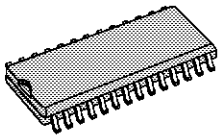
SGS-THOMSON MICROELECTRONICS

TDA7316

FOUR BANDS DIGITAL CONTROLLED GRAPHIC EQUALIZER

ADVANCE DATA

- VOLUME CONTROL IN 0.375dB STEP
- FOUR BANDS STEREO GRAPHIC EQUALIZER
- CENTER FREQUENCY, BANDWIDTH, MAX BOOST/CUT DEFINED BY EXTERNAL COMPONENTS
- ±14dB CUT/BOOST CONTROL IN 2dB/STEP
- ALL FUNCTIONS PROGRAMMABLE VIA SERIAL BUS
- VERY LOW DISTORTION
- VERY LOW NOISE AND DC STEPPING BY USE OF A MIXED BIPOLAR/CMOS TECHNOLOGY



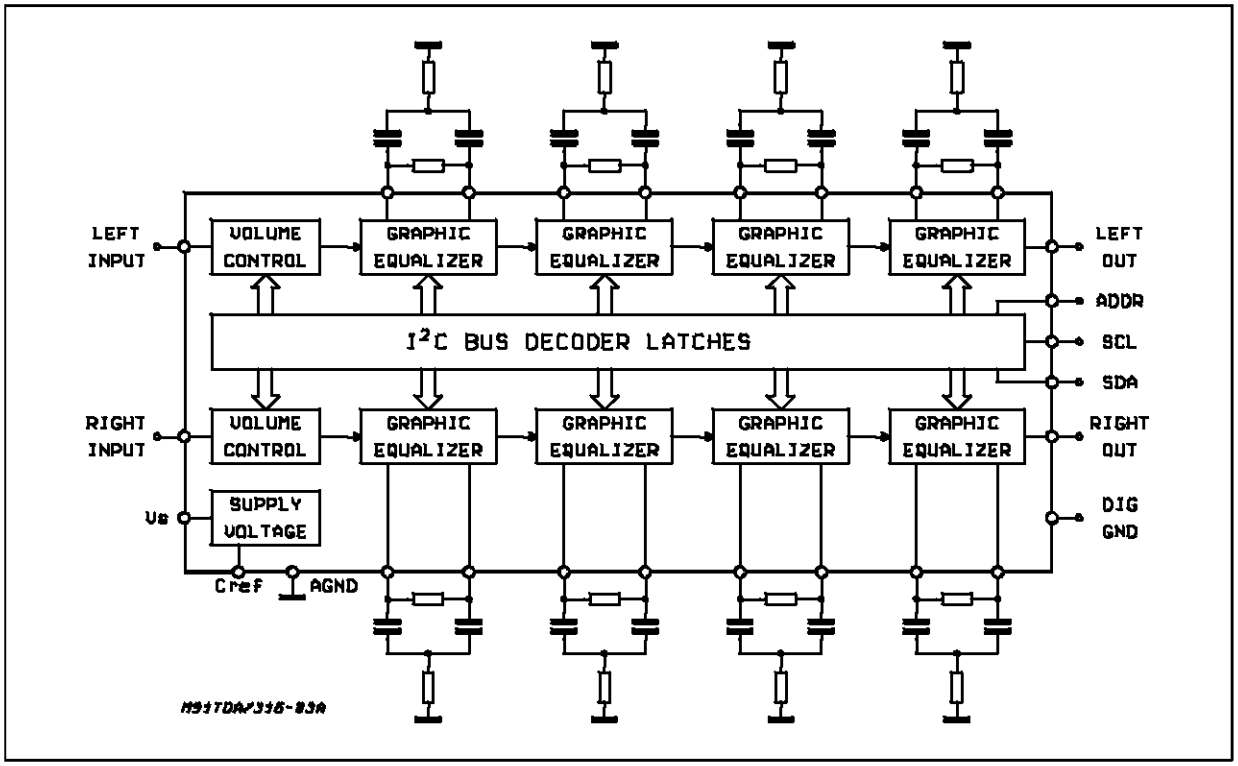
SO28

ORDERING NUMBER: TDA7316

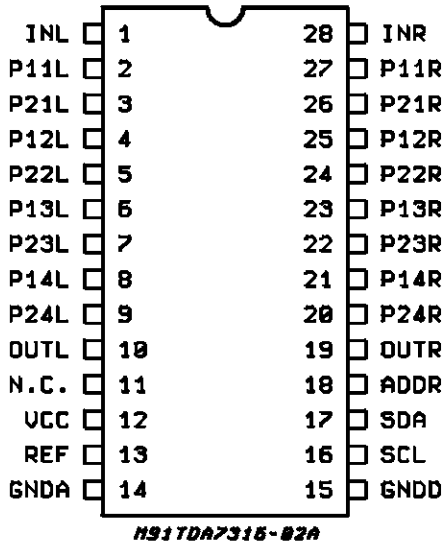
DESCRIPTION

The TDA7316 is a monolithic, digitally controlled graphic equalizer realized in BiCMOS mixed technology. The stereo signal, before any filtering, can be attenuated down to -17.625dB in 0.375dB step. All the functions can be programmed via serial bus making easy to build a µP controlled system. Signal path is designed for very low noise and distortion.

BLOCK DIAGRAM



PIN CONNECTION



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter		Value	Unit
V_S	Supply Voltage		10.2	V
T_{op}	Operating Temperature Range		-40 to +85	°C
T_{stg}	Storage Temperature Range		-55 to +150	°C
R_{tjvins}	Thermal Resistance Junction pins	max	85	°C/W

ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C, V_S = 9V, R_L = 10KΩ, R_g = 600Ω, f = 1KHz V_{IN} = 1Vrms, all controls in flat position (AV = 0dB) unless otherwise specified).

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
SUPPLY						
V_S	Supply Voltage		6	9	10	V
I_S	Supply Current		8	14	20	mA
SVR	Ripple Rejection		60	80		dB

ELECTRICAL CHARACTERISTICS (continued)

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
INPUT						
R_I	Input Resistance		20	30	40	KΩ
$V_{IN\ max}$	Max Input Signal	THD = 0.3%	2.0	2.5		V_{RMS}
IN_S	Input Separation (1)		80	100		dB
