PEB-A-001
(SPI to CAN)

Hardware Manual

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List of Figures

List of Tables

Conventions, Abbreviations and Acronyms

This hardware manual describes the PEB-A-001 PHYTEC Extension Board. The manual specifies the extension boards design and function. Precise specifications for the MCP2515 CAN controller can be found in the Data Sheet/User's Manual.

Conventions

The conventions used in this manual are as follows:

- Signals that are preceded by a "n", "/", or “#”character (e.g.: nRD, /RD, or #RD), or that have a dash on top of the signal name (e.g.: $\overline{RD}$) are designated as active low signals. That is, their active state is when they are driven low, or are driving low.
- A "0" indicates a logic zero or low-level signal, while a "1" represents a logic one or high-level signal.
- Tables which describe jumper settings show the default position in **bold, blue text**.
- Text in *blue italic* indicates a hyperlink within, or external to the document. Click these links to quickly jump to the applicable URL, part, chapter, table, or figure.
- References made to the expansion connectors always refer to pin header connector X8 and X9 on the phyCARD Carrier Board.

Abbreviations and Acronyms

Many acronyms and abbreviations are used throughout this manual. Use the table below to navigate unfamiliar terms used in this document.

Abbreviation	Definition
BSP	Board Support Package (Software delivered with the Development Kit including an operating system (Windows, or Linux) preinstalled on the module and Development Tools).
CB	Carrier Board; used in reference to the phyBASE Development Kit Carrier Board.

Abbreviation	Definition
EMI	Electromagnetic Interference.
GPI	General purpose input.
GPIO	General purpose input and output.
GPO	General purpose output.
J	Solder jumper; these types of jumpers require solder equipment to remove and place.
JP	Solderless jumper; these types of jumpers can be removed and placed by hand with no special tools.
PCB	Printed circuit board.
PEB	PHYTEC Extension Board
PDI	PHYTEC Display Interface
SBC	Single Board Computer; used in reference to the PCA-A-xx /phyCARD-A-xx Single Board Computer
SMT	Surface mount technology.
Sx	User button Sx (e.g. S1, S2, etc.) used in reference to the available user buttons, or DIP-Switches
Sx_y	Switch y of DIP-Switch Sx; used in reference to the DIP-Switches on the display adapter or Carrier Board.

Table 1: Abbreviations and Acronyms used in this Manual

Note:
The BSP delivered with the phyCARDs usually includes drivers and/or software for also controlling the PHYTEC Extension Boards. Therefore programming close to hardware at register level is not necessary in most cases. For this reason, this manual contains no information relevant for software development. Please refer to the Quickstart Manual "OSELAS.BSP()" for phyCARDs and the CAN controller's Datasheet if such information is needed.

Preface

As a member of PHYTEC's new phyCARD product family the PEB-A-001 is one of a series of PHYTEC Extension Boards that provide additional functions and interfaces to the standard phyCARD Carrier Board.

PHYTEC's new phyCARD Rapid Development Kit family consists of a series of extremely compact embedded control engines featuring various processing performance classes while using the newly developed X-Arc embedded bus standard. The standardized connector footprint and pin assignment of the X-Arc bus makes this new SBC generation extremely scalable and flexible. This also allows to use the same carrier board to create different applications depending on the required processing power. PHYTEC Extensions Boards (PEBs) facilitate adding even more functions and interfaces. With this new SBC concept it is possible to design entire embedded product families around vastly different processor performances while optimizing overall system cost. In addition, future advances in processor technology are already considered with this new embedded bus standard making product upgrades very easy. Another major advantage is the forgone risk of potential system hardware redesign steps caused by processor or other critical component discontinuation. Just use one of PHYTEC's other phyCARD SBCs thereby ensuring an extended product life cycle of your embedded application.

PHYTEC supports a variety of PEBs in two ways:

(1) as add-ons for Rapid Development Kits which serve as a reference and evaluation platform

(2) as insert-ready, fully functional OEM extension board, which can be embedded directly into the user’s peripheral hardware design.

Implementation of an OEM-able subassembly as the "core" of a specific function, or interface allows you to focus on the development of customer specific circuitry without expending resources to "re-invent" standard functions and interface circuitry. Furthermore, much

of the value of the PHYTEC Extension Boards lies in its layout and test.

Production-ready Board Support Packages (BSPs) and Design Services for our hardware will further reduce your development time and risk and allow you to focus on your product expertise. Take advantage of PHYTEC products to shorten time-to-market, reduce development costs, and avoid substantial design issues and risks. With this new innovative full system solution you will be able to bring your new ideas to market in the most timely and cost-efficient manner.

For more information go to:

http://www.phytec.com/services/

Ordering Information

The part numbering of the PHYTEC Extension Boards has the following structure:

PEB-A-*xxx*

Generation

A = First generation

Model number[1]

001 = SPI to CAN
002 = USB to Ethernet
003 = I^2C, or SPI to GPIO

In order to receive product specific information on changes and updates in the best way also in the future, we recommend to register at

http://www.phytec.de/de/support/registrierung.html

You can also get technical support and additional information concerning your product.

[1]: Please also visit our website www.phytec.de for information on additional PEBs

The support section of our web site provides product specific information, such as errata sheets, application notes, FAQs, etc.

http://www.phytec.de/de/support/faq

Declaration of Electro Magnetic Conformity of the PHYTEC PEB-A-001

PHYTEC Single Board Computers (henceforth products) are designed for installation in electrical appliances or as dedicated Evaluation Boards (i.e.: for use as a test and prototype platform for hardware/software development) in laboratory environments.

Caution:
PHYTEC products lacking protective enclosures are subject to damage by ESD and, hence, may only be unpacked, handled or operated in environments in which sufficient precautionary measures have been taken in respect to ESD-dangers. It is also necessary that only appropriately trained personnel (such as electricians, technicians and engineers) handle and/or operate these products. Moreover, PHYTEC products should not be operated without protection circuitry if connections to the product's pin header rows are longer than 3 m.

PHYTEC products fulfill the norms of the European Union's Directive for Electro Magnetic Conformity only in accordance to the descriptions and rules of usage indicated in this hardware manual (particularly in respect to the pin header row connectors, power connector and serial interface to a host-PC).

Implementation of PHYTEC products into target devices, as well as user modifications and extensions of PHYTEC products, is subject to renewed establishment of conformity to, and certification of, Electro Magnetic Directives. Users should ensure conformance following any modifications to the products as well as implementation of the products into target systems.
*

1 Introduction

The PHYTEC Extension Board PEB-A-001 belongs to a series of add-on modules for PHYTEC's phyCARD Single Board Computer module family. These add-on modules allow easy development of complex applications with off-the-shelf components.

