



ADVANCE INFORMATION

UAC 3552A
Universal Serial Bus
DAC

Edition May 18, 1999
6251-487-1AI

 **MICRONAS**

INTERMETALL

Contents

Page	Section	Title
4	1.	Introduction
5	1.1.	Features
7	2.	Functional Description
7	2.1.	Hardware
7	2.1.1.	USB Interface
7	2.1.1.1.	Transceiver
7	2.1.1.2.	Interface Engine
7	2.1.1.3.	Microcontroller
7	2.1.2.	Audio Control Interface
7	2.1.3.	Audio Streaming Interface
7	2.1.4.	Audio Processing Unit
7	2.1.5.	Analog Back-end
7	2.1.5.1.	DAC
8	2.1.5.2.	Analog Low-pass
8	2.1.5.3.	Postfilter Op Amps
8	2.1.5.4.	Input Mixer
9	2.1.5.5.	Analog Volume Control
9	2.1.5.6.	Line-out/Headphone Amplifier
9	2.1.6.	General Purpose I/O
9	2.1.7.	Special I/O
9	2.1.7.1.	SOF (Start of Frame)
9	2.1.7.2.	AUXEN
9	2.1.7.3.	SUSPEND
10	2.1.8.	Clock System
10	2.2.	Software
10	2.2.1.	USB Microcontroller Software
10	2.2.1.1.	Chapter 9 Functions
10	2.2.1.2.	Device Descriptor
10	2.2.1.3.	String Descriptor
10	2.2.1.4.	HID Report Descriptor
10	2.2.2.	Audio Processing Software
10	2.2.2.1.	Sample Rate Converter
11	2.2.2.2.	Automatic Gain Control
11	2.2.2.3.	Bass Control
11	2.2.2.4.	Treble Control
11	2.2.2.5.	Bass Boost Control
12	2.2.2.6.	Parametric Equalizer
12	2.2.2.7.	Volume and Balance Control
12	2.2.3.	Mute Control
12	2.2.3.1.	Oversampling

Contents, continued

Page	Section	Title
13	3.	Specifications
13	3.1.	Outline Dimensions
13	3.2.	Pin Connections and Short Descriptions
15	3.3.	Pin Descriptions
15	3.3.1.	Power Supply Pins
15	3.3.2.	Analog Audio Pins
16	3.3.3.	Other Pins
16	3.4.	Pin Configuration
17	3.5.	Pin Circuits
18	3.6.	Electrical Characteristics
18	3.6.1.	Absolute Maximum Ratings
18	3.6.2.	Recommended Operating Conditions
20	3.6.3.	Characteristics
24	4.	Applications
24	4.1.	Recommended Low-Pass Filters for Analog Outputs
25	4.2.	Typical Application
28	5.	Data Sheet History

Universal Serial Bus DAC

1. Introduction

The UAC 3552A is the first member of MICRONAS INTERMETALL's USB audio controller family of ICs targeting a wide variety of audio applications on the USB. The UAC 3552A is a single-chip, high-precision digital-to-analog audio converter. It includes a high-quality audio sample rate converter and is able to support a wide range of sample rates, as well as different audio formats.

The IC contains a complete USB transceiver that allows direct connection to the USB. An on-chip EEPROM allows storing of manufacturer-specific data or product identification. The EEPROM can be programmed directly via the USB.

Baseband audio processing is handled by an internal, powerful DSP. Apart from basic audio features, like tone and volume control, there is enough processing power left to realize customer-specific applications.

The audio DAC uses MICRONAS INTERMETALL's proprietary multibit sigma-delta technique. It features very low sensitivity to clock jitter, high linearity, and a superior S/N ratio. The UAC 3552A provides an on-chip headphone/speaker amplifier. Moreover, mixing additional analog audio sources to the D/A-converted signal is supported.

The IC is designed for all kinds of USB audio applications, such as USB active speakers, USB headphones, and USB interfaces to home stereo equipment, etc.

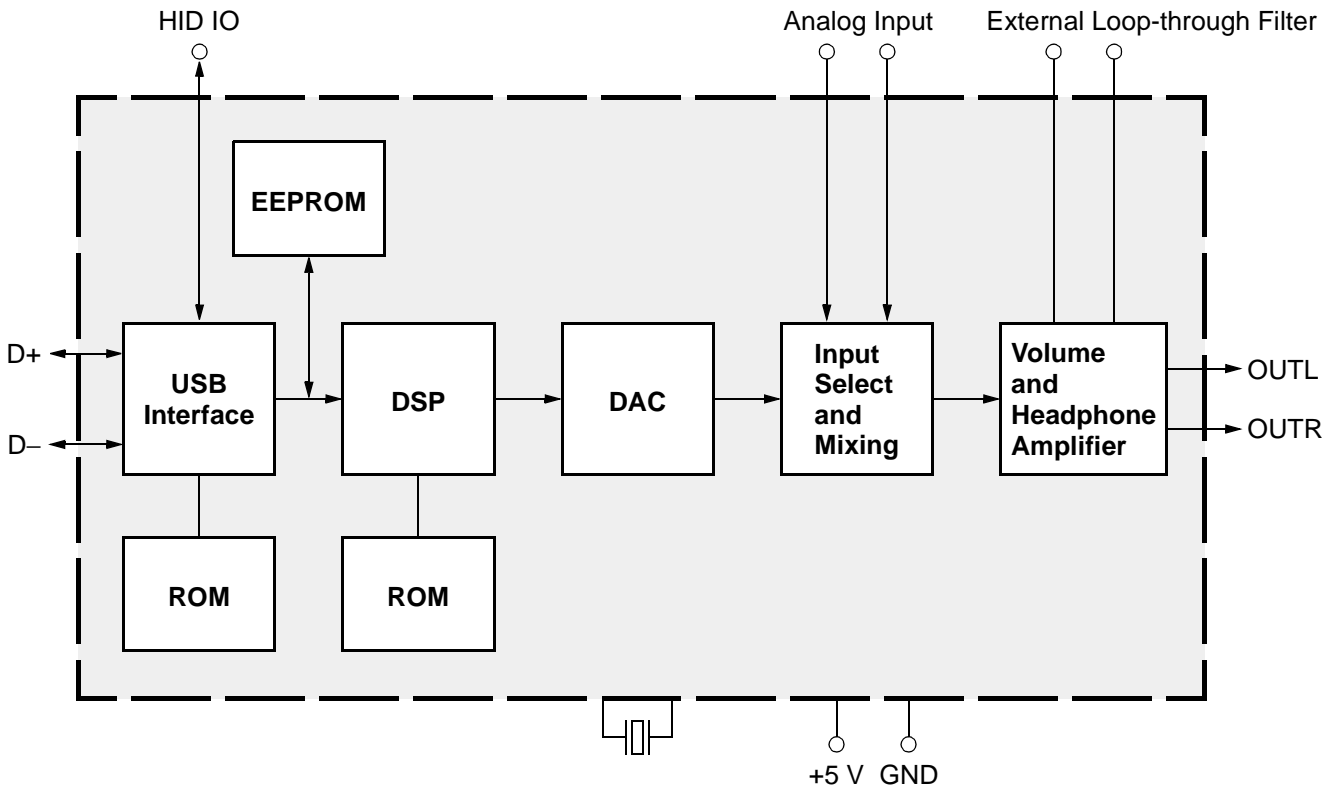


Fig. 1-1: Block diagram of the UAC 3552A

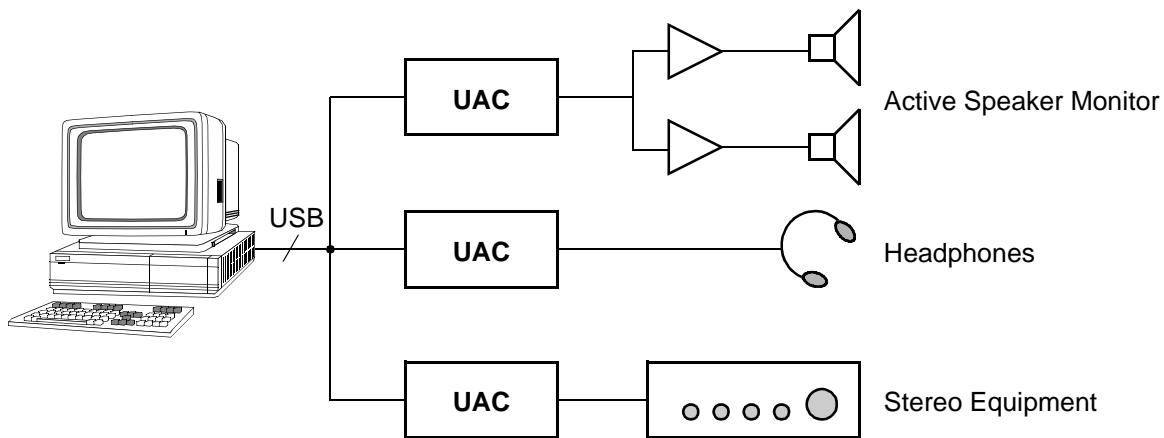


Fig. 1–2: System application diagram.