VOLUME CONTROL						
C_{RANGE}	Control Range			17.625		dB
A_{VMIN}	Min. Attenuation		-0.5	0	0.5	dB
A_{VMAX}	Max. Attenuation		16.7	17.625	18.6	dB
A_{STEP}	Step Resolution		0.175	0.375	0.575	dB
E_A	Attenuation Set Error		-1.0		1	dB
E_T	Tracking Error				0.5	dB
V_{DC}	DC Steps	adjacent attenuation steps		0	3.0	mV
GRAPHIC EQUALIZER						
THD	Distortion			0.01	0.1	%
C_s	Channel Separation		80	100		dB
e_{NO}	Output Noise	BW = 20Hz to 20KHz flat, AV = 0dB		8	20	μV
		A curve		6		μV
		BW = 20Hz to 20KHz AV = 0dB All bands = max. boost All bands = max. cut		 24 6		 μV μV
S/N	Signal to Noise Ratio	A_V = 0dB; V_{ref} = $1V_{RMS}$		100		dB
B_{step}	Step Resolution		1	2	3	dB
C_{RANGE}	Control Range	max boost/cut	±12	±14	±16	dB
VDC	DC Steps	Adiacent Control Steps		0.5	3	mV
AUDIO OUTPUTS						
V_O	Output Voltage		2	2.5		V_{RMS}
R_L	Output Load Resistance		2			KΩ
C_L	Output Load Capacitance				10	nF
R_O	Output Resistance		5	10	20	Ω
V_{OUT}	DC Voltage Level		4.2	4.5	4.8	V
BUS INPUTS						
V_{IL}	Input Low Voltage				1	V
V_{IH}	Input High Voltage		3			V
I_{IN}	Input Current		-5		+5	μA
V_O	Output Voltage SDA Acknowledge	I_O = 1.6mA			0.4	V
ADDRESS PIN (Internal 50KΩ pull down resistor)						
V_{IL}	Input Low Voltage				1	V
V_{IH}	Input High Voltage		V_{CC} -1V			V

NOTE1: The selected input is grounded thre the 2.2μF capacitor

DEVICE DESCRIPTION

The TDA7316 is a four bands, digitally controlled stereo Graphic Equalizer.
The device is intended for high quality audio application in Hi-Fi, TV and car radio systems where feature like low noise and THD are key factors. A mixed Bipolar Cmos Technology allows:
Cmos analog switches for pop free commutations, high frequency op.amp. (GWB = 10MHz) and high linearity polisilicon resistor for THD = 0.01 (at Vin = 1Vrms) and a S/N ratio of 102dB.
The internal Block Diagram is shown on page 1.

