16bits Stereo Audio DAC Integrated Headphone Driver with Volume Control

FEATURES

- Operation range: 2.7V~6.5V
- Volume control range : 6dB to –39dB, 1.5dB/step
- Low power consumption, 17mW at V_{DD}=3.3V (Audio code = 0000H)
- Mute function
- Flexibility power management
- No pop-noise
- No zero crossing distortion
- Audio format : Right justified, I^2S
- Serial control interface : I^2C, SPI
- Output voltage adjusted by the external resisters
- Excellent Power Supply Rejection Ratio(PSRR)
- Component less
- Cost effective
- Housed in SSOP20(MS6334), SSOP16, QFN16 package

APPLICATIONS

Multimedia system, MP3, PDA, Portable Digital Audio.

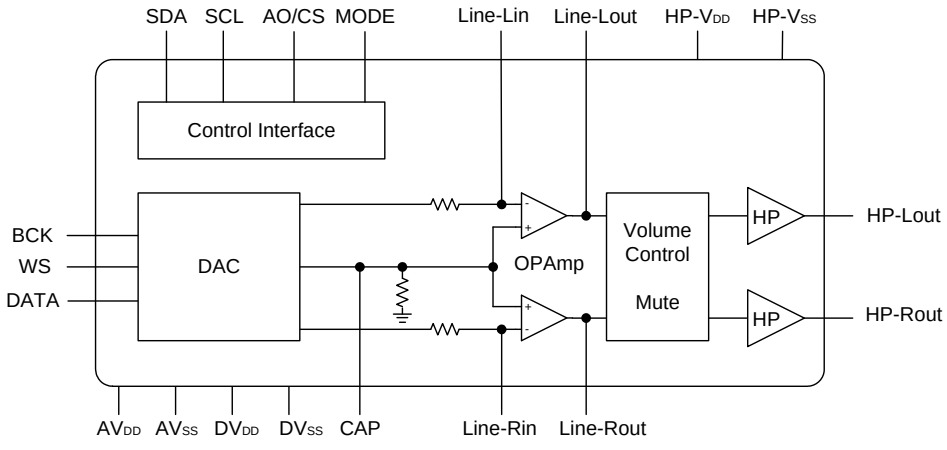
DESCRIPTION

The MS6334 is a 16-bits voltage-output Digital-to-Analog Converter (DAC) integrated class AB stereo headphone driver with volume control. It is fabricated in a CMOS process and features extremely low power dissipation, small package size and easy application. The accuracy of the matched coarse current sources, combined with the unique symmetrical decoding method, preclude zero-crossing distortion and ensures high quality audio reproduction.

The MS6334 has good feature for portable equipment, these features include the low voltage operation, low power consumption, flexible power management, component less and small package SSOP20, make the MS6334 ideally suited for use in portable digital audio equipments.

The MS6335 only has I^2C interface, the smaller package SSOP16, QFN16 , and other functions are the same as the MS6334.

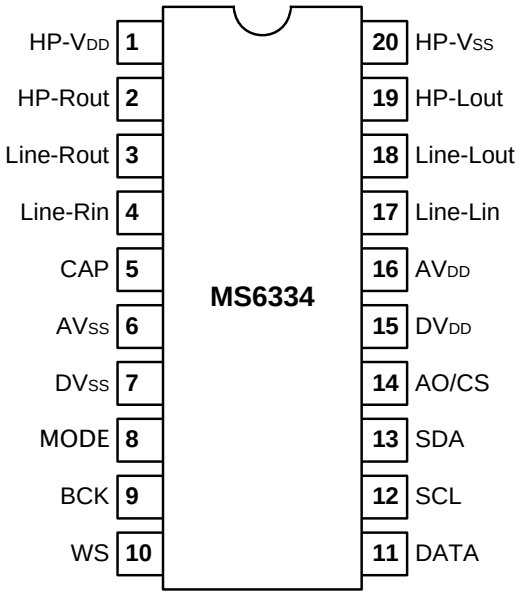
BLOCK DIAGRAM



PIN CONFIGURATION

MS6334

Symbol	Pin	Description
HP-V_{DD}	1	Headphone supply voltage
HP-Rout	2	Right channel headphone output
Line-Rout	3	Right channel line output
Line-Rin	4	Right channel line input
CAP	5	Capacitor connected
AV_{SS}	6	Analog ground
DV_{SS}	7	Digital ground
MODE	8	Control interface selection Low : I^2C, High : SPI
BCK	9	Audio bit clock input
WS	10	Audio word select input
DATA	11	Audio data input
SCL	12	I^2C clock input SPI clock input
SDA	13	I^2C data input SPI data input
AO/CS	14	I^2C address option SPI chip select
DV_{DD}	15	Digital supply voltage
AV_{DD}	16	Analog supply voltage
Line-Lin	17	Left channel line input
Line-Lout	18	Left channel line output
HP-Lout	19	Left channel headphone output
HP-V_{SS}	20	Headphone ground

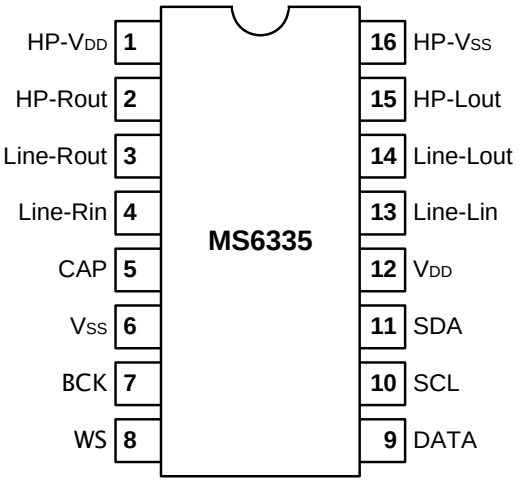


SSOP20, I^2C / SPI interface

Note: 1. MODE = low, the interface is I^2C and pin14 is address option (AO).
AO = low, the address code is 8CH (10001100B).
AO = high, the address code is 88H (10001000B).
2. MODE = high, the interface is SPI and pin14 is chip selection (CS).

MS6335

Symbol	Pin	Description
HP-V_{DD}	1	Headphone supply voltage
HP-Rout	2	Right channel headphone output
Line-Rout	3	Right channel line output
Line-Rin	4	Right channel line input
CAP	5	Capacitor connected
V_{SS}	6	Ground
BCK	7	Audio bit clock input
WS	8	Audio word select input
DATA	9	Audio data input
SCL	10	I^2C clock input
SDA	11	I^2C data input
V_{DD}	12	Supply voltage
Line-Lin	13	Left channel line input
Line-Lout	14	Left channel line output
HP-Lout	15	Left channel headphone output
HP-V_{SS}	16	Headphone ground

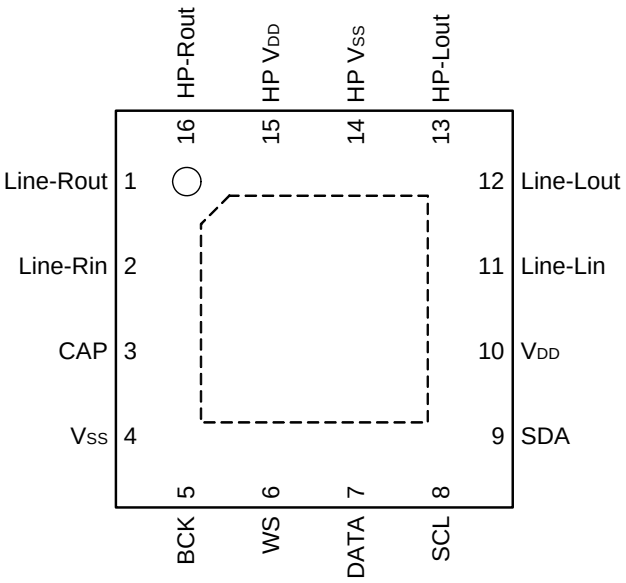


SSOP16, I^2C interface

Note: The control interface is I^2C only. The address code is 8CH (10001100B).

MS6335

Symbol	Pin	Description
Line-Rout	1	Right channel line output
Line-Rin	2	Right channel line input
CAP	3	Capacitor connected
V_{SS}	4	Ground
BCK	5	Audio bit clock input
WS	6	Audio word select input
DATA	7	Audio data input
SCL	8	I^2C clock input
SDA	9	I^2C data input
V_{DD}	10	Supply voltage
Line-Lin	11	Left channel line input
Line-Lout	12	Left channel line output
HP-Lout	13	Left channel headphone output
HP-V_{SS}	14	Headphone ground
HP-V_{DD}	15	Headphone supply voltage
HP-Rout	16	Right channel headphone output



QFN16, I^2C interface

Note: The control interface is I^2C only. The address code is 88H (10001000B).

