

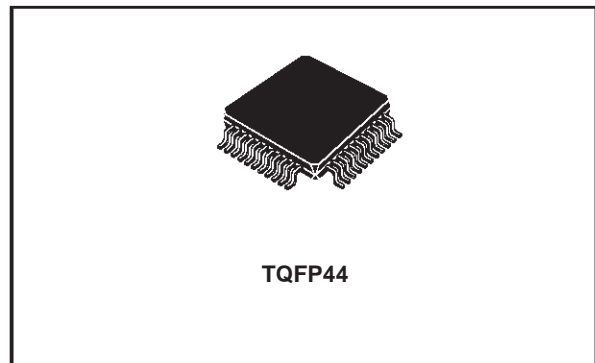


# TDA7501

## LINE-DRIVER FOR DIGITAL CARRADIO SIGNAL PROCESSOR

PRODUCT PREVIEW

- **INPUTS:**
  - QUASI DIFFERENTIAL STEREO INPUT FOR CD
  - DIFFERENTIAL STEREO INPUTS FOR PHONE, NAVIGATION, FM, AM
  - SINGLE-ENDED INPUT FOR CASSETTE
  - FOUR INDEPENDENT INPUT MULTIPLEXER AND GAIN STAGES
  - ENVELOPE-DETECTOR FOR AM-NOISEBLANKING
  - MIXING OF PHONE AND NAVIGATION
  - DC-CONNECTION TO DSP
  - DUAL MPX INPUTS
- **OUTPUTS:**
  - 6 OUTPUT CHANNELS WITH INDEPENDENT VOLUME CONTROL
  - 4 MAIN OUTPUT CHANNELS WITH ADDITIONAL INPUT SELECTOR FOR PHONE AND/OR NAVIGATION OR CD
  - OUTPUTS FOR UP TO 4V rms
  - AC-CONNECTION FROM DSP
- **DIGITAL CONTROL:**
  - SPI-BUS OR I<sup>2</sup>C BUS INTERFACE (SELECTABLE)
  - DIRECT MUTE FOR THE OUTPUT STAGES AND/OR HIGH IMPEDANCE MPX MUTE

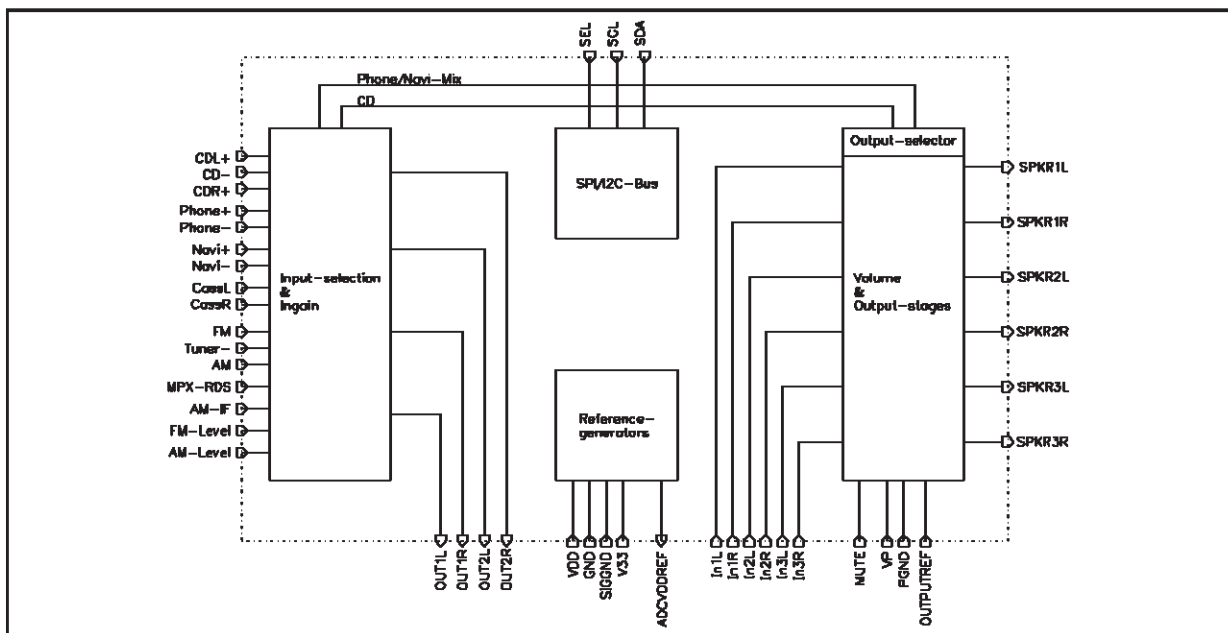


### DESCRIPTION

The Linedriver handles all analog input- and output-signals for the Digital Carradio Signal Processor TDA7501. The device contains four independent input multiplexers to select the sources for the DSP's four AD-converters. Four additional gain stages allow an adaptation to run the ADCs in best S/N condition.

The six outputs have independent volume stages with a large dynamic range. Using a 12V-supply the outputs are able to drive up to 4Vrms .

### BLOCK DIAGRAM



# TDA7501

## SUPPLY

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
V <sub>dd</sub>	Supply Voltage		7.5	8.3	10	V
V <sub>P</sub>	Output Supply Voltage			12		V
I <sub>S8</sub>	Supply Current V <sub>dd</sub>	V <sub>dd</sub> = 8.3V		15		mA
I <sub>S12</sub>	Supply Current V <sub>P</sub>	V <sub>P</sub> = 12V		15		mA
SVRR	Ripple Rejection @ 1kHz			60		dB

