

# DATA SHEET

## **TDA1306T** Noise shaping filter DAC

Preliminary specification  
File under Integrated Circuits, IC01

September 1994

**Philips Semiconductors**



**PHILIPS**

## Noise shaping filter DAC

## TDA1306T

### FEATURES

#### General

- Double-speed mode
- Digital volume control
- Soft mute function
- 12 dB attenuation
- Low power dissipation
- Digital de-emphasis
- TDA1305T pin compatible.

#### Easy application

- Voltage output
- Only 1st-order analog post-filtering required
- Operational amplifiers and digital filter integrated
- Selectable system clock ( $f_{\text{sys}}$ )  $256f_s$  or  $384f_s$
- I<sup>2</sup>S-bus ( $f_{\text{sys}} = 256f_s$ ) or 16, 18 or 20 bits LSB fixed serial input format ( $f_{\text{sys}} = 384f_s$ ).
- Single rail supply.

#### High performance

- Superior signal-to-noise ratio
- Wide dynamic range
- No zero crossing distortion
- Inherently monotonic
- Continuous calibration digital-to-analog conversion combined with noise shaping technique.

### GENERAL DESCRIPTION

The TDA1306T is a dual CMOS digital-to-analog converter with up-sampling filter and noise shaper. The combination of oversampling up to  $4f_s$ , noise shaping and continuous calibration conversion ensures that only simple 1st-order analog post-filtering is required.

The TDA1306T supports the I<sup>2</sup>S-bus data input mode ( $f_{\text{sys}} = 256f_s$ ) with word lengths of up to 20 bits and the LSB fixed serial data input format ( $f_{\text{sys}} = 384f_s$ ) with word lengths of 16, 18 or 20 bits. Two cascaded IIR filters increase the sampling rate 4 times.

The DACs are of the continuous calibration type and incorporate a special data coding. This ensures a high signal-to-noise ratio, wide dynamic range and immunity to process variation and component ageing.

Two on-board operational amplifiers convert the digital-to-analog current to an output voltage.

### ORDERING INFORMATION

TYPE NUMBER	PACKAGE		
	NAME	DESCRIPTION	VERSION
TDA1306T	SO24	plastic small outline package; 24 leads; body width 7.5 mm.	SOT137-1

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**QUICK REFERENCE DATA**

All power supply pins  $V_{DD}$  and  $V_{SS}$  must be connected to the same external supply unit.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
<b>Supply</b>						
$V_{DDD}$	digital supply voltage		4.5	5.0	5.5	V
$V_{DDA}$	analog supply voltage		4.5	5.0	5.5	V
$V_{DDO}$	operational amplifier supply voltage		4.5	5.0	5.5	V
$I_{DDD}$	digital supply current	$V_{DDD} = 5\text{ V};$ at code 00000H	–	5	8	mA
$I_{DDA}$	analog supply current	$V_{DDA} = 5\text{ V};$ at code 00000H	–	3	5	mA
$I_{DDO}$	operational amplifier supply current	$V_{DDO} = 5\text{ V};$ at code 00000H	–	2	4	mA
<b>Analog signals</b>						
$V_{FS(rms)}$	full-scale output voltage (RMS value)	$V_{DDD} = V_{DDA} = V_{DDO} = 5\text{ V};$ $R_L > 5\text{ k}\Omega$	0.935	1.1	1.265	V
$R_L$	output load resistance		5	–	–	$\text{k}\Omega$
<b>DAC performance</b>						
(THD + N)/S	total harmonic distortion plus noise-to-signal ratio	at 0 dB signal level; $f_i = 1\text{ kHz};$	–	–70	–	dB
			–	0.032	–	%
		at –60 dB signal level; $f_i = 1\text{ kHz};$	–	–42	–32	dB
			–	0.8	2.5	%
$S/N_{ds}$	signal-to-noise ratio at digital silence	no signal; A-weighted	–	–108	–96	dB
BR	input bit rate at data input	$f_s = 44.1\text{ kHz};$ normal speed	–	–	2.822	Mbits/s
		$f_s = 44.1\text{ kHz};$ double speed	–	–	5.645	Mbits/s
$f_{sys}$	system clock frequency (pin 12)		6.4	–	18.432	MHz
$T_{amb}$	operating ambient temperature		–40	–	+85	$^{\circ}\text{C}$

