TECHNICAL REPORT

USB AUDIO-DAC
UDA1321
EVALUATION BOARD
AND
APPLICATION DOCUMENTATION

Version 1.4

DML98001

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Keywords:

Universal Serial Bus (USB)
Digital-Analog Converter (DAC)
UDA1321
UDA1331H
USB-DAC configuration editor
UniCoDes © 1999-2000
Windows™ 98
iMac™

Date: June 14th, 2000

Abstract

This application note describes the installation and application of the Philips Semiconductors USB-Digital to Analog Converter solutions UDA1321 for the Universal Serial Bus (USB). Specific information is given about hardware and software requirements necessary to make the USB-Audio function work in a USB-enabled computer system.

Notice: *Windows™ 95, Windows ™ 98 and Windows™ NT are registered trademarks of Microsoft ® Corporation.*

USB compliant conform USB specifications v1.0

Purchase of Philips I^2C components conveys a license under the I^2C patent to use the components in the I^2C system, provided the system conforms to the I^2C specifications defined by Philips.

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1. Introduction

1.1 General Information

This application note describes the installation and use of the Philips Semiconductors USB-Digital to Analog Converters UDA1321 evaluation boards. It furthermore explains the application of the USB-DAC in an environment as a USB-Audio Device.

The type number UDA1331H, USB-APP, refers to the special QFP64 package version of the UDA1321. The essential difference between the two products is that the UDA1331H has its firmware in an external EPROM while the UDA1321 has its code built into an internal ROM. The basic functionality of both IC's is the same. The UDA1321x /N101 devices have firmware version 2.1.1.7 implemented and is currently sold on the market. An update is under development in the form of release USB-DAC / N103.

Given that both UDA1321 and UDA1331H are essentially the same circuits all information in this document will apply to the UDA1321 as well as for the UDA1331H unless explicitly stated that information is only valid for one of the devices.

This application note will explain the Universal Serial Bus only in a few brief words (see section 1.2). If you want (or need) any further information or specific details please refer to the USB Specification, to the USB Audio Device Class Description and other documents. You will find details in Chapter 4 - References.

The application of the USB-DAC UDA1321 requires a USB enabled PC running with the official release of Windows 98.

Important Notice: Neither the UDA1331H nor the UDA1321 can at this time be used with other or earlier Windows operating systems than Windows 98. These operating systems do not provide the USB Audio Class and Streaming Class drivers and the system support, necessary to operate audio devices attached to the Universal Serial Bus. Support for iMac systems is under development by Apple Computers, Inc. A frequent check of their website for updates on USB drivers is advisable.

To achieve full system functionality, it is necessary that the PC hardware, the PC operating system, the installed driver software and the µC firmware of the chip work flawlessly together.

Legal usage of the Philips USB-AUDIO DACs:

It is very important that you are aware that use of one of the four internal maps is legal if you are the legal owner of the internal map. In any other case, you may **NOT** use any of the internal maps, other than for test purposes ! Otherwise you can and will be prosecuted to the maximum extent possible under law and you can count on severe civil and criminal penalties. So, if you are not a legal owner of one of the internal maps, you must implement your own configuration by means of an external I²C-EEPROM and program your companies VID as explained in application note 2 of the UDA1321.
The internal maps are dedicated to either Philips products or customers of Philips who have a legal agreement / contract to use one of the internal maps.

1.2 Universal Serial Bus Overview

The Universal Serial Bus (USB) is a “medium speed” serial bus designed to be part of every computer system (i.e. desktop as well as laptop, home as well as business…). USB is a royalty free bus that was invented for PC’s with basically two important goals in mind:

- To allow installation of additional hardware without opening the computer case
- To allow easy and intuitive installation and configuration of additional Hardware without additional user installable software (Plug‘n’Play).

The maximum speed of USB is 12 Mbit/s. This allows for a maximum “bulk” data rate in the order of 1 MByte/s. This is obviously plenty for peripheral devices such as keyboards, mice etc. that only generate data in small amounts “once in a while”. More than that, it is perfectly suited for Digital Audio Applications. Good quality Digital Audio requires data rates of less than 200 kByte/s (full-blown CD-Audio e.g. at 48kHz, 16 bit Stereo requires only about 13% of the bus bandwidth).

USB has the topology of a “Tiered Star”. The one (and only) host in the system is connected to the “Root Hub” (usually found right on the PC’s motherboard) and is responsible for all data traffic. This means that all data interactions are initiated by the host. The host polls all devices to find out which devices want to receive or transmit data. All other devices need to wait to be polled, they can not initiate data traffic by themselves.
The Root Hub can have one or more so called “Downstream Ports” (since they are facing away from the Host). In the simplest form the USB has only one other USB device connected directly to one of the Root Hub’s downstream ports.

