16-Bit Stereo Audio DAC & Mono 1.8W Power Amplifier Plus Stereo Headphone Function

FEATURES

- Operation range: 2.7V~6.5V
- 16-bit resolution audio DAC
- Output mode : Speaker(BTL)/Headphone(SE)
- Output power, THD+N=1%

Mode	R_L	5V	3.3V	2.7V
BTL	4Ω	1.8W	0.72W	450mW
	8Ω	1.2W	0.52W	330mW
SE	8Ω	0.3W	125mW	85mW
	32Ω	90mW	43mW	25mW

- Component less
- No zero crossing distortion
- Fast setting time permits 2*, 4*, and 8* oversampling (serial input) or double speed operation at 4* oversampling
- Audio format：I^2S, Right justified。
- The minimum HIGH voltage of digital clocks(WS,DATA and BCK)and the control inputs can be 1.6V at Vdd = 5V.
- Excellent Power Supply Rejection Ratio(PSRR)
- Low power consumption
- Shutdown function
- Output voltages can be adjusted by the external resisters
- Housed in 24 pin SSOP(150mil), QFN(4x4x0.8)packages

APPLICATIONS

- Multimedia system, Portable Digital Audio.

DESCRIPTION

The MS6337 is a 16-bits voltage-output Digital-to-Analog Converter (DAC) integrated class AB stereo headphone driver and mono speaker power amplifier. It can drive 1.8W of continuous average power into a mono 4Ω bridged-tied (BTL) speaker or 2 * 90mW into stereo 32Ω single ended (SE) headphone. The 16-bit DAC supports popular formats as I2S, Right Justified.

The MS6337 is with the excellent Power Supply Rejection Ratio(PSRR) 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. These unique features, combined with its exceptional performance, make the MS6337 ideally suited for use in digital audio equipment.

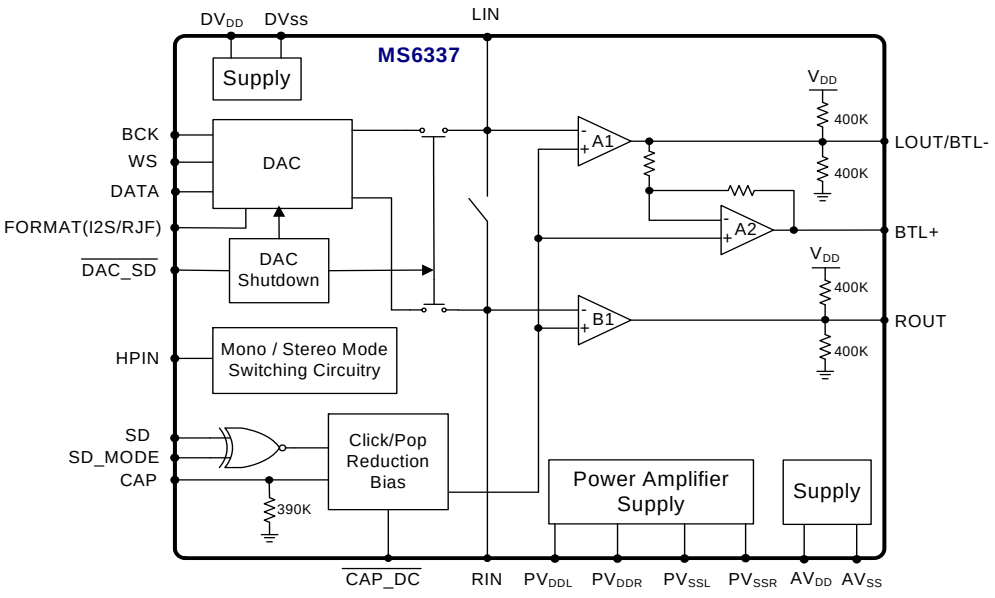
BLOCK DIAGRAM

Shutdown control		
SD Mode	SD	Status
0	0	Shutdown
0	1	Active
1	0	Active
1	1	Shutdown