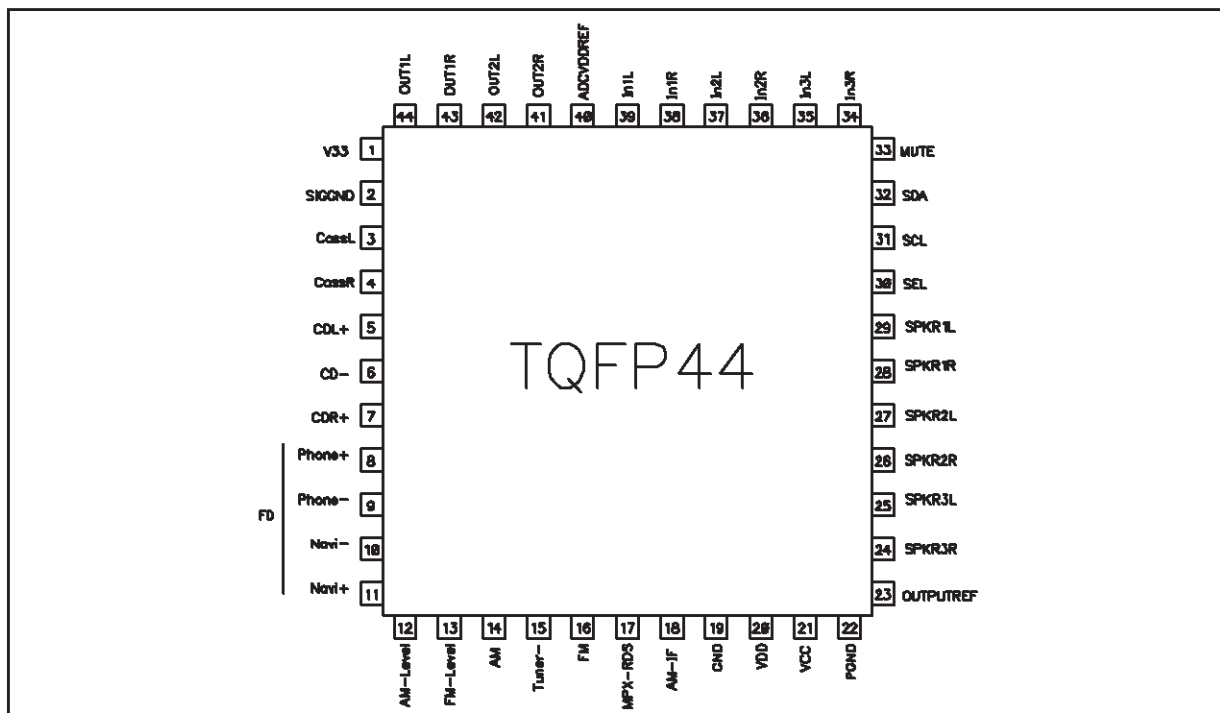
## ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V <sub>DDmax</sub>	Operating Supply Voltage V <sub>DD</sub>	10.5	V
V <sub>Smax</sub>	Operating Supply Voltage V <sub>s</sub>	13.0	V
T <sub>amb</sub>	Operating Temperature Range	-40 to 85	°C
T <sub>stg</sub>	Storage Temperature Range	-55 to +150	°C

## ESD:

All pins are protected against ESD according to the MIL883 standard.

## PIN CONNECTION



## THERMAL DATA

Symbol	Parameter	Value	Unit
R <sub>thj-pins</sub>	Thermal Resistance Junction-pins	Max. 65	°C/W

**ELECTRICAL CHARACTERISTICS** ( $V_{DD} = V_S = 8.3V$ ;  $T_{amb} = 25^{\circ}C$ ;  $R_L = 10k\Omega$ ; all gains = 0dB;  $f = 1kHz$ ; unless otherwise specified)

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
<b>GENERAL</b>						
$V_{CL}$	Input Clipping Level			2.3		$V_{RMS}$
$S_{IN}$	Input Separation		80	100		dB
$G_{IN\ MIN}$	Min. Input Gain			0		dB
$G_{IN\ MAX}$	Max. Input Gain			15		dB
$G_{STEP}$	Step Resolution			1		dB
$V_{DC}$	DC Steps	Adjacent Gain Steps		0.5		mV
		$G_{MIN}$ to $G_{MAX}$		5		mV
$d_{IN}$	Distortion	$V_{OUT} = 0.7V_{RMS}$		0.002	0.08	%
$V_{DCout}$	Output DC-voltage	pins 41..44		1.65		V
$R_{out}$	Output impedance			3		$k\Omega$
<b>QUASI DIFFERENTIAL CD STEREO INPUT (non inverting)</b>						
$R_{in}$	Input Resistance (see Fig. 2)	Differential	70	100	130	$k\Omega$
CMRR	Common Mode Rejection Ratio	$V_{CM} = 1V_{RMS}$ @ 1kHz	45	70		dB
		$V_{CM} = 1V_{RMS}$ @ 10kHz	45	60		dB
$V_N$	Output-Noise	20Hz - 20kHz; unweighted		2.5		$\mu V$
<b>DIFFERENTIAL PHONE/NAVIGATION/FM/AM INPUT (inverting)</b>						
$R_{in}$	Input Resistance (see Fig. 3)		35	50	65	$k\Omega$
CMRR	Common Mode Rejection Ratio	$V_{CM} = 1V_{RMS}$ @ 1kHz	40	70		dB
		$V_{CM} = 1V_{RMS}$ @ 10kHz	40	60		dB
<b>AM IF INPUT</b>						
$R_{in}$	Input Resistance		35	50	65	$k\Omega$
<b>CASSETTE INPUT (non inverting)</b>						
$R_{in}$	Input Resistance		70	100	130	$k\Omega$
<b>AM/FM-LEVEL INPUT</b>						
$R_{in}$	Input Resistance		70	100	130	$k\Omega$
$V_{min}$	Minimum Input Voltage		-0.4			V
$V_{max}$	Maximum Input Voltage				7	V
<b>Dual MPX control (pin TUNER-)</b>						
$V_{CTRLMPX1}$	Control voltage for MPX 1+2	MPX1 -> MPX1 + MPX2		1.5		V
$V_{CTRLMPX2}$	Control voltage for MPX2	MPX1 + MPX1 -> MPX2		4		V
$V_{CTRLMPX3}$	Control voltage for MPX 1+2	MPX2 -> MPX1 + MPX2		3.5		V
$V_{CTRLMPX4}$	Control voltage for MPX1	MPX1 + MPX2 -> MPX2		1		V
<b>SPEAKER OUTPUTS</b>						
$R_{in}$	Input Impedance		35	50	65	$k\Omega$
$G_{MAX}$	Max. Gain	single supply mode		15		dB
		dual supply mode		21		dB
$A_{MAX}$	Max. Attenuation	single supply mode		-79		dB
		dual supply mode		-73		dB

