classification

The system operates according to the IEEE 802.3.cg standard in class 12 with the parameters marked in red in the table below.

	IEEE 802.3bu										Unit
Class	12 V unregulated		12 V regulated		24 V unregulated		24 V regulated		48 V regulated		
Class #	0	1	2	3	4	5	6	7	8	9	
$V_{PSE(max)}$	18				36				60		V
$V_{PSE(min)}$	6		14.4		12		26		48		V
$I_{PI(max)}$	101	227	249	471	97	339	215	461	735	1360	mA
$P_{PD(max)}$	0.5	1	3	5	1	3	5	10	30	50	W
$V_{PD(min)}$	4.94	4.41	12	10.6	10.3	8.86	23.3	21.7	40.8	36.7	V
Cable											AWG
Cable lenght											m

	IEEE 802.3cg						Unit
Class	24 V			55 V			
Class #	10	11	12	13	14	15	
$V_{PSE(max)}$	30			58			V
$V_{PSE(min)}$	20			50			V
$I_{PI(max)}$	92	240	632	231	600	1579	mA
$P_{PD(max)}$	1.23	3.2	8.3	7.7	20	52	W
$V_{PD(min)}$	14	14	14	35	35	35	V
Cable	18	14	24	18	14	24	AWG
Cable lenght	1000	1000	1000	1000	1000	300	m

Table 2: *Physical layer parameters of SPoE systems.*

CAUTION:
Exceeding the values as given in the tables may affect the device negatively and may cause permanent damage. We recommend a maximum wire length of 100 m for the connection between PSE and PD in this Evaluation Kit.

4. BOARD CONFIGURATION

Power Source Equipment (PSE)

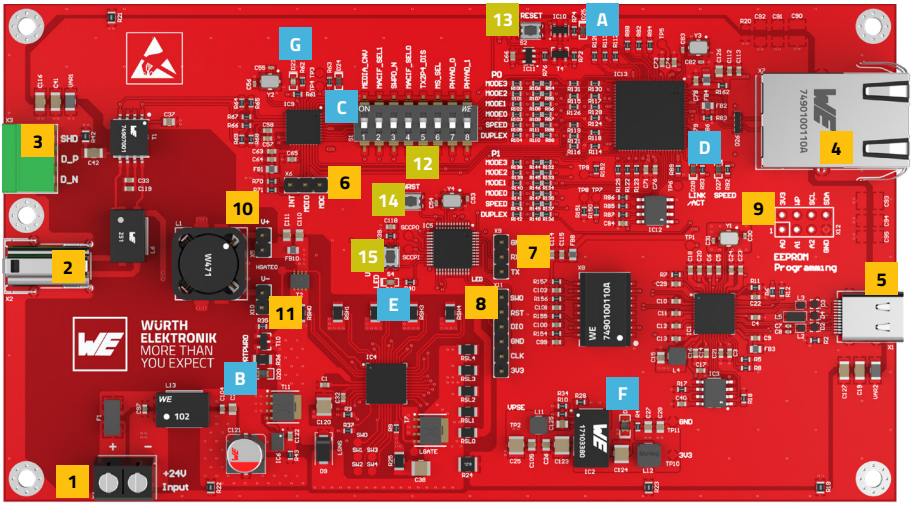


Figure 2: *749949 SPE with PoDL PSE board. Top view with labelling of connectors, switches and pushbuttons and LEDs.*

Connectors (yellow squares with black numbers)

Label	Ref Des	Description
1	X4	Power input +24 VDC
2	X2	Single Pair Ethernet connector, Harting
3	X3	Single Pair Ethernet connector, terminal block, 3,5 mm
4	X7	Ethernet connector
5	X1	USB-C connector, no power availability
6		MDIO management interface for 10BASE-T1L Phy
7	X9	Debugging connector for Microcontroller (UART)
8	X11	Programming header for Microcontroller
9	X12	Programming header for EEPROM of Ethernet bridge
10	X5	V+ Supply from DC-DC converter to coupling/decoupling network
11	X6	V- Supply from DC-DC converter to coupling/decoupling network

4. BOARD CONFIGURATION

Switches and pushbuttons (green squares with white numbers)