Format control	
FORMAT	Status
0	I2S
1	RJF

DAC control	
$\overline{DACSD}$	Status
0	Shutdown
1	Active

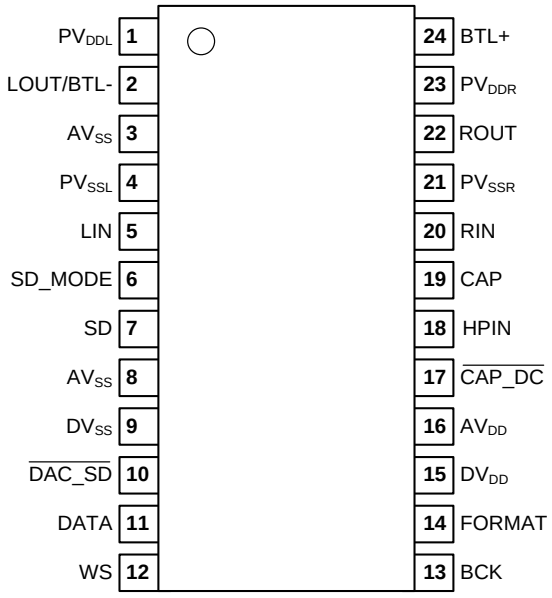
CAP control	
$\overline{CAP_DC}$	Status
0	Discharge
1	Charge



PIN CONFIGURATION

SSOP24

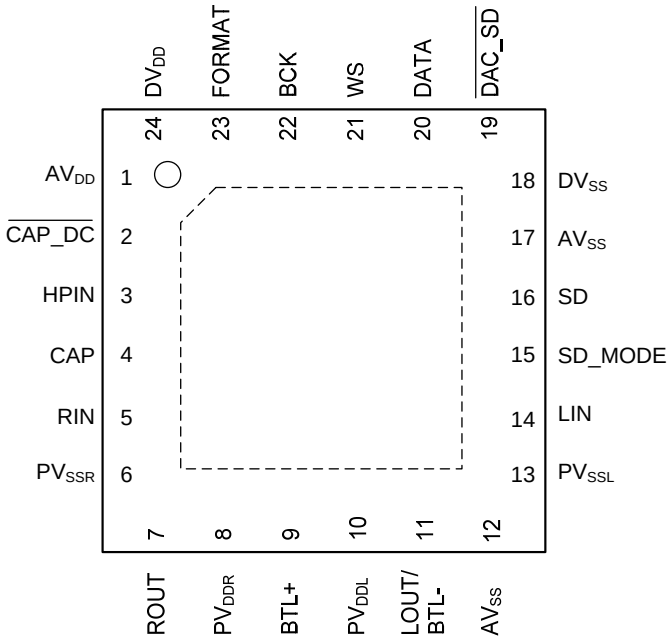
Symbol	Pin	Description
PV_{DDL}	1	Positive supply voltage for left channel of power amplifier
LOUT/BTL-	2	SE left channel output or negative output of BTL
AV_{SS}	3	Negative supply voltage
PV_{SSL}	4	Negative supply voltage for left channel of power amplifier
LIN	5	Left channel input
SD_MODE	6	The shutdown mode selects the shutdown logic level of the SD pin.
SD	7	SD_MODE = 0, the device is shutdown when SD is logic low. SD_MODE = 1, the device is shutdown when SD is logic high.
AV_{SS}	8	Negative supply voltage
DV_{SS}	9	Digital Ground
/DAC_SD	10	DAC shutdown pin. /DAC_SD=0, DAC is shutdown. /DAC_SD=1, DAC is Active.
DATA	11	Audio data input
WS	12	Audio word select input
BCK	13	Audio bit clock input
FORMAT	14	Audio format. FORMAT=0, I2S format. FORMAT=1, Right justified format.
DV_{DD}	15	Digital Positive supply voltage
AV_{DD}	16	Analog Positive supply voltage
/CAP_DC	17	CAP discharge. This pin is functional only as the system is shutdown.
HPIN	18	Headphone input detection.(refer to Page.14 for detection levels) A logical low sets BTL mode, a logical high sets SE mode.
CAP	19	Capacitor connected
RIN	20	Right channel input
PV_{SSR}	21	Negative supply voltage for right channel of power amplifier
ROUT	22	SE right channel output
PV_{DDR}	23	Positive supply voltage for right channel of power amplifier
BTL+	24	Positive output of BTL