## ELECTRICAL CHARACTERISTICS (continued)

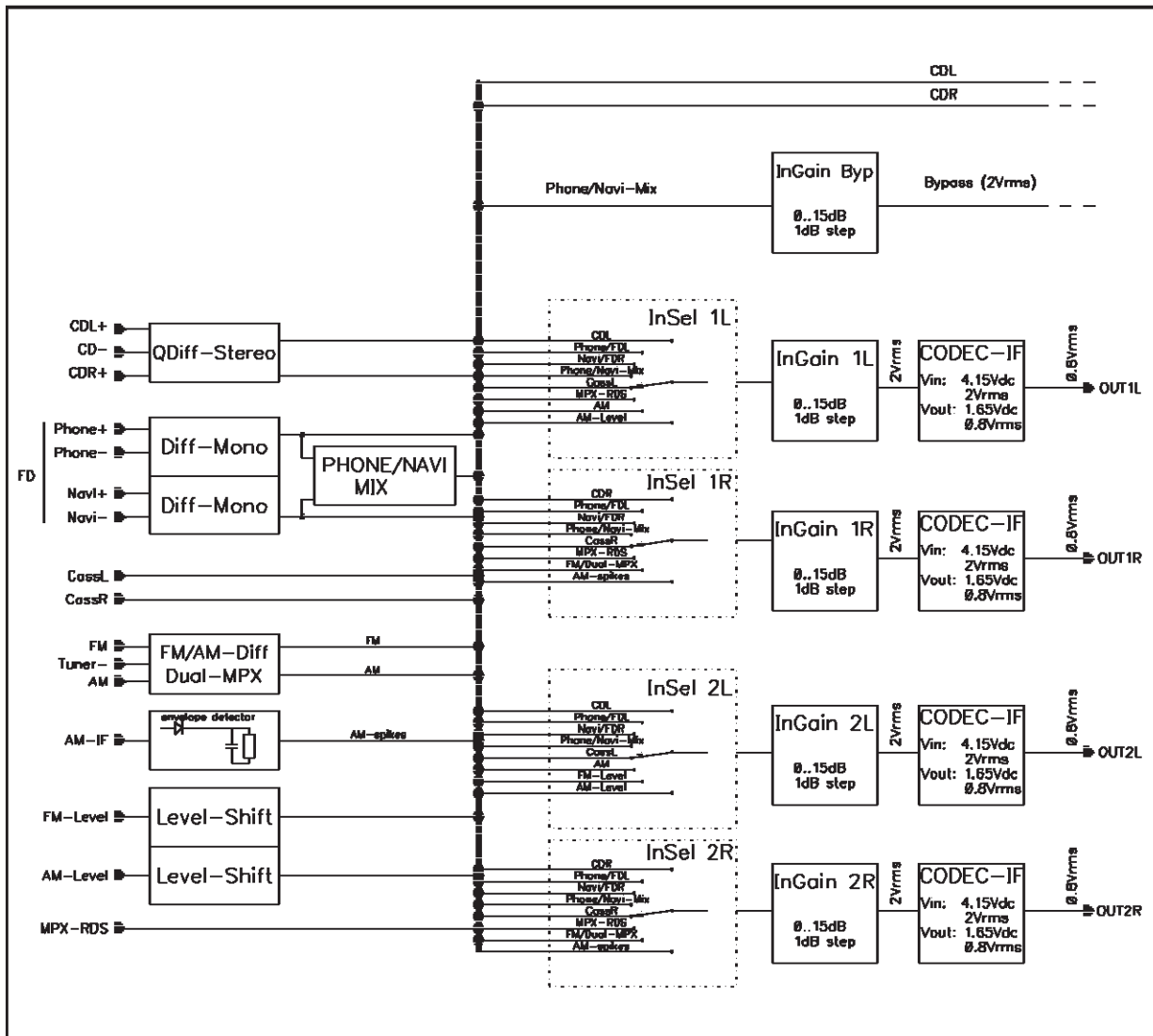
Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
A <sub>STEP</sub>	Step Resolution			1		dB
A <sub>MUTE</sub>	Output Mute Attenuation		80	100		dB
E <sub>E</sub>	Attenuation Set Error	from +15 to -40dB			2	dB
V <sub>DC</sub>	DC Steps	Adjacent Attenuation Steps		0.1	3	mV
V <sub>DCOUT</sub>	Output DC-voltage	single supply mode dual supply mode		4.15 outref		V V
V <sub>CLIP</sub>	Output Clipping Level	d = 0.3%, V <sub>CC</sub> = V <sub>DD</sub> = 8.3V gain = 0dB gain = 6dB		2.3 2.8		V <sub>RMS</sub> V <sub>RMS</sub>
		d = 0.3%, V <sub>CC</sub> = 12V V <sub>DD</sub> = 8.3V gain = 0dB		4		V <sub>RMS</sub>
R <sub>L</sub>	Output Load Resistance	AC-coupled	5			kΩ
C <sub>L</sub>	Output Load Capacitance				10	nF
R <sub>OUT</sub>	Output Impedance			30	120	Ω
V <sub>N</sub>	Output Noise	BW = 20Hz-20kHz muted 0dB muted 6dB gain = 0dB gain = 6dB		3		μV
				7.5		μV
				10		μV
				13		μV
S/N	Signal to Noise Ratio	BW = 20Hz-20kHz V <sub>O</sub> = 2V <sub>RMS</sub> V <sub>O</sub> = 4V <sub>RMS</sub>		106		dB
				110		dB
d <sub>out</sub>	distortion	V <sub>OUT</sub> = 1V <sub>RMS</sub> ; all stages 0dB		0.005	0.08	%
S <sub>C</sub>	Channel Separation left/right		80	100		dB
<b>ADCVDDREF (CODEC reference)</b>						
I <sub>maxadc</sub>	Max. Output Current	pin 40			5	mA
<b>BUS INPUTS</b>						
V <sub>low</sub>	Voltage for logic "0"	inputs SEL, SCL,SDA,MUTE		0.8		V
V <sub>high</sub>	Voltage for logic "1"	inputs SEL, SCL,SDA,MUTE		2.4		V

**DESCRIPTION OF THE INPUT PART**

On the input side, the DSPLD (see figure 1) connects the external audio- and tuner-signals to the four AD-converters of the Digital Carradio Signal Processor TDA7500. The audio signals are adjusted by the input gain stage to the internal refer-

ence signal with 2V rms referred to 4.15V (=V33 Æ 1.2575). The following CODEC-interface attenuates the 2V<sub>rms</sub> to 0.8V<sub>rms</sub> referred to the CODEC's reference voltage of 1.65V which allows a DC-coupling to the TDA7500.

**Figure 1. Input part.**



**Input Stages**

The device offers several input stages for the different signals which have to be handled by the system. A quasi differential input (see figure 2) can be used for (external) CD-changer. The two mono differential inputs allow the connection of Phone and Navigation (see figure 3) or it could be used as fully differential stereo input. Additionally a single-ended stereo input is available for Cassette applications. The lower part of the input

section is dedicated to the tuner signals. Another quasi differential input (see figure 4) is used to connect AM and FM referred to the tuner reference (Tuner-). This concept supports also double tuner systems. Also two separate level inputs are present which are followed by level-shifters to allow the use of the TDA7500's ADCs. For AM noise blanking an envelope-detector driven by the AM-IF is also available.



Figure 2. Quasi differential input-stage.