Label	Ref Des	Description
12	S1	HW-configuration for 10BASE-T1L Phy
13	S2	PSE system reset
14	S3	RESET for microcontroller
15	S4	User defined switch for microcontroller operation

LDEs (blue squares with white letters)

Label	Ref Des	Description
A	D25	Reset active
B	D20	Power Switch PSE controller, port 0, power good
C	D24	On when link is established, and blink when there is activity
D	D27, D28	Link(Act) and Speed for Ethernet
E	D21	User defined LED for debugging
F	D5	Power good, 3,3 V
G	D23	Spare LED, disabled

4. BOARD CONFIGURATION

Powered Device (PD)

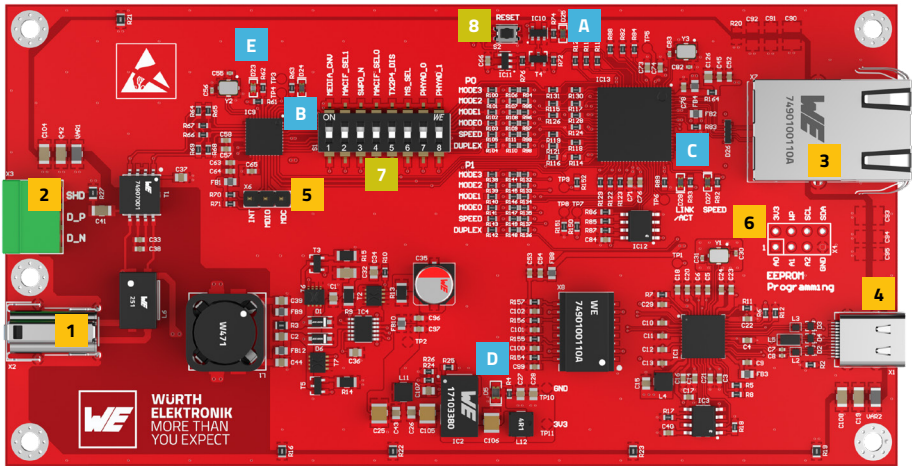


Figure 3: *749950 SPE with PoDL PD board. Top view with labelling of connectors, switches and pushbuttons and LEDs.*

Connectors (yellow squares with black numbers)

Label	Ref Des	Description
1	X2	Single Pair Ethernet connector, Harting
2	X3	Single Pair Ethernet connector, terminal block, 3,5 mm
3	X7	Ethernet connector
4	X1	USB-C connector, no power availability
5	X6	MDIO management interface for 10BASE-T1L Phy
6	X4	Programming header for EEPROM of Ethernet bridge

Switches and pushbuttons (green squares with white numbers)

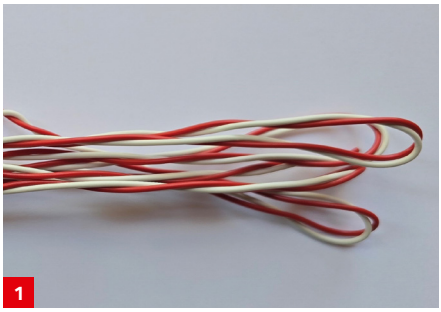
Label	Ref Des	Description
7	S1	HW-configuration for 10BASE-T1L Phy
8	S2	PD system reset

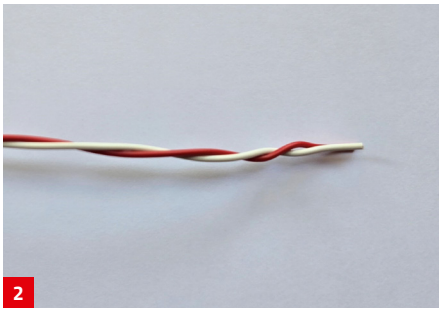
LDEs (blue squares with white letters)

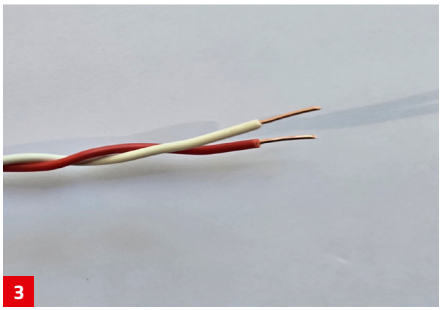
Label	Ref Des	Description
A	D25	Reset active
B	D24	On when link is established, and blink when there is activity
C	D27, D28	Link (Act) and Speed for Ethernet
D	D5	Power good, 3,3 V
E	D23	Spare LED, disabled