The first stage is a volume control. The control range is 0 to -17.625dB with 0.375dBstep.
The very high resolution (0.375dB step) allows the implementation of closed loop amplitude control system completely free from any acustical effect (stepping variation and pumping effect).

The volume control is followed by a serial four bands equalizer. Each filtering cell is the biquad cell shown in fig. 1

The internal resistor string is fixing the boost/cut value while the buffer makes the Q (quality factor) and central frequency, set by external components, fully indipendent from the internal resistors. Each filtering cell is realized using only 4 external components (2 capacitors and 2 resistors) allowing a flexible selection of centre frequency fo, Q factor and gain. Here below the basic formulae and the key features of each band pass filter are reported:

f_o = center frequency

Gv = gain/loss at the center frequency f_o
Gv = 20log(Av)

$$Q = \frac{f_o}{f_2 - f_1}$$

where f_2, f_1 = 3dB Bandwidth limits.

$$A_v = \frac{(R2 \cdot C2) + (R2 \cdot C1) + (R1 \cdot C1)}{(R2 \cdot C1) + (R2 \cdot C2)}$$

$$Q = \frac{\sqrt{(R1 \cdot C1 \cdot R2 \cdot C2)}}{(R2 \cdot C1) + (R2 \cdot C2)}$$

$$f_o = \frac{1}{2\pi \cdot \sqrt{(R1 \cdot R2 \cdot C1 \cdot C2)}}$$

If C1 is fixed, then:

$$C2 = \frac{Q^2}{A_v - 1 - Q^2} \cdot C1$$

$$R2 = \frac{1}{2\pi \cdot C1 \cdot f_o \cdot \frac{(A_v - 1) \cdot Q}{(A_v - 1 - Q^2)}}$$

$$R1 = \frac{(A_v - 1)^2}{A_v - 1 - Q^2} \cdot R2$$

Likewise, the components values can be determined byfixing one of the other three parameters. Referring to fig. 1 the suggested R2 value should be higher than 2KΩ in order to have a good THD (internal op. amp. current limit).
Viceversa the R1 value should be equal or lower than 51KΩ in order to keep the "click"(DC step) very low.