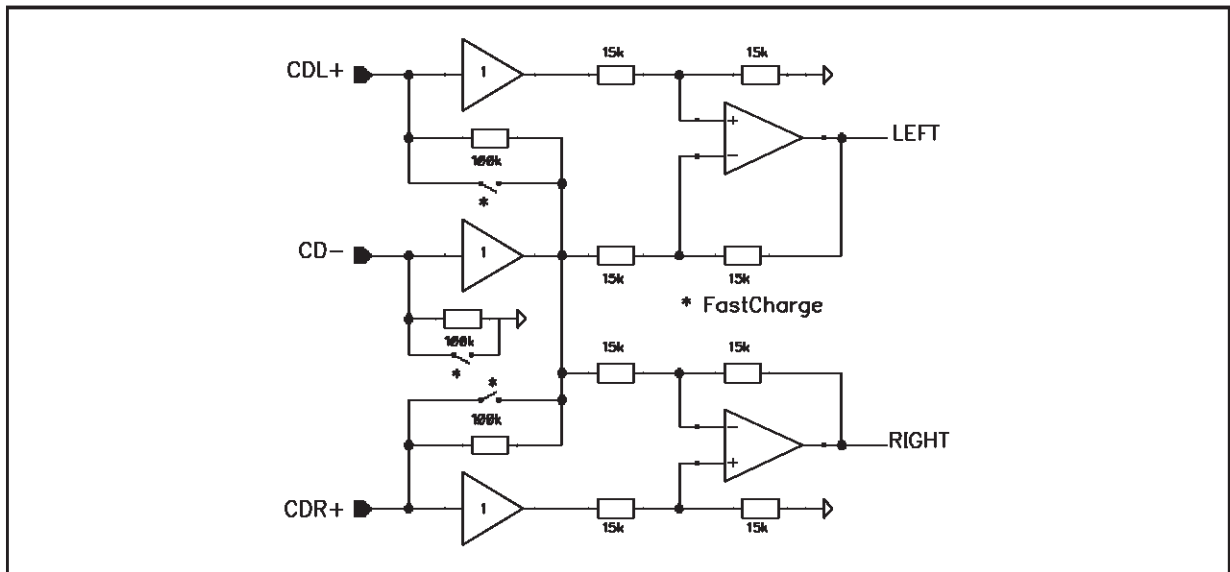


Figure 3. Mono differential input-stage.

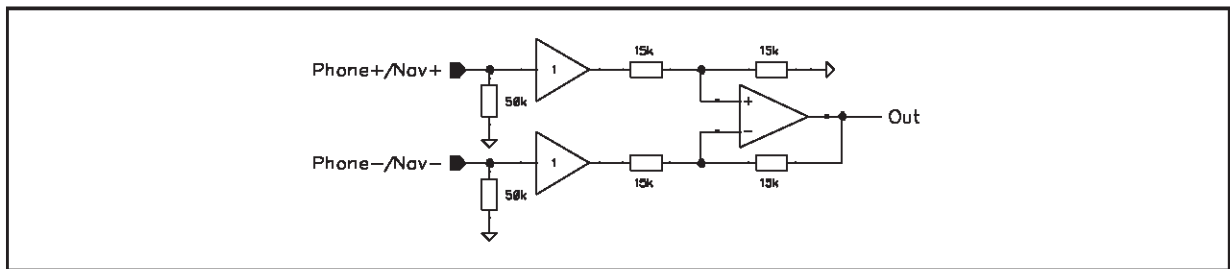
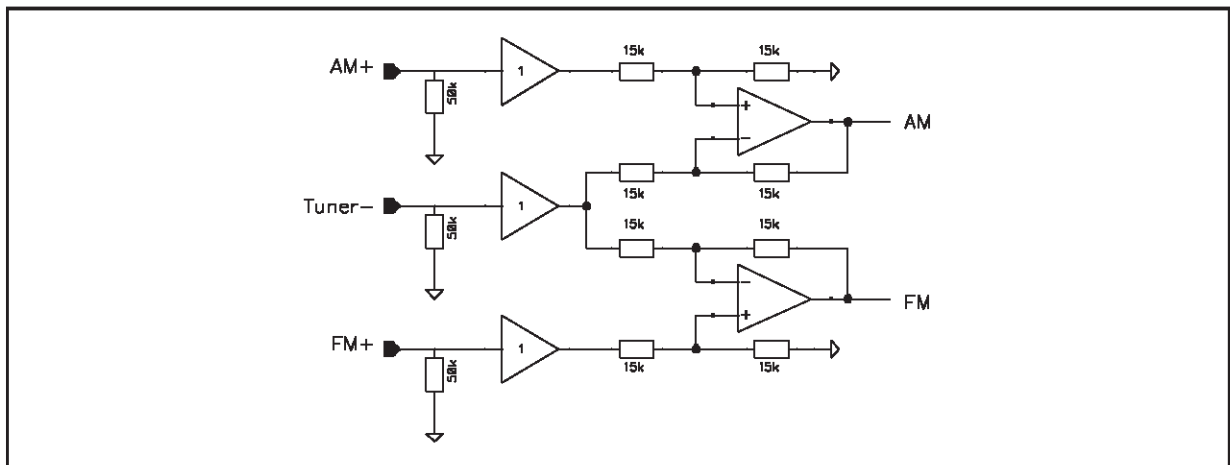


Figure 4. Differential input-stage for AM/FM.



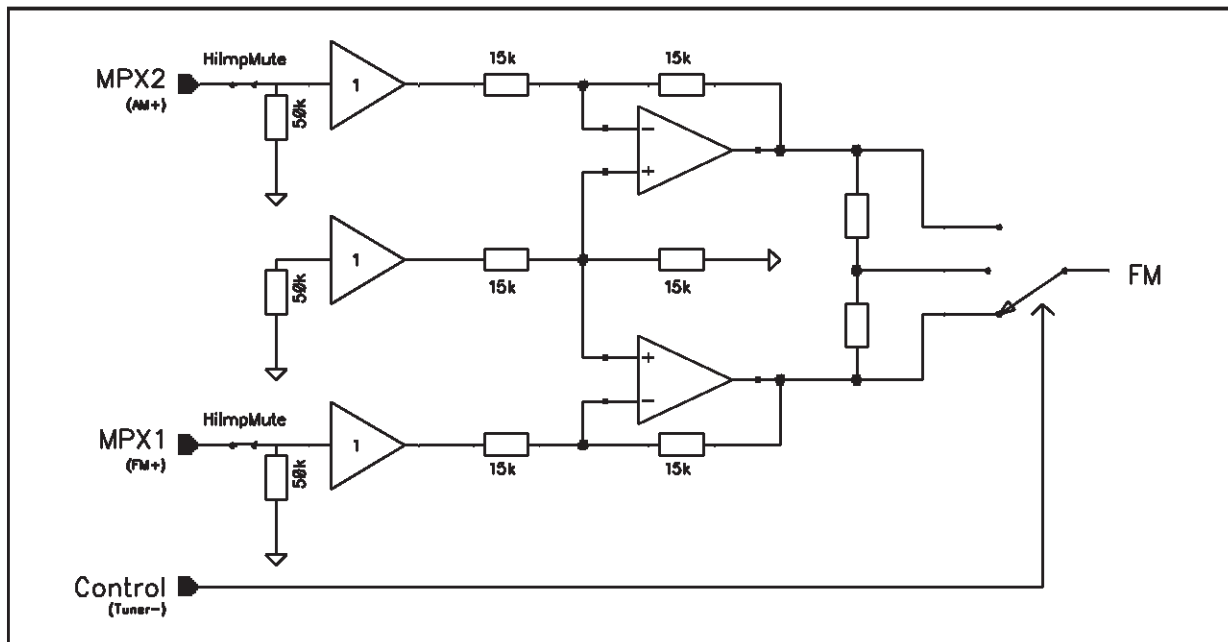
### Dual MPX mode

The TDA7501 is able to support a twin tuner concept via the Dual-MPX-Mode. In this configuration the MPX-pin and the AM-pin are acting as MPX1 and MPX2 inputs. The DC-Voltage at the TUNER- -pin controls whether one or

both MPX-signals are used to decode the stereo FM-signal (see figure 4 Please note that the thresholds have a hysteresis of 500mV. During this mode the highohmic-mute acts on both inputs in parallel.