MS6337, SSOP24

QFN20

Symbol	Pin	Description
AV_{DD}	1	Analog Positive supply voltage
/CAP_DC	2	CAP discharge. This pin is functional only as the system is shutdown.
HPIN	3	Headphone input detection.(refer to Page.14 for detection levels) A logical low sets BTL mode, a logical high sets SE mode.
CAP	4	Capacitor connected
RIN	5	Right channel input
PV_{SSR}	6	Negative supply voltage for right channel of power amplifier
ROUT	7	SE right channel output
PV_{DDR}	8	Positive supply voltage for right channel of power amplifier
BTL+	9	Positive output of BTL
PV_{DDL}	10	Positive supply voltage for left channel of power amplifier
LOUT/BTL-	11	SE left channel output or negative output of BTL
AV_{SS}	12	Negative supply voltage
PV_{SSL}	13	Negative supply voltage for left channel of power amplifier
LIN	14	Left channel input
SD_MODE	15	The shutdown mode selects the shutdown logic level of the SD pin.
SD	16	SD_MODE = 0, the device is shutdown when SD is logic low. SD_MODE = 1, the device is shutdown when SD is logic high.
AV_{SS}	17	Negative supply voltage
DV_{SS}	18	Digital Ground
/DAC_SD	19	DAC shutdown pin. /DAC_SD=0, DAC is shutdown. /DAC_SD=1, DAC is Active.
DATA	20	Audio data input
WS	21	Audio word select input
BCK	22	Audio bit clock input
FORMAT	23	Audio format. FORMAT=0, I2S format. FORMAT=1,Right justified format.
DV_{DD}	24	Digital Positive supply voltage



MS6337, QFN24

ORDERING INFORMATION

Package	Part number	Packaging Marking	Transport Media
24-Pin SSOP (lead free)	MS6337GTR	MS6337G	2.5k Units Tape and Reel
24-Pin SSOP (lead free)	MS6337GU	MS6337G	56 Units Tube
24-Pin QFN (lead free)	MS6337QTR	6337	5k Units Tape and Reel

RoHS Compliance

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Rating	Unit
V_{DD}	Positive Supply Voltage	6.5	V
V_{ESD}	Electrostatic Handling	-2000 to 2000	V
T_{STG}	Storage Temperature Range	-40 to 125	℃
T_A	Operating Ambient Temperature Range	-40 to 85	℃
T_J	Maximum Junction Temperature	120	℃
T_S	Soldering Temperature, 10 seconds	260	℃
R_{THJA}	Thermal Resistance from Junction to Ambient in Free Air SSOP24 QFN24（enhance thermal pad）	 90 65	℃/W

OPERATING RATINGS

Symbol	Parameter	Min	Typ.	Max	Unit
V_{DD}	Supply Voltage	2.7	5	6.5	V

5V ELECTRICAL CHARACTERISTICS

(Ta=25℃, V_{DD}=5V, V_{SS}=0V, f=1kHz ,R_F=24KΩ[refer to Fig. 4], BW<30kHz; Unless otherwise specified)

Symbol	Parameter	Conditions	Min	Typ.	Max	Unit
DC Characteristics						
V_{CAP}	Voltage at CAP		2.35	2.5	2.65	V
V_{FS}	Full scale output voltage	V_{FS}=0.015775* R_F *V_{DD}	V_{FS}-10%	V_{FS}	V_{FS}+10%	V
I_Q	Quiescent current	Audio code 0000H, BTL	6	8	12	mA
		Audio code 0000H, SE	4.4	5.5	6.6	
I_{SD}	Shutdown current	All devices shutdown	11	17	25	uA
V_{HP}	Headphone hysteresis point	SE Mode	3.8	-	-	V
		BTL Mode	-	-	3.2	
AC Characteristics						
Res	Resolution		-	-	16	bits
PSRR	Power supply rejection ratio	BTL Mode , R_L=8Ω CAP=1uF, f=200Hz		61		dB
		SE Mode , R_L=32Ω CAP=1uF, f=200Hz		66		dB
CS	Channel separation	SE Mode, R_L=32Ω, V_{FS}		90		dB
THD+N	Total harmonic distortion plus Noise	SE mode, R_L=32Ω, V_{FS}		-64	-60	dB
				0.062	0.1	%
S/N	Signal-to-noise ratio	SE mode, A-weighting, V_{FS}	86	90		dB
Po	Output power	BTL Mode, R_L = 4Ω THD+N = 1%	-	1.8	-	W
		BTL Mode, R_L = 8Ω THD+N = 1%	-	1.2	-	W
		SE Mode, R_L =8Ω THD+N = 1%	-	300m	-	W
		SE Mode, R_L = 32Ω THD+N = 1%	-	90m	-	W