1.1. Features

- single-chip, USB specification 1.0/1.1 compliant, stereo audio D/A converter
- 12-Mbit/s USB transceiver
- adaptive isochronous endpoint for USB Audio
- USB-programmable vendor IDs (1024-bit EEPROM on chip)
- four general purpose input pins and four output pins (human interface pins)
- supports 8-bit, 16-bit, and 24-bit mono or stereo audio data
- adaptive sample rate converter for 5 to 50 kHz input sampling rate
- audio baseband control: bass, treble, volume, and balance, additional analog volume, mute
- bass boost
- automatic gain control (AGC)
- “PerfectSpeaker” digital speaker equalizer
- THD better than 0.01%, SNR of 96 dB
- integrated low-power stereo headphone amplifier
- on-chip op amps for external analog filter
- analog stereo input (AUX) with source selection and mixing
- single 5-V power supply

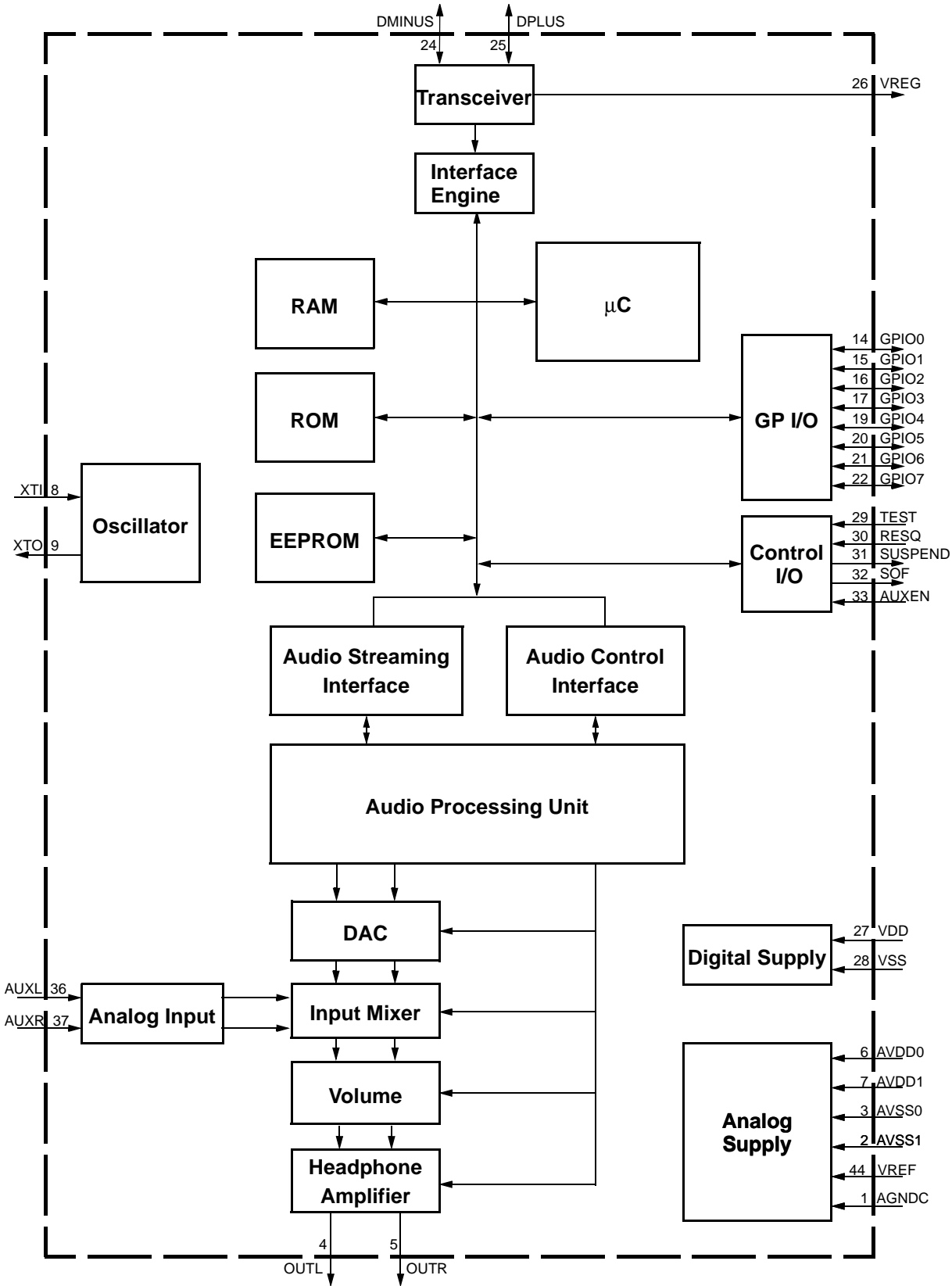


Fig. 1-3: Block diagram of the UAC 3552A

2. Functional Description

2.1. Hardware

2.1.1. USB Interface

2.1.1.1. Transceiver

The differential input receiver is used to accept the USB data signal according to the full-speed (12 MB/s) USB driver characteristics (USB SPEC 1.1 - 7.1.4).

2.1.1.2. Interface Engine

The interface engine comprises two major sections: the transceiver logic and the receiver logic. The transceiver logic transmits data packets built in memory by the microcontroller. These packets are converted from a serial to a parallel data stream. This includes NRZI encoding, bit stuffing, CRC-computation, and addition of SYNC field and EOP. The receiver logic will receive USB data and stores these packets in its memory for processing by the microcontroller. Serial USB data is converted to a byte-wide parallel data stream and stored in system memory. In addition to USB basic data decoding, the Rx logic performs a PID check and protocol layer checks.

2.1.1.3. Microcontroller

The microcontroller manages buffers for all enabled endpoints and interacts with the interface engine. The buffers are built and decoded in memory. This way, the microcontroller realizes the USB protocol handling, like USB reset, enumeration, and all chapter 9 processing, error handling, as well as class-specific endpoint handling, like audio class and HID class. The audio-class processing consists of interpreting the USB audio commands and accordingly controlling the DSP-audio function through a dedicated audio-control-interface to the DSP. HID class processing means polling keys providing the corresponding key-codes to the host-computer's requests. These keys are connected to the GPIO-pins. The RAM can be accessed by the microcontroller and by the interface-engine's DMA-controller. All endpoint communication is realized with intelligent buffer management built up in the RAM.

The ROM contains the USB drivers for the microcontroller as well as the complete descriptor table including the report descriptor for the HID-class. Some parts of the descriptor which are subjected to be changed by the customer, however, reside in the EEPROM.

The EEPROM is built to keep static customer-related data that will customize the UAC 3552A-based USB device during production.

The 128×8 bit EEPROM contains the customer specific information of the USB device descriptor, like vendor ID, product ID, as well as strings for manufacturer, product and serial number. Apart from this USB-related information, the EEPROM holds customer-specific parameters for the PerfectSpeaker equalizer.

The UAC 3552A is shipped with a preprogrammed EEPROM that allows normal USB functionality even if no reprogramming is performed on the customer's side

The EEPROM can be programmed via USB by means of a specific Win98 software which is part of the UAC 3552A application tools.

2.1.2. Audio Control Interface

The audio control interface links the microcontroller to the DSP and is used to initialize the DSP and to transmit audio-related USB control data, like volume setting, tone control etc.

2.1.3. Audio Streaming Interface

The audio streaming interface directly connects the serial interface engine to the DSP in order to transmit the digital audio data. The interface collects and buffers the burst audio data for further processing by the audio processing unit.

2.1.4. Audio Processing Unit

The audio processing unit is a powerful DSP core which allows high-quality sample conversion, base-band audio processing, and interpolation filtering used for oversampling DAC, as well as customized algorithms. For more details on the software see Section 2.2.2. "Audio Processing Software" on page 10.

2.1.5. Analog Back-end

The analog back-end comprises the audio DAC, analog filters, input mixer, op amps for optimal external postfiltering, analog volume and mute, and the output amplifier.

2.1.5.1. DAC

The DAC uses oversampling technique with 3rd-order multibit noise-shaping. This technique results in extremely low quantization noise in the audio band.

2.1.5.2. Analog Low-pass

The analog low-pass is a first-order filter with a cut-off frequency of approximately 1.4 MHz and removes the high frequency components of the noise-shaping signal.

2.1.5.3. Postfilter Op Amps

This block contains the active components for the optional analog postfilters. It is recommended to use a second-order filter (see Section 4. “Applications” on page 24) in order to attenuate the out-of-band noise caused by the noise shaper. The op amps and all I/O-pins for this block are shown in Fig. 4-1.