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## BLOCK DIAGRAM

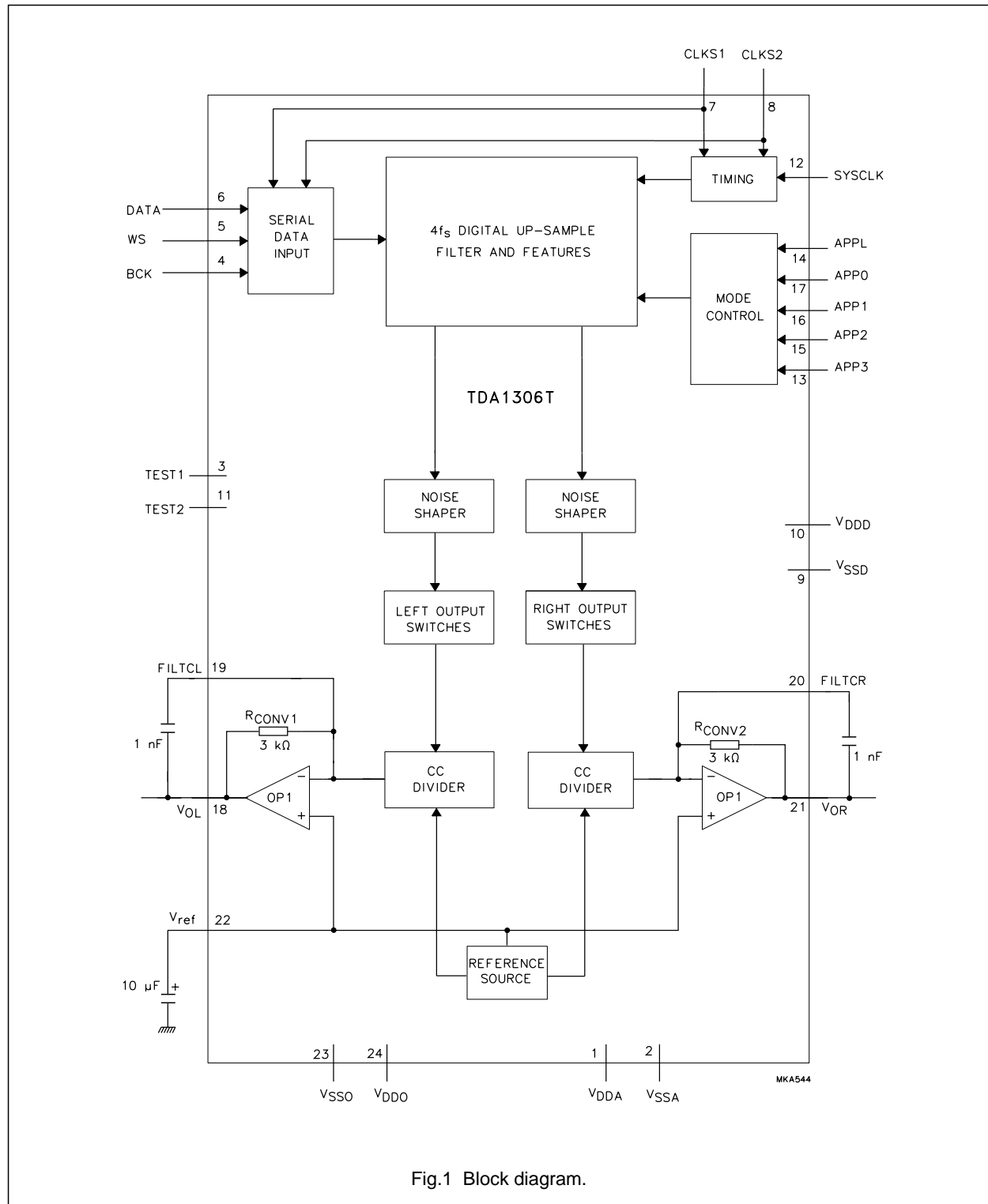


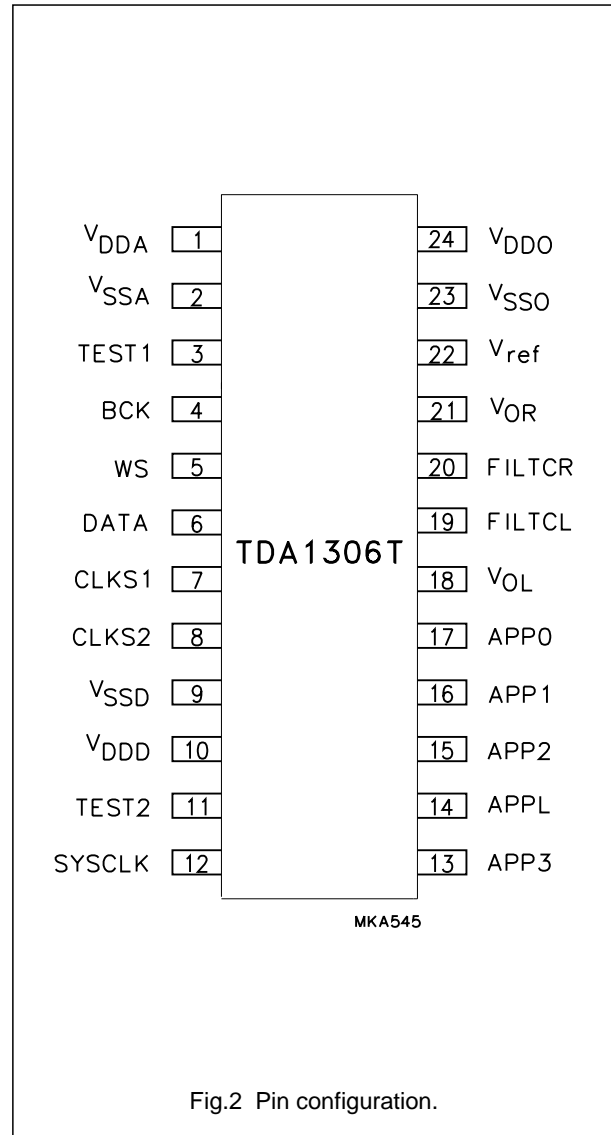
Fig.1 Block diagram.

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## PINNING

SYMBOL	PIN	DESCRIPTION
V <sub>DDA</sub>	1	analog supply voltage (+5 V)
V <sub>SSA</sub>	2	analog ground
TEST1	3	test input 1; pin should be connected to ground
BCK	4	bit clock input
WS	5	word select input
DATA	6	data input
CLKS1	7	clock and format selection 1 input
CLKS2	8	clock and format selection 2 input
V <sub>SSD</sub>	9	digital ground
V <sub>DDD</sub>	10	digital supply voltage (+5 V)
TEST2	11	test input 2; pin should be connected to ground
SYSCLK	12	system clock input 256f <sub>s</sub> or 384f <sub>s</sub>
APP3	13	application mode 3 input
APPL	14	application mode selection input
APP2	15	application mode 2 input
APP1	16	application mode 1 input
APP0	17	application mode 0 input
V <sub>OL</sub>	18	left channel output
FILTCL	19	capacitor for left channel 1st order filter function; should be connected between pins 19 and 18
FILTCR	20	capacitor for right channel 1st order filter function; should be connected between pins 20 and 21
V <sub>OR</sub>	21	right channel output
V <sub>ref</sub>	22	internal reference voltage for output channels; 0.5V <sub>DDO</sub> (typ.)
V <sub>SSO</sub>	23	operational amplifier ground
V <sub>DDO</sub>	24	operational amplifier supply voltage



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**FUNCTIONAL DESCRIPTION**

The TDA1306T CMOS DAC incorporates an up-sampling filter, a noise shaper, continuous calibrated current sources and operational amplifiers.

**System clock and data input format**

The TDA1306T accommodates slave mode only. Consequently, in all applications, the system devices must provide the system clock. The system frequency is selectable at pins CLKS1 and CLKS2 (see Table 1).

The TDA1306T supports the following data input modes:

- I<sup>2</sup>S-bus with data word length of up to 20 bits ( $f_{\text{sys}} = 256f_s$ )
- LSB fixed serial format with data word length of 16, 18 or 20 bits ( $f_{\text{sys}} = 384f_s$ ). As this format idles on the MSB it is necessary to know how many bits are being transmitted.

The input formats are illustrated in Fig.9. Left and right data channel words are time multiplexed.

**Table 1** Data input format and system clock.

CLKS1	CLKS2	DATA INPUT FORMAT	SYSTEM CLOCK	
			NORMAL SPEED	DOUBLE SPEED
0	0	I <sup>2</sup> S-bus	256f <sub>s</sub>	128f <sub>s</sub>
0	1	LSB fixed 16 bits	384f <sub>s</sub>	192f <sub>s</sub>
1	0	LSB fixed 18 bits	384f <sub>s</sub>	192f <sub>s</sub>
1	1	LSB fixed 20 bits	384f <sub>s</sub>	192f <sub>s</sub>

**Device operation**

When the APPL pin is held HIGH and APP3 is held LOW, pins APP0, APP1 and APP2 form a microcontroller interface. When the APPL pin is held LOW, pins APP0, APP1, APP2 and APP3 form a pseudo-static application (TDA1305T pin compatible).

**PSEUDO-STATIC APPLICATION MODE (APPL = LOGIC 0)**

In this mode, the device operation is controlled by pseudo-static application pins where:

- APP0 = attenuation mode control
- APP1 = double-speed mode control
- APP2 = mute mode control
- APP3 = de-emphasis mode control.

In the pseudo-static application mode the TDA1306T is pin compatible with the TDA1305T slave mode. The correspondence between TDA1306T pin number, TDA1306T pin name, TDA1305T pin mnemonic and a description of the effects is given in Table 2.

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**Table 2** Pseudo-static application mode.

PIN MNEMONIC	PIN NUMBER	TDA1305T FUNCTION	VALUE	DESCRIPTION
APP0	17	ATSB	0	12 dB attenuation (from full scale) activated (only if MUSB = logic 1)
			1	full scale (only if MUSB = logic 1)
APP1	16	DSMB	0	double-speed mode
			1	normal-speed mode
APP2	15	MUSB	0	samples decrease to mute level
			1	level according to ATSB
APP3	13	DEEM1	0	de-emphasis OFF (44.1 kHz)
			1	de-emphasis ON (44.1 kHz)

MICROCONTROLLER APPLICATION MODE (APPL = LOGIC 1, APP3 = LOGIC 0).