Figure 3-1 below gives the simplest USB topology possible. It contains a ‘Host Processor’, the ‘Root Hub’ and a single USB device connected to one of the Root Hub’s ports. The USB-Device could in this case e.g. be the UDA1321 evaluation board.

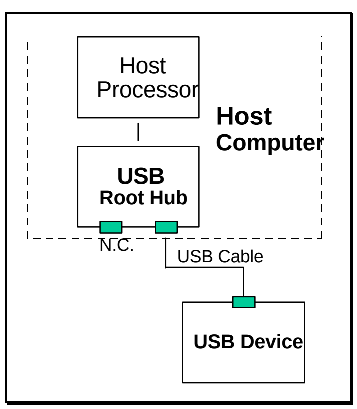


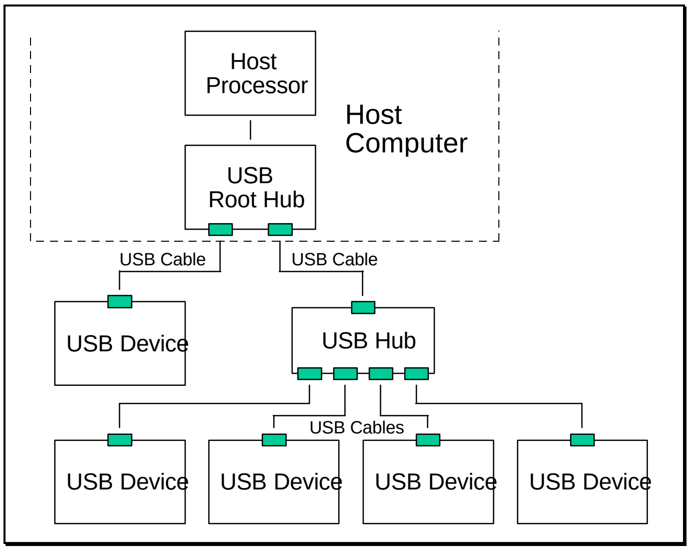
Figure 1-1 *Simplest possible USB Topology*

The ‘Host Processor’ is responsible to control all USB ‘Data Traffic’. It can send, for example, digital audio data on the bus to a specific USB audio device, which is capable of playing this audio data and receiving control data to control, for example, the volume settings.

An additional USB Hub device is only needed to build more complex topologies, it doesn’t add real functionality to a USB environment.

Figure 1-2 shows a typical, more complex USB topology:

Figure 1-2 *Typical, more complex USB Topology*



There is a whole variety of USB devices that will make their appearance in the market in the near future. The most popular applications are:

- Keyboards
- Mice
- Joysticks
- Monitors
- Audio / Speakers
- Printers
- Scanners
- Video Conferencing Cameras
- Modems / Phones

Given these applications, a typical "real life" application could look like the example shown in Figure 1-3.

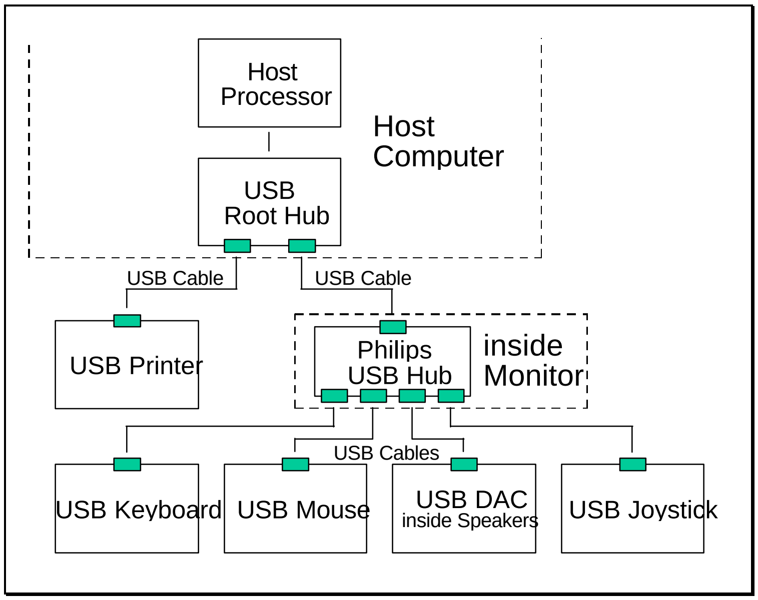


Figure 1-3 *Complex "Real Life" USB Topology*

The maximum number of devices that can be connected to the USB is limited to 127 (using 7 address bits. Remark: Since the Root Hub already counts as one device the number of external devices on the bus is actually limited to 126). Given the fact that all these devices would have to be *outside* of the computer case, this number should be sufficient for most computer systems.