3.3V ELECTRICAL CHARACTERISTICS

(Ta=25℃, V_{DD}=3.3V, V_{SS}=0V, f=1kHz, R_F=24KΩ[refer to Fig, 4] ; Unless otherwise specified)

Symbol	Parameter	Conditions	Min	Typ.	Max	Unit
DC Characteristics						
V_{CAP}	Voltage at CAP		1.55	1.65	1.75	V
V_{DC}	Output DC level		1.55	1.65	1.75	V
V_{FS}	Full scale output voltage	V_{FS}=0.015775* R_F *V_{DD}	V_{FS}-10%	V_{FS}	V_{FS}+10%	V
I_Q	Quiescent current	Audio code 0000H, BTL	5.4	6.6	9.9	mA
		Audio code 0000H, SE	3.8	4.8	5.8	mA
I_{SD}	Shutdown current	All devices shutdown	7.3	11.2	16.5	uA
V_{HP}	Headphone hysteresis point	SE Mode	2.3	-	-	V
		BTL Mode	-	-	1.9	
AC Characteristics						
THD+N	Total harmonic distortion plus noise	SE mode, R_L=32Ω, V_{FS}		-63	-58	dB
				0.07	0.126	%
Po	Output power	BTL Mode, R_L = 4Ω THD+N = 1%	-	0.72	-	W
		BTL Mode, R_L = 8Ω THD+N = 1%	-	0.52	-	W
		SE Mode, R_L =8Ω THD+N = 1%	-	125m	-	W
		SE Mode, R_L = 32Ω THD+N = 1%	-	43m	-	W

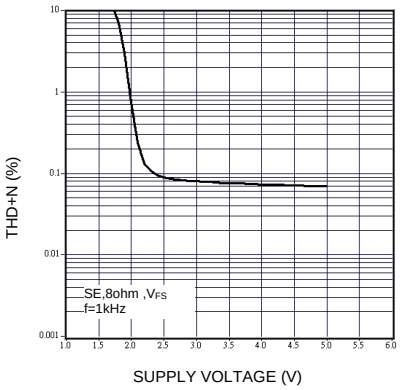
2.7V ELECTRICAL CHARACTERISTICS

(Ta=25℃, V_{DD}=2.7V, V_{SS}=0V, f=1kHz, R_F=24KΩ[refer to Fig, 4]; Unless otherwise specified)

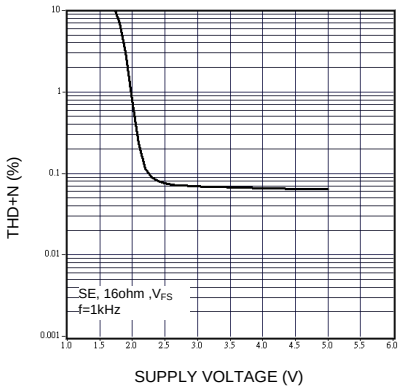
Symbol	Parameter	Conditions	Min	Typ.	Max	Unit
DC Characteristics						
V_{CAP}	Voltage at CAP		1.25	1.35	1.45	V
V_{DC}	Output DC level		1.25	1.35	1.45	V
V_{FS}	Full scale output voltage	V_{FS}=0. 015775* R_F *V_{DD}	V_{FS}-10%	V_{FS}	V_{FS}+10%	V
I_Q	Quiescent current	Audio code 0000H, BTL	4.5	6	9	mA
		Audio code 0000H, SE	3.6	4.5	5.4	mA
I_{SD}	Shutdown current	All devices shutdown	5.5	9.2	13.5	uA
V_{HP}	Headphone hysteresis point	SE Mode	1.8	-	-	V
		BTL Mode	-	-	1.5	
AC Characteristics						
THD+N	Total harmonic distortion plus noise	SE mode, R_L=32Ω, V_{FS}		-63	-58	dB
				0.07	0.126	%
Po	Output power	BTL Mode, R_L = 4Ω, THD+N = 1%	-	0.45	-	W
		BTL Mode; R_L = 8Ω THD+N = 1%	-	0.33	-	W
		SE Mode; R_L = 8Ω THD+N = 1%	-	85m	-	W
		SE Mode; R_L = 32Ω THD+N = 1%	-	25m	-	W