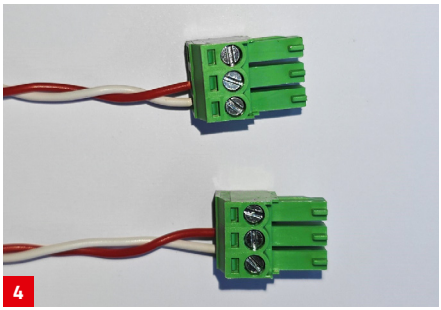
5. CONSTRUCTING THE UNSHIELDED 2 WIRE CABLE

Just carefully peel the insulation of the ends of the wires to a length of approx. 5-6 mm to provide enough exposed copper for a secure connection. Insert the peeled ends into the designated slots of the connectors (ensure that each wire is securely placed in the correct slot). And finally tighten the screws on the connector to firmly hold the wires in place. Make sure the connection is secure and there is no risk of the wires coming loose.









6. SYSTEM SET-UP

Block diagram of the system

The figure below shows a possible set- up of the system. A USB/Ser converter can be connected to X9 of the PSE (not included in the set), via which the functional structure of the data traffic between the boards can be checked with a notebook.

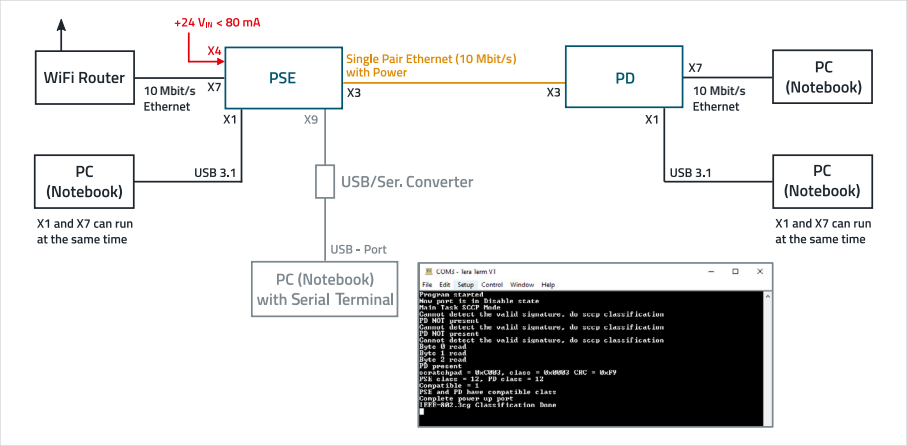


Figure 4: *Block diagram of the 749951 SPE with PoDL system.*

6. SYSTEM SET-UP

Step by step procedure for set up and operation

a) Equipment to prepare
1x PSE board
1x PD board
1x USB-to-serial adapter with cable
1x WiFi-router
1x PC/LapTop.
1x LAN/Ethernet cable
1x USB3.2 type C to type A cable

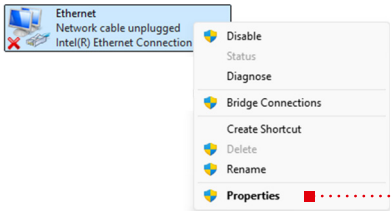
b) Setup the WiFi-router and connect to internet

c) Adjust the data rate for the system
This example here was carried out using a notebook with the Windows version "Windows 10 Pro, Version 22H2". The PoDL Interface is a SPE 10 Mbit/s Ethernet connection. The buffer between the LAN9355 bridge and the SPE Phy ADIN1100 is only working correctly, when the speed is reduced to 10 Mbit/s in the auxiliary equipment:

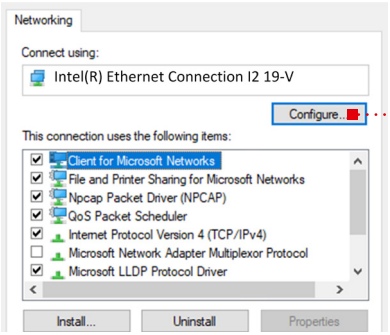
1. The network adaptor options need to be changed at the control panel