PHYTEC Extension Boards PEB-A-xxx are compatible to the two, identical Extension Connectors X8 and X9 on the phyCARD Carrier Board PBA-A-01. Thus they are interchangeable and the same phyCARD / phyBASE combination might serve for different applications just by changing the extension board and the software.

Figure 1 depicts the modular concept of the phyCARD Development Kit family and the usage of the PHYTEC Extension Boards.

All add-on modules are supported within the BSPs[1] available for the different phyCARD SBCs.

The PEB-A-001 is a subminiature (92 x 68 mm) insert-ready interface card populated with the Microchip MCP2515 CAN controller. If mounted on the carrier board (phyBASE) it connects to any phyCARD populating the phyBASE via the SPI interface. It provides CAN connectivity to many external CAN devices.

Precise specifications for the components populating the board can be found in the applicable *User's Manuals* or *Data Sheets.*

1: To ensure that the PEB of your choice is supported by the BSP use only the latest BSP, or check on the PHYTEC website from which version on the driver is implemented.

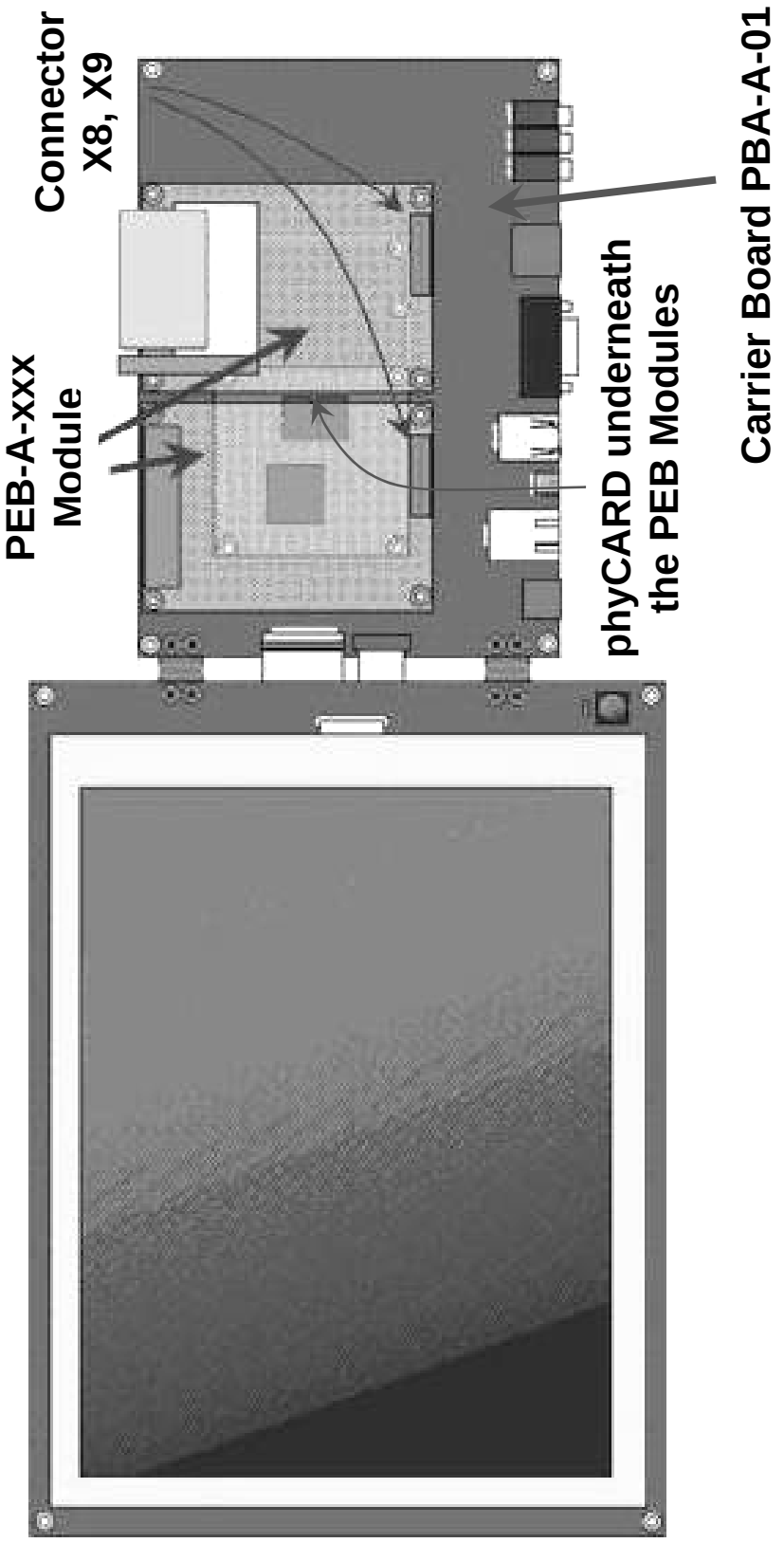


Figure 1: Modular Concept of the phyCARD Development Kit family

The PEB-A-001 offers the following features:

- Subminiature Extension Board (92 x 68 mm) achieved through modern SMD technology
- Compatible to the phyCARD Development Kit Carrier Board (phyBASE) PBA-A-001
- Improved interference safety achieved through multi-layer PCB technology and dedicated Ground pins
- Operates off of a two supply voltages (+3.3V and +5V)
- Expansion connector for phyBASE connectivity via SPI interface
- Galvanically separated CAN signals at male DB-9 connector
- MCP2515 stand-alone CAN controller, implements CAN V2.0B
- PCA82C250 CAN controller interface fully compatible with the "ISO 11898" standard
- 1-Wire EEPROM for internal use only
- Mounting wholes to screw the PEB to the phyBASE