For the programming of the Dual-MPX-Mode see the programming section.

Figure 4. Block diagram Dual MPX.



**DESCRIPTION OF THE OUTPUT PART**

The TDA7501 has 6 independent outputstage with volume control. The first 4 (main) outputs have an input selector which allows to select besides the DAC-outputs CD-direct or Phone/Navigation-mix. In addition one can mix the SPKR1 with Phone/Navigation so that traffic or navigation announcements can bypass the DSP (see figure 5).

The TDA7500 CODEC outputs have a maximum

output voltage of 0.5Vrms . To obtain 4Vrms , (in the dual supply mode only) the signal is first amplified to have a reference amplitude of 2V rms. The following volume stage offers up to 15dB gain which gives along with the programmable 6dB gain in the output-stage enough overdrive capability. To achieve the maximum output swing of 4Vrms the device must be supplied with an additional supply of 12V. With a single supply ( $V_{dd} = V_{CC} = 8.3V$ ) 2.8Vrms are obtained at the output at maximum.

Figure 5. Output part.

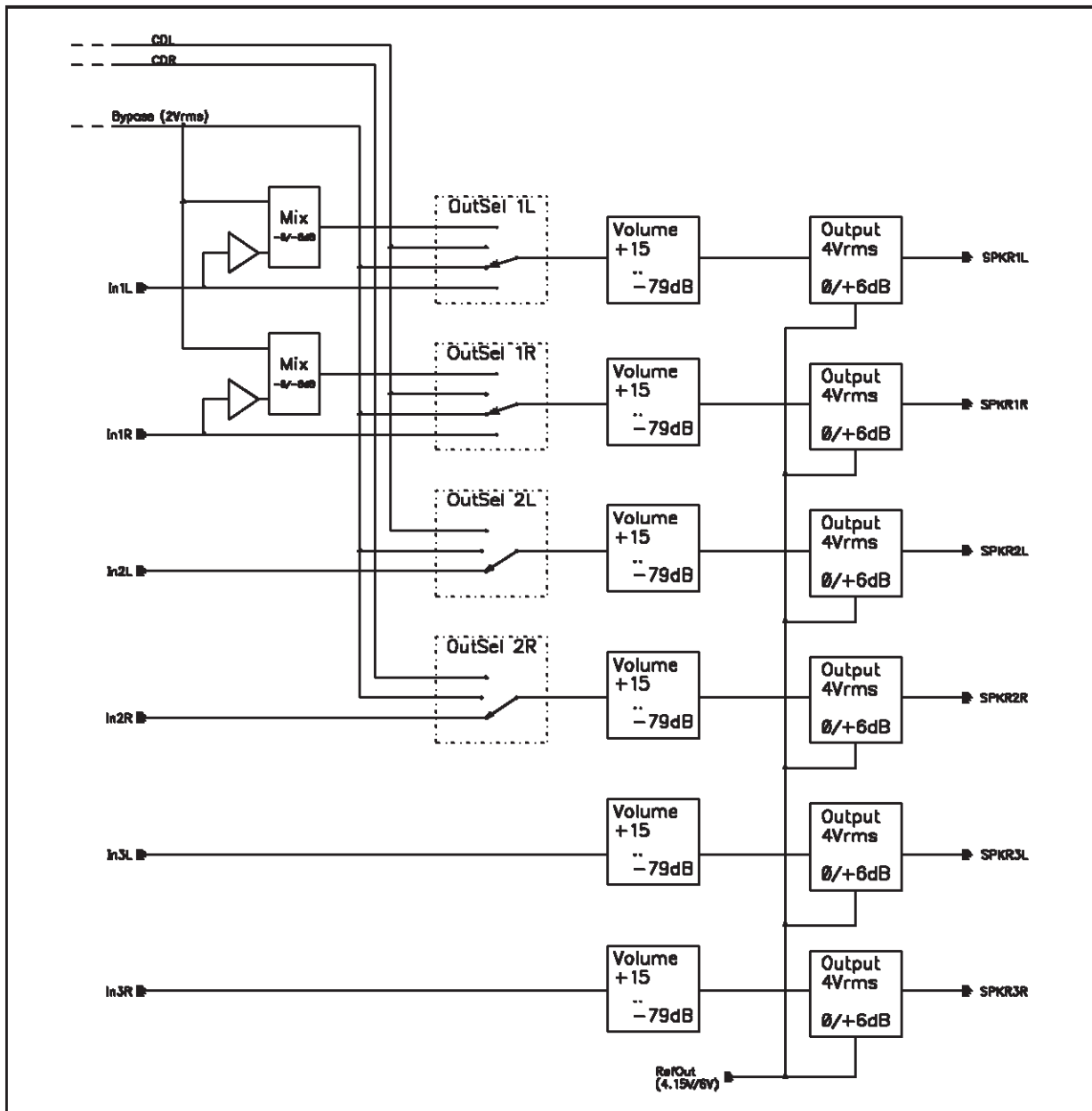
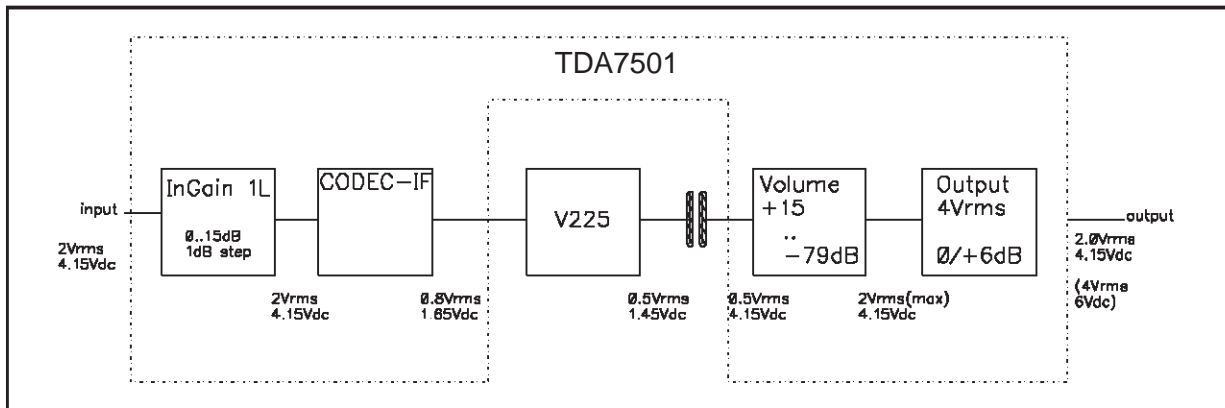




Figure 6. Level-diagram.



**REFERENCE CONCEPT**

For the input section the TDA7501 generates the internal reference voltage by multiplying the V33 voltage by 1.2575.