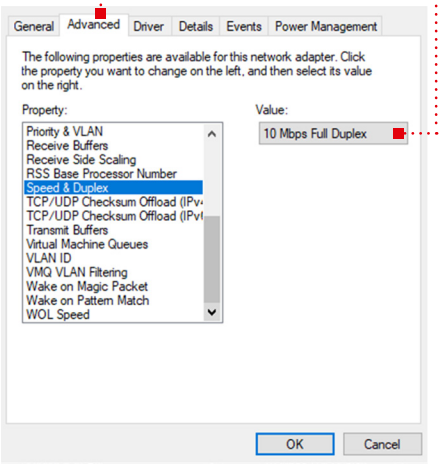
2. Click on properties:



3. Click on configure



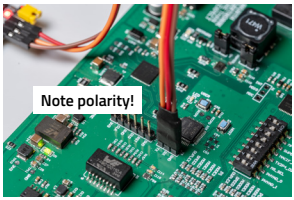
4. Change the speed in advanced to 10 Mbit/s, full duplex

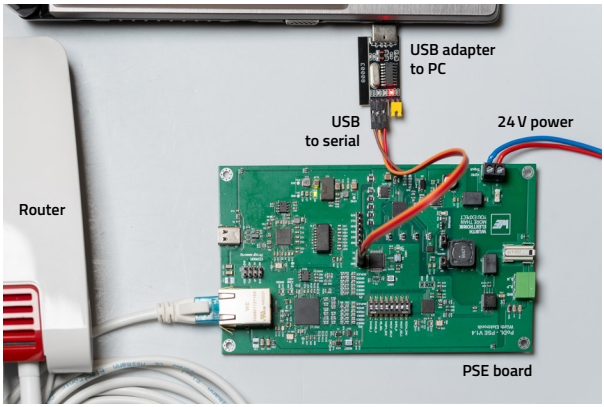


6. SYSTEM SET-UP

d) Setup the PSE board

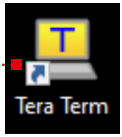
1. Connect power +24 V to X4
2. Connect PSE board to router via LAN cable
3. Connect USB-to-serial adapter with cable to X9



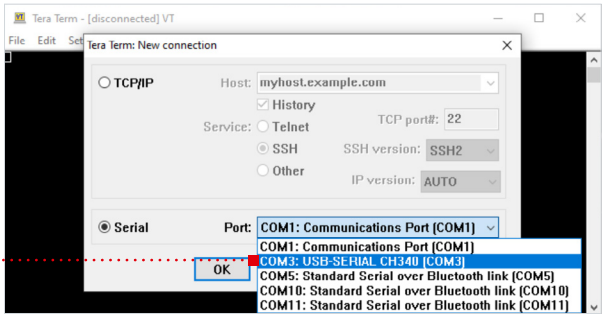


e) Set up serial terminal on PC

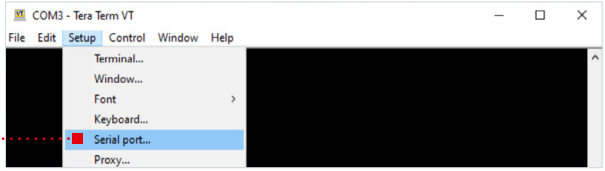
1. Use “Tera Term” or any similar terminal https://teratermproject.github.io/index-en.html