In this mode, the device operation is controlled by a set of flags in an 8-bit mode control register. The 8-bit mode control register is written by a microcontroller interface where:

- APPL = logic 1
- APP0 = Data
- APP1 = Clock
- APP2 = RAB
- APP3 = logic 0.

The correspondence between serial-to-parallel conversion, mode control flags and a summary of the effect of the control flags is given in Table 3. Figures 3 and 4 illustrate the mode set timing.

### MICROCONTROLLER WRITE OPERATION SEQUENCE

The microcontroller write operation follows the following sequence:

- APP2 is held LOW by the microcontroller
- Microcontroller data is clocked into the internal shift register on the LOW-to-HIGH transition on pin APP1
- Data D7 to D0 is latched into the appropriate control register on the LOW-to-HIGH transition of pin APP2 (APP1 = HIGH)
- If more data is clocked into the TDA1306T before the LOW-to-HIGH transition on pin APP2 then only the last 8 bits are used
- If less data is clocked into the TDA1306T unpredictable operation will result
- If the LOW-to-HIGH transition of pin APP2 occurs when APP1 = LOW, the command will be disregarded.

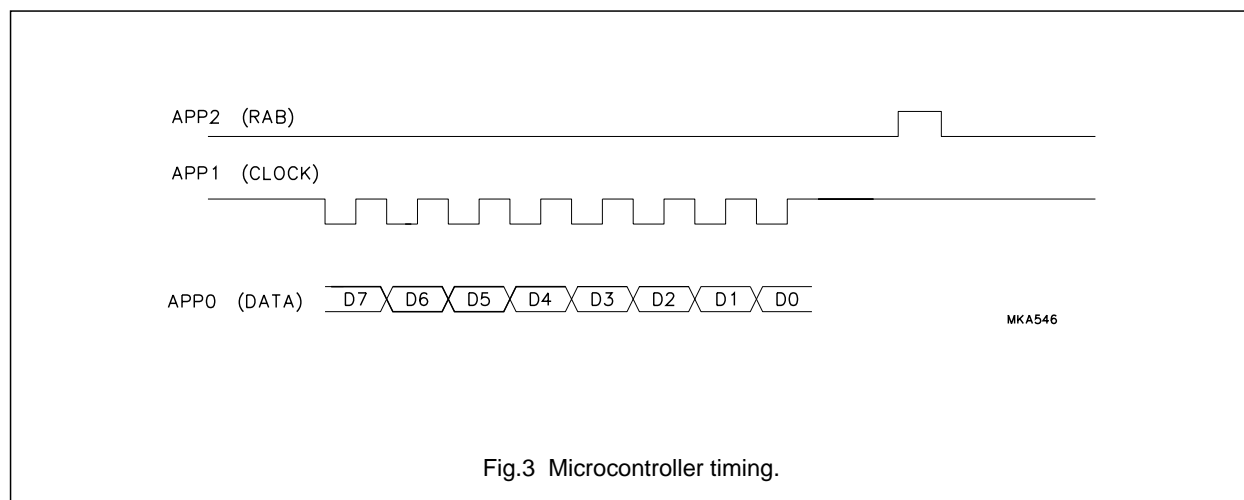


Fig.3 Microcontroller timing.

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MICROCONTROLLER WRITE OPERATION SEQUENCE (REPEAT MODE)

The same command can be repeated several times (e.g. for fade function) by applying APP2 pulses as shown in Fig.4. It should be noted that APP1 must stay HIGH

between APP2 pulses. A minimum pause of 22 ms is necessary between any two step-up or step-down commands.

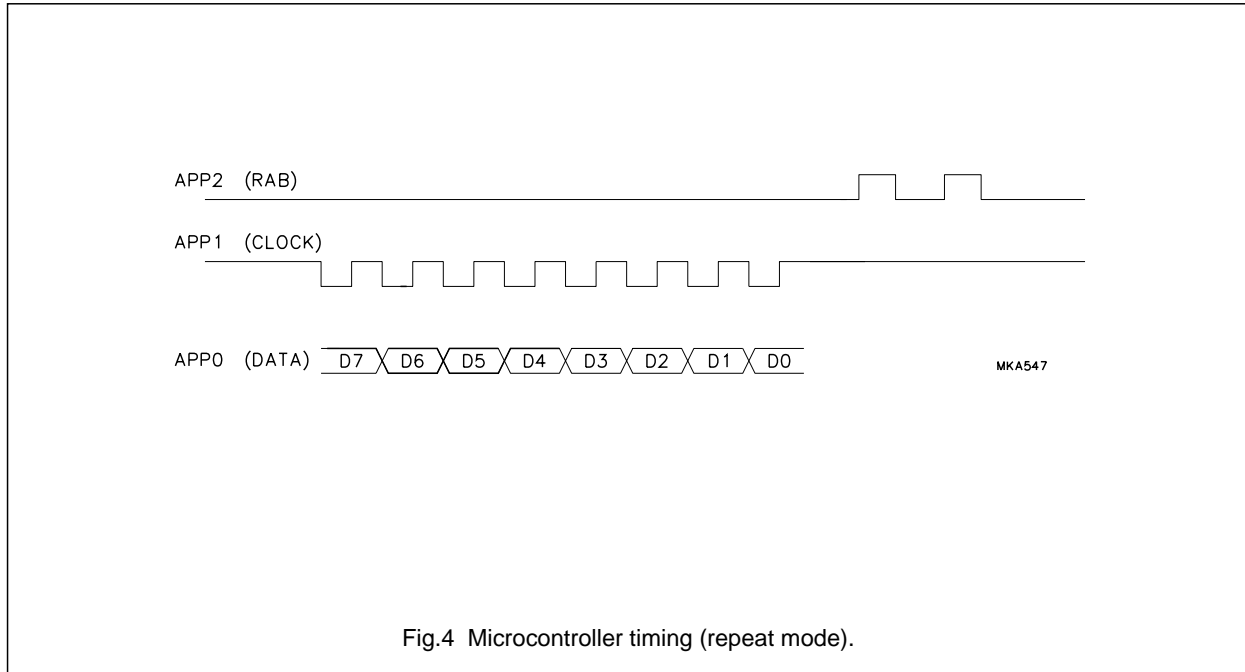


Fig.4 Microcontroller timing (repeat mode).

**Table 3** Microcontroller mode control register.

BIT POSITION	FUNCTION	DESCRIPTION	ACTIVE LEVEL
D7	ATSB	12 dB attenuation (from full scale)	LOW
D6	DSMB	double speed	LOW
D5	MUSB	mute	LOW
D4	DEEM	de-emphasis	HIGH
D3	FS	full scale	HIGH
D2	INCR	increment	HIGH
D1	DECR	decrement	HIGH
D0	not applicable	reserved	not applicable



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**Volume control**

A digital level control is incorporated in the TDA1306T which performs the function of soft mute and attenuation (pseudo-static application mode) or soft mute, attenuation, fade, increment and decrement (microcontroller application mode). The volume control of both channels can be varied in small step changes determined by the value of the internal fade counter where:

$$\text{audio level} = \text{counter} \times \text{maximum level}/120,$$

where the counter is a 7-bit binary number between 0 and 120. The time taken for mute to vary from 120 to 0 is  $1/120f_s$ . For example, when  $f_s = 44.1 \text{ kHz}$ , the time taken is approximately 3 ms.