ORDERING INFORMATION

Package	Part number	Packaging Marking	Transport Media
20-Pin SSOP (lead free)	MS6334GTR	MS6334G	2.5k Units Tape and Reel
20-Pin SSOP (lead free)	MS6334GU	MS6334G	50 Units Tube
16-Pin SSOP (lead free)	MS6335GTR	MS6335G	2.5k Units Tape and Reel
16-Pin SSOP (lead free)	MS6335GU	MS6335G	100 Units Tube
16-Pin QFN (lead free)	MS6335QTR	6335	5k Units Tape and Reel
16-Pin QFN (lead free)	MS6335Q	6335	490 Units Tray

RoHS Compliance

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Rating	Unit
V_{DD}	Positive Supply Voltage	6.5	V
V_{ESD}	Electrostatic Handling	-3000 to 3000	V
T_{STG}	Storage Temperature Range	-65 to 150	℃
T_A	Operating Ambient Temperature Range	-40 to 85	℃
T_J	Maximum Junction Temperature	150	℃
T_S	Soldering Temperature, 10 seconds	260	℃
R_{THJA}	Thermal Resistance from Junction to Ambient in Free Air SSOP20 SSOP16 QFN16	 210 210 120	℃/W

OPERATING RATINGS

Symbol	Parameter	Min	Typ	Max	Unit
V_{DD}	Supply Voltage	2.7	-	6.5	V

3.3V ELECTRICAL CHARACTERISTICS

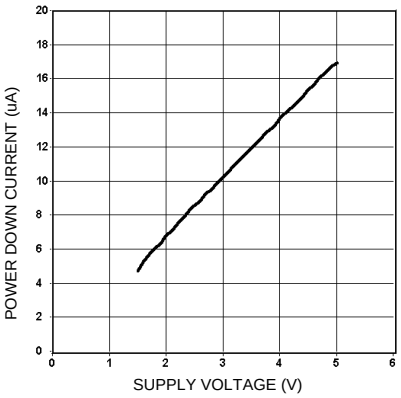
(Ta=25℃, V_{DD}=3.3V, V_{SS}=0V, f=1kHz, R_L=32Ω; unless otherwise specified)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
DC Characteristics						
V_{CAP}	Voltage at CAP		1.60	1.65	1.70	V
V_{DC}	Output DC level		1.60	1.65	1.70	V
V_{FS}	Full scale output voltage	V_{FS}=0.02* R_F *V_{DD}	V_{FS}-10%	V_{FS}	V_{FS}+10%	V
I_Q	Quiescent current	Audio code 0000H	-	5.4	-	mA
I_{PD}	Power down current		-	11	-	uA
PSRR	Power supply rejection ratio	CAP=2.2uF (100Hz)	58	63		dB
		CAP=10uF (100Hz)	67	72		dB
CS	Channel separation		76	82	-	dB
ATT	Mute attenuation		100	110	-	dB
A_{GA}	Gain/Attenuation	Max gain	-	6	-	dB
		Max attenuation	-	-39	-	dB
A_{STEP}	Gain/Attenuation step		-	1.5	-	dB
E_{GA}	Gain/Attenuation step error		-	0.3	-	dB
AC Characteristics						
Res	Resolution		-	-	16	bits
THD+N	Total harmonic distortion plus noise		-	-65	-60	dB
			-	0.056	0.1	%
S/N	Signal-to-noise ratio		86	92	-	dB
Po	Maximum output power	(THD+N)/S < 0.1%	-	20	-	mW
Vo	Maximum output voltage swing	(THD+N)/S < 0.1%	-	1.6	-	Vpp
Bus Characteristics						
V_{IH}	Bus high input level		-	-	0.7V_{DD}	V
V_{IL}	Bus low input level		0.3V_{DD}	-	-	V

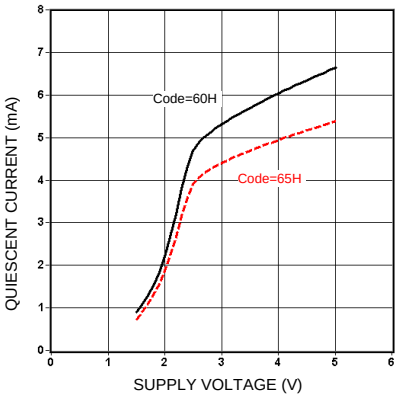
Note : R_F : Feedback resistor

TYPICAL PERFORMANCE CHARACTERISTICS

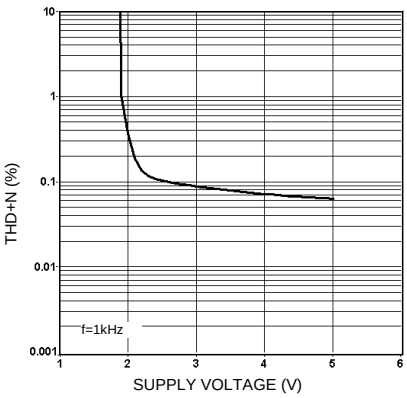
(Ta=25℃, R_L=32Ω, R_F=22k, sampling rate=4fs; unless otherwise specified)



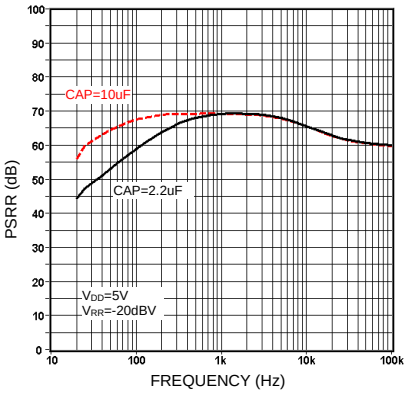
Power down current vs. supply voltage



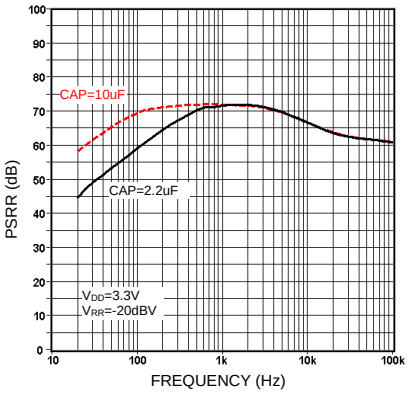
Quiescent current vs. supply voltage



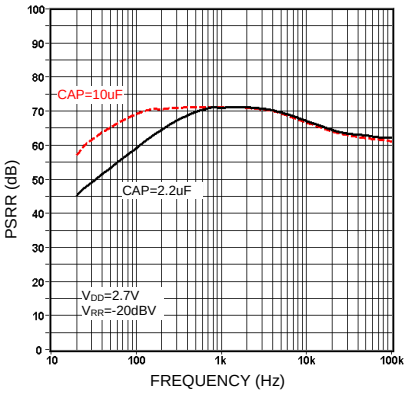
THD+N vs. supply voltage



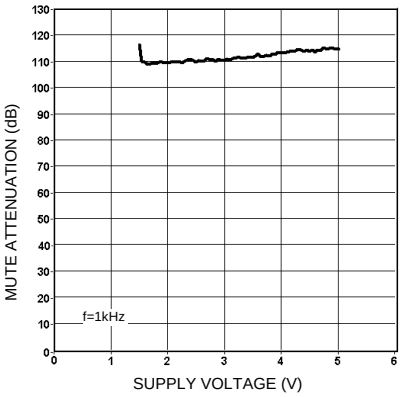
PSRR vs. frequency



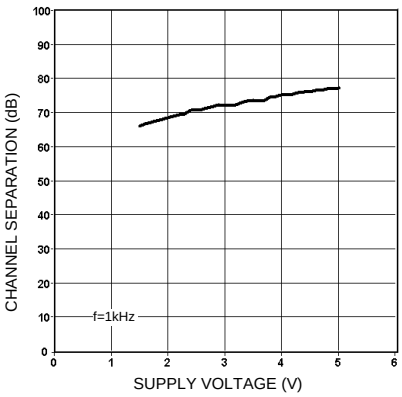
PSRR vs. frequency



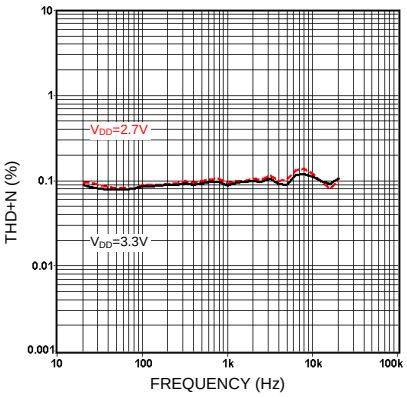
PSRR vs. frequency



Mute attenuation vs. supply voltage



Channel separation vs. supply voltage



THD+N vs. frequency

AUDIO TIMING AND FORMAT

The MS6334 accepts input serial data formats of 16-bit word length. Left and right data words are time multiplexed. The MSB must always be first.