2.1.5.4. Input Mixer

This block is used to mix the auxiliary inputs and the signals coming from the DAC. This allows to use an UAC 3552A-based USB speaker in a non-USB environment, like WIN 3.11 or other operating systems. On the other hand, it allows to connect additional analog sources, like CD-player or Walkman even while the

speaker is connected to the USB. The input mixer is hardware-controlled by the AUXEN pin.

Table 2-1: AUXEN pin

AUXEN	
0	AUX not selected
1	AUX selected

This allows to use a jack that switches the AUXEN to low when an analog source is plugged in, according to the application note Section 4. “Applications” on page 24. The DAC-signal is permanently connected to the mixer because the DAC is extremely quiet if no USB audio is applied.

The AUXEN pin also keeps the UAC 3552A from entering the suspend mode when an analog source is connected¹⁾. If the USB is not connected the GPIO pins work as an USB-independent volume control (see Table 2-2). BassBoost is not supported in this mode)

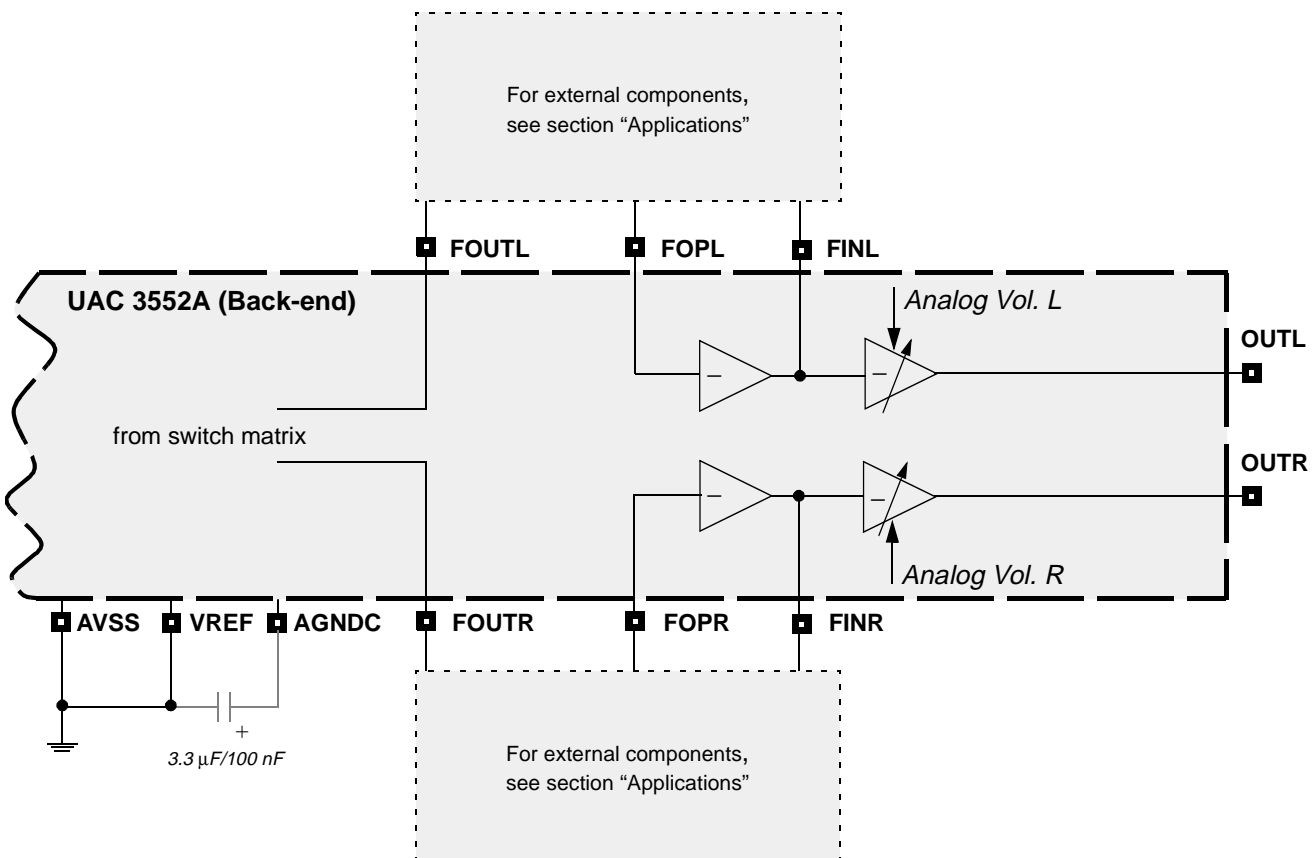


Fig. 2-1: Postfilter op amps and analog volume

¹⁾ Please note: In this mode, the UAC 3552A is not USB-compliant.

2.1.5.5. Analog Volume Control

The analog volume control covers a range from 0 dB to -75 dB plus an additional mute position.

The analog step size is split into a 3-dB and a 1.5-dB range:

- 75 dB...-54 dB: 3 dB step size
- 54 dB...0 dB: 1.5 dB step size

The overall volume system, however, consists not only of the analog volume. An additional digital volume control allows a step size of 0.5 dB over the complete range. See Section 2.2.2.7. "Volume and Balance Control" on page 12.

Please note, that analog input signals (AUXL, AUXR) don't have the additional digital volume control.

2.1.5.6. Line-out/Headphone Amplifier

The line-out/headphone amplifier output is provided at the OUTL and OUTR pins connected either to stereo headphones or to the power amplifier within an USB speaker. The stereo headphones require external 47-Ω serial resistors in both channels. See Section 4. "Applications" on page 24.

2.1.6. General Purpose I/O

The GPIO pins are used to connect keys which are related to the USB HID class or for vendor-specific control functions and LEDs in order to indicate on/off states for example. The standard configuration defines the GPIOs as four input pins (GPIO0...GPIO3) and four output pins (GPIO4...GPIO7). The function of the input pins is shown in Table 2-2.

Table 2-2: Standard Key Configuration

Pin	Function	Key code	Usage ID
GPIO0	Volume Up	1	E9
GPIO1	Volume Down	2	EA
GPIO2	MuteToggle	4	E2
GPIO3	BassBoost Toggle	8	E5

The keys are polled by the microcontroller at an approximate 1-ms time basis and the corresponding key codes are transmitted to the host on request. The relation between key code and usage ID (see USB HID Usage Tables page 62) is defined in the HID report descriptor (see Section 2.2.1.4. "HID Report Descriptor" on page 10) which is transmitted to the

host along with the configuration descriptor during the bus enumeration.

When the device is not connected to USB, the functionality of the volume-control and mute pins are preserved. In this case, however, the parameters are directly transferred to the DSP-core. This allows using the device in non-Win98-mode providing volume and mute control for analog sources.

The output pins are not predefined and therefore not related to any USB functions. They can be set or reset by vendor-specific software.

The standard configuration can be changed also by vendor-specific USB software, but in this case, Table 2-2 is no longer valid.

2.1.7. Special I/O

2.1.7.1. SOF (Start of Frame)

The SOF-pin provides a 1-ms signal which is synchronous to the USB 1-ms frame rate. It can be used for test purpose or as an USB-synchronous reference for vendor-specific external circuitry.

2.1.7.2. AUXEN

This is a digital input that has to be used if an analog signal is connected to the AUX R/L pins. It triggers the microcontroller to switch the input mixer to the analog input (the DAC signal always remains active!) and it keeps the device from entering the suspend mode which can be requested by the host PC or by disconnecting the device from the USB.

2.1.7.3. SUSPEND

The SUSPEND pin indicates the suspend mode. It can be used to power down external circuitry, like power amplifiers in an USB speaker.

Table 2-3: SUSPEND pin

SUSPEND	
low	not suspended
high	suspended

2.1.8. Clock System

The UAC 3552A requires a 12-MHz clock source, which is realized as an on-chip oscillator with external crystal. Also an external oscillator can be used. In this case, the clock has to be connected to XTI. The 12 MHz is the input clock for a PLL circuit which generates all clocks needed within the IC.

2.2. Software

The functionality of the UAC 3552A is mainly defined by software. The internal μ -controller handles the USB requests whereas the Audio Processing Unit processes the sound features.

2.2.1. USB Microcontroller Software

2.2.1.1. Chapter 9 Functions

The chapter 9 of the USB Spec 1.1 defines the USB device framework which is the middle layer of the USB protocol hierarchy (see USB Spec 1.1 page 175). It handles routing data between the bus interface and various endpoints. The endpoint is a source or sink for data within the device.

2.2.1.2. Device Descriptor

Unlike the configuration descriptor, which is located in ROM, the device descriptor is more flexible. The manufacturer-related data are stored in the on-chip EEPROM, and can therefore individually be adapted. In detail these data are

- vendor ID
- product ID
- device release number
- index-to-string descriptors

A comfortable programming tool allows to define this data and writes it into the corresponding EEPROM locations.