2. After opened Tera Term, select COM port to “USB-SERIAL” then click “OK”

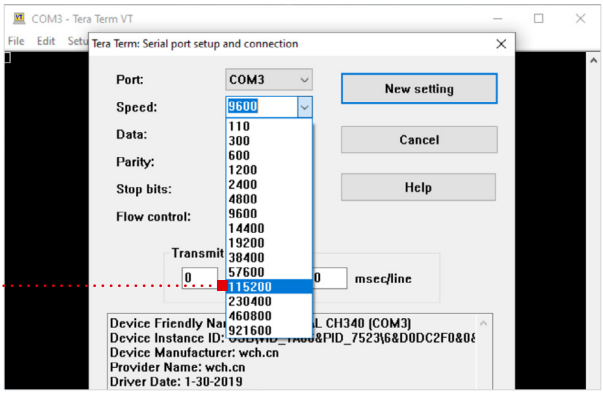


3. Select tab “Setup” and then “Serial port”

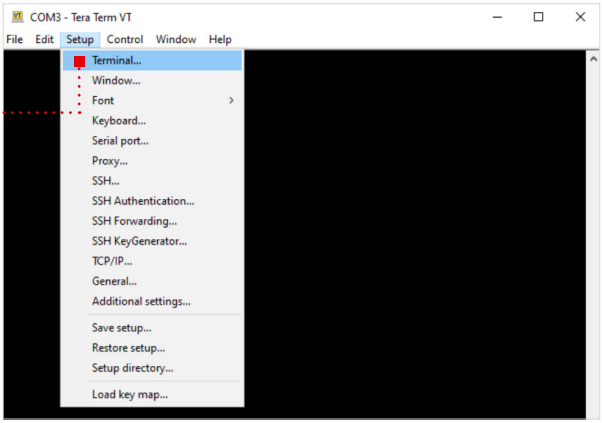


6. SYSTEM SET-UP

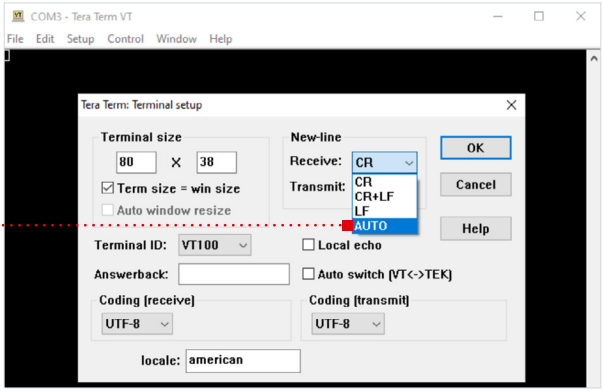
4. Select speed to “115200” then click “New setting”



5. Select tab “Setup” and then “Terminal”



6. At “Receiver”, select „AUTO” then click “OK”



6. SYSTEM SET-UP

f) Power on the PSE board (+24 V)

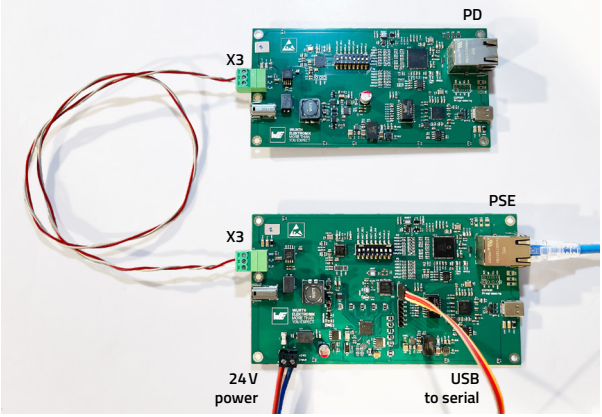
If the settings are correct, the serial terminal will print-out the status as on the right. The message shows that the PSE works in SCCP mode, no PD device connected.



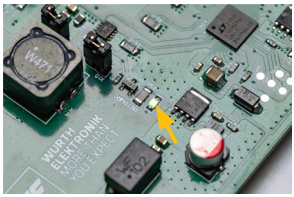
g) Connect the PD board to the PSE

1. Connect X2 of both boards via SPE-cable or alternatively

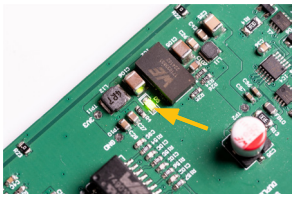
2. Connect X3 of both boards via 2 wire cable, like shown in the figure below.



3. If the power +24 V from the PSE board is supplied to the PD board correctly,



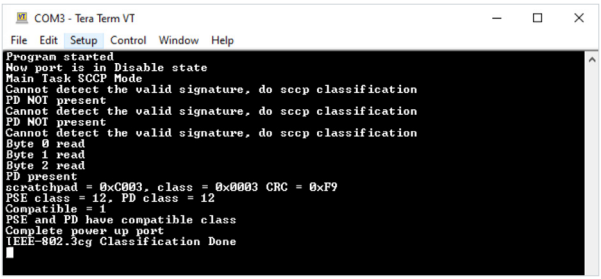
LED D20 (PRTPWR0) on PSE board will light-up.