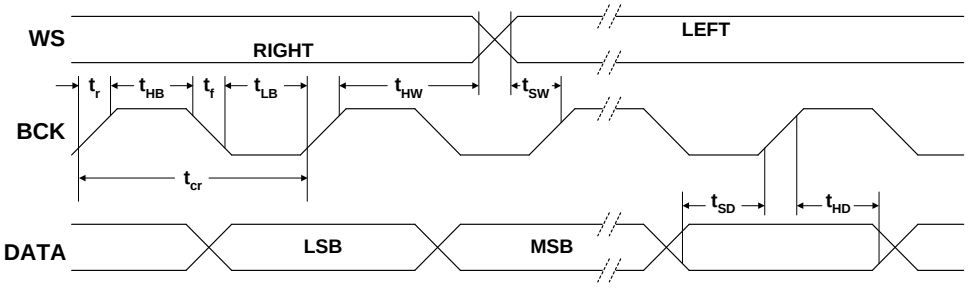


Fig.1 Timing of input signals

Audio data format (BCK, WS, DATA)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{IL}	Input LOW level		-	-	0.3V_{DD}	V
V_{IH}	Input HIGH level		0.7V_{DD}	-	-	V
f_{BCK}	Input Clock Frequency		-	-	18.4	MHz
BR	Bit Rate Data Input		-	-	18.4	Mbits/s
f_{WS}	Word Select Input		-	-	384	kHz
t_r	Rise Time		-	-	12	ns
t_f	Fall Time		-	-	12	ns
t_{CY}	Bit Clock Cycle Time		54	-	-	ns
t_{HB}	Bit Clock High Time		15	-	-	ns
t_{LB}	Bit Clock Low Time		15	-	-	ns
t_{SD}	Data Set-up Time		12	-	-	ns
t_{HD}	Data Hold Time to Bit Clock		2	-	-	ns
t_{HW}	Word Select Hold Time		2	-	-	ns
t_{SW}	Word Select Set-up Time		12	-	-	ns

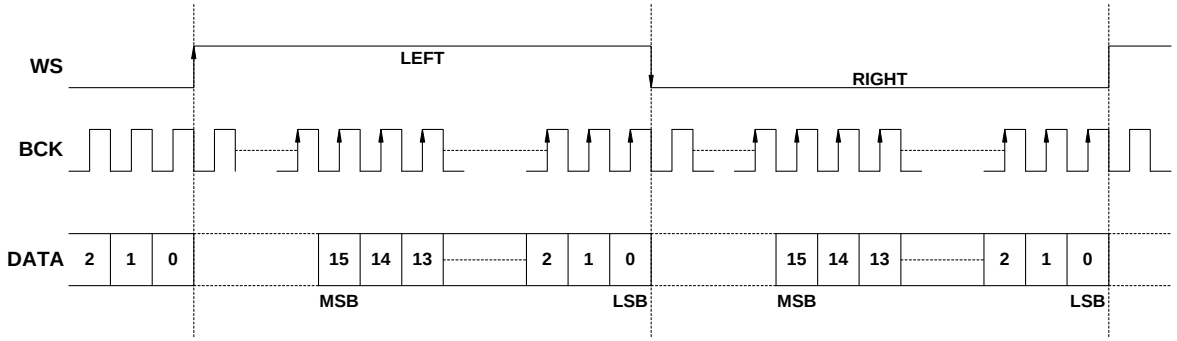


Fig.2 Right justified format (Normal format)

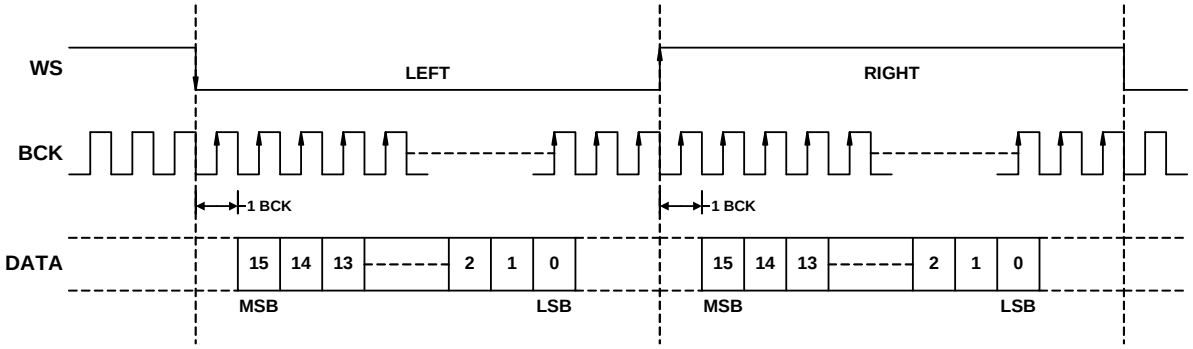


Fig.3 I²S format

I²C BUS INTERFACE

I²C interface protocol

The format consists of the following

- A START condition
- A chip address byte including the chip address. (7bits)
- The 8th bit of the byte must be "0".(write=0, read=1)
- The chip must always acknowledge the end of each transmitted byte.
- A data sequence (N-bytes + Acknowledge)
- A STOP condition

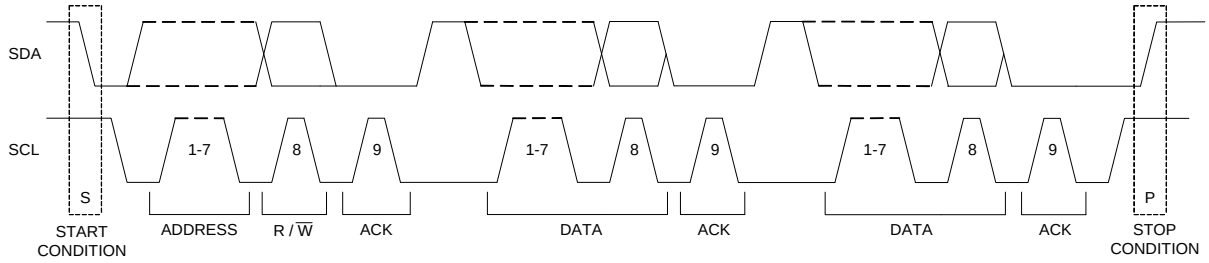
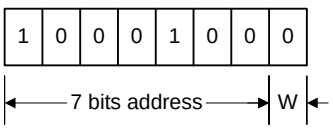


Fig.4 I²C format

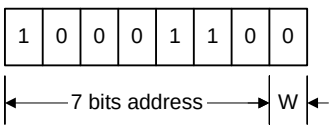
I²C chip address

88H



For MS6334, MODE=Low, AO/CS=High,
For MS6335 QFN16 package only

8CH



For MS6334, MODE=Low, AO/CS=Low
For MS6335 SSOP16 package only

I²C data bytes description

Volume control								
MSB							**LSB**	**Function**
0	0	0	**b4**	**b3**	**b2**	**b1**	**b0**	2-channel, 1.5dB/step
0	0	1						Left channel, 1.5dB/step
0	1	0						Right channel, 1.5dB/step