The V33 voltage is also buffered and fed back to the CODEC where it is used to generate all necessary references. For best performance it is recommended to filter the V33 reference pin by means of a passive second order lowpass as shown in figure 7 This concept allows a direct DC coupling between the TDA7501 and the DSP

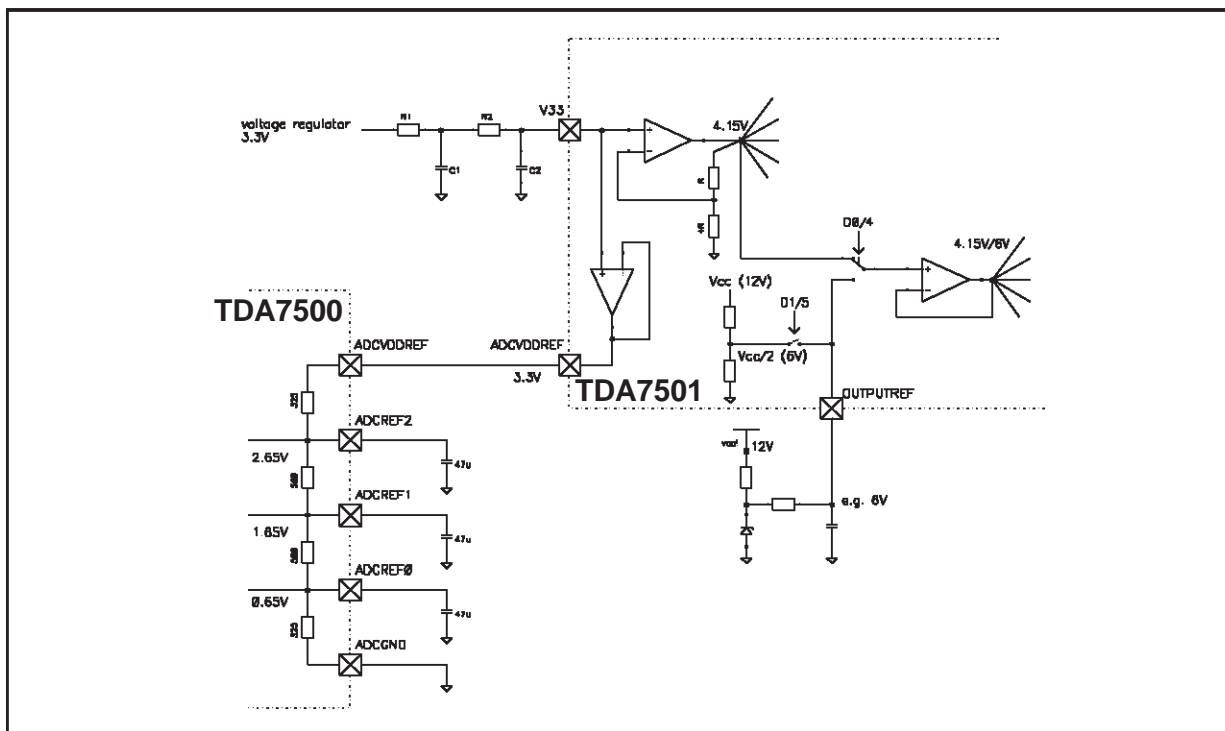
because of the accurate matching of DC levels. On the output side the TDA7501 offers two main

modes: a single supply and a dual supply mode.

**Dual supply mode**

In this mode the outputs are able to provide up to 4V rms with a minimum supply  $V_{CC}$  of 12V as well as a output reference voltage set to half of  $V_{CC}$  (bit D0 of the mode select byte set to '1'). If the switch D1/byte mode select is open the output reference voltage must be defined externally e.g. a zener diode with RC-lowpass. If the switch is closed the reference voltage will be half of  $V_{CC}$  and only an external capacitor has to be added.

Figure 7. Reference voltage generation





**SOFTWARE SPECIFICATION FOR BOTH MODES****Auto increment**

If bit I in the subaddress byte is set to "1", the autoincrement of the subaddress is enabled.

**Reset condition**

A Power-On-Reset is invoked if the Supply-Voltage  $V_{dd}$  is below than 3.5V. After POR the following data is written automatically into the registers of all subaddresses :

MSB							LSB
1	1	1	1	1	1	1	0

The programming after POR is marked bold-face in the programming tables.

With this programming all the outputs are muted to their corresponding reference voltages.

**Subaddresses**

MSB				LSB				Name
D7	D6	I	D4	SA3	SA2	SA1	SA0	
				0	0	0	0	Input selector 1L
				0	0	0	1	Input selector 1R
				0	0	1	0	Input selector 2L
				0	0	1	1	Input selector 2R
				0	1	0	0	Bypass selector
				0	1	0	1	Configuration
				0	1	1	0	Mode select
				0	1	1	1	Output selector
				1	0	0	0	Volume 1L
				1	0	0	1	Volume 1R
				1	0	1	0	Volume 2L
				1	0	1	1	Volume 2R
				1	1	0	0	Volume 3L
				1	1	0	1	Volume 3R
		0						Autoincrement mode off
		1						Autoincrement mode on
0	0		0					must be "0"

**Input selector 1L..3R, bits D<sub>7</sub> ..D<sub>3</sub> (subaddresses 0..3)**

MSB				LSB				Function
D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>	
				0				<b>mute</b>
				1				<b>off</b>
								<b>on</b>
0	0	0	0					<b>gain</b>
0	0	0	1					15dB
0	0	1	0					14dB
0	0	1	1					13dB
0	1	0	0					12dB
0	1	0	1					11dB
0	1	1	0					10dB
0	1	1	1					9dB
1	0	0	0					8dB
1	0	0	1					7dB
1	0	1	0					6dB
1	0	1	1					5dB
1	1	0	0					4dB
1	1	0	1					3dB
1	1	1	0					2dB
1	1	1	1					1dB
1	1	1	1					<b>0dB</b>

Input selector 1L, bits D<sub>2</sub> ..D<sub>0</sub> (subaddresses 0)

MSB							LSB	Function
D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>	
					0	0	0	source select
					0	0	1	CDL
					0	1	0	Phone/FDL
					0	1	1	Navigation/FDR
					1	0	0	Phone/Navigation mix
					1	0	1	CassL
					1	1	0	MPX-RDS
					1	1	1	<b>AM</b>
								AM-level

Input selector 1R, bits D<sub>2</sub> ..D<sub>0</sub> (subaddresses 1)

MSB							LSB	Function
D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>	
					0	0	0	<b>source select</b>
					0	0	1	CDR
					0	1	0	Phone/FDL
					0	1	1	Navigation/FDR
					1	0	0	Phone/Navigation mix
					1	0	1	CassR
					1	1	0	MPX-RDS
					1	1	1	<b>FM</b> (or MPX1/MPX2 in Dual MPX mode)
								AM-spikes

Input selector 2L, bits D<sub>2</sub> ..D<sub>0</sub> (subaddresses 2)