TYPICAL PERFORMANCE CHARACTERISTICS

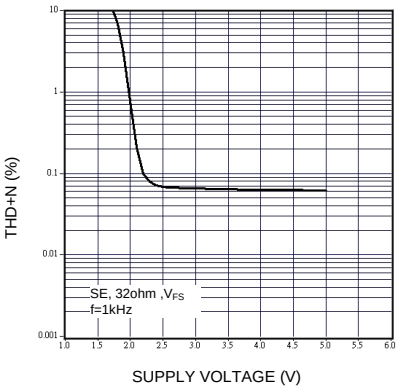
(Ta=25℃, sampling rate=4fs, fs= 44.1kHz, R_F = 24K; unless otherwise specified)



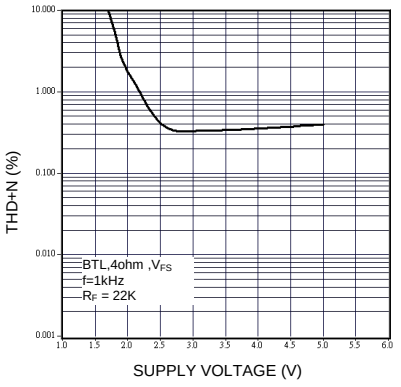
THD+N vs. supply voltage



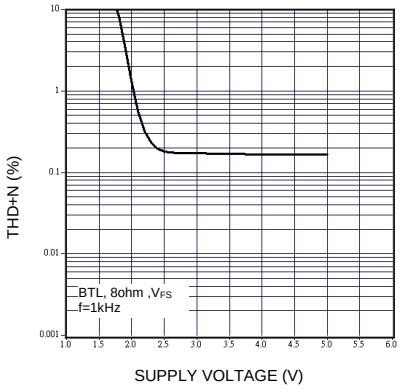
THD+N vs. supply voltage



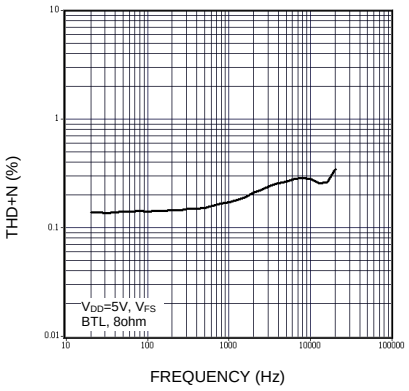
THD+N vs. supply voltage



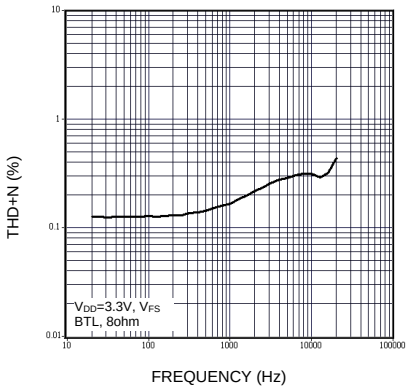
THD+N vs. supply voltage



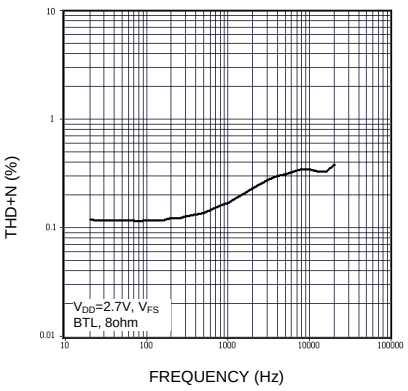
THD+N vs. supply voltage