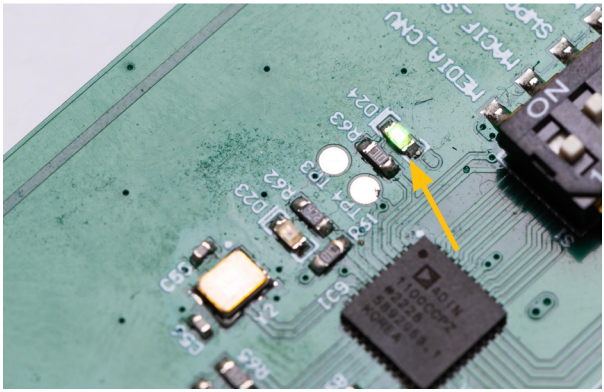
LED D5 (+3.3 V) on PD board will light-up.

6. SYSTEM SET-UP

Serial terminal will show the status as below.



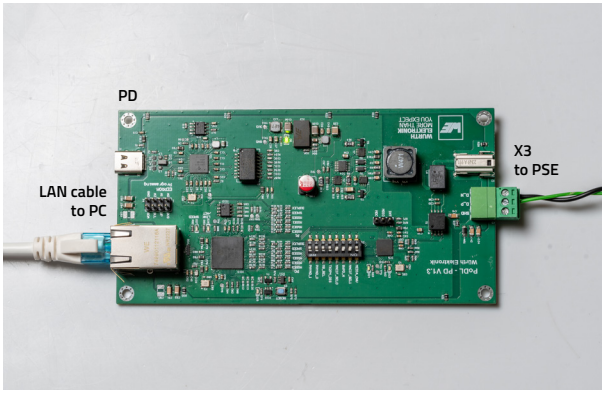
If the communication between the PSE and the PD works, LED D24 of both boards will be blinking.