The UAC 3552A is shipped with the MICRONAS device descriptor and allows USB functionality without any EEPROM reprogramming.

2.2.1.3. String Descriptor

The string descriptor is located in the EEPROM. The UAC 3552A holds three strings of variable length with a maximum length of 52 bytes. The programming tool handles this procedure and will take care of string length control also.

The UAC 3552A is shipped with the MICRONAS string

descriptor and allows USB functionality without any EEPROM reprogramming.

2.2.1.4. HID Report Descriptor

The HID report descriptor defines the functionality of the GPIO Pins. The basic information here are the usage IDs for the key inputs. These IDs are stored in the EEPROM and can therefore be modified if the default configuration does not fit the application. The UAC 3552A, however, only supports the default functions: volume up/down, mute on/off and BassBoost on/off. This means, that all nonstandard usage IDs will be transmitted to the host on request and can be used with vendor specific software, but only the default IDs will work together with basic Win98 USB control.

2.2.2. Audio Processing Software

All audio processing is realized by DSP-software, apart from volume control which is located in the analog back-end. The audio building blocks split into USB-independent features, like sample rate conversion and oversampling filters and blocks which belong to the so called USB feature unit, defined in the USB Device Class Definition for Audio Devices. The feature unit provides basic manipulation of the incoming logical channels. The UAC 3552A supports two logical channels (i.e. left & right). Multichannel or surround systems, however, can also be realized using more than one UAC 3552A, because phase or delay distortion is eliminated by locking the audio processing to the USB frame rate. An overview of the architecture is given in Fig. 2–2.

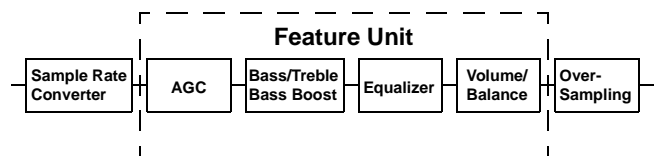


Fig. 2–2: Audio processing

2.2.2.1. Sample Rate Converter

The purpose of the sample rate converter is first to transform the block transferred audio data into a continuous data stream and second to convert all incoming sample rates to a fixed 50-kHz sample rate. This technique eliminates input data jitter. Furthermore, all audio algorithms and the DAC run on a single sample rate and no parameter switching is required on change of audio sampling rate. Furthermore, all audio clocks, such as sampling clock, noise-shaping clock, and DAC-clock can be derived from a single free-running 12-MHz oscillator. This mechanism allows continuous input sampling rates from 5 kHz up to 50 kHz.

2.2.2.2. Automatic Gain Control

The Automatic Gain Control (AGC) is one of the building blocks of the feature unit (USB Device Class Definition for Audio Devices 1.0, page 39).

Different sound sources fairly often do not have the same volume level. The Automatic Gain Control solves this problem and equalizes the volume levels.

The absolute value of the incoming signal is fed into a filter with 10 ms attack time and 4 s decay time. This attack/decay filter block works similar to a peak hold function. The output of this filter is used to calculate a volume correction value with a quasi continuous step size.

The Automatic Gain Control (AGC) works with an internal reference level of -3 dBFS. This means, input signals with a volume level of -3 dBFS will not be affected by the AGC.

If the input signals vary in a range of -15 dB to 0 dB, the AGC compensates this. The AGC works on both channels and can be switched on and off under Win98-USB-control.

2.2.2.3. Bass Control

The bass control provides gain or attenuation to frequency components below a corner frequency of 120 Hz. The characteristic is shown in Fig. 2-3.

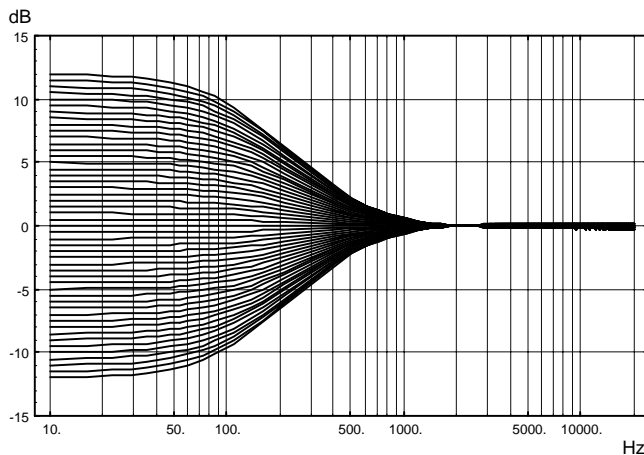


Fig. 2-3: Bass control

The bass control works identically on both channels.

Table 2-4: Bass Control Characteristics

Min	Max	Step
-12 dB	+12 dB	0.5 dB

2.2.2.4. Treble Control

The treble control provides gain or attenuation to frequency components above a corner frequency of 6 kHz. The characteristic is shown in Fig. 2-4.

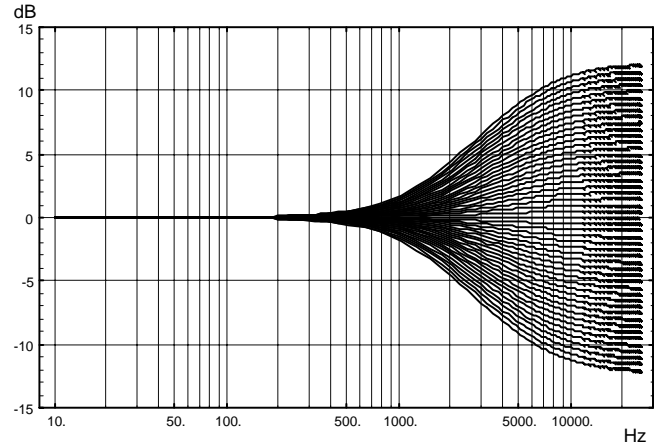


Fig. 2-4: Treble control

The treble control works identically on both channels.

Table 2-5: Treble Control Characteristics

Min	Max	Step
-12 dB	+12 dB	0.5 dB

2.2.2.5. Bass Boost Control

The bass boost algorithm provides an additional 12-dB gain for the low-frequency components. The characteristic is shown in Fig. 2-5.

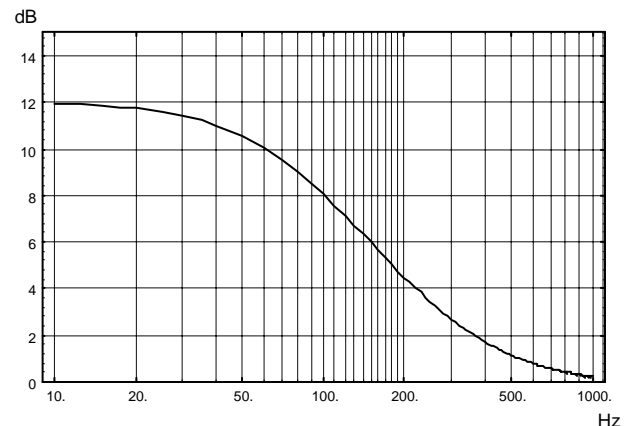


Fig. 2-5: Bass boost

The bass boost works on both channels and can be switched on and off under USB control.

2.2.2.6. Parametric Equalizer

The parametric equalizer is a non-USB audio feature. It allows the compensation of unwanted frequency responses of a speaker. Alternatively, frequency responses can be set to suit individual tastes. The equalizer consists of 5 individually adjustable bands. The control parameters and the parameter range for each band is shown in Table 2–6.

Table 2–6: Equalizer Parameters

Parameter	Min	Max
center frequency	50 Hz	15 kHz
gain/attenuation	–6 dB	+6 dB
filter quality (Q)	0.5	3

The adjustment of the equalizer is supported by an application program that allows to set up frequency responses and to download the corresponding filter coefficients into the UAC 3552A. When the frequency response fits the target, it can be programmed into the on-chip EEPROM. The UAC 3552A is shipped with a flat frequency response.

2.2.2.7. Volume and Balance Control

The volume and balance control operate separately on the left and right channel.

Table 2–7: Volume and Balance Control

Min	Max	Step
–75 dB	0 dB	0.5 dB

The volume control is realized in the analog back-end. This preserves high audio quality (SNR) at low volume settings because signal and noise are attenuated in the same way, which is not the case for pure digital volume control. The UAC 3552A uses digital volume control only for the fine tuning of the 0.5 dB step size. The volume setting is smoothed by an internal ramping algorithm in order to avoid audible clicks during volume change.

The splitting between analog and digital volume is handled by the UAC 3552A automatically.

2.2.3. Mute Control

The mute control is part of the volume system in the UAC 3552A. It functions simultaneously on both channels and can be switched on and off under USB control. As with the volume control, clicks are avoided by a ramping algorithm.