One of the interesting features of USB is that it allows for devices to be either Self powered or Bus powered. Self-powered devices have some kind of connection to an external power source, e.g. to a DC power supply or a mains power outlet. They draw all their current from this external power source whereas the USB connection delivers only regular data and control information.

Bus powered devices, on the other hand, do not have any connections to external power sources. They draw all the necessary current through the USB cables from the hub to which they are connected. However, the maximum current that a single device can draw is limited to 500 mA (thus the total power consumption is limited to 2.5 W). This is only possible if the hub is self powered and allows attached devices to pull the mentioned current. To ensure that the mentioned limits are not exceeded a device has to start up in a "low power mode" with a maximum of 100 mA. It then negotiates whether the hub can provide the necessary current or not. It is possible that a desired bus topology is not possible because of certain power / current constraints of the various devices involved. It's within the responsibility of the operating system to notify a user of these conflicts.

There are basically 4 different “Data Types”. These are:

- Isochronous
- Control
- Interrupt
- Bulk

Isochronous (“Equally spaced in time“) Data Transfers are used for devices where data delivery to or from the host is absolutely time critical. These include Audio or Video Conferencing devices where the data is basically “useless” when not delivered in time. Devices that need isochronous data delivery need to negotiate a guaranteed time slot from the host. Once granted, the specific time slot will be reserved whether actual data needs to be transmitted or not.

Control Data is usually not as time critical as audio or video data. For that reason, control data is transmitted “asynchronously”, meaning that it will be transmitted “on demand only”. Control data does not have a guaranteed time slot and can thus experience a delay.

Interrupt data are actually not really interrupts. Since all data traffic has to be initiated by the host, devices don’t have a chance to announce that they need service. Fact is that the host needs to poll the different devices that can generate interrupt data to find out if they need service. The polling mechanism itself can consequently be described as “isochronous” whereas the interrupt data itself will only be transmitted “on demand”, meaning “asynchronously”.

Bulk data is the transfer of a large amount of data. This could be the data transferred to a printer in order to print a postscript or bitmap file. This kind of data transmission is not time-critical and will not be handled using “isochronous” transfer. It will actually be used to “fill” an opening in a time slot during a certain transmission. This means that if the bus is already heavily loaded with isochronous data transfers like audio or video it can take a very long time to print a single page. If there is no load at all on the bus, data rates of about 1 MByte/s can be achieved.

A specific feature of USB devices is that they consist of more than one “real device”. They are for that reason called “compound devices”. The USB-DAC is a good example since it is an Audio Device as well as a Human Interface Device (HID) used to control the volume, bass and treble. All these specific devices need to negotiate their own special kind of data traffic and their own time slot with the host.

Every single device on the USB can have one or more so-called “Endpoints”. Endpoints are the real “data sources and sinks”. Every device must have at least ONE endpoint (using the internal number ID=0) which is used to communicate with the host. Endpoint zero contains the descriptors that explain the type of device and the data transfer needs to the host. On top of that, a device can have up to 15 more endpoints that communicate using different types of data transfer. Please note that the actual maximum number of endpoints in a system is 127 x 16 = 2032.

1.4 Definitions, Acronyms and Abbreviations

The following explains a number of terms and acronyms that are used in this document.

Term	***Description***
ADAC	Asynchronous Digital Audio Converter
APP	Audio Playback Peripheral
ASR	Audio Sample rate Redistributor
DAC	Digital to Analog Converter
Descriptor	Registers inside the chip containing descriptive information about the device
Device Class	Collection of devices that share certain properties.
GPIO	General Purpose Input / Output
EEPROM	Electrical Erasable Programmable Read Only Memory
Endpoint	Actual final data sink in a device. Every device has at least one endpoint.
Hub	A USB device that has one upstream connector (towards the Host) and a number of downstream ports (usually between 4 and 7). A Hub Device enhances the number of USB devices (including other hubs) that can be connected to the USB bus. It does not add any further functionality to the bus.
Memphis	Microsoft's internal code-name for Windows™ 98 during the development cycle.
Port	USB connection on a Hub Device, enabling one USB Device (possibly a Hub) to be connected.
USB	Universal Serial Bus
USB-DAC	All parts of the implementation of the USBDAC including the hardware and the software/firmware
Windows™ 98	Microsoft® Operating System, upgrade to Windows™ 95, First official release in May 1998, beta version have been available to developers since about 7/1997

See additionally the terms, definitions, acronyms and abbreviations section as given in the USB specification version 1.0 November 1995 for those terms not mentioned in this section.

2. Installing the USB-DAC Evaluation Board

To ensure that the Evaluation Board is working, a number of things have to be checked and possibly adjusted:

- The hardware of the PC you intend to use as a host computer system,
- The version of the operating system that your host computer system is running,
- The version of the firmware inside/outside the chip on the evaluation board.
- The Sub-control PCB for USB-DAC boards.