1.1 Block Diagram

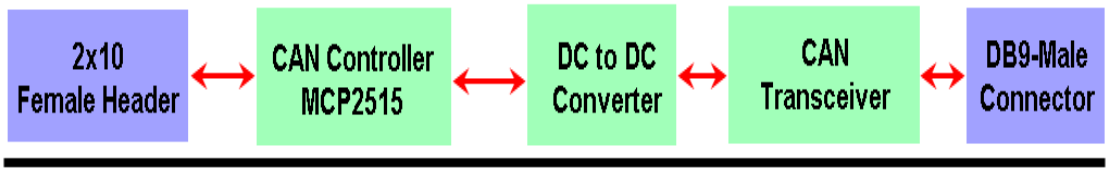


Figure 2: Block Diagram PEB-A-001

1.2 View of the PEB-A-001

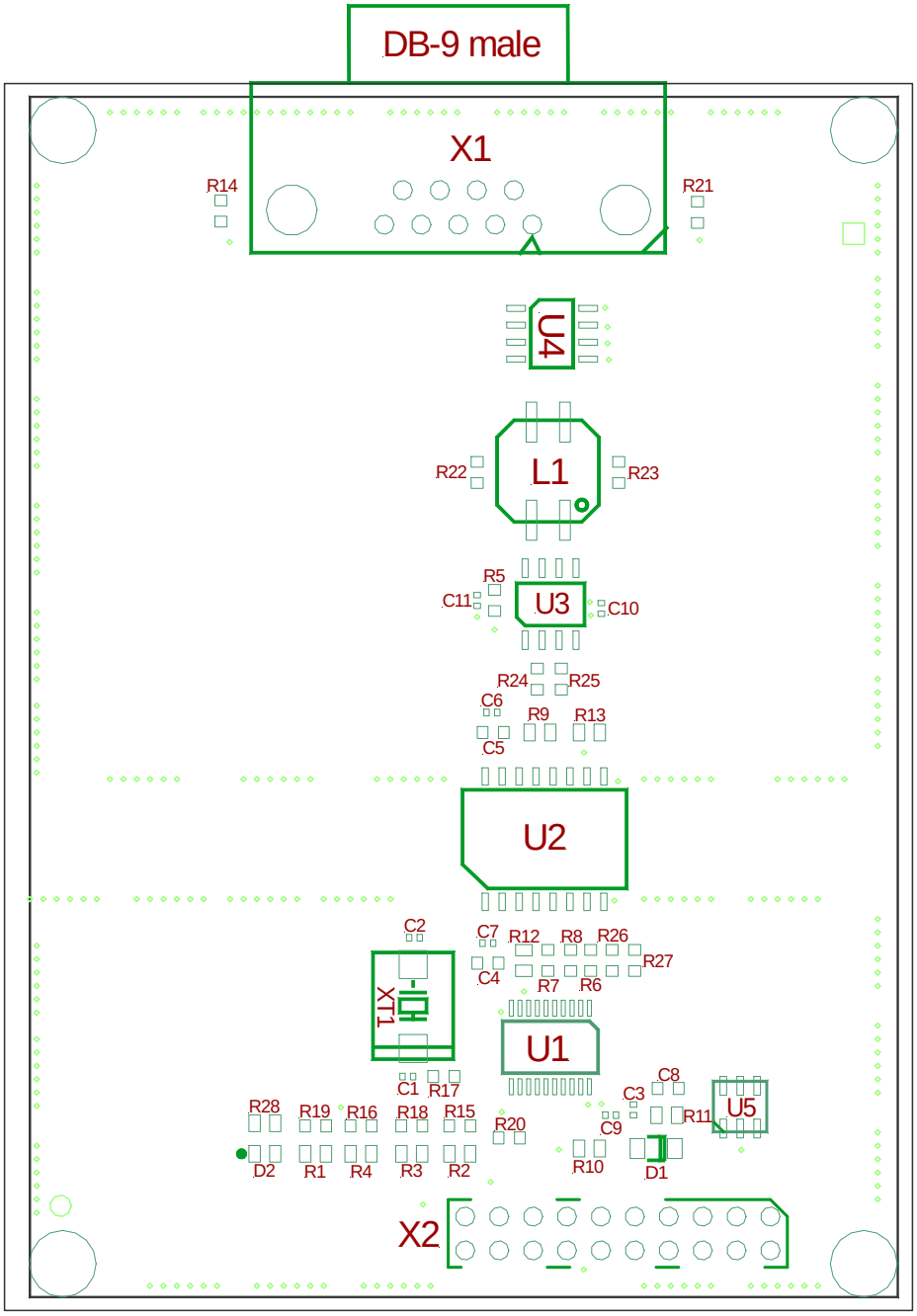


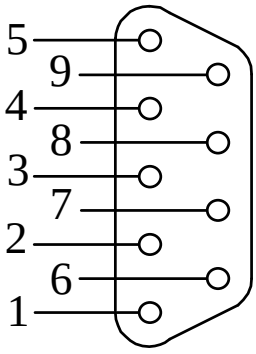
Figure 3: View of the PEB-A-001

2 Pin Description

Please note that all module connections are not to exceed their expressed maximum voltage or current. Maximum signal input values are indicated in the corresponding controller manuals/data sheets. As damage from improper connections varies according to use and application, it is the user's responsibility to take appropriate safety measures to ensure that the module connections are protected from overloading through connected peripherals.

As shown in *Figure 3* a 2 x 10 connector socket (X2) at the underside of the board connects the PEB-A-001 to the carrier board. The CAN interface is available at the DB9-male connector (X1) on the upper side.

2.1 Pinout of the CAN Interface (X1)



Pin 3:	CAN_GND
Pin 7:	CAN-H0 (galvanically separated)
Pin 2:	CAN-L0 (galvanically separated)
Pin 6:	CAN_GND

Figure 4: Pin Assignment of the DB-9 Plug X1

2.2 Pinout of the Expansion Connector (X2)

Table 2 provides an overview of the pinout of the expansion connector at X2. The table lists only signals used on the PEB-A-001. Several more signals are available at the expansion connectors X8 and X9 on the phyBASE. Please refer to the hardware manual of your phyCARD for a complete pinout.

Pin #	Signal Name	Description
1	VCC5V	5V power supply
2	VCC5V	5V power supply
3	VCC3V3	3,3V power supply
4	VCC3V3	3,3V power supply
5	GND	Ground
6	GND	Ground
7	N/C	not connected
8	N/C	not connected
9	PHYWIRE	Hardware Introspection Interface. **For internal use only**
10	GND	Ground
11	/SPI_CS	SPI chip select
12	SPI_SI	SPI slave input
13	SPI_SCK	SPI clock input
14	SPI_SO	SPI slave output
15	N/C	not connected
16	/INT	Interrupt output of the CAN controller
17	GND	Ground
18	GND	Ground
19	N/C	not connected
20	N/C	not connected

Table 2: Pinout of the Expansion Connector X2

3 Power

The PEB-A-001 operates off of a two supply voltages(+3.3V and +5V) which are fed through the expansion connector X2 of the PEB. The +3.3V voltage supplies the CAN controller, whereas 5V are needed to generate the voltage for the CAN bus. An integrated on-board DC-to-DC converter provides an isolated supply voltage for the CAN controller interface at U3.