**VOLUME CONTROL (PSEUDO-STATIC APPLICATION MODE)**

In the pseudo-static application mode (APPL = logic 0) the digital audio output level is controlled by APP0 (attenuation) and APP2 (mute) so only the final volume levels full scale, 12 dB (attenuate) and mute (-infinity dB) can be selected. The mute function has priority over the attenuation function. Accordingly, if MUSB is LOW, the state of ATSB has no effect. An example of volume control in this application mode is illustrated in Fig.5.

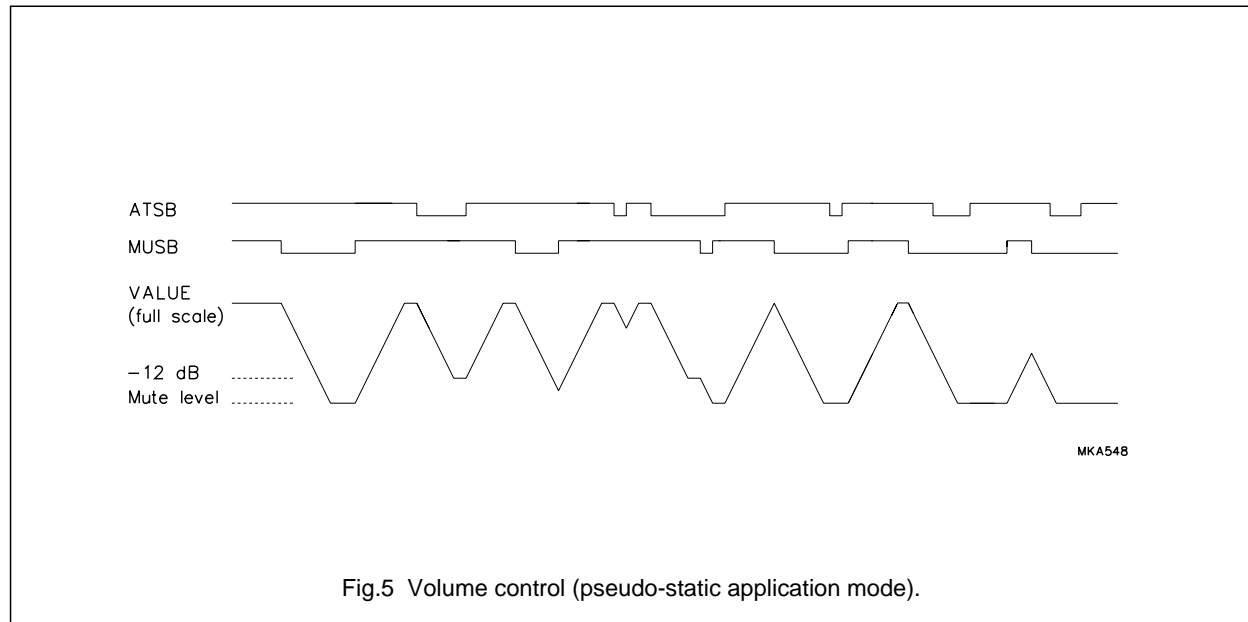


Fig.5 Volume control (pseudo-static application mode).

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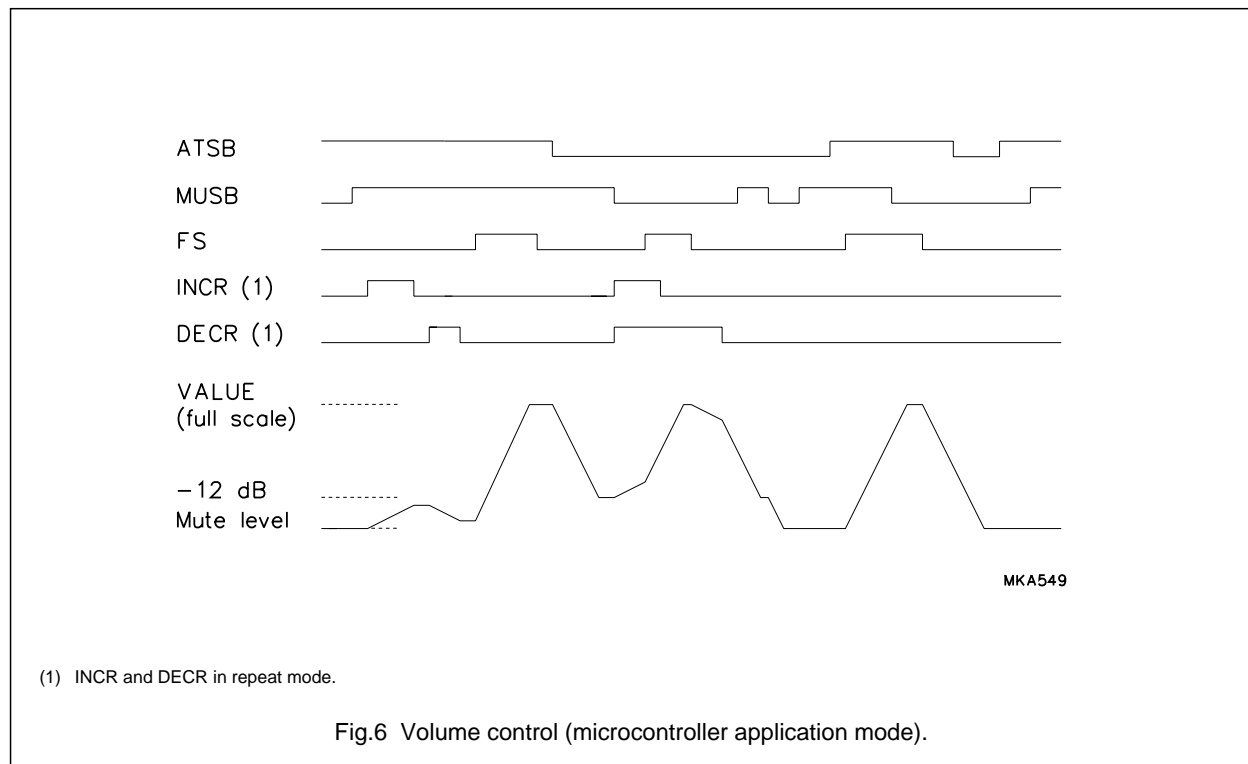
## VOLUME CONTROL (MICROCONTROLLER APPLICATION MODE)

In the microcontroller application mode (APPL = logic 1, APP3 = logic 0) the audio output level is controlled by volume control bits ATSB, MUSB, FS, INCR and DECR.

Mute is activated by sending the MUSB command to the mode control register via the microcontroller interface. The audio output level will be reduced to zero in a maximum of 120 steps (depending on the current position of the fade counter) and taking a maximum of 3 ms. Mute, attenuation and full scale are synchronized to prevent operation in the middle of a word.