As pointed out earlier, USB is a new and emerging technology that is continuously developing so that the compatibility between versions is not guaranteed. Continuous efforts of all parties involved will guarantee that this problem is solved when the updates of Microsoft Windows98 is released to the public.

The following paragraphs give details about the installation procedure.

2.1 PC Hardware Requirements

The PC used to install the UDA1321/UDA1331H evaluation board needs to be based on a motherboard that has USB support and on which the USB circuitry is fully assembled. These motherboards first appeared in the second half of 1996 and are now basically standard. Accordingly, chances are that you will find an assembled and enabled USB port on a new computer with a 166 MHz Pentium Processor or better. It is possible that the USB option on the motherboard is assembled but still needs the connectors to the outside to be hooked up (non ATX-type motherboards). These should be available for purchase in computer stores. Most Desktop Systems have two USB ports in the back, newer laptops usually offer one or two USB ports. To allow CD audio played through the IDE interface (RedBook audio) you need a CD-DA drive. These drives allows you to play audio CD’s digitally without the use of DA conversion on the CD drive itself. If you don’t know if your drive is a good CD-DA drive you can run the RBTEST.EXE file from Microsoft. This is a test program to test the CD drive. It can be found on the DDK disk from Microsoft.

2.2 PC Software Requirements

It is necessary that the PC running the USB hardware has the Microsoft ® Windows™98 operating system installed.

2.3 Board Installation

There are so called “A” and “B” type USB connectors. Every USB cable must have a type A connector on one side and a type B connector on the other. Type “A” connectors are used for “Downstream Ports” (leading away from the host computer - to be found e.g. on the back of a USB equipped desktop computer) whereas type “B” connectors are used on “Upstream Ports” (leading towards the host computer).

Plug the type B connector of a USB cable into the USB port connector on the evaluation board. In case of doubt, just try it, there is only one way to do it. Now connect the other side of the USB cable (the type A connector) into the USB port on the back of your USB enabled computer. It is not necessary to connect any power source to the evaluation board since the device can work in bus-powered mode (meaning that all necessary supplies are provided through the USB cable - please check the jumper setting on the board for correct setting). If you already have other USB devices connected to your system and the usual two USB connectors on your desktop system (one on laptops), you can connect the evaluation board to a downstream port of any hub device connected to the system.

As soon as the USB-DAC is connected to the system the host is notified of the existence of a new device. The operating system interrogates the new device and makes an attempt to install the necessary software from its internal database. The user will see a number of message boxes that announce the fact that new hardware has been found and that the software for it is being installed.

The evaluation board can operate in bus-powered and in self-powered modes. When bus powered, no external power supply is needed, and power from the PC is used. In standalone mode, a 3.3V power supply must be used. The UDA1321 can be used in bus-powered mode (handy for test-purposes), but since the USB-DAC and USB-APP do both not meet the suspend current budget as specified with the USB specification, you will not be able to pass the USB-IF tests during Plugfests with such a product. You must therefore use the USB-DAC and USB-APP as self-powered devices.

The evaluation board can be connected directly to a standard loudspeaker system.

In case of the some versions of the UDA1321 boards, there will be a sub-control PCB available for additional functionality and controllability. For more information, please read application note 2, *DML98002.PDF.* For now the installation is not neseccary for simple - testing purposes.

Remark: It is possible that Windows™ 98 asks for the operating system CD in the CD-ROM drive during installation since the operating system will look for the latest drivers in that location. Make sure to have the CD-ROM handy.

Since the USB-DAC and USB-APP are Composite Devices - consisting of an Audio Device as well as a HID control device - the installation will happen in stages announcing first the Philips USB System itself, followed by a Composite Device, then an Audio Device and finally a HID device. Once all these installations have been successfully completed the device should be ready to play audio. An easy way to verify this is to play a wave file through the USB devices (using the “Media Player” application that comes with the operating system). The music should be playing through the speakers or headphone attached to the evaluation board.

2.4 In case of problems

Following are a number of common problems that have been observed. As pointed out earlier, they are in most cases related to incompatibilities between different versions of the Windows™ 98 operating system, the device drivers and the firmware built into the device.

One specific check that is generally advisable is to check the entries in the “Control Panel -> System-> System Properties->General “ section of the Windows™ operating system registry. The different USB devices need to be listed there and should have no remarks (such as exclamation marks or red tags). In case of the USB-DAC and USB-APP, you need to find at least one entry for the USB Root Hub, one entry for the USB Audio Device and one entry for the Human Interface Device. The Human Interface Device is part of the audio device and used for functions such as volume, bass and treble control.

If you can’t find the mentioned devices or they are tagged as not being fully functional you need to reinstall the device or investigate further details (see below).