2.2.3.1. Oversampling

The oversampling filter increases the audio sampling rate by a factor of 4. The final upsampling to the noise-shaping rate is handled by a sample and hold circuit. The pass-band characteristic of the oversampling filter is shown in Fig. 2–6.

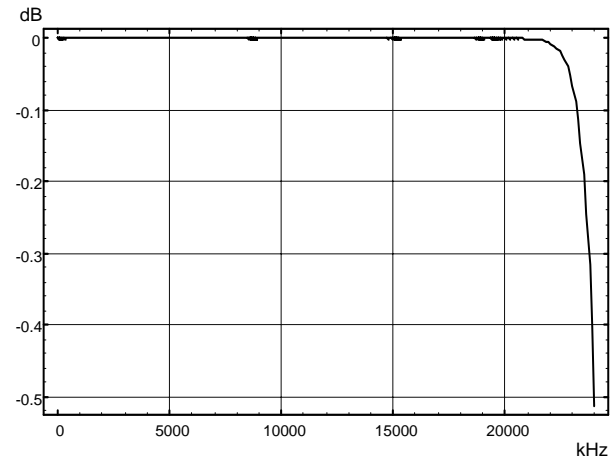
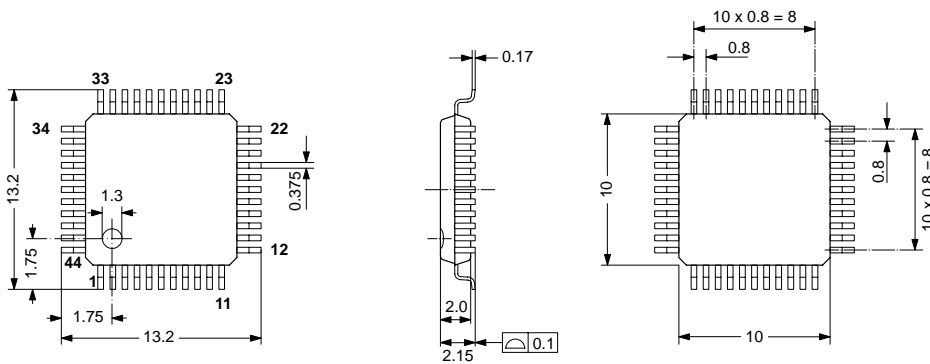


Fig. 2–6: 1 to 4 Oversampling filter, pass-band

3. Specifications

3.1. Outline Dimensions



D0024/2E

Fig. 3-1:
44-Pin Plastic Metric Quad Flat Pack
(PMQFP44)

Weight approximately 0.4 g

Dimensions in mm

3.2. Pin Connections and Short Descriptions

NC = not connected, leave vacant

LV = if not used, leave vacant

VSS = if not used, connect to VSS

X = obligatory; connect as described in circuit diagram

VDD = connect to VDD

Pin No.	Pin Name	Type	Connection (If not used)	Short Description
1	AGNDC	IN/OUT	X	Analog reference voltage
2	AVSS1	IN	X	VSS 1 for audio back-end
3	AVSS0	IN	X	VSS 0 for audio output amplifiers
4	OUTL	OUT	LV	Audio Output: Headphone left or Speaker +
5	OUTR	OUT	LV	Audio Output: Headphone right or Speaker -
6	AVDD0	IN	X	VDD 0 for audio output amplifiers
7	AVDD1	IN	X	VDD 1 for audio back-end
8	XTI	IN	X	quartz oscillator pin 1
9	XTO	OUT	X	quartz oscillator pin 2
10	NC		LV	Not connected
11	NC		LV	Not connected
12	NC		LV	Not connected
13	NC		LV	Not connected
14	GPIO 0	IN	VSS	HID IO 0
15	GPIO 1	IN	VSS	HID IO 1

Pin No.	Pin Name	Type	Connection (If not used)	Short Description
16	GPIO 2	IN	VSS	HID IO 2
17	GPIO 3	IN	VSS	HID IO 3
18	NC		LV	Not connected
19	GPIO 4	OUT	LV	HID IO 4
20	GPIO 5	OUT	LV	HID IO 5
21	GPIO 6	OUT	LV	HID IO 6
22	GPIO 7	OUT	LV	HID IO 7
23	TRDY	OUT		Acknowledge Test Transfer
24	DMINUS	IN/OUT		USB DATA MINUS
25	DPLUS	IN/OUT		USB DATA PLUS
26	VREG	OUT		CAP for DC-DC Converter
27	VDD	IN	X	digital VDD
28	VSS	IN	X	digital VSS
29	TEST	IN	X	Test Enable
30	RESQ	IN	VDD	Power On Reset, active low
31	SUSPEND	OUT	LV	SUSPEND MODE Indicator
32	SOF	OUT	LV	1-ms Start-Of-Frame Signal
33	AUXEN	IN	VSS	Enable AUX Input
34	NC		LV	Not connected
35	NC		LV	Not connected
36	AUXL	IN	VSS	AUX Input Left
37	AUXR	IN	VSS	AUX Input Right
38	FOUTL	OUT	X	Output to left external filter
39	FOPL	IN/OUT	X	Filter op amp inverting input, left
40	FINL	IN/OUT	X	Input for FiltoutL or filter op amp output (line out)
41	FOUTR	OUT	X	Output to right filter op amp
42	FOPR	IN/OUT	X	Right Filter op amp inverting input
43	FINR	IN/OUT	X	Input for FILTOUTR or Filter op amp output (line out)
44	VREF	IN	X	Analog reference Ground

3.3. Pin Descriptions

3.3.1. Power Supply Pins

The UAC 3552A combines various analog and digital functions which may be used in different modes. For optimized performance, major parts have their own power supply pins. All VSS power supply pins must be connected.

VDD (27)

VSS (28)

The VDD and VSS power supply pair are connected internally with all digital parts of the UAC 3552A.

AVDD0 (6)

AVSS0 (3)

AVDD0 and AVSS0 are separate power supply pins that are exclusively used for the on-chip headphone/loudspeaker amplifiers.

AVDD1 (7)

AVSS1 (2)

The AVDD1 and AVSS1 pins supply the analog audio processing parts, except the headphone/loudspeaker amplifiers.

3.3.2. Analog Audio Pins

AGNDC (1)

Reference for analog audio signals. This pin is used as reference for the internal op amps. This pin must be blocked against VREF with a 3.3- μ F capacitor.

Note: The pin has a typical DC-level of 2.25 V. It can be used as reference input for external op amps when no current load is applied.

VREF (44)

Reference ground for the internal band-gap and biasing circuits. This pin should be connected to a clean ground potential. Any external distortions on this pin will affect the analog performance of the UAC 3552A.

DMINUS (24)

DPLUS (25)

Differential USB port pins.

AUXL (36)

AUXR (37)

The AUX pins provide two analog stereo inputs. Auxiliary input signals, e.g. the output of a conventional receiver circuit or the output of a tape recorder can be connected with these inputs. The input signals have to be connected by capacitive coupling.

FOUTL (38)

FOPL (39)

FINL (40)

FOUR (41)

FOPR (42)

FINR (43)

Filter op amps are provided in the analog baseband signal paths. These inverting op amps are freely accessible for external use by these pins.

The FOUTL/R pins are connected with the buffered output of the internal switch matrix. The FOPL/R-pins are directly connected with the inputs of the inverting filter op amps. The FINL/R pins are connected with the outputs of the op amps.

OUTL (4)

OUTR (57)

The OUTL/R pins are connected to the internal output amplifiers. They can be used for either line-out or stereo headphones.

Caution: A short circuit at these pins for more than a momentary period may result in destruction of the internal circuits.

XTI (8)

XTO (9)

The XTI pin is connected to the input of the internal crystal oscillator; the XTO pin to its output. Both pins should be directly connected to the crystal and two ground-connected capacitors (see application diagram).

3.3.3. Other Pins

TEST (29)

Test enable. This pin is for test purposes only and must always be connected to VSS.

VREG (26)

This pin is used to connect an external buffer capacitor to stabilize the internal supply for the USB transceiver.

RESQ (30)

This pin may be used to reset the chip.

GPIO 0 ... GPIO 7 (14,15,16,17,19,20,21,22)

These pins are configurable to be either input or output and can be used to connect audio function keys or signalling LEDs.

SUSPEND (31)

This pin indicates that the host PC sets the USB bus to the suspend-mode state.

SOF(32)

Start of Frame Signal. 1-ms signal that can be used for external application circuits.

AUXEN (33)

Aux enable. This pin must be connected to VSS if an analog source is connected to the AUX input. Otherwise connect to VDD.