A typical application is shown by fig. 2

Fig. 1

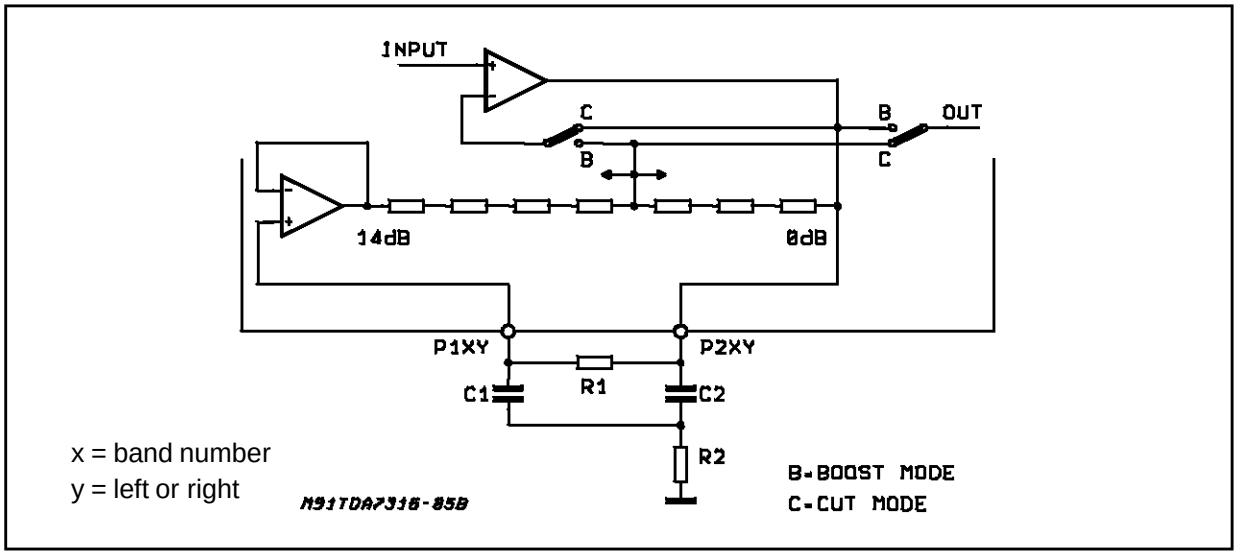
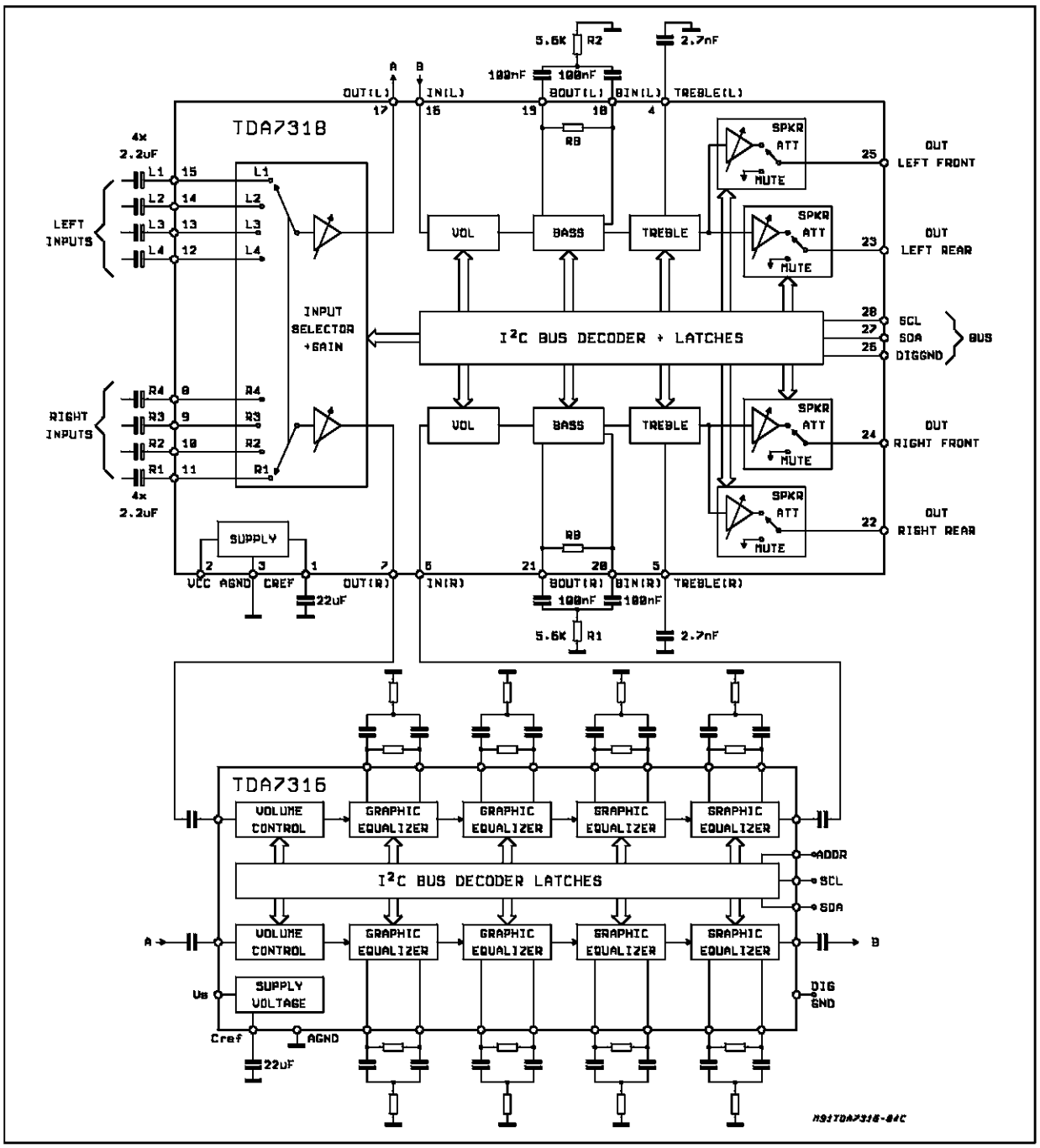


Figure 2: Application Circuit



A five bands graphic equalizer is implemented using the 4 bands of the TDA7316 plus a fifth band obtained from the bass control circuit of the TDA7318 (or another audioprocessor of the SGS-THOMSON 731X family). Applications requiring higher number of external equalizer bands could be implemented by cascading 2 or more TDA7316 devices. In fact the dedicated ADDR pin allows 2 addresses selection. Anyway, the address of the graphic equalizer is different from the audioprocessor one.

For example, 9 bands are implemented by using of 2 TDA7316 plus an audioprocessor (TDA731X family).