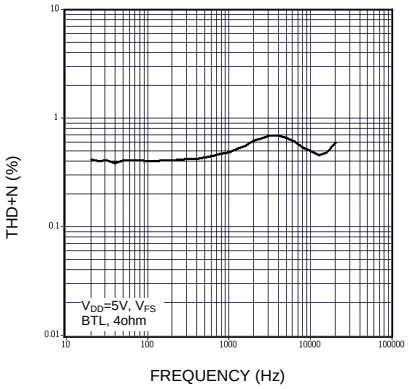
THD+N vs. frequency



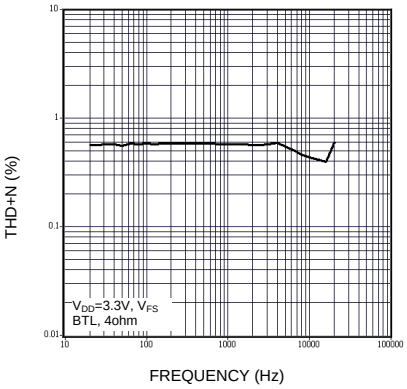
THD+N vs. frequency



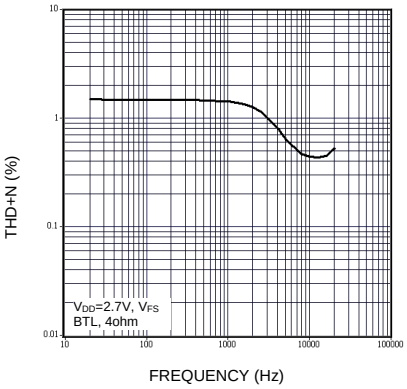
THD+N vs. frequency



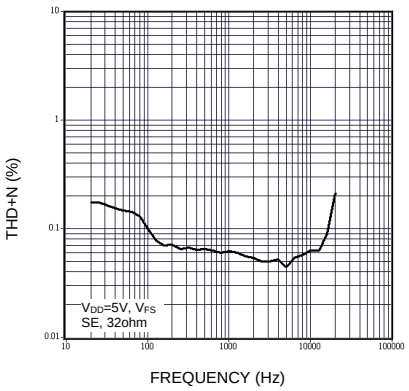
THD+N vs. frequency



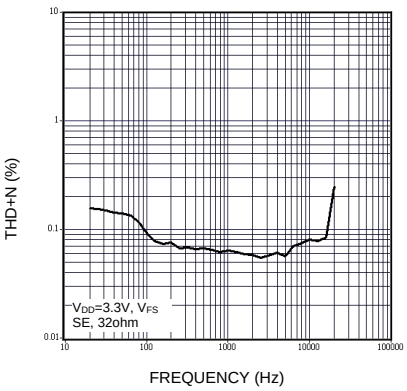
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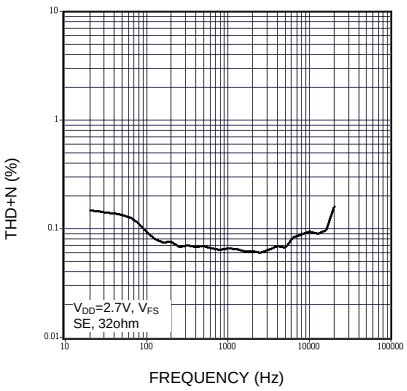
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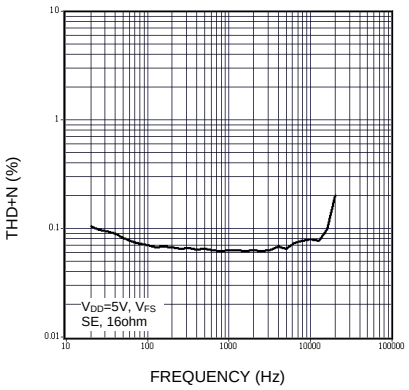
THD+N vs. frequency