- The counter is preset to 120 by the full scale command.
- The counter is preset to 30 by the attenuate command when its value is more than 30. If the value of the counter is less than 30 dB the ATSB command has no effect.
- The counter is preset to logic 0 by the mute command MUSB.
- Attenuation (-12 dB) is activated by sending the ATSB command to the fade control register (D7).
- Attenuation and mute are cancelled by sending the full-scale command to the fade control register (Register D3).

To control the fade counter in a continuous way, the INCREMENT and DECREMENT commands are available (fade control Registers D1 and D2). They will increment and decrement the counter by 1 for each register write operation. When issuing more than 1 step-up or step-down command in sequence, the write repeat mode may be used (see microcontroller application mode). An example of volume control in this application mode is illustrated in Fig.6.



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There are two recommended application situations within the microcontroller mode:

- The customer wants to use the microcontroller interface without the volume setting facility. In this event the operation is as follows:
  - Mute ON; by sending the MUSB command
  - Mute OFF; by sending the FS command
  - Attenuation ON; by sending the ATSB command
  - Attenuation OFF; by sending the FS command.
 It is possible to switch from 'Attenuation ON' to 'Mute ON' but not vice-versa.
- Incorporating the volume control feature operates as follows:
  - Mute ON; by sending the MUSB command the microcontroller has to store the previous volume setting
  - Mute OFF; by sending succeeding INCR commands until the previous volume is reached
  - Attenuation ON; by sending succeeding DECR commands until a relative downstep of  $-12$  dB is reached. The microcontroller has to store the previous volume
  - Attenuation OFF; by sending the succeeding INCR commands until the previous volume is reached
  - Volume UP; by sending succeeding INCR commands
  - Volume DOWN; by sending succeeding DECR commands.

### De-emphasis

A digital de-emphasis is implemented in the TDA1306T. By selecting the DEEM bit at register D4 (microcontroller application mode) or activating the APP3 pin (pseudo-static application mode), de-emphasis can be

applied by means of an IIR filter. De-emphasis is synchronized to prevent operation in the middle of a word.

### Double-speed mode

The double-speed mode is controlled by the DSMB bit at register D6 (microcontroller application mode) or by activating the APP1 pin (pseudo-static application mode). When the control bit is active LOW the device operates in the double-speed mode.

### Oversampling filter and noise shaper

The digital filter is a four times oversampling filter. It consists of two sections which each increase the sample rate by 2. The noise-shaper operates on  $4f_s$  and reduces the in-band noise density.

### DAC and operational amplifiers

In this noise shaping filter DAC a special data code and bidirectional current sources are used in order to achieve true low-noise performance. The special data code guarantees that only small values of current flow to the output during small signal passages while larger positive or negative values are generated using the bidirectional current sources. The noise shaping filter-DAC uses the continuous calibration conversion technique.

The operational amplifiers and the internal conversion resistors  $R_{CONV1}$  and  $R_{CONV2}$  convert the DAC current to an output voltage available at  $V_{OL}$  and  $V_{OR}$ . Connecting an external capacitor between  $FILTCL$  and  $V_{OL}$ ,  $FILTCR$  and  $V_{OR}$  respectively provides the required 1st-order post filtering.

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**LIMITING VALUES**

In accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$V_{DD}$	supply voltage	note 1	–	7.0	V
$T_{xtal}$	maximum crystal temperature		–	+150	°C
$T_{stg}$	storage temperature		–65	+125	°C
$T_{amb}$	operating ambient temperature		–40	+85	°C
$V_{es}$	electrostatic handling	note 2	–2000	+2000	V
		note 3	–200	+200	V

**Notes**

1. All  $V_{DD}$  and  $V_{SS}$  connections must be made to the same power supply.
2. Equivalent to discharging a 100 pF capacitor via a 1.5 k $\Omega$  series resistor.
3. Equivalent to discharging a 200 pF capacitor via a 2.5 mH series inductor.

**THERMAL CHARACTERISTICS**

SYMBOL	PARAMETER	VALUE	UNIT
$R_{th\ j-a}$	thermal resistance from junction to ambient in free air	69	K/W

**QUALITY SPECIFICATION**

In accordance with "UZW-BO/FQ-0601". The numbers of the quality specification can be found in the "Quality Reference Handbook". The handbook can be ordered using the code 9398 510 63011.

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**DC CHARACTERISTICS**

$V_{DDD} = V_{DDA} = V_{DDO} = 5\text{ V}$ ;  $T_{\text{amb}} = 25\text{ °C}$ ; all voltages referenced to ground (pins 2, 9 and 23); unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$V_{DDD}$	digital supply voltage (pin 10)	note 1	4.5	5.0	5.5	V
$V_{DDA}$	analog supply voltage (pin 1)	note 1	4.5	5.0	5.5	V
$V_{DDO}$	operational amplifier supply voltage (pin 24)	note 1	4.5	5.0	5.5	V
$I_{DDD}$	digital supply current	$f_{\text{sys}} = 11.28\text{ MHz}$	–	5	8	mA
$I_{DDA}$	analog supply current	at digital silence	–	3	6	mA
$I_{DDO}$	operational amplifier supply current	no operational amplifier load resistor	–	2	4	mA
$P_{\text{tot}}$	total power dissipation	$f_{\text{sys}} = 11.28\text{ MHz}$ ; digital silence; no operational amplifier load resistor	–	50	90	mW
$V_{\text{IH}}$	HIGH level digital input voltage (pins 3 to 8 and 11 to 17)		$0.7V_{\text{DDD}}$	–	$V_{\text{DDD}} + 0.5$	V
$V_{\text{IL}}$	LOW level digital input voltage (pins 3 to 8 and 11 to 17)		–0.5	–	$0.3V_{\text{DDD}}$	V
$R_{\text{pd}}$	internal pull-down resistor to $V_{\text{SSD}}$ (pins 3 and 11)		17	–	134	k $\Omega$
$ I_{\text{L}} $	input leakage current		–	–	10	$\mu\text{A}$
$C_{\text{i}}$	input capacitance		–	–	10	pF
$V_{\text{ref}}$	reference voltage (pin 22)	with respect to $V_{\text{SSO}}$	$0.45V_{\text{DDO}}$	$0.5V_{\text{DDO}}$	$0.55V_{\text{DDO}}$	V
$R_{\text{CONV}}$	current-to-voltage conversion resistor		2.4	3.0	3.6	k $\Omega$
$V_{\text{FS(rms)}}$	full-scale output voltage (RMS value)	$R_{\text{L}} > 5\text{ k}\Omega$ ; note 2	0.935	1.1	1.265	V
$R_{\text{L}}$	output load resistance		5	–	–	k $\Omega$

**Notes**

- All power supply pins ( $V_{\text{DD}}$  and  $V_{\text{SS}}$ ) must be connected to the same external power supply unit.
- $R_{\text{L}}$  is the AC resistance of the external circuitry connected to the audio outputs of the application circuit.