In case one filtering cell is not needed, a short circuit must be provided between the P1xy and P2xy pins.

I²C BUS INTERFACE

Data transmission from microprocessor to the TDA7316 and viceversa takes place thru the 2 wires I²C BUS interface, consisting of the two lines SDA and SCL (pull-up resistors to positive supply voltage must be externally connected).

Data Validity

As shown in fig. 3, the data on the SDA line must be stable during the high period of the clock. The HIGH and LOW state of the data line can only change when the clock signal on the SCL line is LOW.

Start and Stop Conditions

As shown in fig.4 a start condition is a HIGH to LOW transition of the SDA line while SCL is HIGH. The stop condition is a LOW to HIGH transition of the SDA line while SCL is HIGH.

Byte Format

Every byte transferred to the SDA line must contain 8 bits. Each byte must be followed by an acknowledge bit. The MSB is transferred first.

Acknowledge

The master (µP) puts a resistive HIGH level on the SDA line during the acknowledge clock pulse (see fig. 5). The peripheral (audioprocessor) that acknowledges has to pull-down (LOW) the SDA line during the acknowledge clock pulse, so that the SDA line is stable LOW during this clock pulse.

The audioprocessor which has been addressed has to generate an acknowledge after the reception of each byte, otherwise the SDA line remains at the HIGH level during the ninth clock pulse time. In this case the master transmitter can generate the STOP information in order to abort the transfer.

Transmission without Acknowledge

Avoiding to detect the acknowledge of the audioprocessor, the µP can use a simplier transmission: simply it generates the 9th clock pulse without checking the slave acknowledging, and then sends the new data.

This approach of course is less protected from misworking and decreases the noise immunity.

Figure 3: Data Validity on the I²CBUS

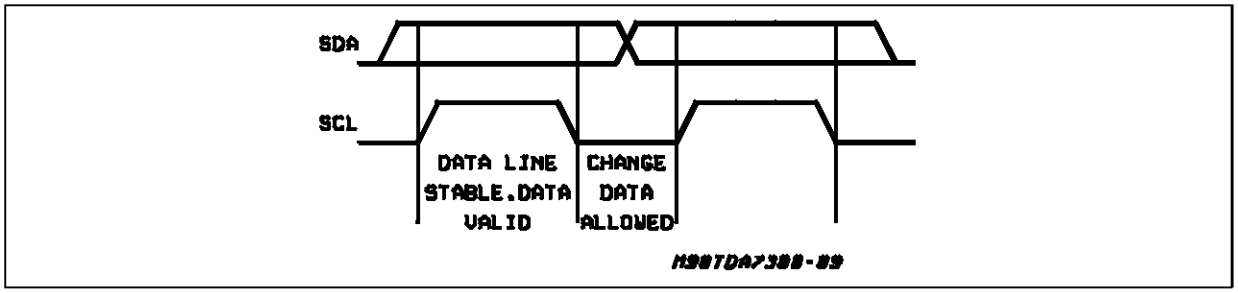


Figure 4: Timing Diagram of I²CBUS

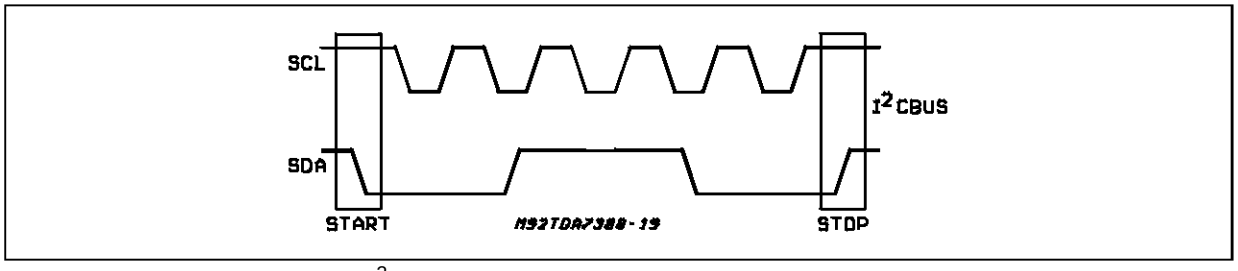
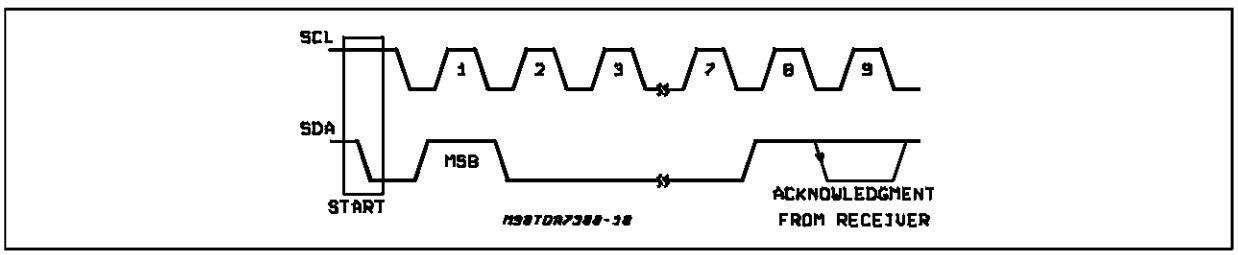