MSB							LSB	Function
D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>	
					0	0	0	<b>source select</b>
					0	0	1	CDL
					0	1	0	Phone/FDL
					0	1	1	Navigation/FDR
					1	0	0	Phone/Navigation mix
					1	0	1	CassL
					1	1	0	AM
					1	1	1	<b>FM-level</b>
								AM-level

Input selector 2R, bits D<sub>2</sub> ..D<sub>0</sub> (subaddresses 3)

MSB							LSB	Function
D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>	
					0	0	0	<b>source select</b>
					0	0	1	CDR
					0	1	0	Phone/FDL
					0	1	1	Navigation/FDR
					1	0	0	Phone/Navigation mix
					1	0	1	CassR
					1	1	0	MPX-RDS
					1	1	1	<b>FM</b> (or MPX1/MPX2 in Dual MPX mode)
								AM-spikes

## Bypass selector (subaddress 4)

MSB							LSB		Function
D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>		
					0	0	0	<b>mix level phone/navigation</b>	
					0	0	1	0/mute	
					0	1	0	-1.6dB/-15.5dB	
					0	1	1	-3.6/-9.6dB	
					1	0	0	-6/-6dB	
					1	0	1	-9.6/-3.6dB	
					1	0	1	-15.5/-1.6dB	
					1	1	0	mute/0dB	
					1	1	1	mute	
				1				<b>must be "1"</b>	
								<b>gain</b>	
0	0	0	0					15dB	
0	0	0	1					14dB	
0	0	1	0					13dB	
0	0	1	1					12dB	
0	1	0	0					11dB	
0	1	0	1					10dB	
0	1	0	0					9dB	
0	1	1	1					8dB	
1	0	0	0					7dB	
1	0	0	1					6dB	
1	0	1	0					5dB	
1	0	1	1					4dB	
1	1	0	0					3dB	
1	1	0	1					2dB	
1	1	0	0					1dB	
1	1	1	1					0dB	

## Mode select (subaddress 5)

MSB							LSB		Function
D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>		
							0	<b>output gain</b>	
							1	0dB	
								+6dB	
						0		<b>reference voltage setting for output</b>	
						1		internal reference (V <sub>33</sub> *1.25)	
								<b>external reference</b>	
					0			<b>internal divider for output reference voltage</b>	
					1			connected to VCC/2	
								<b>disconnected</b>	
				0				fastcharge (switches at CD input)	
				1				open	
								<b>closed</b>	
			1					<b>must be "1"</b>	
		0						RDS-mute (high impedance)	
		1						muted	
								<b>unmuted</b>	
	0							mute pin function I	
	1							"0" does not activate the output mute	
								<b>"1" activates the output mute</b>	
0								mute pin function II	
1								"0" activates the high impedance mute	
								<b>"1" does not activate the high impedance mute</b>	

## Configuration (subaddress 6)

MSB							LSB		Function
D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>		
						0 0 1 1	0 1 0 1	<b>AM-IF rectifier gain</b> +18dB +15.5dB <b>+12dB</b> +6dB	
				0 0 1 1	0 1 0 1			<b>AM-IF rectifier corner frequency</b> 14kHz 18.5kHz 28kHz <b>56kHz</b>	
			1					<b>must be "1"</b>	
		0 1						<b>Dual MPX mode</b> on (control through Tuner-voltage) <b>off</b>	
0 0 1 1	0 1 0 1							<b>forced Dual MPX control</b> MPX1 (allows automatic selection) MPX2 (overwrites automatic selection) MPX1+MPX2 (overwrites automatic selection) MPX1 (overwrites automatic selection)	

## Output selector (subaddress 7)

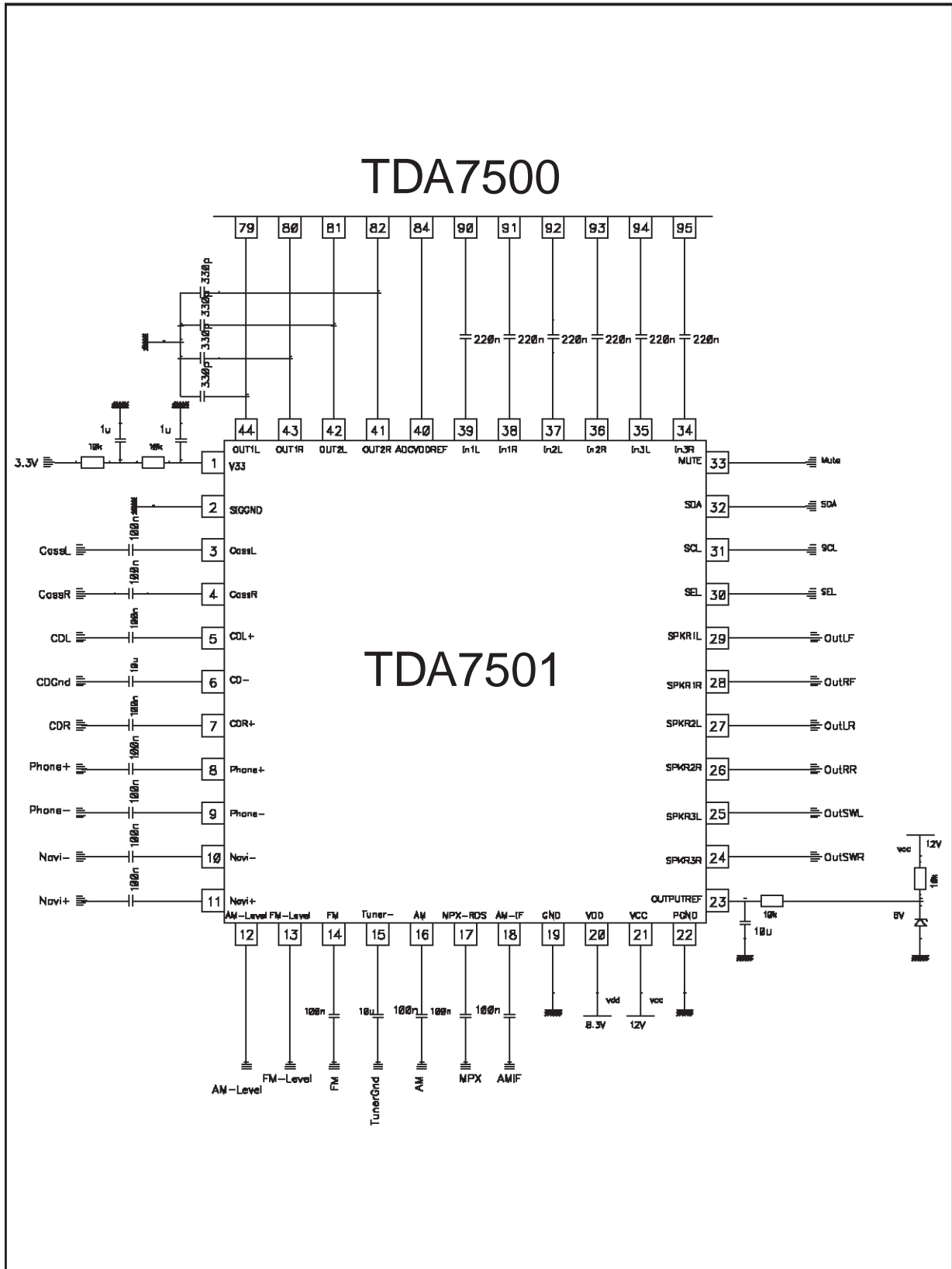
MSB							LSB		Function
D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>		
						0 0 1 1	0 1 0 1	<b>source select SPKR 1L</b> Bypass CDL <b>Phone/Navigation mix / IN1L</b> IN1L	
				0 0 1 1	0 1 0 1			<b>source select SPKR 1R</b> Bypass CDL Phone/Navigation mix / IN1R <b>IN1R</b>	
		0 0 1 1	0 1 0 1					<b>source select SPKR 2L</b> Bypass CDL mute <b>IN2L</b>	
0 0 1 1	0 1 0 1							<b>source select SPKR 2R</b> Bypass CDL mute <b>IN2R</b>	