h) Connect PD board to PC

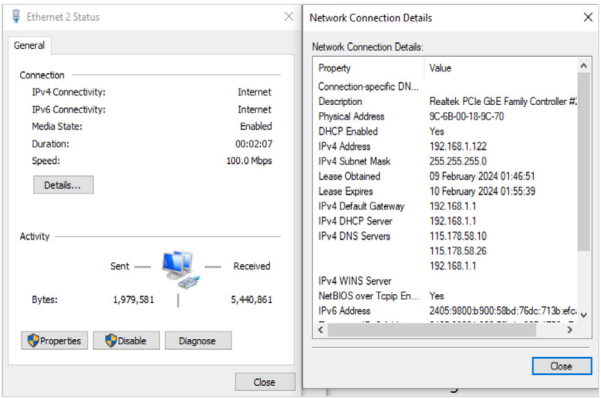
1. Via LAN cable

1.1. Connect a LAN cable between PD board and PC



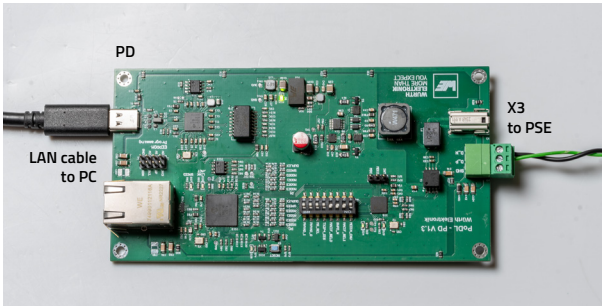
6. SYSTEM SET-UP

1.2. Check if the PC can get the IP address from the router.

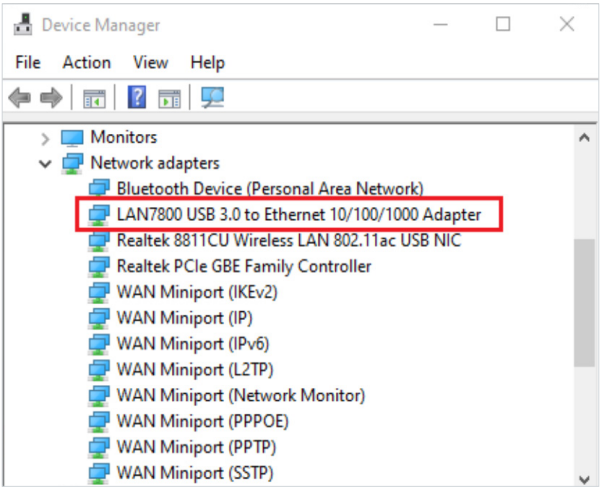


2. Via USB-C cable

2.1. Connect an USB3.2 type C to type A cable between PD board and PC.

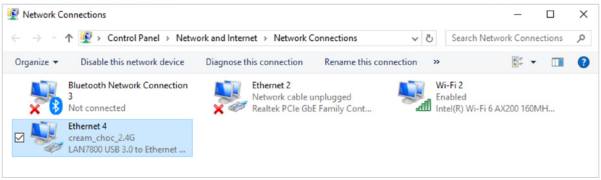


2.2. On PC, open the Device Manager to make sure if the PD board is connected and works properly.



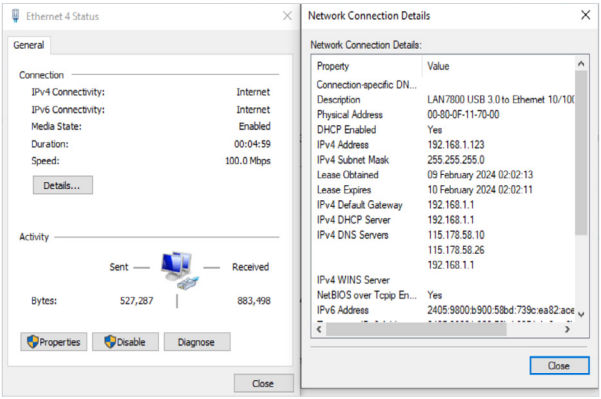
6. SYSTEM SET-UP

2.3. Open “Network connections” and make sure that the PC connects to the “LAN7800 USB 3.0 to Ethernet 10/100/1000 Adapter”.



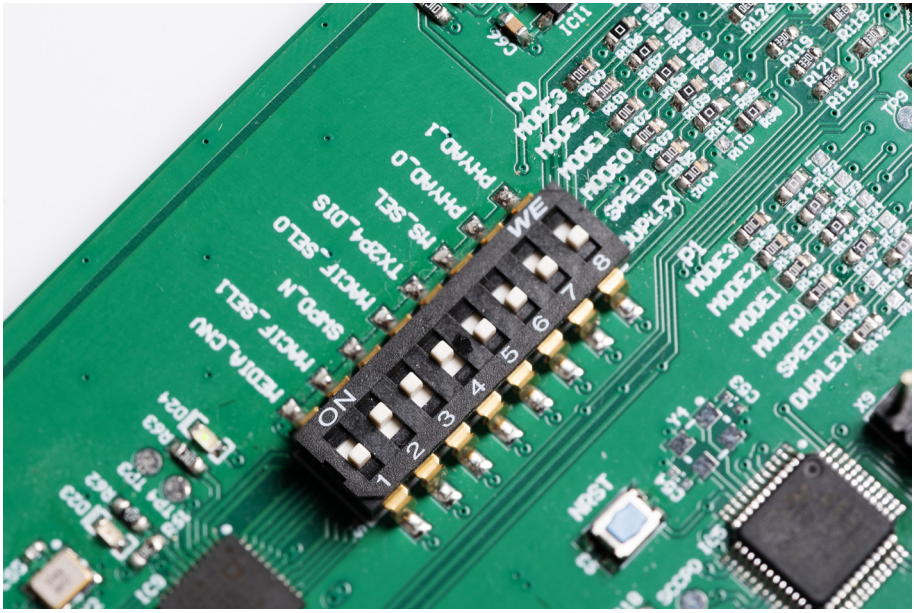
2.4. Check if the PC can get an IP address from the router.