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**AC CHARACTERISTICS (ANALOG)**

$V_{DD3} = V_{DDA} = V_{DDO} = 5\text{ V}$ ;  $T_{\text{amb}} = 25\text{ }^{\circ}\text{C}$ ; all voltages referenced to ground (pins 2, 9 and 23); unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
<b>DACs</b>						
SVRR	supply voltage ripple rejection $V_{DDA}$ and $V_{DDO}$	$f_{\text{ripple}} = 1\text{ kHz}$ ; $V_{\text{ripple}} = 100\text{ mV (p-p)}$ ; $C22 = 10\text{ }\mu\text{F}$	–	40	–	dB
$\Delta G_v$	unbalance between the 2 DAC voltage outputs (pins 18 and 21)	maximum volume	–	–	0.5	dB
$\alpha_{\text{ct}}$	crosstalk between the 2 DAC voltage outputs (pins 18 and 21)	one output digital silence the other maximum volume	–	–110	–85	dB
(THD + N)/S	total harmonic distortion plus noise-to-signal ratio	at 0 dB signal level; $f_i = 1\text{ kHz}$	–	–70	–	dB
			–	0.032	–	%
		at –60 dB signal level; $f_i = 1\text{ kHz}$	–	–42	–32	dB
		–	0.8	2.5	%	
S/N <sub>ds</sub>	signal-to-noise ratio at digital silence	no signal; A-weighted	–	–108	–96	dB
<b>Operational amplifiers</b>						
$G_v$	open-loop voltage gain		–	85	–	dB
PSRR	power supply rejection ratio	$f_{\text{ripple}} = 3\text{ kHz}$ ; $V_{\text{ripple}} = 100\text{ mV (p-p)}$ ; A-weighted	–	90	–	dB
(THD + N)/S	total harmonic distortion plus noise-to-signal ratio	$R_L > 5\text{ k}\Omega$ ; $f_i = 1\text{ kHz}$ ; $V_o = 2.8\text{ V (p-p)}$	–	–100	–	dB
$f_{\text{UG}}$	unity gain frequency	open loop	–	4.5	–	MHz
$ Z_o $	AC output impedance	$R_L > 5\text{ k}\Omega$	–	1.5	150	$\Omega$

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**AC CHARACTERISTICS (DIGITAL)**

$V_{DD3} = V_{DD4} = V_{DD0}$  4.5 to 5.5 V; all voltages referenced to ground (pins 2, 9 and 23);  $T_{amb} = -40$  to  $+85$  °C; unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$T_{WX}$	clock cycle time	$f_{sys} = 384f_s$ ; normal speed	54.2	59.1	104	ns
		$f_{sys} = 192f_s$ ; double speed	54.2	59.1	104	ns
		$f_{sys} = 256f_s$ ; normal speed	81.3	88.6	156	ns
		$f_{sys} = 128f_s$ ; double speed	81.3	88.6	156	ns
$t_{CWL}$	$f_{sys}$ LOW level pulse width		22	–	–	ns
$t_{CWH}$	$f_{sys}$ HIGH level pulse width		22	–	–	ns
<b>Serial input data timing (see Fig.8)</b>						
$f_s$	word select input audio sample frequency	normal speed	25	44.1	48	kHz
		double speed	50	88.2	96	kHz
$f_{BCK}$	clock input frequency (data input rate)	$f_{sys} = 384f_s$ ; normal speed; note 1	–	–	$64f_s$	kHz
		$f_{sys} = 192f_s$ ; double speed; note 1	–	–	$64f_s$	kHz
		$f_{sys} = 256f_s$ ; normal speed	–	–	$64f_s$	kHz
		$f_{sys} = 128f_s$ ; double speed; note 2	–	–	$48f_s$	kHz
$t_r$	rise time		–	–	20	ns
$t_f$	fall time		–	–	20	ns
$t_H$	bit clock HIGH time		55	–	–	ns
$t_L$	bit clock LOW time		55	–	–	ns
$t_{su}$	data set-up time		20	–	–	ns
$t_h$	data hold time		10	–	–	ns
$t_{suWS}$	word select set-up time		20	–	–	ns
$t_{hWS}$	word select hold time		10	–	–	ns
<b>Microcontroller interface timing (see Fig.9)</b>						
$t_L$	input LOW time		2	–	–	$\mu s$
$t_H$	Input HIGH time		2	–	–	$\mu s$
$t_{suDC}$	set-up time DATA to CLOCK		1	–	–	$\mu s$
$t_{hCD}$	hold time CLOCK to DATA		1	–	–	$\mu s$
$t_{suCR}$	set-up time CLOCK to RAB		1	–	–	$\mu s$

**Notes**

1. A clock frequency of up to  $96f_s$  is possible in the event of a rising edge of BCK occurring during  $SYSCLK = LOW$ .
2. A clock frequency of up to  $64f_s$  is possible in the event of a rising edge of BCK occurring during  $SYSCLK = LOW$ .

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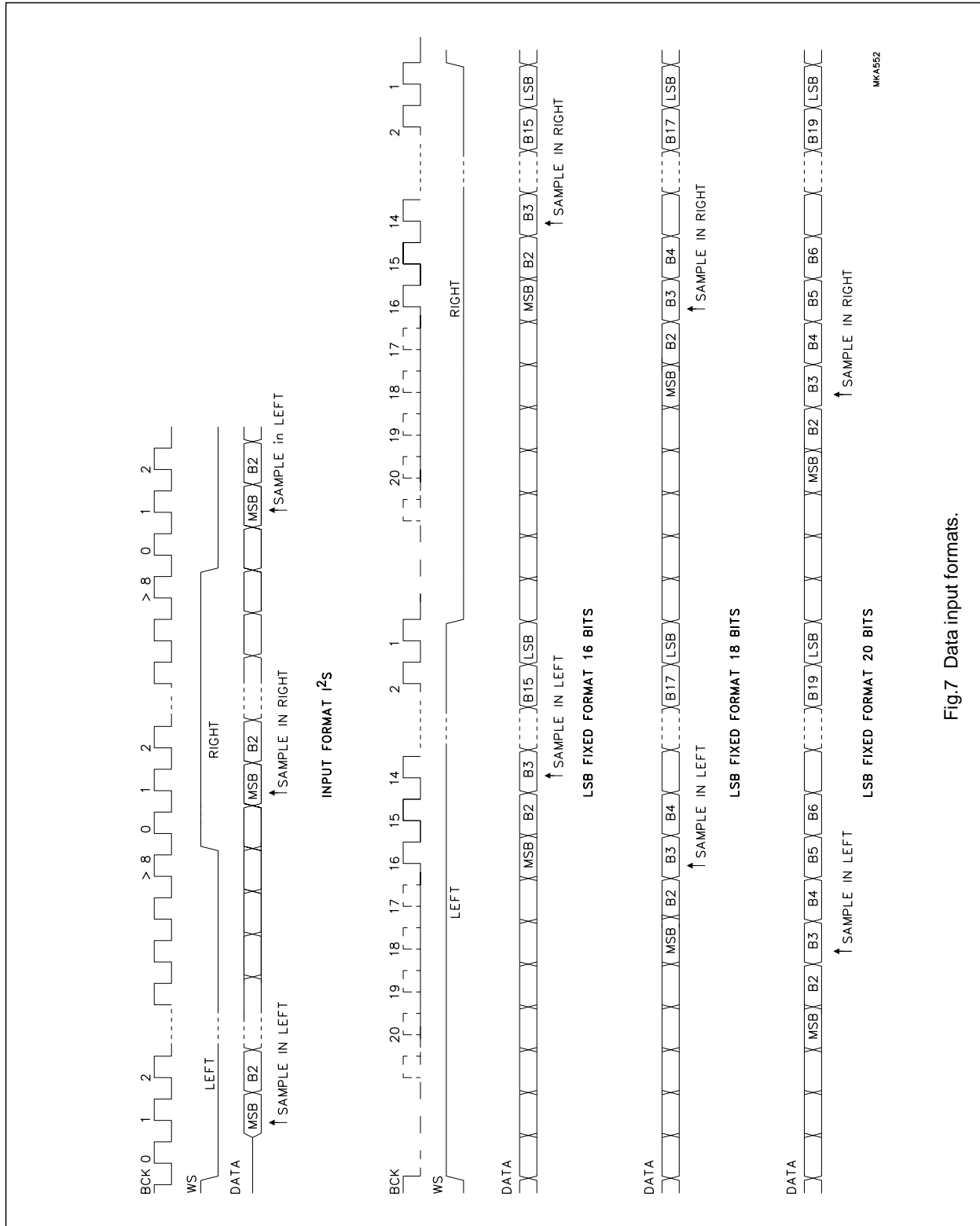