## Volume speaker outputs (subaddresses 8...13)

MSB				LSB				Function
D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>	
1	0	0	0	1	1	1	1	+15dB
:	:	:	:	:	:	:	:	:
1	0	0	0	0	0	0	1	+1dB
1	0	0	0	0	0	0	0	0dB
0	0	0	0	0	0	0	0	0dB
0	0	0	0	0	0	0	1	-1dB
:	:	:	:	:	:	:	:	:
0	0	0	0	1	1	1	1	-15dB
0	0	0	1	0	0	0	0	-16dB
:	:	:	:	:	:	:	:	:
0	1	0	0	1	1	1	0	-78dB
0	1	0	0	1	1	1	1	-79dB
x	1	1	x	x	x	x	x	Mute

The unused subaddresses 14/15 must be programmed to "11111110" to allow software compatibility to future extensions.

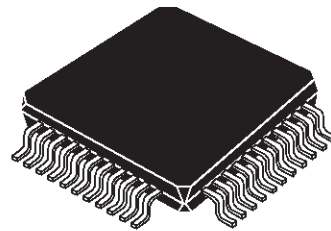
Figure 9. Application diagram.



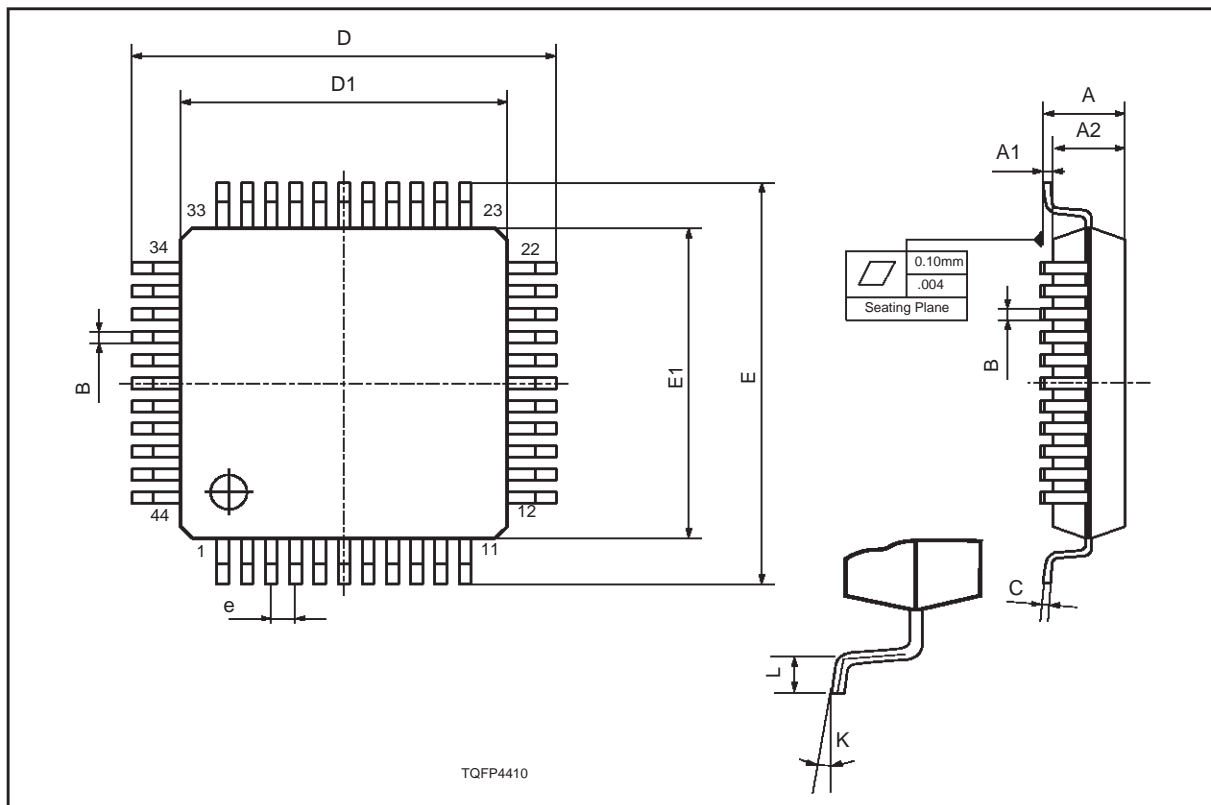


DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			1.60			0.063
A1	0.05		0.15	0.002		0.006
A2	1.35	1.40	1.45	0.053	0.055	0.057
B	0.30	0.37	0.45	0.012	0.014	0.018
C	0.09		0.20	0.004		0.008
D		12.00			0.472	
D1		10.00			0.394	
D3		8.00			0.315	
e		0.80			0.031	
E		12.00			0.472	
E1		10.00			0.394	
E3		8.00			0.315	
L	0.45	0.60	0.75	0.018	0.024	0.030
L1		1.00			0.039	
K	0°(min.), 3.5°(typ.), 7°(max.)					

**OUTLINE AND MECHANICAL DATA**



**TQFP44 (10 x 10)**



Information furnished is believed to be accurate and reliable. However, STMicroelectronics assumes no responsibility for the consequences of use of such information nor for any infringement of patents or other rights of third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of STMicroelectronics. Specification mentioned in this publication are subject to change without notice. This publication supersedes and replaces all information previously supplied. STMicroelectronics products are not authorized for use as critical components in life support devices or systems without express written approval of STMicroelectronics.

The ST logo is a registered trademark of STMicroelectronics

© 1999 STMicroelectronics – Printed in Italy – All Rights Reserved

STMicroelectronics GROUP OF COMPANIES

Australia - Brazil - Canada - China - France - Germany - Italy - Japan - Korea - Malaysia - Malta - Mexico - Morocco - The Netherlands - Singapore - Spain - Sweden - Switzerland - Taiwan - Thailand - United Kingdom - U.S.A.

<http://www.st.com>