Gain / Attenuation bits												
b4	**b3**	**b2**	**b1**	**b0**	**Value (dB)**							**Value (dB)**
0	0	0	0	0	Mute	1	0	0	0	0		-16.5
0	0	0	0	1	-39	1	0	0	0	1		-15
0	0	0	1	0	-37.5	1	0	0	1	0		-13.5
0	0	0	1	1	-36	1	0	0	1	1		-12
0	0	1	0	0	-34.5	1	0	1	0	0		-10.5
0	0	1	0	1	-33	1	0	1	0	1		-9
0	0	1	1	0	-31.5	1	0	1	1	0		-7.5
0	0	1	1	1	-30	1	0	1	1	1		-6
0	1	0	0	0	-28.5	1	1	0	0	0		-4.5
0	1	0	0	1	-27	1	1	0	0	1		-3
0	1	0	1	0	-25.5	1	1	0	1	0		-1.5
0	1	0	1	1	-24	1	1	0	1	1		0
0	1	1	0	0	-22.5	1	1	1	0	0		+1.5
0	1	1	0	1	-21	1	1	1	0	1		+3
0	1	1	1	0	-19.5	1	1	1	1	0		+4.5
0	1	1	1	1	-18	1	1	1	1	1		+6

Initial state: Mute

Power down mode								
MSB							**LSB**	**Function**
0	1	1	**b4**	**b3**	**b2**	**b1**	**b0**	Power down mode selection

Power down bits
b4=1, Pull down CAP pin to ground (CAPGD) b4=0, Set the voltage of CAP to middle of supply voltage (CAPGD)
b3=1, Enable OPAmp power down (OPAPD) b3=0, Disable OPAmp power down (OPAPD)
b2=1, Enable DAC power down (DACPD) b2=0, Disable DAC power down (DACPD)
b1=1, Enable headphone power down (HPPD) b1=0, Disable headphone power down (HPPD)
b0=1, Enable DAC mute (DACM) b0=0, Disable DAC mute (DACM)

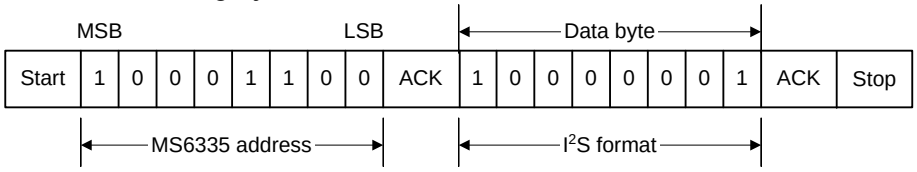
Initial state: b0=b1=b2=b3=b4=1

Audio format and power off								
MSB							**LSB**	**Function**
1	0	0	0	0	0	**b1**	**b0**	Audio format selection and preparation for power off
Audio format and power off bits								
b1=1, Enable preparation for power off b1=0, Disable preparation for power off								
b0=1, I^2S format b0=0, Right justified format (normal format)								

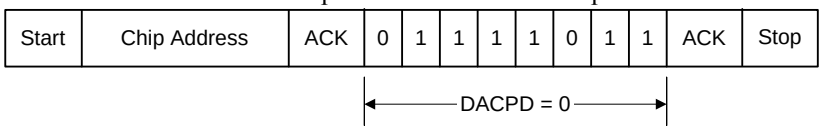
Initial state: b0=b1=0. Power off : V_{DD} down to 0V

I^2C example

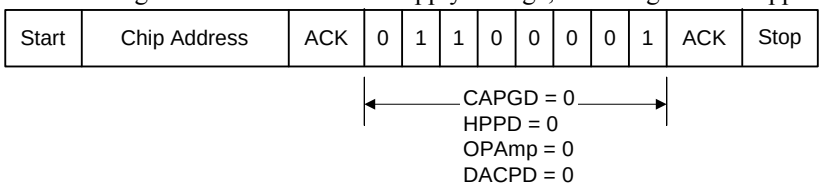
The audio format is selected I^2S format. Audio format code = 81H.
The initial state is right justified format.



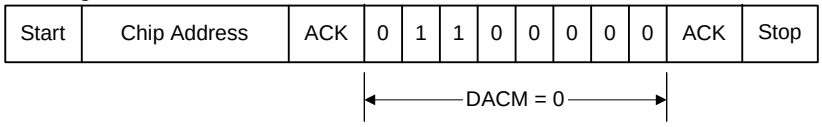
DAC active. Code = 7BH.
The initial state is enabled all power down mode when power on.



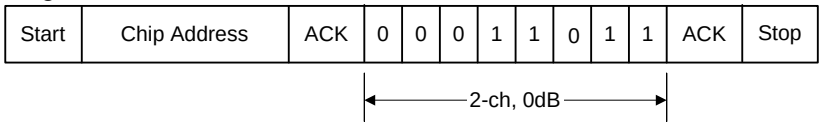
HP active, OPAmp active, CAP to 1/2 V_{DD}, DAC keep active. Code = 61H.
Set the voltage of CAP to middle of supply voltage, the charge time is approximately 1 second.



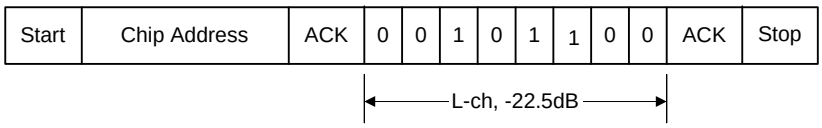
DAC mute off. Code = 60H.
The chip entered active mode.



Set gain of 2 channel at 0dB. Volume control code = 1BH.



Set attenuation of left channel at –22.5dB. Volume control code = 2CH.



Set attenuation of right channel at –22.5dB. Volume control code = 4CH.

Start	Chip Address	ACK	0	1	0	0	1	1	0	0	ACK	Stop

R-ch, -22.5dB

Preparation for power off. Code = 82H or 83H.

Start	Chip Address	ACK	1	0	0	0	0	0	1	x	ACK	Stop

Power Off Preparation = 1

FM application. OPAmp active, HP active. DAC inactive, DAC mute off. Code = 65H.
The chip enters line-in mode.

Start	Chip Address	ACK	0	1	1	0	0	1	0	1	ACK	Stop

HPPD = 0
OPAmp = 0

Power down mode (shut down mode). Code = 6FH
The chip enters power down mode. The shut down current is approximately 11uA.

Start	Chip Address	ACK	0	1	1	0	1	1	1	1	ACK	Stop

DACM = 1
DACPD = 1
HPPD =1
OPAmp =1

SPI BUS INTERFACE

In SPI mode, SCL is serial clock, SDA is serial data and AO/CS latches the data word into the MS6334. A control word consist of 16bit, starting with the MSB. The data bits are latched on the rising edge of SCL. A rising edge of AO/CS latches the data into the MS6334 after sixteenth rising clock edge.

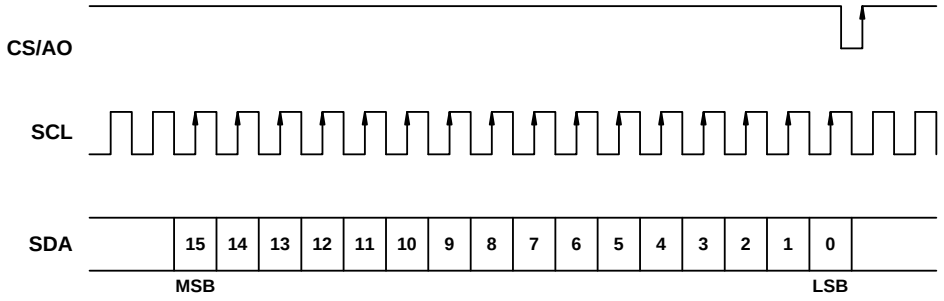


Fig.5 SPI format

SPI data word description

MSB															LSB
b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
0	0	0	0	0	0	0	0	Reference to I^2C data bytes description The initial state is the same as I^2C							

OPERATION PROCEDURE

The sequence of operation: power on→ active → power down → active → power off. The basic flowcharts are as follows:

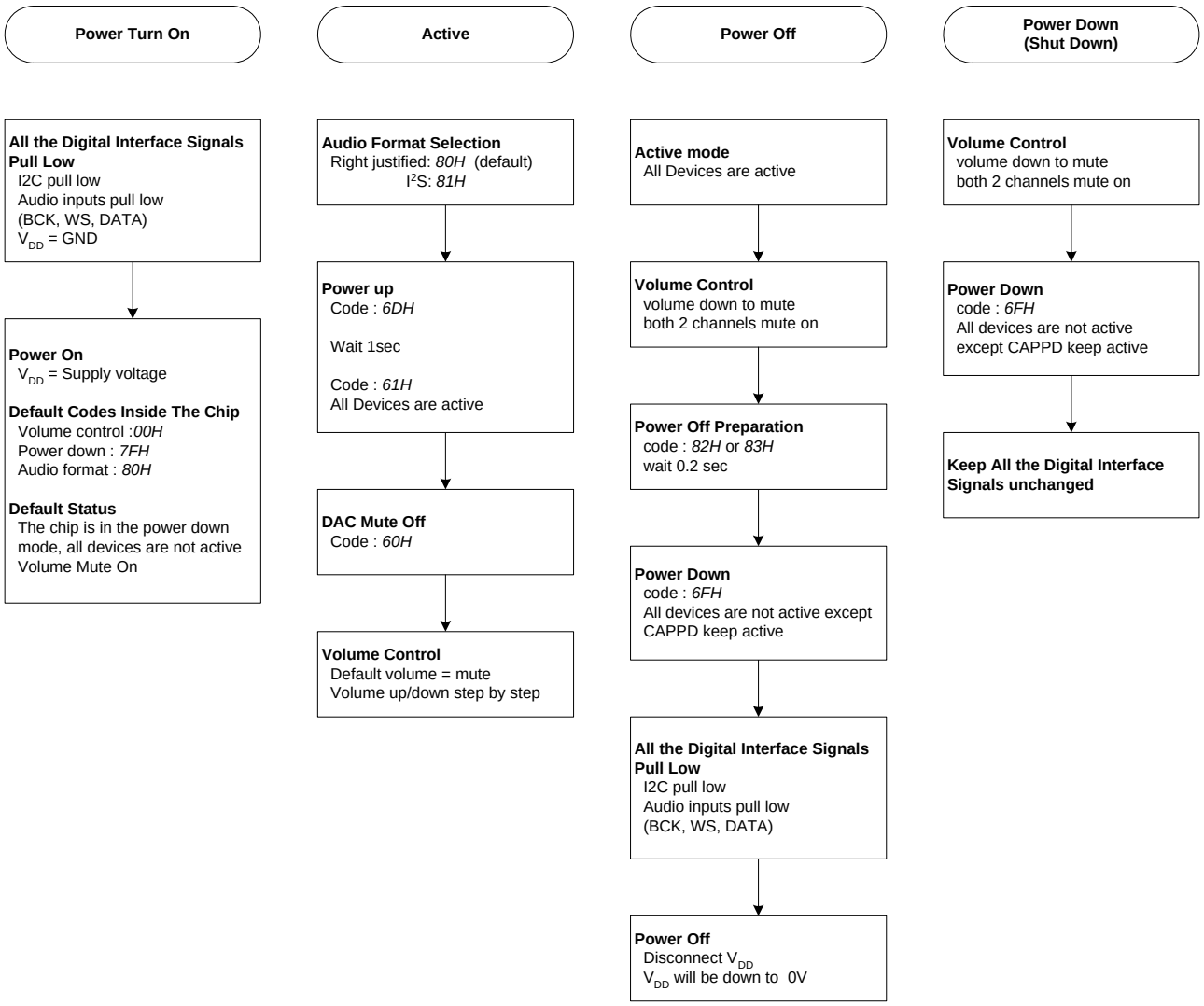
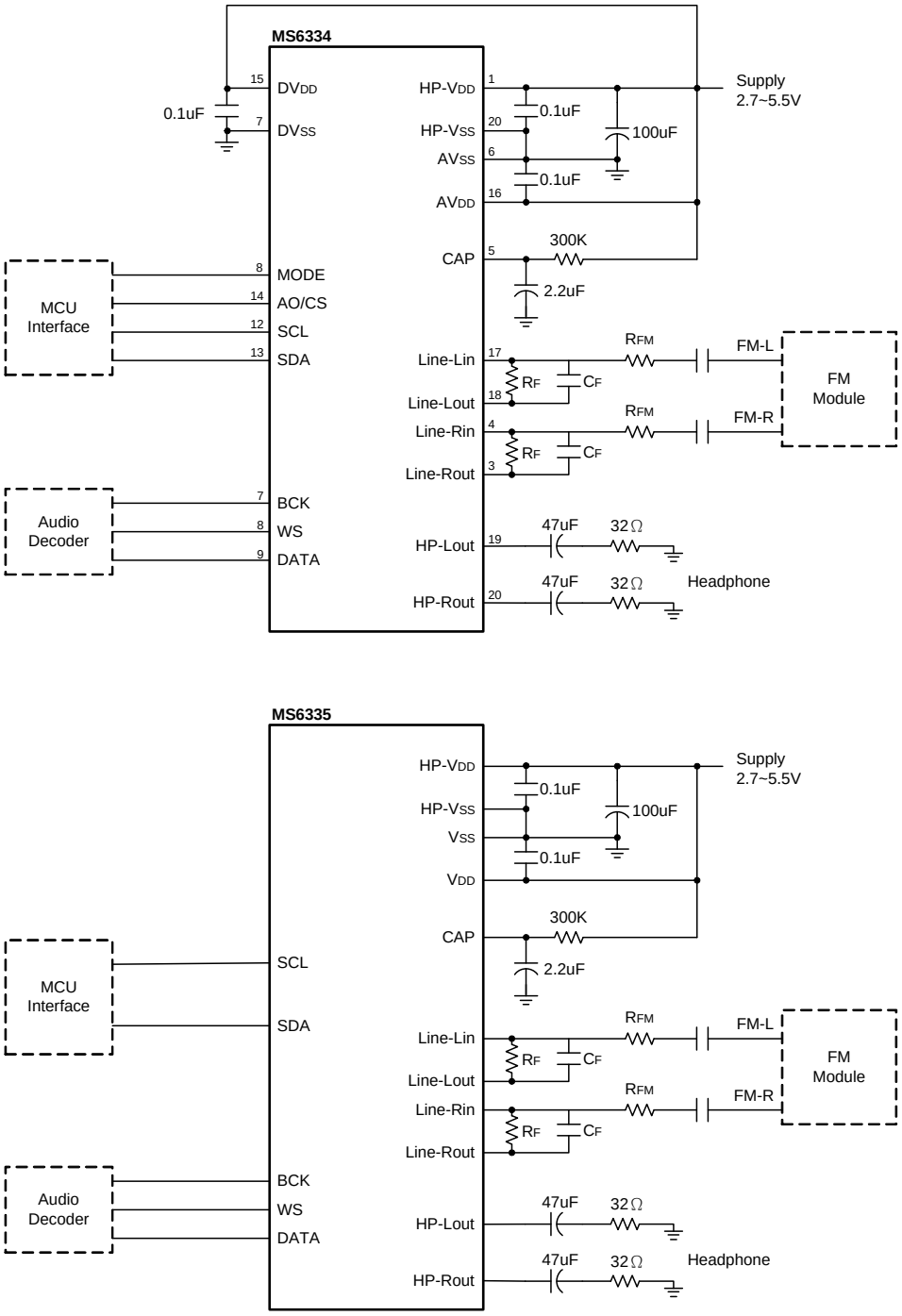


Fig.6 Operational procedure

APPLICATION INFORMATION

A MP3 with FM application

The analog and digital power can be supplied as single voltage.

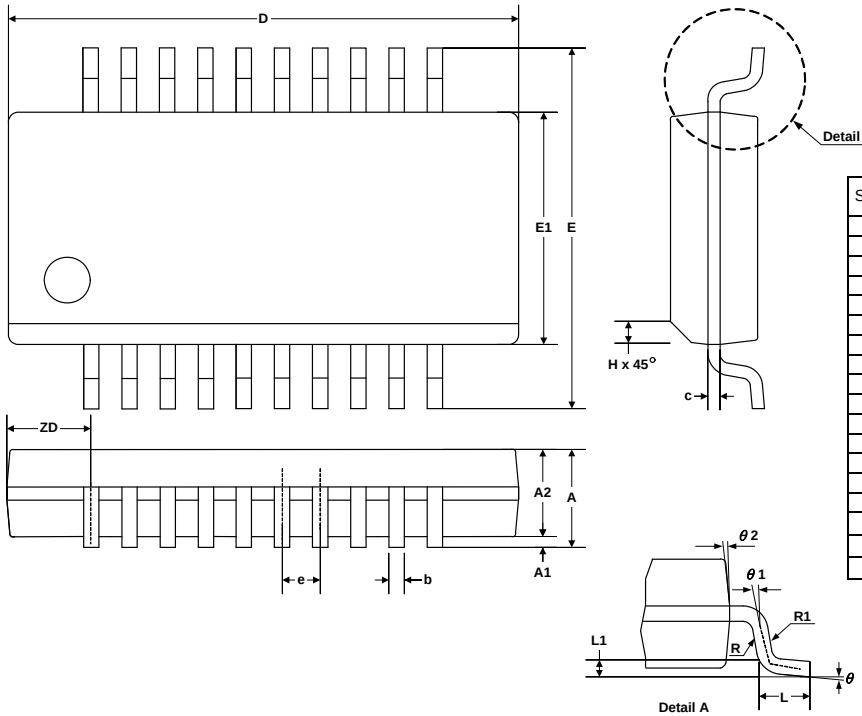


Note : Vo=0.02269*R_F*V_{DD} Vpp at 0dB gain
R_F//C_F to decide –3dB point
For V_{DD}=3V, R_L=32Ω, R_F =24k, C_F =390pF, Vo=1.63Vpp
R_L=16Ω, R_F =22k, C_F =470pF, Vo=1.50Vpp
FM mode, V_{Line} DC Gain = R_F/ R_{FM}

Fig.7 MP3 with FM application circuit.