2.4.1 “USB Device not responding”

This message appears on the screen during the interrogation process when the operating system has detected a new device on the USB but is not able to properly receive a description of the device. Since the OS doesn’t know who the new client is, the necessary software can and will not be installed. There are various ways you can try to solve this:

- Verify once more the Operating System version number and the USB-DAC firmware version number. Make sure that they are compatible. Contact the Philips Semiconductors support if you don’t have enough information or can’t match the versions.
- Make sure that you have the correct drivers from the Window™ 98 CD-ROM. If you had an earlier version of the driver installed the operating system you will have to explicitly specify that you want newer drivers to be used. You can do so after the fact by checking the driver version in the “Control Panel -> System-> System Properties->General “ section and then ask to “Update Driver”. You will have to specify the location on the latest version of the Window ™ 98 CD-ROM.
- Reboot the host computer system and try again to attach the evaluation board once the OS is up and running.
- Leave the USB device attached and reboot the host computer system.
- Change the bus topology - if you have been using an extra hub eliminate it. If you didn’t use an extra hub, try and insert a hub into the system now.
- Try and use another port on the host computer system or on the hub (if you are using one). A working port on a hub is frequently indicated through a lit LED.

2.4.2 Device is recognized but there is no sound

If the device has been recognized but there is no sound it is possible that your system audio mixer is at a very low volume or muted. You can check that by accessing the “Programs->Accessories->Multimedia->Volume Control” application on the “Start” Menu. Make sure that the “Wave” Device is not muted and at a reasonable level.

Should this not help, it is possible that you still have an old ‘legacy” sound card in your system (which might not be hooked up to speakers or an amplifier anymore). Please refer to the following section 2.4.3 how to handle this case.

2.4.3 Sound is still coming from the ‘old’ sound system

If you installed the evaluation board on a computer system that already had a sound card (e.g. Soundblaster or similar) installed, it is possible that the sound still plays through the old channels instead of the new USB system. It is in this case necessary to change the routing inside the Windows ™ operating system. This can be done in the “Settings->Control Panel -> Multimedia” section under the Audio tab in the “Preferred Device” slot. Choose the USB Audio System as your playback device.

The other (more radical) possibility is to delete the “legacy” audio device from the computer system. This is again done in the “Control Panel -> System -> System Properties -> Device Manager” dialog box. Select the device(s) by clicking the right mouse button on them and choose “Delete”. You will be prompted whether you really want to permanently delete the specific device from the system. Boldly answer “Yes”.

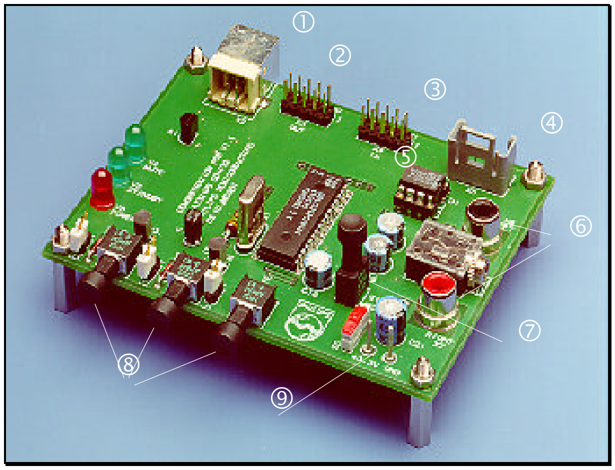
Once all the “legacy” audio devices are deleted, try again to see if the USB Audio Device now plays your audio. If this is still not the case you might need to reboot the system. When the system is powered down it is a good time to remove the “legacy” hardware from your system. Should you decide not to remove the hardware and your hardware is Plug’n’Play compatible your system will detect the “legacy” sound card again and will prompt you to install drivers for it. In this case it is necessary that you choose the “Don’t install a driver” option. Otherwise the device(s) will be installed again.

3. Hardware Description

3.1 UDA1321PS and UDA1321T Application / Demo Boards

The following picture shows a descriptive photograph of the UDA1321PS application / demo board:

① USB-connector
② I^{2}S-out (send)
③ I^{2}S-in (receive)
④ I^{2}C-connector
⑤ I^{2}C-EEPROM
⑥ Analog outputs
⑦ Reset switch
⑧ HID switches
⑨ External power supply pins



UDA1321PS / N101 (SDIP32) board version 1.1

① USB-connector
② I^{2}S-out (send)
③ I^{2}S-in (receive)
④ I^{2}C-connector
⑤ I^{2}C-EEPROM
⑥ Analog outputs
⑦ Reset switch
⑧ HID switches
⑨ External power supply pins

BOARD LOOKS SIMILAR AS
THE UDA1321PS – BOARD, BUT INSTEAD
IT HAS A *YAMAICHI SO28 – SOCKET*.