3.1 Primary System Power (+3V3 and +5V)

For proper operation the PEB-A-001 must be supplied with a voltage source of 3.3V at the "+3V3" pins and 5V at the "+5V"on the expansion connector X2.

+3V3:	X2	3, 4
+5V:	X2	1, 2

Connect all VCC input pins and all GND pins to your power supply.

Corresponding GND: X2 5, 6, 17, 18

Caution:
As a general design rule we recommend connecting all GND pins neighboring signals which are being used in the application circuitry. For maximum EMI performance all GND pins should be connected to a solid ground plane.

The following sections of this chapter discuss the primary power pins on the phyCARD-Connector X2 in detail.

3.2 On-board Voltage Regulator (U1)

The PEB-A-001 provides an integrated on-board DC-to-DC converter to supply the connector side of the CAN controller interface with an isolated supply voltage

The switching regulator has a single input voltage rail +5V as can be seen in *Figure* 5. +5V is supplied from the voltage input pins. The following list summarizes the relation between the different voltage rails and the devices on the PEB-A-001:

External voltages:

- +3V3: CAN controller
- +5V: Isolator with integrated DC-to-DC converter

Internally generated voltages:

- +5V_CAN CAN Controller Interface Power Supply.

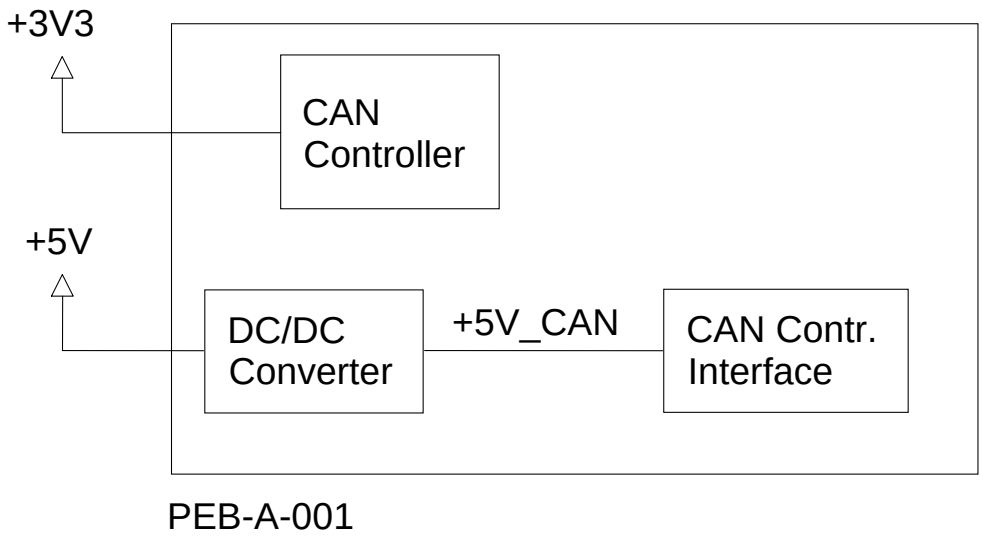


Figure 5: Power Supply Diagram

4 CAN Interfaces

The CAN signals on the PEB-A-001 are generated by a stand-alone CAN controller (MCP2515). They extend to a quad-channel isolator, which separates the CAN controller and the CAN transceiver galvanically. The CAN transceivers generate the corresponding CAN High and CAN Low signals which are available at the DB9 male connector X1 (refer to *Figure 4* for the pinout). These signals can be directly connected to a CAN dual-wire bus.

Programming of the CAN controller is done via SPI bus interface. The SPI bus extends from the expansion connector X2 to the CAN controller. For interrupt controlled applications the interrupt of the CAN controller is also brought out to expansion connector X2.

The CAN bus transceiver device supports signal conversion of the CAN transmit (TXCAN) and receive (RXCAN) lines. The CAN transceiver supports up to 110 nodes on a single CAN bus. Data transmission occurs with differential signals between CAN High and CAN Low.

Note:
A Ground connection between nodes on a CAN bus is not required, yet is recommended to better protect the network from electromagnetic interference (EMI). In order to ensure proper message transmission via the CAN bus, a 120 Ohm termination resistor must be connected to each end of the CAN bus. There are no termination resistors on the PEB-A-001.

Parameters for configuring a proper CAN bus system can be found in the DS102 norms from the CiA[1] (CAN in Automation) User and Manufacturer's Interest Group.

[1]: CiA: CAN in Automation. Founded in March 1992, CiA provides technical, product and marketing information with the aim of fostering Controller Area Network's image and providing a path for future developments of the CAN protocol.

5 Technical Specifications

The physical dimensions of the PEB-A-001 are represented in *Figure* 6. The module's profile is ca. 22 mm thick, with a maximum component height of 7 mm on the bottom (connector) side of the PCB and approximately 13 mm on the top (microcontroller) side. The board itself is approximately 1.8 mm thick.

Additional specifications:

• Dimensions:	92 mm x 68 mm
• Weight:	approximately 36 g with all optional components mounted on the circuit board
• Storage temperature:	-40°C to +90°C
• Operating temperature:	standard: 0°C to +70°C extended: -40°C to +85°C
• Humidity:	95 % r.F. not condensed
• Operating voltage:	VCC 3.3 V 5 %, VCC2 5 V 5 %, VBAT 3 V 20 %
• Power consumption:	**TBD**

These specifications describe the standard configuration of the PEB-A-001 as of the printing of this manual.