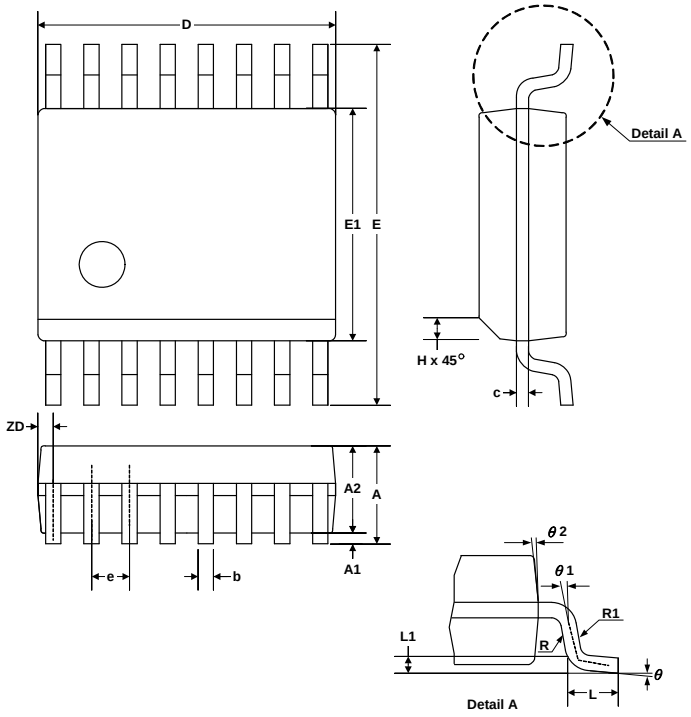
EXTERNAL DIMENSIONS

SSOP20



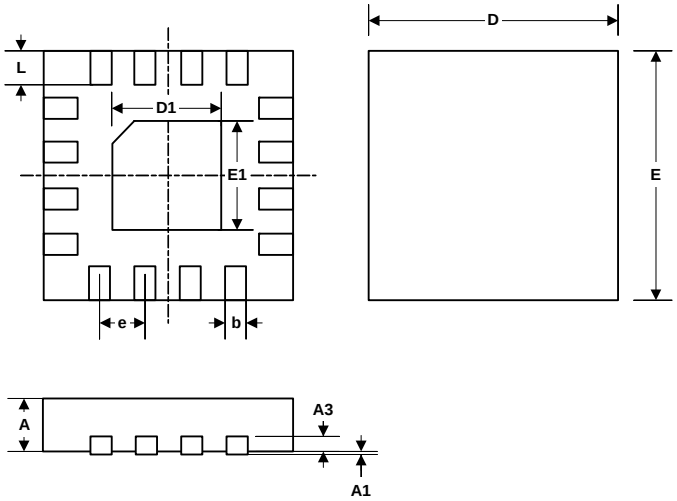
Symbol	Dimension in mm		Dimension in inch	
	Min	Max	Min	Max
A	1.35	1.75	0.053	0.069
A1	0.10	0.25	0.004	0.010
A2		1.50		0.059
b	0.20	0.30	0.008	0.012
c	0.18	0.25	0.007	0.010
e	0.635 BASIC		0.025 BASIC	
D	8.56	8.74	0.337	0.344
E	5.79	6.20	0.228	0.244
E1	3.81	3.99	0.150	0.157
L	0.41	1.27	0.016	0.050
h	0.25	0.50	0.010	0.020
L1	0.254 BASIC		0.010 BASIC	
ZD	1.4732 REF		0.058 REF	
R1	0.20	0.33	0.008	0.013
R	0.20		0.008	
θ	0^o	8^o	0^o	8^o
θ1	0^o		0^o	
θ2	5^o	15^o	5^o	15^o

SSOP16



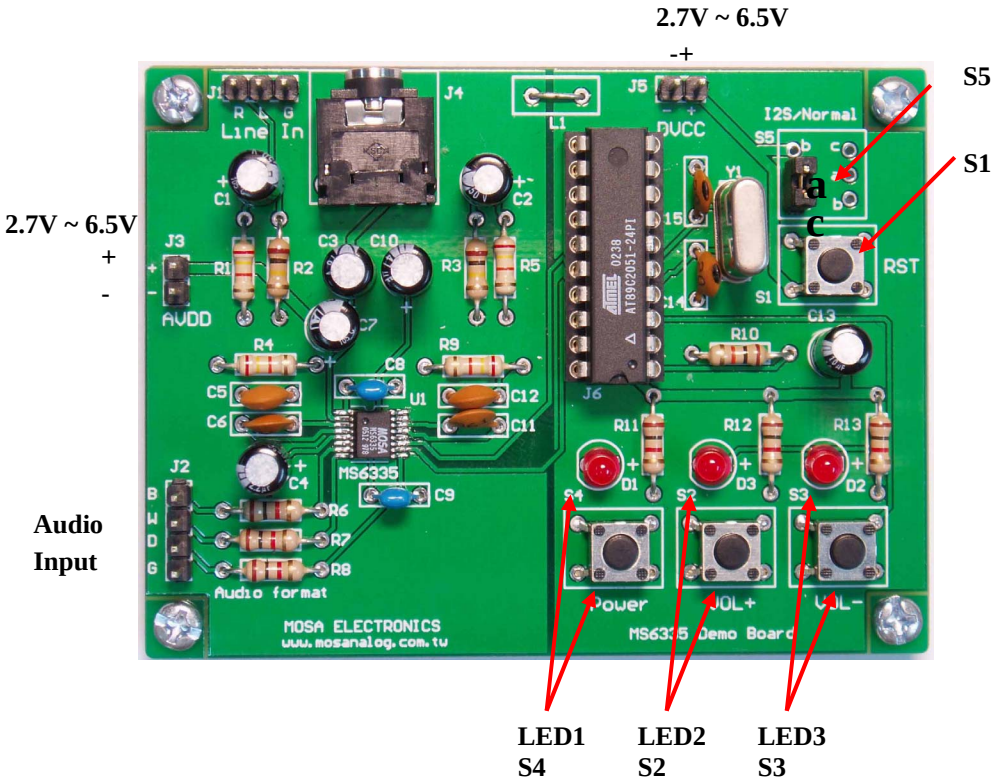
Symbol	Dimension in mm		Dimension in inch	
	Min	Max	Min	Max
A	1.35	1.75	0.053	0.069
A1	0.10	0.25	0.004	0.010
A2		1.50		0.059
b	0.20	0.30	0.008	0.012
c	0.18	0.25	0.007	0.010
e	0.635 BASIC		0.025 BASIC	
D	4.80	5.00	0.189	0.197
E	5.79	6.20	0.228	0.244
E1	3.81	3.99	0.150	0.157
L	0.41	1.27	0.016	0.050
h	0.25	0.50	0.010	0.020
L1	0.254 BASIC		0.010 BASIC	
ZD	0.229 REF		0.009 REF	
R1	0.20	0.33	0.008	0.013
R	0.20		0.008	
θ	0^o	8^o	0^o	8^o
θ1	0^o		0^o	
θ2	5^o	15^o	5^o	15^o

QFN16 (3x3mm)



Symbol	Dimension in mm		
	Min	Nom	Max
A	0.70	0.75	0.80
A1	0	0.02	0.05
A3	-	0.203REF	-
b	0.18	0.23	0.30
D	2.9	3.00	3.10
D1	1.40	1.50	1.60
E	2.9	3.00	3.10
E1	1.40	1.50	1.60
e	-	0.50BSC	-
L	0.30	0.40	0.50

DEMO BOARD



S4 (Power): POWER On/Off

Power On: If this key is pressed until the LED1 power on(about 3 sec),then system is Power On.
Power Off: If this key is pressed until the LED1 power off(about 3 sec),then system is Power Off.