UDA1321T / N101 (SO28) board version 2.0

3.1.1 UDA1321PS Application / Demo Board

The following tables give a list of all active and passive components used on the UDA1321PS demo-board. Please note that the components marked with an asterisk (*) are for test purposes only or up to customer's wishes and will not be required in a final application.

3.1.1.1 Connectors, Jumpers, Headers and Switches

Name	***Descriptions***	***Remarks***
X1*	SDIP32 IC socket	for UDA1321PS
X2	USB Type B Input Connector	Connects the boards upstream port to a downstream port on the bus (e.g. a hub device)
X3*	10-pin Header	Provides Digital Audio (I2S) Output signals to interface e.g. to an external DSP
X4*	10-pin Header	Provides Digital Audio (I2S) Input signals to interface e.g. to an external DSP
X5*	I2C Connector	4 pin connector to connect the I2C bus signals SCL and SDA to other boards/devices
X6	Cinch plug for Left Analog Audio Output	Connects the left analog output signal to an audio amplifier
X7	Cinch plug for Right Analog Audio Output	Connects the right analog output signal to an audio amplifier
X8*	RCA Stereo-Jack Plug	Additional.
J1	Connect/Disconnect	Jumper for enabling connect/disconnect functionality.
J2	Internal map selector	See application note 2 how to select one of the internal configuration maps.
J3	Internal map selector	
S1*	Reset Switch	"Hard" Resets the USB-DAC
S2	HID switch	Programmed as *Volume Up* in internal map no. 4
S3	HID switch	Programmed as *Volume Down* in internal map no. 4
S4	HID switch	Programmed as *Mute* in internal map no. 4
S5*	Power Supply Selector	Select between USB-power or external power supply.

3.1.1.2 Integrated Circuits

Name	***Description***	***Remark***
IC	USB-DAC UDA1321PS (SDIP32)	
A1*	ZR78L033 3.3V stabilisator	Additionally or standard mounted
D1	PCX8582X-2, I²C - EEPROM	Additionally or standard mounted

3.1.1.3 Resistors

Name	***Value***	***Description***	***Remark***
R1*	1E	DC-supply shortcircuit protection of EEPROM	
R3	22E	Serial resistor for correct rise/fall time on ATX, D+	
R4	22E	Serial resistor for correct rise/fall time on ATX, D-	
R12*	1E	DC-supply shortcircuit protection	
R13	10k	Output resistor	
R14	100E	Output series resistance Left	
R15	100E	Output series resistance Right	
R17*	1E	DC-supply shortcircuit protection	
R18	10k	Output resistor	
R19	10k	Pull-up resistor for I^2C SCL line	
R20	10k	Pull-up resistor for I^2C SDA line	
R21	22k	Pull-up resistor	
R22	22k	Pull-up resistor	
R23	22k	Pull-up resistor	
R24	22k	Base resistor to V3	
R25	22k	Base resistor to V2	
R26	22k	Pull-up resistor	
R27	22k	Base resistor to V1	
R28	22k	Pull-up resistor	
R29*	820E	Series resistors for current limitation through LED	LED V4 = Mute
R30*	820E	Series resistors for current limitation through LED	LED V5 = Standby
R31*	820E	Series resistors for current limitation through LED	LED V6 = Power
R32	1.5k	Startup Circuitry, See USB specifications	

3.1.1.4 Capacitors

Name	***Value***	***Description***	***Remark***
C1	10nF	USB supply noise filtering	50 Volt
C2	100nF	HF supply filtering capacitor for Vdd pin of EEPROM	63 Volt
C3	22pF	HF filtering & rise/fall time adjusment on D+	50 Volt
C4	22pF	HF filtering & rise/fall time adjusment on D-	50 Volt
C7	100nF	HF noise filtering capacitor for pin VDDE	63 Volt
C8	100nF	HF noise filtering capacitor for pin VDDI	63 Volt
C9	100nF	HF noise filtering capacitor for pin VDDX	63 Volt
C10	100nF	HF noise filtering capacitor for pin VDDO	63 Volt
C11	47µF	Series capacitor for DC filtering left channel	16 Volt
C12	47µF	Series capacitor for DC filtering right channel	16 Volt
C13	10nF	Oscillator capacitor	50 Volt
C14	4.7pF	Oscillator capacitor	50 Volt
C15	12pF	Oscillator capacitor	50 Volt
C17	100nF	HF noise filtering capacitor for pin Vref	63 Volt
C18	47µF	DC smoothing Vref	16 Volt
C19	100nF	HF noise filtering capacitor for pin VDDA	63 Volt
C21*	100µF	DC power-supply filtering/smoothing capacitor	16Volt
C22	10nF	USB Cable decoupling	50V
C23	100nF	HF noise filtering capacitor for 3.3V stabilisator	63 Volt