3.4. Pin Configuration

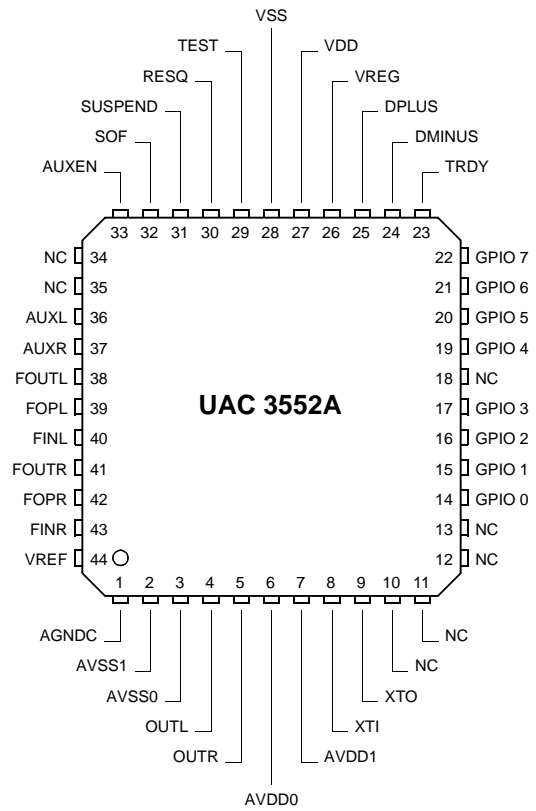


Fig. 3–2: 44-pin PMQFP package

3.5. Pin Circuits

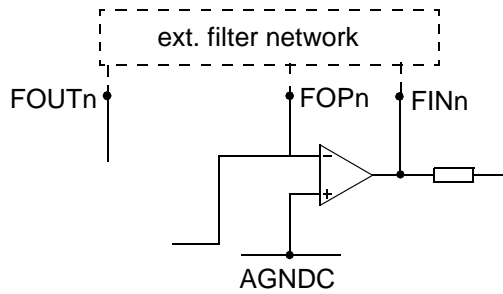


Fig. 3-3: Pins FINR, FOPR, FINL, FOPL

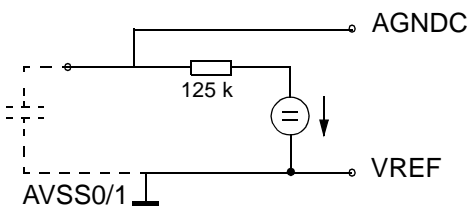


Fig. 3-4: Pins AGNDC, VREF

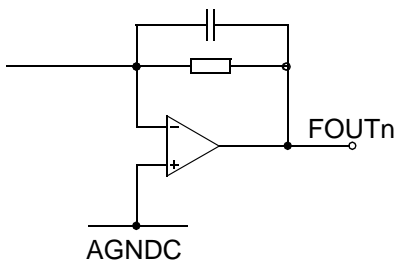


Fig. 3-5: Output Pins FOUTL, FOUTR

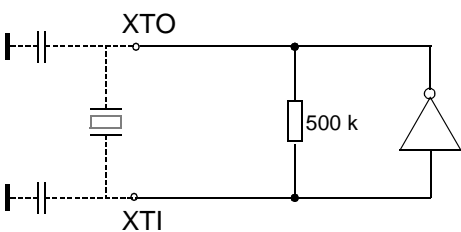


Fig. 3-6: Output/Input Pins XTl, XTO

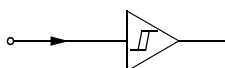


Fig. 3-7: Input Pins RESQ, TEST, AUXEN

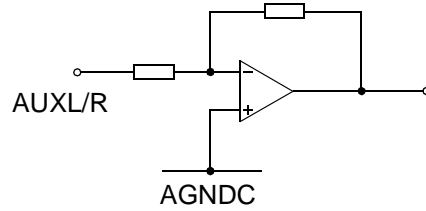


Fig. 3-8: Input Pins AUXL/R

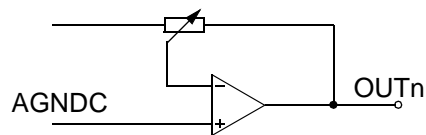


Fig. 3-9: Output Pins OUTL, OTR

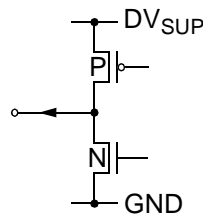


Fig. 3-10: Digital Output Pins SOF, SUSPEND

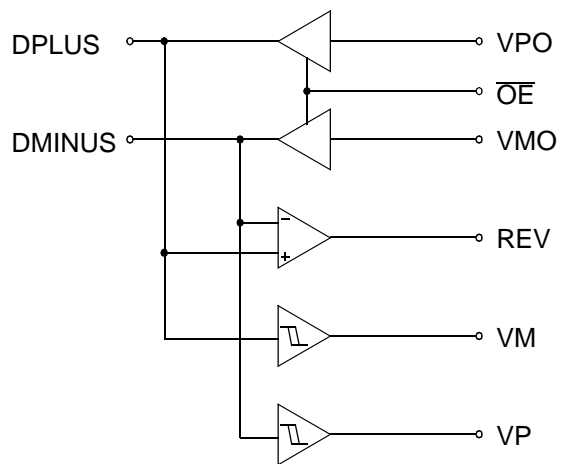


Fig. 3-11: Digital Input/Output Pins DMINUS, DPLUS

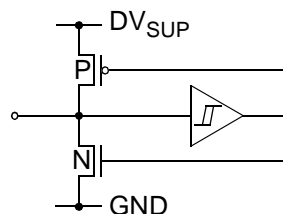


Fig. 3-12: Input/Output Pins GPIO0...GPIO7

3.6. Electrical Characteristics

3.6.1. Absolute Maximum Ratings

Symbol	Parameter	Pin Name	Min.	Max.	Unit
T_A	Ambient Operating Temperature		0	70	°C
T_S	Storage Temperature		-40	125	°C
P_{Pmax}	Power Dissipation		tbd	tbd	mW
V_{SUPA}	Analog Supply Voltage ¹⁾	AVDD0/1	-0.3	6	V
V_{SUPD}	Digital Supply Voltage		-0.3	6	V
V_{Idig}	Input Voltage, all digital inputs		-0.3	$V_{SUPD} + 0.3$	V
I_{Idig}	Input Current, all digital inputs		-5	+0.5	mA
V_{Iana}	Input Voltage, all analog inputs		-0.3	$V_{SUPA} + 0.3$	V
I_{Iana}	Input Current, all analog inputs		-5	+5	mA
I_{Oaudio}	Output Current, audio output ²⁾	OUTL/R		0.2	A
¹⁾ Both have to be connected together! ²⁾ These pins are NOT short-circuit proof!					

Stresses beyond those listed in the “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only. Functional operation of the device at these or any other conditions beyond those indicated in the “Recommended Operating Conditions/Characteristics” of this specification is not implied. Exposure to absolute maximum ratings conditions for extended periods may affect device reliability.

3.6.2. Recommended Operating Conditions

Symbol	Parameter	Pin Name	Min.	Typ.	Max.	Unit
Temperature Ranges and Supply Voltages						
T_A	Ambient Temperature Range		0		70	°C
V_{SUPA1}	Analog Audio Supply Voltage	AVDD0/1	4.5	5.0	5.5	V
V_{SUPD}	Digital Supply Voltage	VDD	4.5	5.0	5.5	V
Relative Supply Voltages						
V_{SUPA}	Analog Audio Supply Voltage in relation to the Digital Supply Voltage	AVDD0/1	$V_{SUPD} - 0.25 V$		5.5 V	
V_{IL}	Input Voltage Low	GPI[7:0], AUXEN,			0.25	V_{SUPD}
V_{IH}	Input Voltage high	GPI[7:0], AUXEN	0.75			V_{SUPD}
V_{RIL}	Reset Input high-low transition voltage	RESQ			0.45	V_{SUPD}

Symbol	Parameter	Pin Name	Min.	Typ.	Max.	Unit
V_{RIH}	Reset Input low-high transition voltage	RESQ	0.8			V_{SUPD}
T_{RL}	Reset low time after VDD stable and oscillator start-up	RESQ	5			μs
Analog Reference						
C_{AGNDC1}	Analog Reference Capacitor	AGNDC	1.0	3.3		μF
C_{AGNDC2}	Analog Reference Capacitor	AGNDC		10		nF
Analog Audio Inputs						
V_{AI}	Analog Input Voltage AC	AUXL/R		0.525	1.05	V_{rms}
Analog Filter Input and Output						
Z_{AFLO}	Analog Filter Load Output ¹⁾	FOUTL/R	7.5		6	$k\Omega$ pF
Z_{AFLI}	Analog Filter Load Input ¹⁾	FINL/R	5.0		7.5	$k\Omega$ pF
Analog Audio Output						
Z_{AOL_HP}	Analog Output Load HP (47 Ω Series Resistor required)	OUTL/R		32 400		Ω pF
Quartz Characteristics						
T_{AC}	Ambient Temperature Range		0		70	$^{\circ}C$
F_P	Load Resonance Frequency at $C_1 = 20 pF$			12		MHz
$\Delta F/F_s$	Accuracy of Adjustment		-20		20	ppm
$\Delta F/F_s$	Frequency Variation versus Temperature		-20		20	ppm
R_{EQ}	Equivalent Series Resistance			12	30	Ω
C_0	Shunt (parallel) Capacitance			3	5	pF
¹⁾ Please refer to Section 4.1. "Recommended Low-Pass Filters for Analog Outputs ¹⁾ " on page 24.						