S2 (UP) & S3 (Down): Volume Control

The volume key is used to adjust the volume of playing, and the segment is divided to 31 levels(-39dB～+6dB).
The prime value is level 5(-33dB).
Express full volume when LED3 is bright continuously.
Express mute on when LED2 is bright continuously.

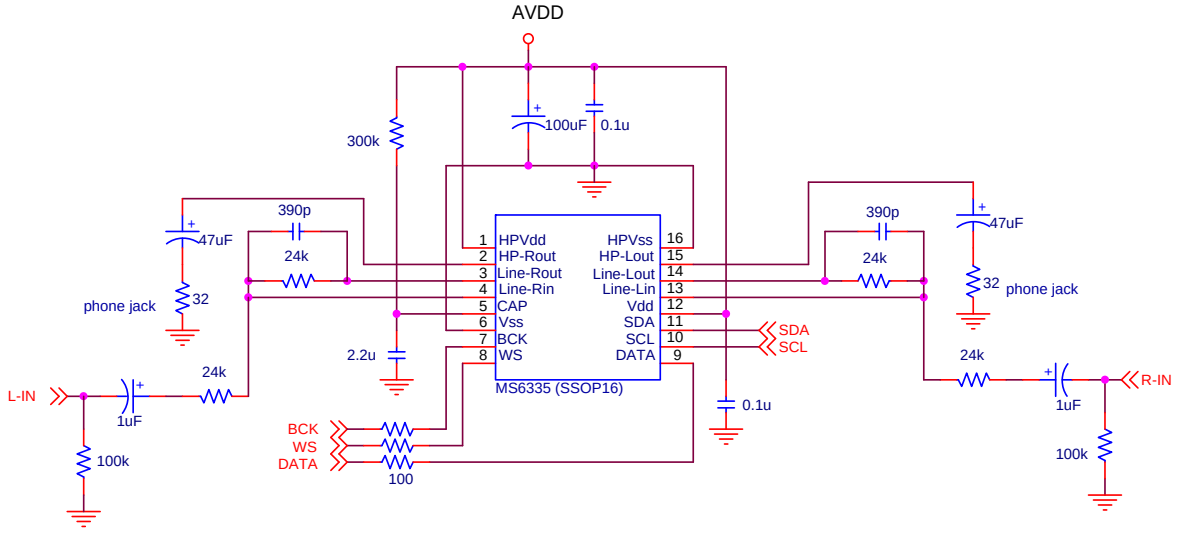
S1: Reset

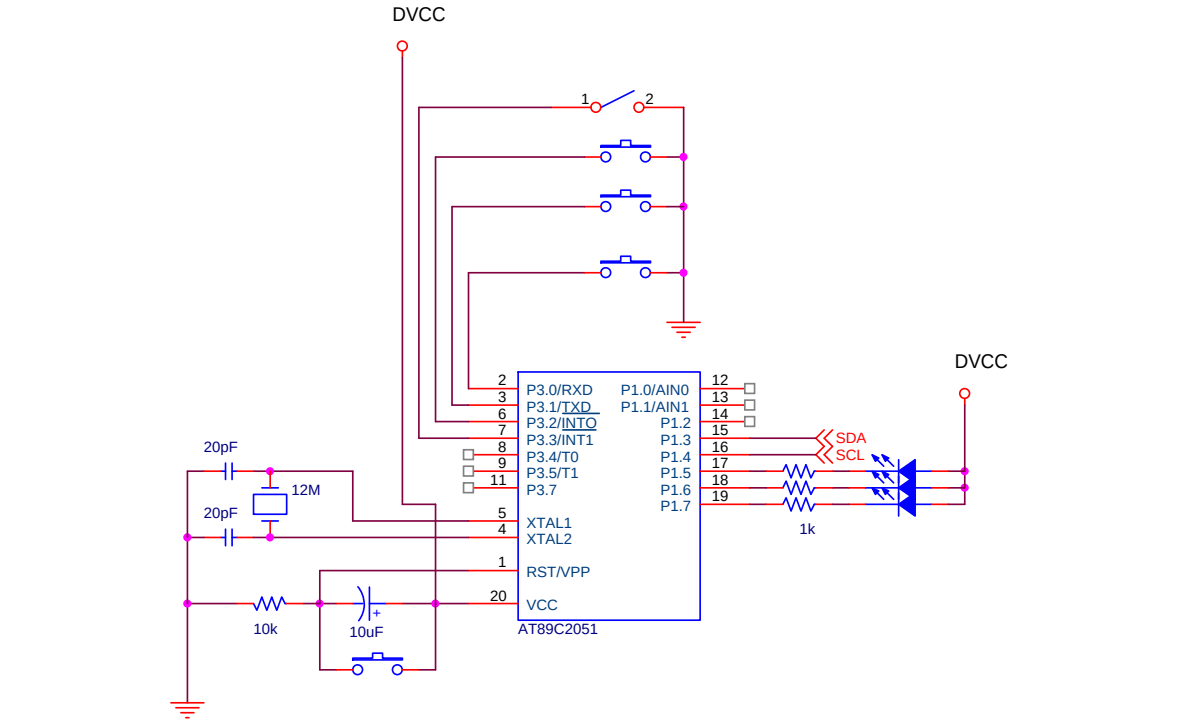
All I/O pins are reset to high.

S5: I^2S/Normal

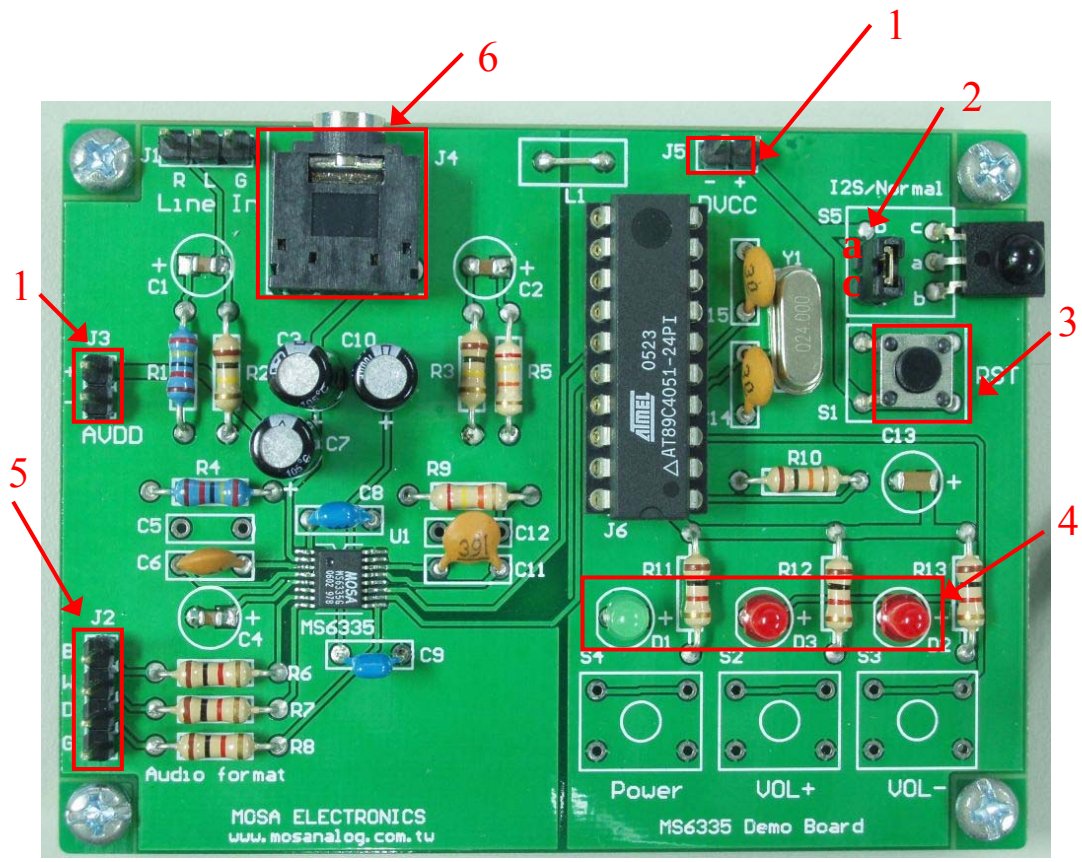
This PIN is used to switch the mode of audio format.
I^2S : a & c open.
Normal : a & c short.