3.1.1.5 Inductors

Name	*Value*	*Description*	*Remark*
L5	1.5µH	Oscillator inductor	
L6*		Common mode chokes	ZJY-M4A

3.1.1.6 Crystal Oscillators

Name	*Value*	*Description*	*Remark*
B1	48MHz	3rd Overtone Crystal for Oscillator Circuit	*Klove*

3.1.1.7 Semiconductors

Name	*Value*	*Description*	*Remark*
V1	BC559B	For startup circuit	PNP
V2	BC549B	For startup circuit	NPN
V3	BC549B	For startup circuit	NPN
V4	LED	Mute status	
V5	LED	Standby status	
V6	LED	Power status	
V7	BAW62	Any low power/cost diode applicable	
V8	BAW62	Any low power/cost diode applicable	

3.1.2 UDA1321T Application / Demo Board

The following tables give a list of all active and passive components used on the UDA1321T demo board. Please note that the components marked with an asterisk (*) are for test purposes only or up to customer's wishes and will not be required in a final application.

3.1.2.1 Connectors, Jumpers, Headers and Switches

Name	***Descriptions***	***Remarks***
X1	USB Type B Input Connector	Connects the boards upstream port to a downstream port on the bus (e.g. a hub device)
X2*	10-pin Header	Provides Digital Audio (I2S) Output signals to interface e.g. to an external DSP
X3*	10-pin Header	Provides Digital Audio (I2S) Input signals to interface e.g. to an external DSP
X4*	I2C Connector	4 pin connector to connect the I2C bus signals SCL and SDA to other boards/devices
X5	Cinch plug for Left Analog Audio Output	Connects the left analog output signal to an audio amplifier
X6*	SO28 IC socket	for UDA1321T
X7*	RCA Stereo-Jack Plug	Additional.
X8	Cinch plug for Right Analog Audio Output	Connects the right analog output signal to an audio amplifier
J1	Connect/Disconnect	Jumper for enabling connect/disconnect functionality.
J2	Internal map selector	See application note 2 how to select one of the internal
J3	Internal map selector	configuration maps.
S1*	Reset Switch	"Hard" Resets the USB-DAC
S2	HID switch	Programmed as *Volume Up* in internal map no. 4
S3	HID switch	Programmed as *Volume Down* in internal map no. 4
S4	HID switch	Programmed as *Mute* in internal map no. 4
S5*	Power Supply Selector	Select between USB-power or external power supply.

3.1.2.2 Integrated Circuits

Name	***Description***	***Remark***
--	USB-DAC UDA1321T (S028)	
A1*	ZR78L033 3.3V stabilisator	Additionally or standard mounted
D1	PCX8582X-2, I²C - EEPROM	Additionally or standard mounted

3.1.2.3 Resistors

Name	***Value***	***Description***	***Remark***
R1	10k	Pull-up resistor for I²C SDA line	
R2	10k	Pull-up resistor for I²C SCL line	
R3	22E	Serial resistor for correct rise/fall time on ATX, D+	
R4	22E	Serial resistor for correct rise/fall time on ATX, D-	
R5*	820E	Series resistors for current limitation through LED	LED V1 = Mute
R6	100E	Output series resistance Left channel	
R7	10k	Output resistor to ground	
R8	100E	Output series resistance Right channel	
R9	10k	Output resistor to ground	
R10*	820E	Series resistors for current limitation through LED	LED V2 = Standby
R11	1.5k	Startup Circuitry	
R12*	820E	Series resistors for current limitation through LED	LED V3 = Power
R13	22k	Pull-up resistor	
R14	22k	Base resistor to V4	
R15	22k	Pull-up resistor	
R16	22k	Pull-up resistor	
R17	22k	Pull-up resistor	
R18	22k	Base resistor to V5	
R19	22k	Base resistor to V6	
R20	22k	Pull-up resistor	

3.1.2.4 Capacitors

Name	*Value*	*Description*	*Remark*
C1	47µF	Series capacitor for DC filtering left channel	16 Volt
C2	47µF	Series capacitor for DC filtering right channel	16 Volt
C3	47µF	DC smoothing Vref	16 Volt
C4*	100µF	DC power-supply filtering/smoothing capacitor	16Volt
C10	10nF	USB Cable decoupling	50V
C11	100nF	HF supply filtering capacitor for Vdd pin of EEPROM	63 Volt
C12	10nF	USB supply noise filtering	50 Volt
C14	22pF	HF filtering & rise/fall time adjusment on D+	50 Volt
C15	22pF	HF filtering & rise/fall time adjusment on D-	50 Volt
C16	100nF	HF noise filtering capacitor for pin VDDE	63 Volt
C17	100nF	HF noise filtering capacitor for pin VDDI	63 Volt
C18	100nF	HF noise filtering capacitor for pin VDDO	63 Volt
C19	10nF	Oscillator capacitor	50 Volt
C20	4.7pF	Oscillator capacitor	50 Volt
C21	12pF	Oscillator capacitor	50 Volt
C22	100nF	HF noise filtering capacitor for pin VDDX	63 Volt
C23	100nF	HF noise filtering capacitor for pin Vref	63 Volt
C24	100nF	HF noise filtering capacitor for pin VDDA	63 Volt