Figure 5: Acknowledge on the I²CBUS

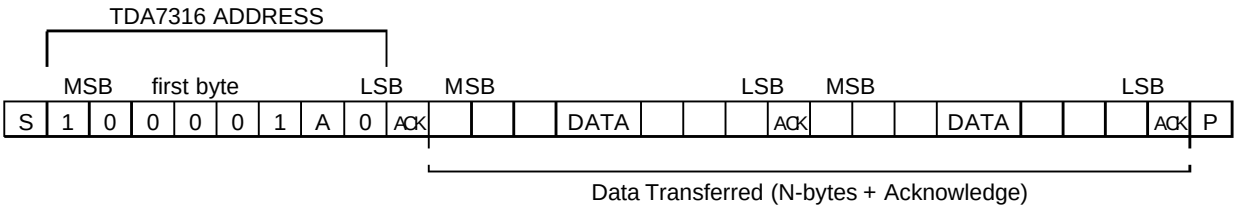


SOFTWARE SPECIFICATION

Interface Protocol

The interface protocol comprises:

- A start condition (s)
- A chip address byte, containing the TDA7316 address (the 8th bit of the byte must be 0). The TDA7316 must always acknowledge at the end of each transmitted byte.
- A sequence of data (N-bytes + acknowledge)
- A stop condition (P)



ACK = Acknowledge
S = Start
P = Stop

MAX CLOCK SPEED 100kbits/s

SOFTWARE SPECIFICATION

Chip address (84 or 86 Hex)

1 MSB	0	0	0	0	1	A	0 LSB

A = Logic level on pin ADDR

A = 1 if ADDR pin = open

A = 0 if ADDR pin = connected to ground

SOFTWARE SPECIFICATION (continued)

DATA BYTES (detailed description)

Volume

MSB							LSB	FUNCTION
0	X	B2	B1	B0	A2	A1	A0	Volume 0.375dB steps
					0	0	0	0
					0	0	1	-0.375
					0	1	0	-0.75
					0	1	1	-1.125
					1	0	0	-1.5
					1	0	1	-1.875
					1	1	0	-2.25
					1	1	1	-2.625
0	X	B2	B1	B0	A2	A1	A0	Volume -3dB steps
		0	0	0				0
		0	0	1				-3
		0	1	0				-6
		0	1	1				-9
		1	0	0				-12
		1	0	1				-15

Graphic Equalizer

MSB							LSB	FUNCTION
1	D3	D2	D1	D0	S2	C1	C0	
	0	0	1					Band 1
	0	1	0					Band 2
	0	1	1					Band 3
	1	0	0					Band 4
	D3	D2	D1	1	C2	C1	C0	cut
	D3	D2	D1	0	C2	C1	C0	Boost
					0	0	0	0dB
					0	0	1	2dB
					0	1	0	4dB
					0	1	1	6dB
					1	0	0	8dB
					1	0	1	10dB
					1	1	0	12dB
					1	1	1	14dB

AX = 0.375dB steps, BX = 3dB steps, CX = 2dB steps, X = dont'care

STATUS AFTER POWER-ON RESET	
Volume	-17.25dB
Graphic equalizer bands	-12dB

SO28 PACKAGE MECHANICAL DATA

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			2.65			0.104
a1	0.1		0.3	0.004		0.012
b	0.35		0.49	0.014		0.019
b1	0.23		0.32	0.009		0.013
C		0.5			0.020	
c1	45° (typ.)					
D	17.7		18.1	0.697		0.713
E	10		10.65	0.394		0.419
e		1.27			0.050	
e3		16.51			0.65	
F	7.4		7.6	0.291		0.299
L	0.4		1.27	0.016		0.050
S	8° (max.)