Fig.7 Data input formats.



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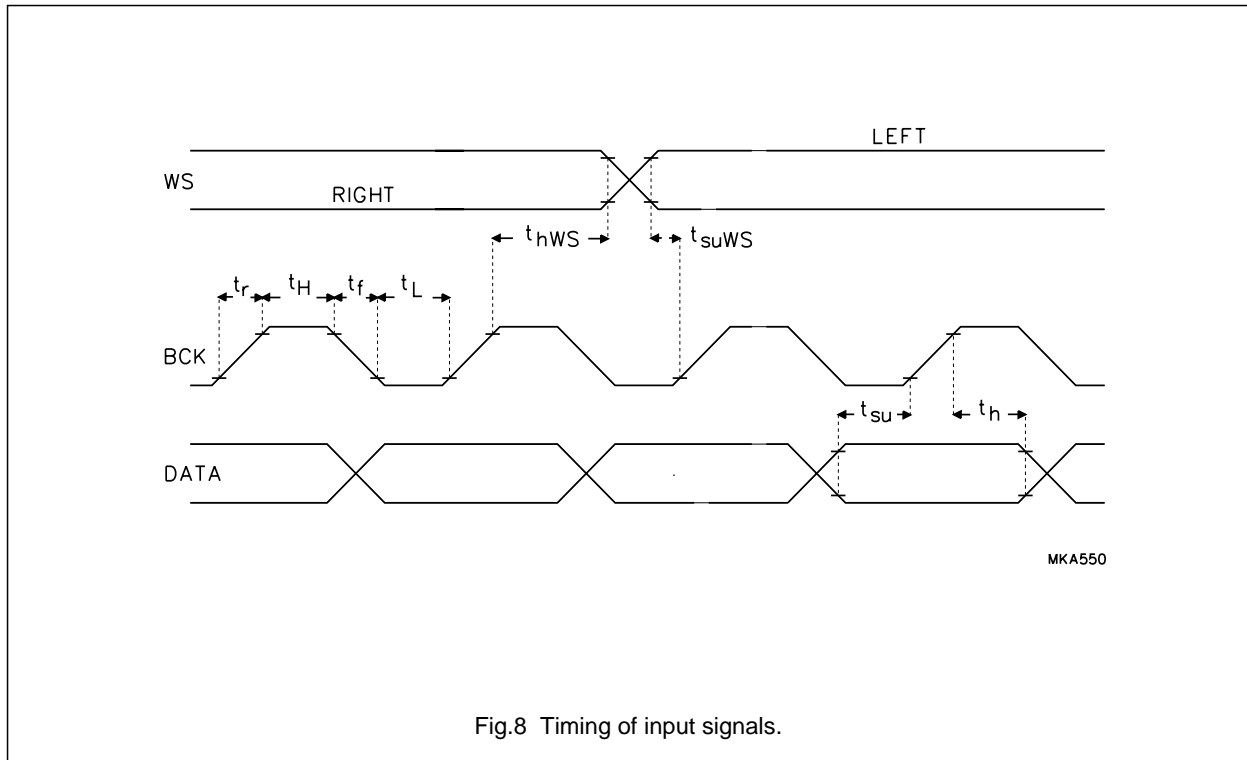


Fig.8 Timing of input signals.

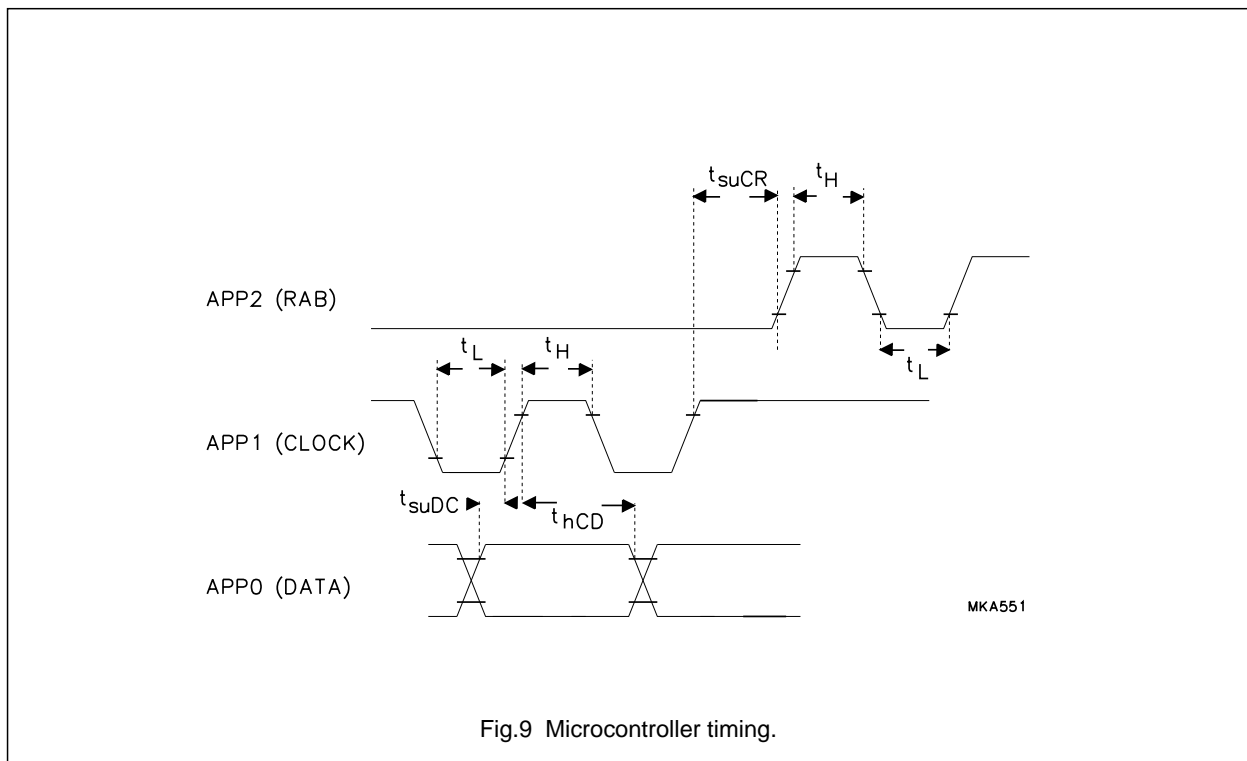


Fig.9 Microcontroller timing.