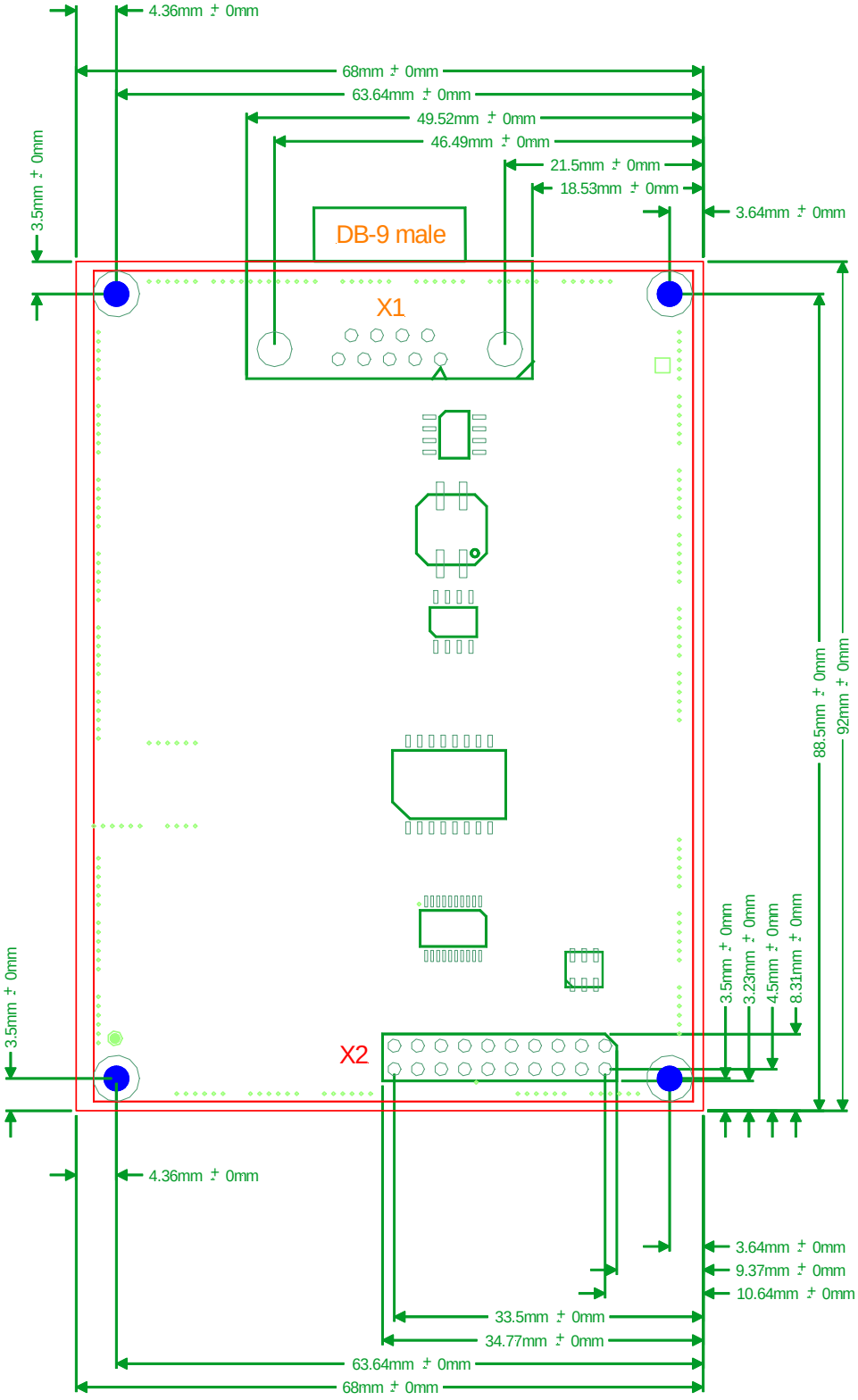


Figure 6: Physical Dimensions

6 Component Placement Diagram

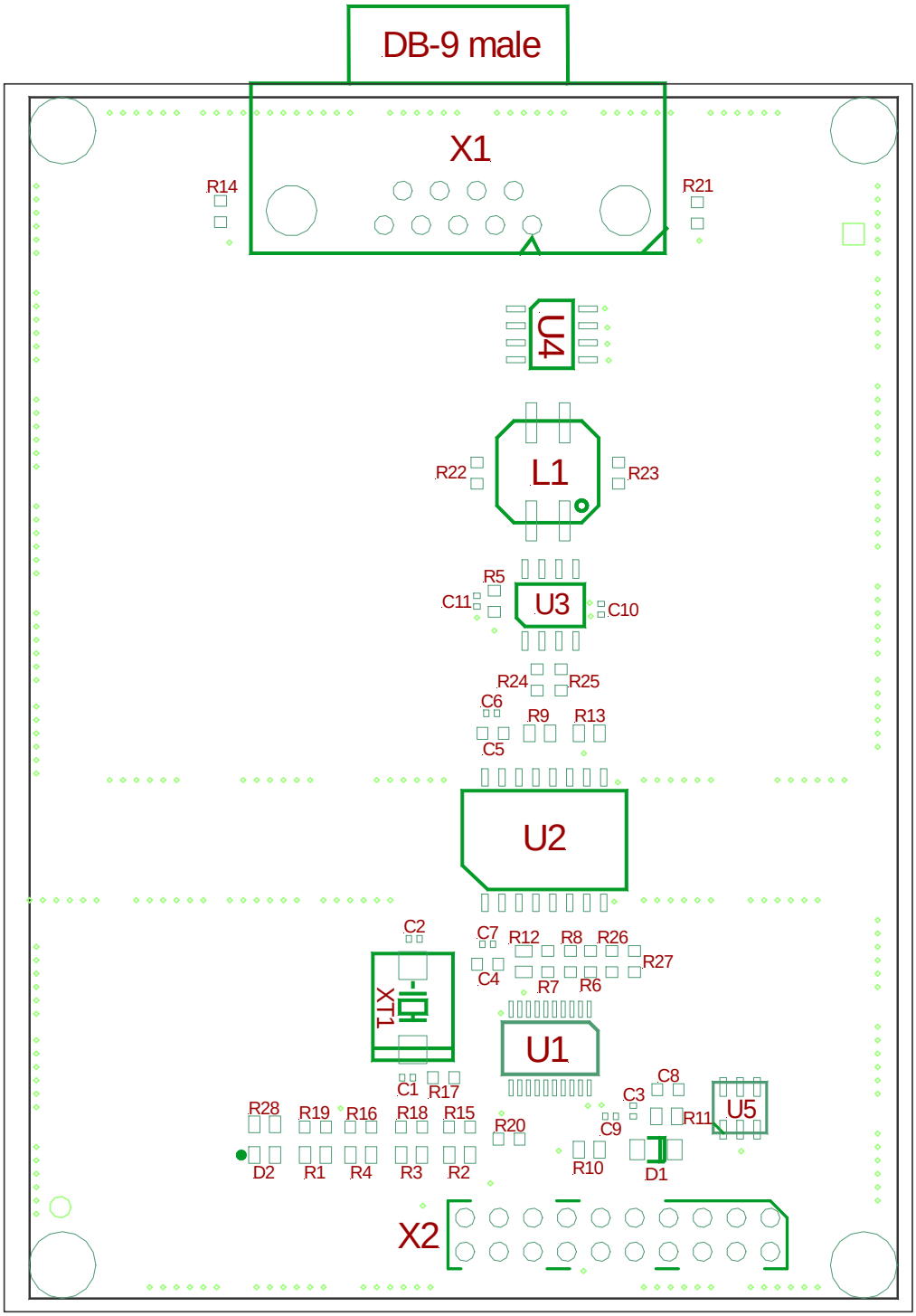


Figure 7: PEB-A-001 Component Placement, Top View

7 Hints for Integrating and Handling the PHYTEC Extension Board

7.1 Integrating the PHYTEC Extension Board

Besides this hardware manual much information is available to facilitate the integration of the PHYTEC Extension Boards into customer applications, or use them as reference design.