Circuit :


AVDD
300k
100uF
0.1u
390p
47uF
24k
32
phone jack
L-IN
1uF
100k
2.2u
BCK
WS
DATA
100
HPVdd
HP-Rout
Line-Rout
Line-Rin
CAP
Vss
BCK
WS
HPVss
HP-Lout
Line-Lout
Line-Lin
Vdd
SDA
SCL
DATA
MS6335 (SSOP16)
SDA
SCL
0.1u
390p
24k
47uF
32
phone jack
24k
1uF
R-IN
100k


DVCC
P3.0/RXD
P3.1/TXD
P3.2/INTO
P3.3/INT1
P3.4/T0
P3.5/T1
P3.7
XTAL1
XTAL2
RST/VPP
VCC
P1.0/AIN0
P1.1/AIN1
P1.2
P1.3
P1.4
P1.5
P1.6
P1.7
AT89C2051
SDA
SCL
1k
DVCC
20pF
12M
20pF
10k
10uF

DEMO BOARD（IR）



Function description

Label 1: Supply Input
Supply voltage range is 2.4V to 6.5V.

Label 2: This PIN is used to switch the mode of audio format.
I^2S : a & c open.
Normal : a & c short.

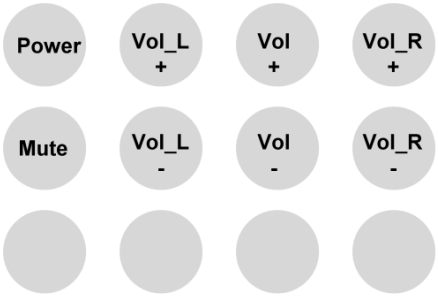
Label 3: Reset
All I/O pins are reset to default values.

Label 4: LED
The LED indicates IR received status and power status.

Label 5: Digital Signal Input
Connected to digital audio formats as I2S, Right Justified and Left Justified.

Label 6: Headphone Jack
Used 3.5mm diameter of headphone with 32ohm

IR Controller



Power ON/OFF : The power key.
Press the key once to set power-on or power-off for MS6864.
The default values are ATTENUATION –33dB.

vol+ : The volume-up switch for stereo channel
The volume increase by +1dB as the switch is pressed once, the maximum value is up to +6dB.
The default value is -33dB on initial status.
L-channel and R-channel are active synchronic.

vol- : The volume-down switch for stereo channel
The volume decrease by -1dB as the switch is pressed once, the minimum value is up to -39dB.
L-channel and R-channel are active synchronic.

Vol_L+ : The volume-up switch for left channel
The volume increase by +1dB as the switch is pressed once, the maximum value is up to +6dB.

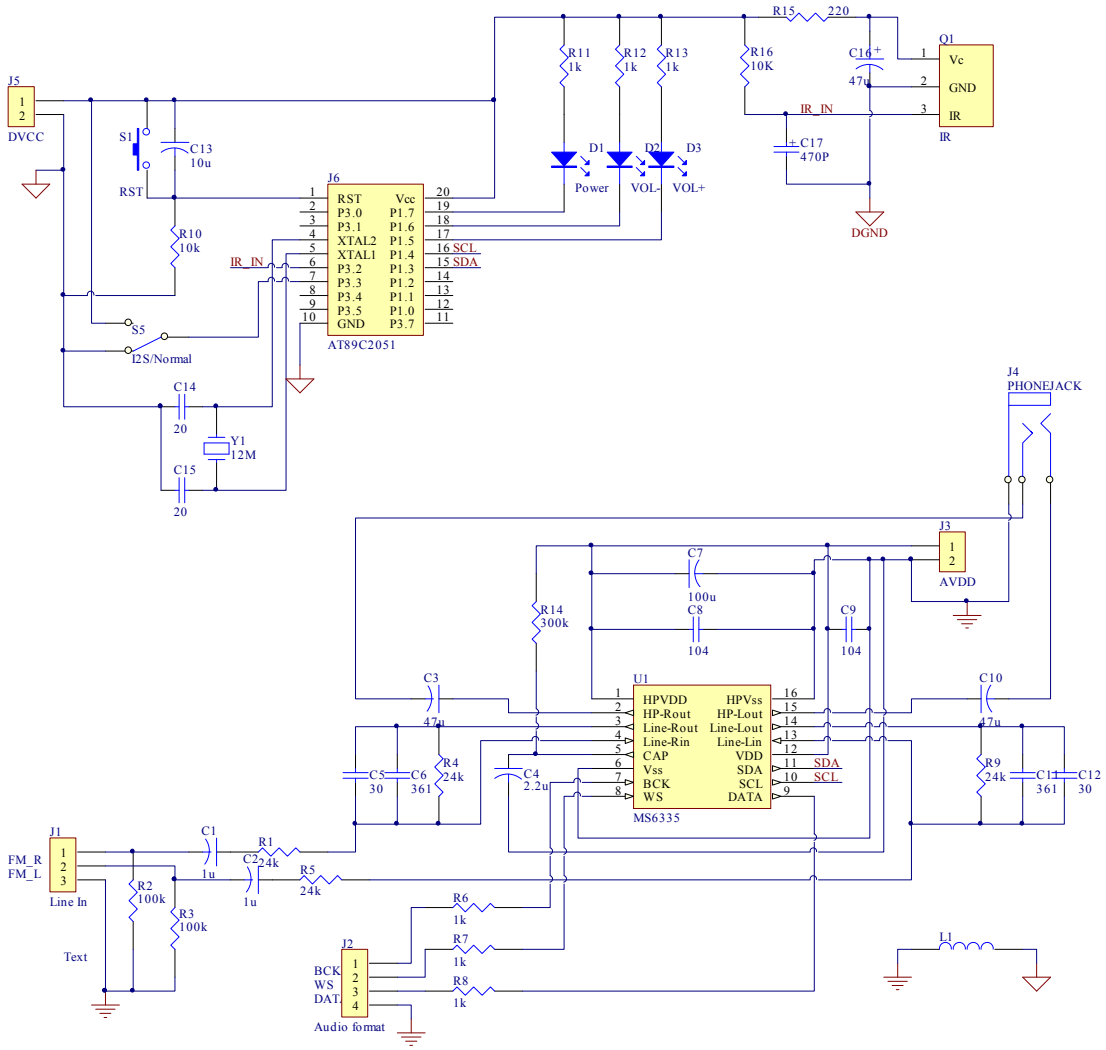
Vol_L - : The volume-down switch for left channel
The volume decrease by -1dB as the switch is pressed once, the minimum value is up to -39dB.

Vol_R+ : The volume-up switch for right channel
The volume increase by +1dB as the switch is pressed once, the maximum value is up to +6dB.

Vol_R- : The volume-down switch for right channel
The volume decrease by -1dB as the switch is pressed once, the minimum value is up to -39dB.

Mute : Press the switch once to enter mute-on or mute-off.
The default status is mute-off on initial status.

Circuit


J5
DVCC
S1
C13
10u
RST
R10
10k
S5
I2S/Normal
C14
20
Y1
12M
C15
20
J6
AT89C2051
IR_IN
R11
1k
R12
1k
R13
1k
D1
Power
D2
VOL-
D3
VOL+
R15
220
R16
10K
C16
47u
C17
470P
DGND
Q1
Vc
GND
IR
IR
J4
PHONEJACK
J3
AVDD
C7
100u
C8
104
C9
104
R14
300k
U1
MS6335
HPVDD
HP-Rout
Line-Rout
Line-Rin
CAP
Vss
BCK
WS
HPVss
HP-Lout
Line-Lout
Line-Lin
VDD
SDA
SCL
DATA
C3
47u
C10
47u
C5
30
C6
361
R4
24k
C4
2.2u
R9
24k
C11
361
C12
30
J1
FM_R
FM_L
Line In
Text
C1
1u
C2
1u
R1
24k
R5
24k
R2
100k
R3
100k
J2
BCK
WS
DAT
Audio format
R6
1k
R7
1k
R8
1k
L1