## Noise shaping filter DAC

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**TEST AND APPLICATION INFORMATION****Filter characteristics****Table 4** Digital filter specification ( $f_s = 44.1$  kHz).

BAND	ATTENUATION
0 to 19 kHz	< 0.001 dB
19 to 20 kHz	< 0.03 dB
24 kHz	> 25 dB
25 to 35 kHz	> 40 dB
35 to 64 kHz	> 50 dB
64 to 68 kHz	> 31 dB
68 kHz	> 35 dB
69 to 88 kHz	> 40 dB

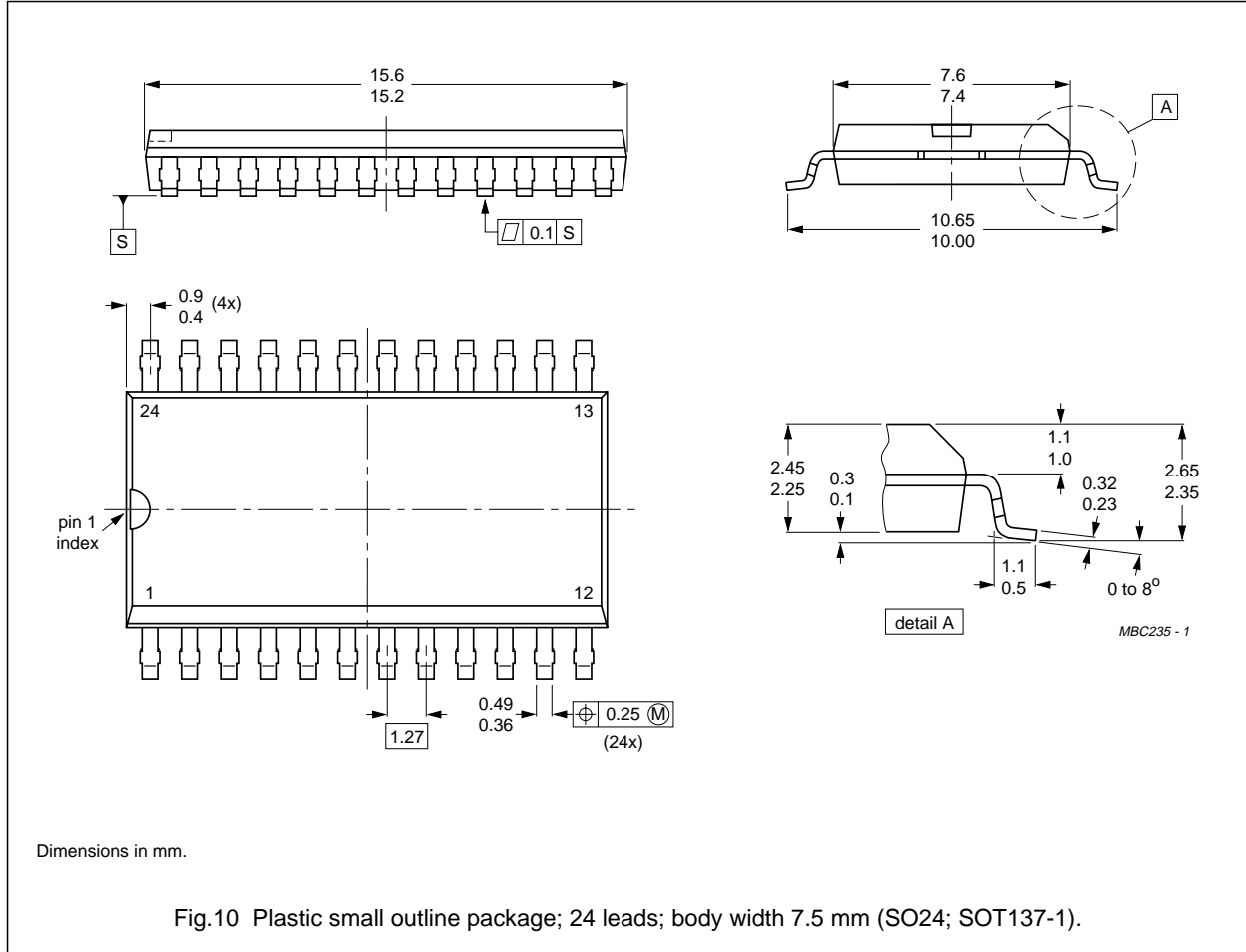
**Table 5** Digital filter phase distortion ( $f_s = 44.1$  kHz).

BAND	PHASE DISTORTION
0 to 16 kHz	< $\pm 1^\circ$

Noise shaping filter DAC

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PACKAGE OUTLINE



## Noise shaping filter DAC

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**SOLDERING****Plastic small-outline packages**

## BY WAVE

During placement and before soldering, the component must be fixed with a droplet of adhesive. After curing the adhesive, the component can be soldered. The adhesive can be applied by screen printing, pin transfer or syringe dispensing.

Maximum permissible solder temperature is 260 °C, and maximum duration of package immersion in solder bath is 10 s, if allowed to cool to less than 150 °C within 6 s. Typical dwell time is 4 s at 250 °C.

A modified wave soldering technique is recommended using two solder waves (dual-wave), in which a turbulent wave with high upward pressure is followed by a smooth laminar wave. Using a mildly-activated flux eliminates the need for removal of corrosive residues in most applications.

## BY SOLDER PASTE REFLOW

Reflow soldering requires the solder paste (a suspension of fine solder particles, flux and binding agent) to be

applied to the substrate by screen printing, stencilling or pressure-syringe dispensing before device placement.

Several techniques exist for reflowing; for example, thermal conduction by heated belt, infrared, and vapour-phase reflow. Dwell times vary between 50 and 300 s according to method. Typical reflow temperatures range from 215 to 250 °C.

Preheating is necessary to dry the paste and evaporate the binding agent. Preheating duration: 45 min at 45 °C.

**REPAIRING SOLDERED JOINTS (BY HAND-HELD SOLDERING IRON OR PULSE-HEATED SOLDER TOOL)**

Fix the component by first soldering two, diagonally opposite, end pins. Apply the heating tool to the flat part of the pin only. Contact time must be limited to 10 s at up to 300 °C. When using proper tools, all other pins can be soldered in one operation within 2 to 5 s at between 270 and 320 °C. (Pulse-heated soldering is not recommended for SO packages.)

For pulse-heated solder tool (resistance) soldering of VSO packages, solder is applied to the substrate by dipping or by an extra thick tin/lead plating before package placement.

**DEFINITIONS**

<b>Data sheet status</b>	
Objective specification	This data sheet contains target or goal specifications for product development.
Preliminary specification	This data sheet contains preliminary data; supplementary data may be published later.
Product specification	This data sheet contains final product specifications.
<b>Limiting values</b>	
Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.	
<b>Application information</b>	
Where application information is given, it is advisory and does not form part of the specification.	

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**NOTES**

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**NOTES**

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