1. many answers to common questions can be found at http://www.phytec.de/de/support/faq, or http://www.phytec.eu/europe/support/faql.
2. different support packages are available to support you in all stages of your embedded development. Please visit http://www.phytec.de/de/support/support-pakete.html, or http://www.phytec.eu/europe/support/support-packages.html, or contact our sales team for more details.

7.2 Handling the PHYTEC Extension Board

- **Modifications on the PHYTEC Extension Board**

Removal of various components, such as the CAN controller is not advisable given the compact nature of the module. Should this nonetheless be necessary, please ensure that the board as well as surrounding components and sockets remain undamaged while de-soldering. Overheating the board can cause the solder pads to loosen, rendering the module inoperable. Carefully heat neighboring connections in pairs. After a few alternations, components can be removed with the solder-iron tip. Alternatively, a hot air gun can be used to heat and loosen the bonds.

Caution!
If any modifications to the module are performed, regardless of their nature, the manufacturer guarantee is voided.

- **Use of the PHYTEC Extension Board as Reference Design**

Successful use as reference design for custom applications greatly depends on the adherence to the layout design rules for the GND connections. As a general design rule we recommend connecting all GND pins neighboring signals which are being used in the application circuitry. For maximum EMI performance all GND pins should be connected to a solid ground plane. It is also advisable to follow the application information given in the data sheets of the different components.

8 The PEB-A-001 on the phyBASE

The phyBASE Carrier Board provides a flexible development platform enabling quick and easy start-up and subsequent programming of the PHYTEC Extension Boards. The Carrier Board design allows easy connection of up to two extension boards featuring various functions that support fast and convenient prototyping and software evaluation. The Carrier Board is compatible with all phyCARDs and PEBs.

The following sections contain specific information relevant to the operation of the PEB-A-001 mounted on the phyBASE Carrier Board.

Note:
Only features of the phyBASE which are needed to support the functioning of the PEB-A-001 are described. Jumper settings and configurations which are not relevant for the use of the PEB-A-001 are not described in the following chapters.

8.1 Overview of the phyBASE Peripherals

The phyBASE is depicted in *Figure 8*. Peripherals required to use the PHYTEC Extension Board PEB-A-001 are highlighted. Additionally all necessary components and peripherals are listed in *Table 3* and *Table 4*. For a more detailed description of each peripheral refer to the appropriate chapter listed in the applicable table.

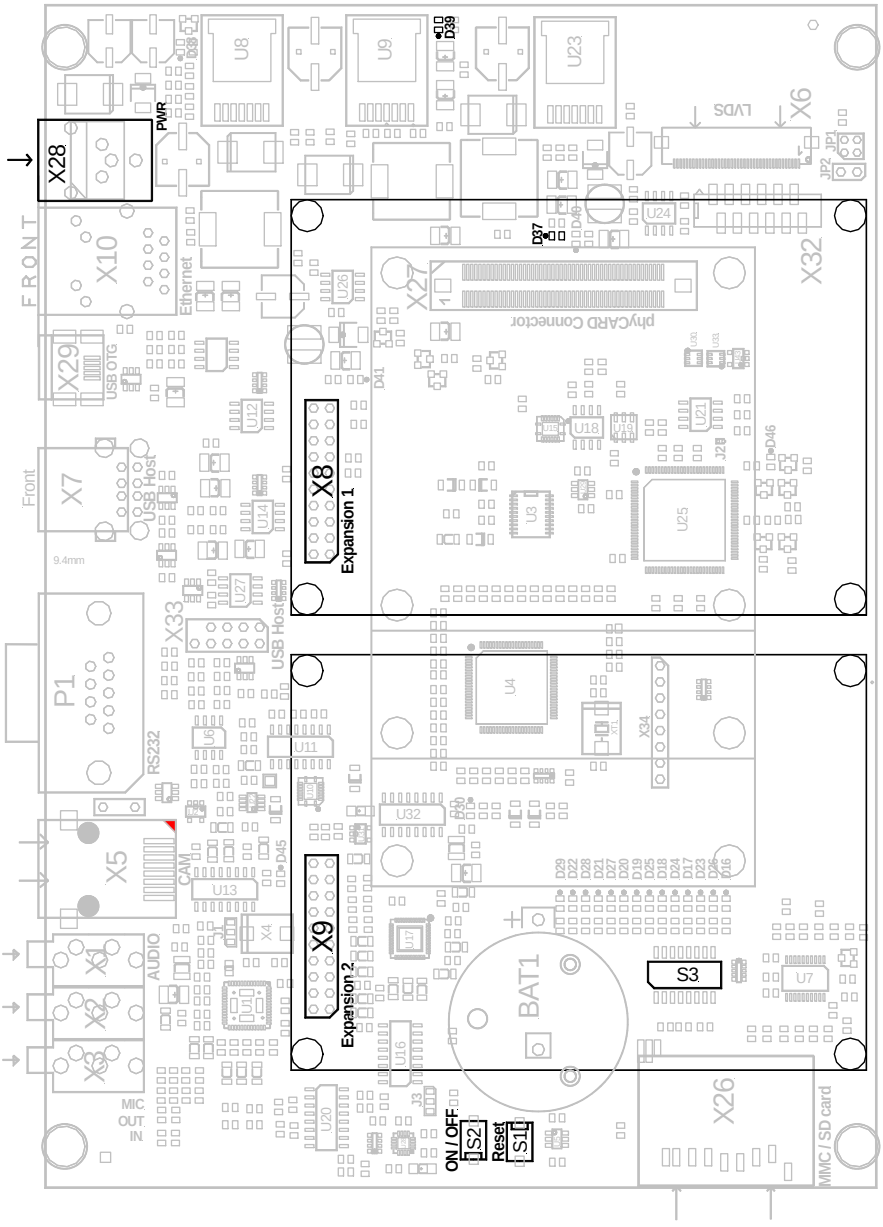


Figure 8: phyBASE Overview of applicable Connectors, LEDs and Buttons

8.1.1 Connectors and Pin Header

Table 3 lists all applicable connectors on the phyBASE. *Figure 8* highlights the location of each connector for easy identification.