2.5. Open any internet browser and check if the internet connection works.



6. SYSTEM SET-UP

PSE and PD HW-Configurations



PSE and PD On-Board Dip-Switch for HW configuration (S1)

Switch Position	Switch Name	Position	Description
1	MEDIA_CNV	Off	Media converter (only for RMII interface mode, not used on this board)
2	MACIF_SEL1	On	MAC Interface Select 1
3	SWPD_N	On	Software power-down
4	MACIF_SEL0	On	MAC Interface Select 0
5	TX2P4_DIS	Off	Transmit amplitude 2.4 V disable (always turn this switch on if AVDD_H = 1.8 V
6	MS_SEL	Off	Master/slave select (used as preference for auto negotiation)
7	PHYAD_0	Off	PHY Address 0 for management interface (MDIO)
8	PHYAD_1	Off	PHY Address 1 for management interface (MDIO)

6. SYSTEM SET-UP

PSE On-Board LEDs status

Name	Designator	Color	Description
Power	D5	Green	+3V3 Power on
PoDL	D20	Green	Port0 Power Good (+24V Output)
SPE	D23	Yellow	In firmware managed modes: 10BASE-T1L transmit amplitude 2.4 V
SPE	D24	Green	10BASE-T1L link up/activity
ETH	D27	Green	Port1 status (Gigabit to USB-C converter): Speed
ETH	D28	Green	Port1 status (Gigabit to USB-C converter): Link/Act
RJ45	X7	Yellow	Port2 status (Lan): Speed
RJ45	X7	Green	Port2 status (Lan): Link/Act
MCU	D21	Blue	User LED
Reset	D25	Red	SPE Communication & Ethernet Reset status

PD On-Board LEDs status

Name	Designator	Color	Description
Power	D5	Green	+3V3 Power on
SPE	D23	Yellow	In firmware managed modes: 10BASE-T1L transmit amplitude 2.4 V
SPE	D24	Green	10BASE-T1L link up/activity
ETH	D27	Green	Port1 status (Gigabit to USB-C converter): Speed
ETH	D28	Green	Port1 status (Gigabit to USB-C converter): Link/Act
RJ45	X7	Yellow	Port2 status (Lan): Speed
RJ45	X7	Green	Port2 status (Lan): Link/Act
Reset	D25	Red	SPE Communication & Ethernet Reset status

7. INFORMATION ABOUT ELECTROMAGNETIC COMPATIBILITY

This reference design HW 749951 has been tested for Electro Magnetic Compatibility emissions according to CISPR 32 (International Special Committee on Radio Interference) class B Limits and it fulfills the industrial immunity requirements according to IEC61000-6-2 with the set-up of CISPR35.

Explore its low emissions and high immunity to continuous and transient interference in our **Application Note 141: The SPoE Interface from an EMC Perspective**, available for download at the Würth Elektronik Home Page.

8. LINKS TO DESCRIPTION OF THE FIRMWARE, ALTIUM JOB FILES

Schematics, PCBs layouts, BOMs, Firmware for STM32G030C8T6 and all Altium files for the two boards (PSE and PD) of this 749951 Evaluation Kit are free to download in the following link:
Design Data at the Würth Elektronik Home Page.

9. LINKS TO FURTHER INFORMATION

Other useful information can be found in the WE Reference Designs related to Gigabit Ethernet and their EMC technical aspects. Free downloading in the following links:
RD016: Gigabit Ethernet Front End | **RD022: Gigabit Ethernet with PoE** at the Würth Elektronik Home Page.

10. IMPORTANT NOTES

This User Manual is based on our knowledge and experience of typical requirements concerning these areas. It serves as general guidance and should not be construed as a commitment for the suitability for customer applications by Würth Elektronik eiSos GmbH & Co. KG. The information in the Application Note is subject to change without notice. This document and parts thereof must not be reproduced or copied without written permission, and contents thereof must not be imparted to a third party nor be used for any unauthorized purpose.

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Useful links

Application Notes / Reference Design Notes

REDEXPERT Design Tool

Toolbox

Product Catalog



Contact Information
Technical Support

Würth Elektronik eiSos GmbH & CO. KG
Max-Eyth-Str. 1
74638 Waldenburg · Germany
Phone: +49 7942 945-0
info@we-online.com
www.we-online.com