3.1.2.5 Inductors

Name	Value	Description	Remark
L5	1.5µH	Oscillator inductor	
L6		Common mode chokes	ZJY-M4A

3.1.2.6 Crystal Oscillators

Name	Value	Description	Remark
B1	48MHz	3rd Overtone Crystal for Oscillator Circuit	

3.1.1.7 Semiconductors

Name	Value	Description	Remark
V1	LED	Mute status	
V2	LED	Standby status	
V3	LED	Power status	
V4	BC549B	For startup circuit	NPN
V5	BC559B	For startup circuit	PNP
V6	BC549B	For startup circuit	NPN
V7	BAW62	Any low power/cost diode applicable	
V8	BAW62	Any low power/cost diode applicable	

3.2 Chip pin out

The following table describes the pins of the SO28 and the SDIP32 versions of the UDA1321:

Name	***Pin SO28***	***Pin SDIP32***	***I/O***	***Pin Description***
GP2/DO	1	1	I/O	General Purpose Pin/ Data Output to external DSP
GP3/WSO	2	2	I/O	General Purpose Pin/ Word Select Output to external DSP
GP4/BCKO	3	3	I/O	General Purpose Pin/ Bit clock Output to external DSP
SHTCB	4	4	I	Shift clock TCB (active high, digital)
NC	-	5	-	Not connected
D-	5	6	I/O	Negative Data signal of the differential bus
D+	6	7	I/O	Positive Data signal of the differential bus
VDDI	7	8	-	Digital supply for digital core
VSSI	8	9	-	Digital ground for core
VSSE	9	10	-	Digital ground for I/O pads
VDDE	10	11	-	Digital supply for I/O pads
NC	-	12	-	Not connected
VSSX	11	13	-	Ground for crystal oscillator
XTAL1	12	14	I	crystal oscillator input (analog)
XTAL2	13	15	O	crystal oscillator output (analog)
VDDX	14	16	-	Digital supply for crystal oscillator
NC	-	17	-	Not connected
VREF	15	18	O	Reference voltage output pin
VSSA	16	19	-	Analog Ground
VDDA	17	20	-	Analog Supply
VOUTR	18	21	O	Voltage output right channel (analog)
VSSO	19	22	-	Ground for Operational amplifiers
VDDO	20	23	-	Supply for Operational amplifiers
VOUTL	21	24	O	Voltage output right channel (analog)
TC	22	25	I	Test control pin (active high, digital)
RTCB	23	26	I	Asynchronous reset TCB (active high, digital)
GP0/BCKI	24	27	I/O	General Purpose Pin/ Bit clock Input from external DSP
NC	-	28	-	Not connected
GP5/WSI	25	29	I/O	General Purpose Pin/ Word Select Input from external DSP
GP6/SCL	26	30	I/O	General Purpose Pin/ I2C Clock Line
GP7/SDA	27	31	I/O	General Purpose Pin/ I2C Data Line
GP1/DI	28	32	I/O	General Purpose Pin/ Data Input from external DSP

4. References

More information on different USB-(AUDIO) topics can be found in the following publications:

[1] UDA1331H datasheet

[2] UDA1321 data sheet

[3] USB-Specification version 1.0 November 1995

[4] USB Device Class Definition for Audio Devices

[5] USB Human interface Device Class specification

[6] USB Human Interface Device Class Usage Table

[7] DML98002.PDF, application note 2 for programming the UDA1321x.

A lot of the above and additional useful information can further be found on the following Internet web site that is fully dedicated to USB support and information:

http://www.usb.org

Information about other Philips USB-AUDIO products can be found at :

http://www.semiconductors.philips.com/usb/products/audio

and

http://www.usbaudio.ce.philips.com

For information about I²C definitions/documentation see:

http://www.semiconductors.philips.com/i2c/facts/

For information about I²S definitions see datasheet page 27.

For information on EMI vs. PCB design issues see:

http://developer.intel.com/design/USB/papers/emi_apps.pdf

5. In case of Problems

Should you still experience problems in operating the Philips Semiconductors UDA1331H or UDA1321 application / demonstration boards, we recommend that you get into contact with your local Philips Semiconductors Field Applications Engineer or Sales Office. These Philips representatives will be able to help you to get your system up and running.