Reference Designator	Description	See Section
X8A	Expansion connector 0	*8.2.2*
X9A	Expansion connector 1	*8.2.2*
X28	Wall adapter input power jack to supply main board power (+9 - +36 V)	*8.2.1*

Table 3: phyBASE Connectors and Pin Headers related to PEB-A-001

Note:
The signal levels of the I^2C and SPI interface are shifted to VCC3V3 (3.3 V) by level shifters on the phyCARD Carrier Board.

Ensure that all module connections are not to exceed their expressed maximum voltage or current. Maximum signal input values are indicated in the corresponding controller User's Manual/Data Sheets. As damage from improper connections varies according to use and application, it is the user‘s responsibility to take appropriate safety measures to ensure that the module connections are protected from overloading through connected peripherals.

8.1.2 Switches

The phyBASE is populated with some switches which are essential for the operation of the phyCARD module and in further consequence of the PEB on the Carrier Board. *Figure* 8 shows the location of the switches and push buttons.

Button	Description
S1	System Reset Button – system reset signal generation
S2	Power Button – powering on and off main supply voltages of the Carrier Board

Table 4: phyBASE push buttons descriptions

Please refer to the hardware manual of your phyCARD for further information on the functioning of these push buttons.

Additionally a DIP-Switch is available at S3.

Switches 7 and 8 of this DIP-Switch allow to configure the mapping of the two slave select signals of the SPI interface as well as the routing of the two GPIO_IRQ signals (GIO0_IRQ, GPIO1_IRQ). The signals can be mapped either to the two expansion connectors X8A (expansion 0) and X9A (expansion 1) or to one of the two expansion connectors and the display data connector at X6. A detailed description of the configurations possible can be found in the hardware manual of your phyCARD.

Note:
To ensure proper functioning of the PHYTEC Extension Board the setting of switches 7 and 8, as well as the parameter used when loading the software driver must match the expansion connector the PEB-A-001 is connected to.
With the default setting (S3_7 and S3_8 OFF) booth expansion connectors can be used.

8.1.3 Jumpers

Various jumpers on the phyBASE allow the user flexibility of configuring a limited number of features for development constraint purposes. However none of the jumpers is relevant for the PHYTEC Extension Board's correct functioning.

8.1.4 LEDs

The phyBASE is populated with numerous LEDs to indicate the status of the various USB-Host interfaces, as well as the different supply voltages. Some of them are also important in the use of the PHYTEC Extension Boards. *Figure 8* shows the location of these LEDs. Their function is listed in the table below:

LED	Color	Description	See Section
D37	green	5V supply voltage for peripherals on the phyBASE	*8.2.1*
D39	green	3V3 supply voltage for peripherals on the phyBASE	

Table 5: phyBASE LEDs descriptions

8.2 Functional Components on the phyBASE Board

This section describes the functional components of the phyBASE Carrier Board supporting the PEB-A-001 Each subsection details a particular connector/interface and associated jumpers for configuring that interface.

8.2.1 Power Supply (X28)

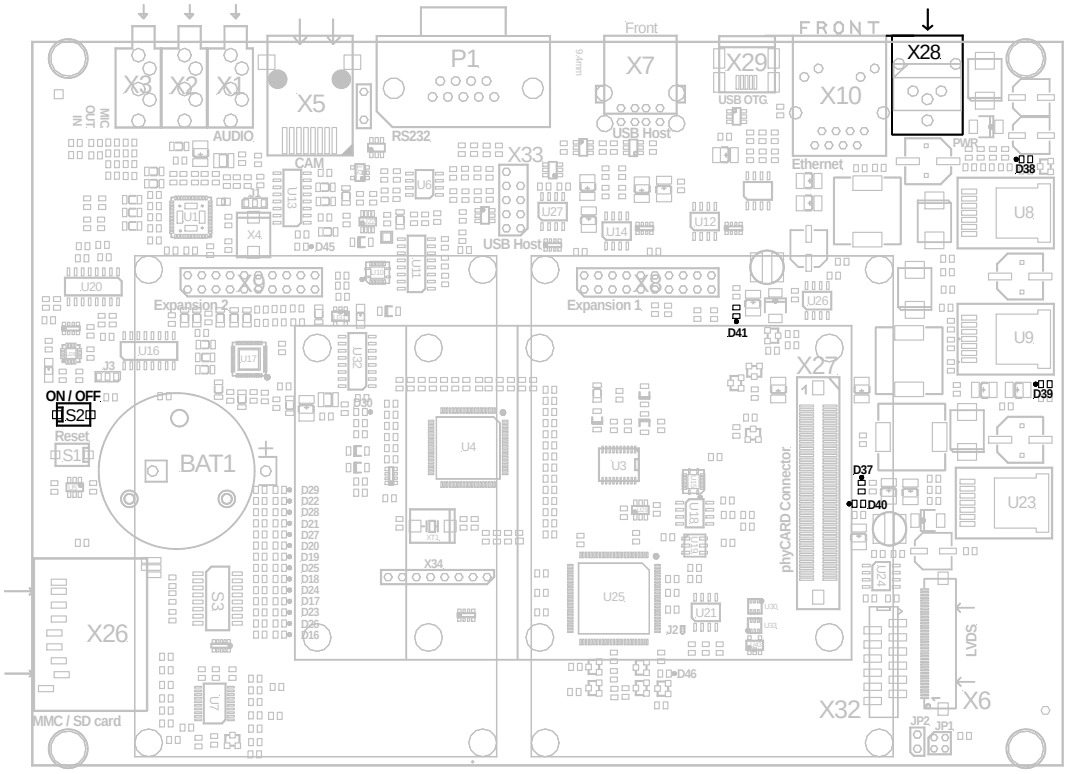


Figure 9: Power adapter

The supply voltages for the PHYTEC Extension Board are derived from the main power supply connected to connector X28 on the phyBASE. They are available at the expansion connectors X8 and X9 as soon, as the phyBASE enters RUN state. The PEBs are powered up only during RUN state of the Carrier Board.

Caution:
Do not use a laboratory adapter to supply power to the Carrier Board! Power spikes during power-on could destroy the phyCARD module and the PEB mounted on the Carrier Board! Do not change modules or jumper settings while the Carrier Board is supplied with power!

Permissible input voltage at X28: +9 - +36 V DC unregulated.

No jumper configuration is required in order to supply power to the PHYTEC Extension Boards!

The phyBASE is assembled with a few power LEDs whose functions are described in the following table:

Two LEDs indicate the availability of the supply voltage at expansion connectors X8 and X9.