3.6.3. Characteristics

At $T_A = 0$ to $70\text{ }^\circ\text{C}$, $V_{\text{SUPD}} = 4.75\text{ V}$ to 5.25 V , $V_{\text{SUPA}} = 4.75\text{ V}$ to 5.25 V ; typical values at $T_J = 27\text{ }^\circ\text{C}$, $V_{\text{SUPD}} = V_{\text{SUPA}} = 5.0\text{ V}$, quartz frequency = 12 MHz , duty cycle = 50% , positive current flows into the IC
bass/treble: 0 dB , bass boost: off, AGC: off, equalizer: off

Symbol	Parameter	Pin Name	Min.	Typ.	Max.	Unit	Test Conditions
Digital Supply							
I_{VDD}	Current Consumption ¹⁾	VDD		100		mA	$V_{\text{SUPD}}=5\text{ V}$
Digital Input Pin – Leakage							
I_{I}	Input Leakage Current	GPI[7:0], AUXEN, RESQ			± 1	μA	$V_{\text{GND}} \leq V_{\text{I}} \leq V_{\text{SUP}}$
Digital Output Pin							
V_{OH}	Output High Voltage	GPO[7:0], SUSPND, SOFO	$V_{\text{SUPD}} - 0.3$			V	no load at output
V_{OL}	Output Low Voltage				0.3	V	
Analog Supply							
I_{AVDD}	Current Consumption Analog Audio			11 2	15	mA mA	SUSPD = 0, Mute SUSPD = 1, Mute
PSRR_{AA}	Power Supply Rejection Ratio for Analog Audio Output	AVDD0/1, OUTL/R		50		dB	1 kHz sine at $100\text{ mV}_{\text{rms}}$
				20		dB	$\leq 100\text{ kHz}$ sine at $100\text{ mV}_{\text{rms}}$
Reference Frequency Generation							
V_{DCXTI}	DC Voltage at Oscillator Pins	XTI/O		$0.5 * V_{\text{SUPA}}$		V	
C_{LI}	Input Capacitance at Oscillator Pin	XTI		3		pF	
C_{LO}	Input Capacitance at Oscillator Pin	XTO		3		pF	
V_{xtalout}	Voltage Swing at Oscillator Pins (peak-peak)	XTI/O	0.6		1.0	pp, V_{DDA}	
	Oscillator Start-Up Time				10	ms	V_{DD} slew rate
EEPROM							
	EEPROM unpowered data retention			10		year	
	Number of write cycles			100			
¹⁾ no load attached to GPO's							

Symbol	Parameter	Pin Name	Min.	Typ.	Max.	Unit	Test Conditions
USB Transceiver							
V _{REG}	Regulator voltage	VREG	3.15	3.3	3.45	V	C _L =470 nF
R _O	Driver output resistance	DPLUS/ DMINUS	28		43	Ω	static, LOW or HIGH
t _r / t _f	Rise and fall times	DPLUS/ DMINUS	4		20	ns	C _L =50 pF, driver mode
MA_TRTF	Rise/fall time matching	DPLUS/ DMINUS	90		111.1	%	C _L =50 pF, driver mode
V _{XOVER}	Crossover voltage	DPLUS/ DMINUS	1.3		2.0	V	C _L =50 pF, driver mode
V _{CM_DREC}	Differential receiver common-mode range	DPLUS/ DMINUS	0.8		2.5	V	
V _{T_SREC}	Single-ended receiver threshold voltage	DPLUS/ DMINUS	0.8		2.0	V	
Analog Audio							
V _{AGNDC}	Analog Reference Voltage	AGNDC		2.25		V	R _L >> 10 MΩ, referred to VREF
R _{IAUX}	Input Resistance at Input Pins	AUXL/R	12.1 11.6	15	17.9 19.0	kΩ kΩ	T _J = 27 °C T _A = 0 to 70 °C Input selected, SUSPD = 0 i = ± 10 μA, referred to VREF
			24.2 23.3	30	35.8 37.9	kΩ kΩ	T _J = 27 °C T _A = 0 to 70 °C Input not selected SUSPD = 1 i = ± 10 μA, referred to VREF
R _{OOULT}	Output Resistance at Output Pins	OUTL/R		700		Ω	T _J = 27 °C SUSPD = 0 i = ± 200 μA, referred to VREF
R _{OFILT}	Output Resistance of Filter Pins	FINL		15		kΩ	SUSPD = 0, Mute i = ± 10 μA, referred to VREF
		FINR		11,25		kΩ	
V _{OffI}	Offset Voltage at Input Pins	AUXL/R	-20		20	mV	SUSPD = 0, referred to AGNDC
V _{OffO}	Offset Voltage at Output Pins	OUTL/R	-10		10	mV	SUSPD = 0, Mute referred to AGNDC
V _{OffFI}	Offset Voltage at Filter Output Pins	FOUTL/R	-20		20	mV	SUSPD = 0, referred to AGNDC
V _{OffFO}	Offset Voltage at Filter Input Pins	FINL/R	-20		20	mV	SUSPD = 0, referred to AGNDC
dV _{DCPD}	Difference of DC Voltage at Output Pins after Back-end Low Power Sequence	OUTL/R	-10		10	mV	Analog Gain = Mute, SUSPD switched from 0 to 1

Symbol	Parameter	Pin Name	Min.	Typ.	Max.	Unit	Test Conditions
$R_{D/A}$	D/A Pass Band Ripple	OUTL/R, FOUTL/R		0.01		dB	0...22 kHz (no external filters used)
$A_{D/A}$	D/A Stop Band Attenuation			60		dB	31 kHz...164 kHz (no external filters used)
BW_{AUX}	Bandwidth for Auxiliary Inputs	AUXL/R, FINL/R		760		kHz	
THD_{HP}	Total Harmonic Distortion	OUTL/R			0.05	%	BW = 20 Hz...0.5 fs, unweighted, $R_L \geq 32 \Omega$ (47 Ω series resistor required), Analog Gain = 0 dB, Input 1 kHz at -3 dBFS
SNR_{AUX}	Signal-to-Noise Ratio from Analog Input to Outputs	AUXn, OUTL/R		96		dB	input -40 dB below 1.05 V_{rms}
SNR_1	Signal-to-Noise Ratio	OUTL/R	89	91		dB	$R_L \geq 32 \Omega$ (external 47 Ω series resistor required) BW = 20 Hz...0.5 fs unweighted, Analog Gain = 0 dB, Input = -20 dBFS
SNR_2	Signal-to-Noise Ratio	OUTL/R	58	62		dB	$R_L \geq 32 \Omega$ (external 47 Ω series resistor required) BW = 20 Hz...0.5 fs unweighted Analog Gain = -40.5 dB, Input = -3 dBFS
Lev_{Mute}	Mute Level	OUTL/R		-110		dBV	BW = 20 Hz...22 kHz unweighted, no digital input signal, Analog Gain = Mute
V_{AO}	Analog Output Voltage AC	OUTL/R	1.0	1.05	1.1	V_{rms}	$R_L > 5 k\Omega$, Analog Gain = 0 dB Input = 0 dBFS digital
G_{AUX}	Gain from Auxiliary Inputs to Outputs	AUXL/R, OUTL/R	-0.5	0	0.5	dB	f = 1 kHz, sine wave, $R_L > 5 k\Omega$ 0.5 V_{rms} to AUXL/R
P_{HP}	Output Power (Headphone)	OUTL/R		12		mW	$R_L = 32 \Omega$, Analog Gain = +2 dB, distortion < 1%, external 47 Ω series resistor required
P_{SP}	Output Power (Speaker)	OUTL/R		280		mW	$R_L = 32 \Omega$ (bridged), Analog Gain = +2 dB, distortion < 10%, INVR = 1