LEDs	Color	Description
D37	green	VCC5V - 5V supply voltage for peripherals on the phyBASE
D39	green	VCC3V3 - 3V3 supply voltage for peripherals on the phyBASE

Table 6: Power state LEDs

Please refer to the corresponding section in your phyCARD Hardware Manual for detailed information on suitable power supplies and the different power states.

8.2.2 Expansion connectors (X8A, X9A)

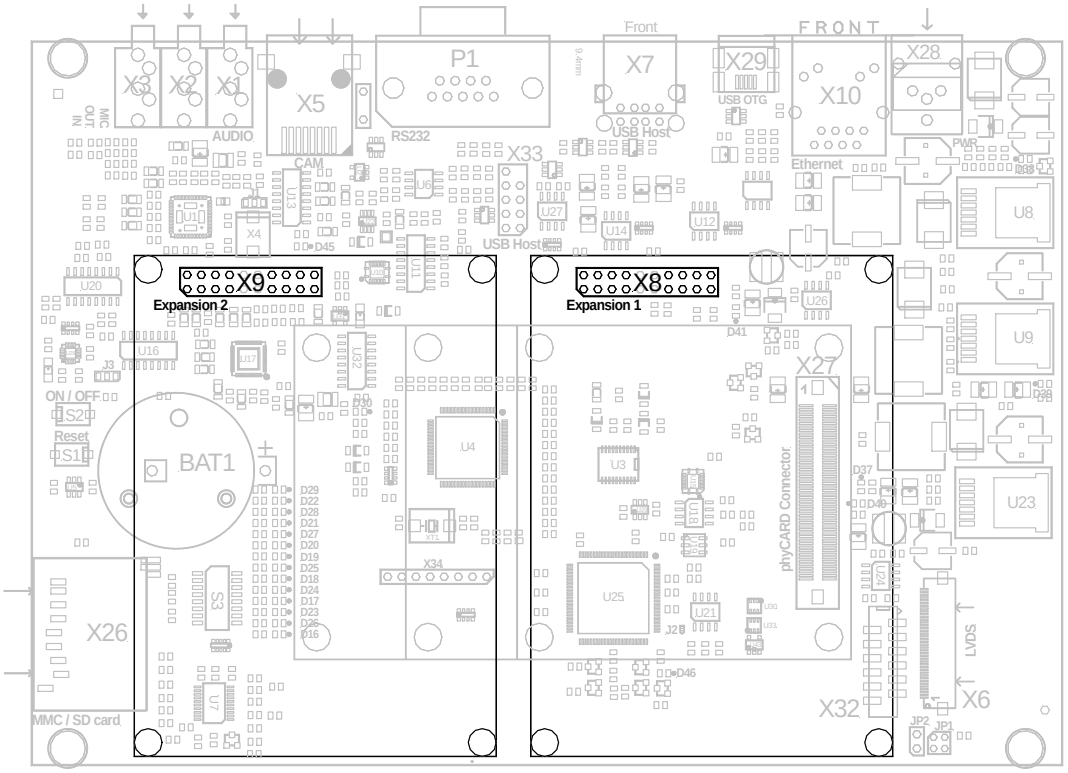


Figure 10: Expansion connector X8A, X9A

The expansion connectors X8A and X9A provide an easy way to connect the PHYTEC Extension Boards to the phyBASE and therefore add other functions and features to it.

As can be seen in *Figure 10* the location of the connectors allows to expand the functionality without expanding the physical dimensions. Mounting wholes can be used to screw the PEBs to the phyBASE.

Various standard interfaces such as USB, SPI and I^2C as well as different supply voltages and one GPIO are available at the pin header rows. Usage of the PEB-A-001 requires the SPI interface, the GPIO/Interrupt input and two different supply voltages (+3.3V and +5 V). A pinout showing all signals which extend on the PEB-A-001 is shown in *Table 2*.

8.2.2.1 SPI Connectivity

Programming of the CAN controller on the PEB-A-001 is done via the phyCARD's SPI bus interface. It is available at expansion connectors X8A and X9A and extends on the PEB-A-001.

Appropriate drivers are available within the BSPs[1] provided with the different phyCARD SBCs (*please refer to the Quickstart Manual "OSELAS.BSP()"*).

The expansion connectors share the SPI interface and the GPIOs of the X-Arc bus with the display data connector X6. Due to the X-Arc bus specification only two slave select signals are available. Because of that the CPLD maps the SPI interface to two of the connectors depending on the configuration of switches 7 and 8 of DIP-Switch S3.

Therefore switches 7 and 8 of DIP-Switch S3 must be configured to map the signals to the connector the PEB-A-001 is plugged onto.

Button	Setting	Description
S3_7/ S3_8	**0/0**	**SS0/GPIO0_IRQ -> expansion 0 (X8A), SS1/GPIO1_IRQ -> expansion 1 (X9A)**
	0/1	SS0/GPIO0_IRQ -> expansion 0 (X8A), SS1/GPIO1_IRQ -> display data connector (X6)
	1/x	SS0/GPIO0_IRQ -> expansion 1 (X9A), SS1/GPIO1_IRQ -> display data connector (X6)

Table 7: SPI and GPIO connector selection

A detailed description of the configurations possible can be found in the hardware manual of your phyCARD.

1: To ensure that the PEB of your choice is supported by the BSP use only the latest BSP, or check on the PHYTEC website from which version on the driver is implemented.

Note:
To ensure proper functioning of the PHYTEC Extension Board the setting of switches 7 and 8, as well as the parameter used when loading the software driver must match the expansion connector the PEB-A-001 is connected to.
With the default setting (S3_7 and S3_8 OFF) booth expansion connectors can be used.

8.2.2.2 GPIO/Interrupt Input

Two (GPIO0_IRQ and GPIO1_IRQ) of the three GPIO / Interrupt signals available at the X-Arc bus are mapped to the expansion connectors X8A and X9A (pin 16).

For interrupt controlled applications the interrupt of the CAN controller is brought out to expansion connector X2. Depending on the socket the PEB is plugged onto it is connected to the IRQ0 (X8A), or the IRQ1 (X9A) input of the phyCARD's X-Arc bus.

Note:
Depending on the configuration at Switches 7 and 8 of DIP-Switch S3 the GPIOx_IRQ signals can also be mapped to the display data connector X6 (pin 5). Ensure correct setting of switches 7 and 8 for proper functioning of the PHYTEC Extension Board (please refer to *section 8.2.2.1* for more information).

9 Revision History

Date	Version numbers	Changes in this manual
20-Apr-2011	Manual L-755e_1	First edition

Index

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