Symbol	Parameter	Pin Name	Min.	Typ.	Max.	Unit	Test Conditions
G_{AO}	Analog Output Gain Setting Range	OUTL/R	-75		18	dB	
dG_{AO1}	Analog Output Gain Step Size	OUTL/R		3.0		dB	Analog Gain: -75 dB...+54 dB
dG_{AO2}	Analog Output Gain Step Size	OUTL/R		1.5		dB	Analog Gain: -54 dB...+18 dB
E_{GA1}	Analog Output Gain Error	OUTL/R	-2		2	dB	Analog Gain = -54 dB
E_{GA2}	Analog Output Gain Error	OUTL/R	-1		1	dB	Analog Gain = -45 dB
E_{GA3}	Analog Output Gain Error	OUTL/R	-0.5		0.5	dB	Analog Gain = -39 dB
E_{dGA}	Analog Output Gain Step Size Error	OUTL/R	-0.5		0.5	dB	Analog Gain = -48 dB
$XTALK_{HP}$	Crosstalk Left/Right Channel (Headphone)	OUTL/R	-70	-80		dB	f = 1 kHz, sine wave, OUTL/R: $R_L \geq 32 \Omega$ (47 Ω series resistor required) Analog Gain = 0 dB, Input = -3 dBFS or 0.7 V _{rms} to AUXL/R
$XTALK_2$	Crosstalk between Input Signal Pairs	AUXnL/R	-70	-80		dB	f = 1 kHz, sine wave, FOUTL/R: $R_L > 7.5 k\Omega$ OUTL/R: $R_L \geq 32 \Omega$ (47- Ω series resistor required) Analog Gain = 0 dB, Input = -3 dBFS and 0.7 V _{rms} to AUXL/R

4. Applications

4.1. Recommended Low-Pass Filters for Analog Outputs¹⁾

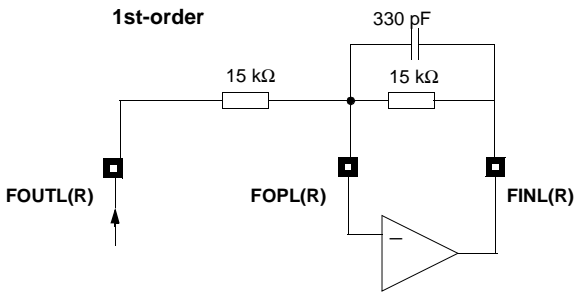


Fig. 4-1: 1st-order low-pass filter

Table 4-1: Attenuation of 1st-order low-pass filter

Frequency	Gain
24 kHz	-2.2 dB
30 kHz	-3.0 dB

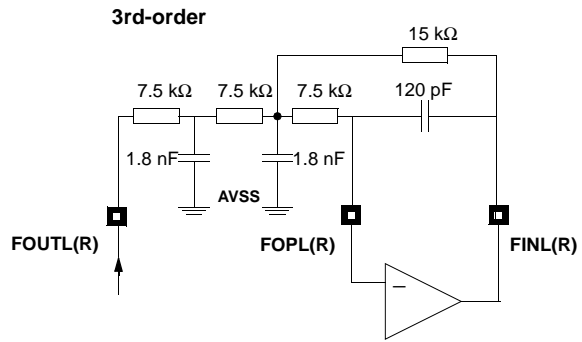


Fig. 4-3: 3rd-order low-pass filter

Table 4-3: Attenuation of 3rd-order low-pass filter

Frequency	Gain
18 kHz	0.17 dB
24 kHz	-0.23 dB
30 kHz	-3.00 dB

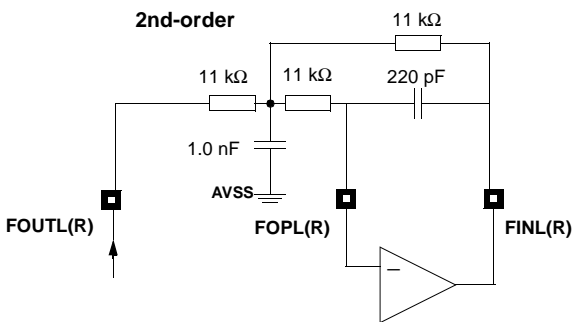


Fig. 4-2: 2nd-order low-pass filter

Table 4-2: Attenuation of 2nd-order low-pass filter

Frequency	Gain
24 kHz	-1.5 dB
30 kHz	-3.0 dB

¹⁾ without deemphasis circuit

4.2. Typical Application

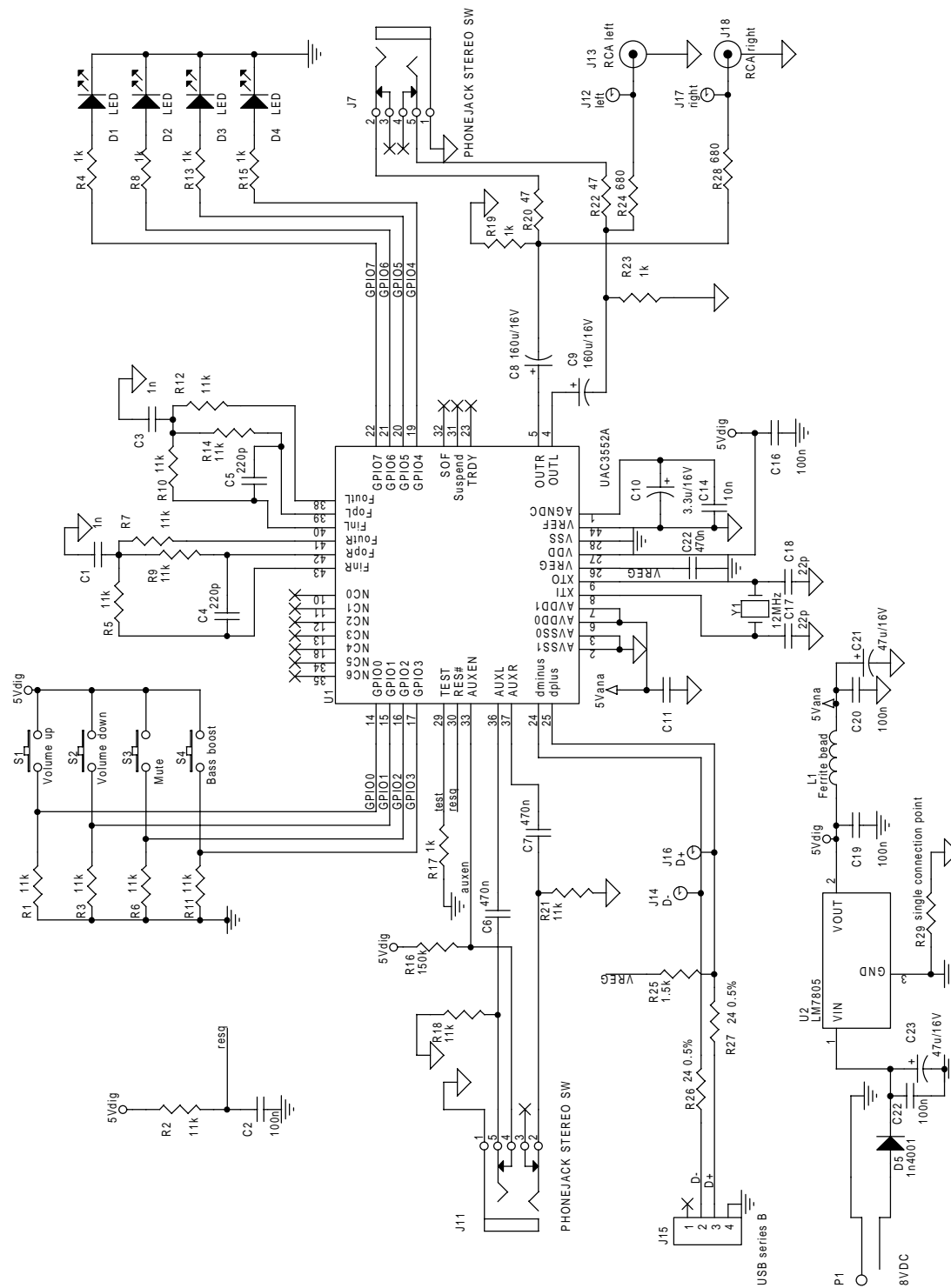


Fig. 4-4: Application circuit

5. Data Sheet History

1. Advance Information: "UAC 3552A Universal Serial Bus DAC, May 18, 1999, 6251-487-1AI. First release of the advance information.

MICRONAS INTERMETALL GmbH
Hans-Bunte-Strasse 19
D-79108 Freiburg (Germany)
P.O. Box 840
D-79008 Freiburg (Germany)
Tel. +49-761-517-0
Fax +49-761-517-2174
E-mail: docservice@intermetall.de
Internet: <http://www.intermetall.de>

Printed in Germany
Order No. 6251-487-1AI

All information and data contained in this data sheet is without any commitment, is not to be considered as an offer for conclusion of a contract nor shall it be construed as to create any liability. Any new issue of this data sheet invalidates previous issues. Product availability and delivery dates are exclusively subject to our respective order confirmation form; the same applies to orders based on development samples delivered. By this publication, MICRONAS INTERMETALL GmbH does not assume responsibility for patent infringements or other rights of third parties which may result from its use. Reprinting is generally permitted, indicating the source. However, our prior consent must be obtained in all cases.