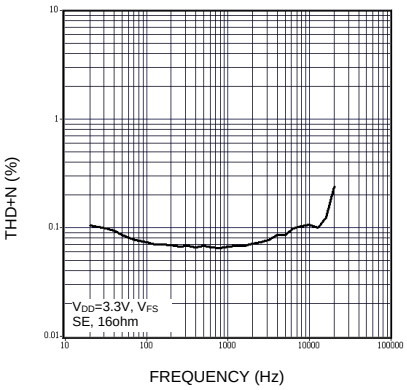
THD+N vs. frequency



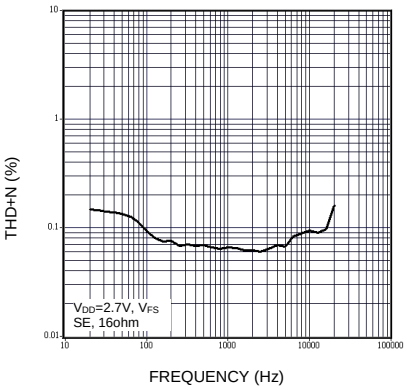
THD+N vs. frequency



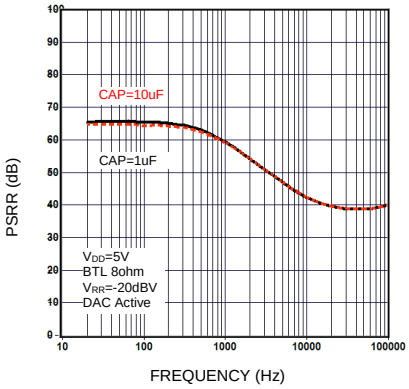
THD+N vs. frequency



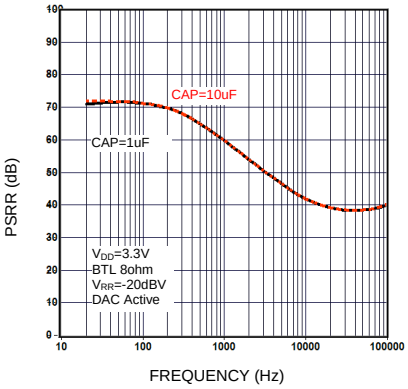
THD+N vs. frequency



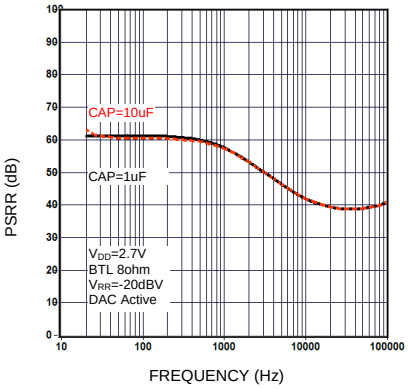
THD+N vs. frequency



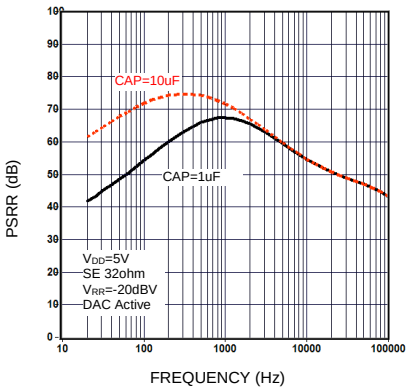
PSRR（5V） vs. frequency



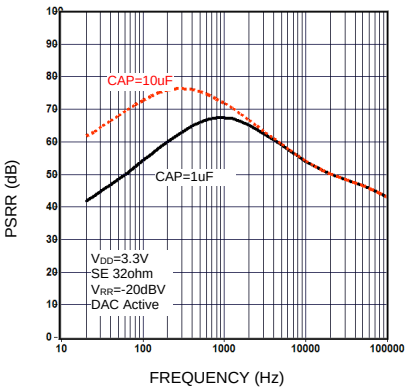
PSRR（3.3V）vs. frequency



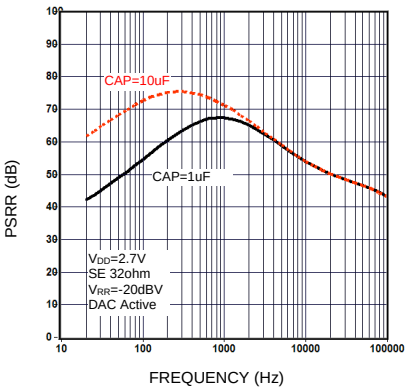
PSRR（2.7V）vs. frequency



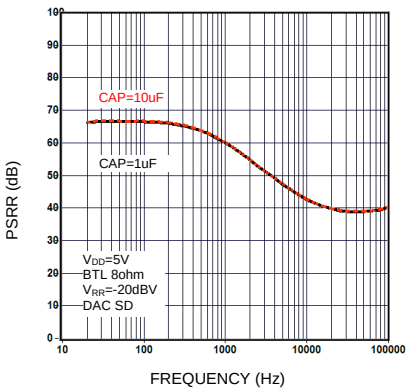
PSRR（5V） vs. frequency



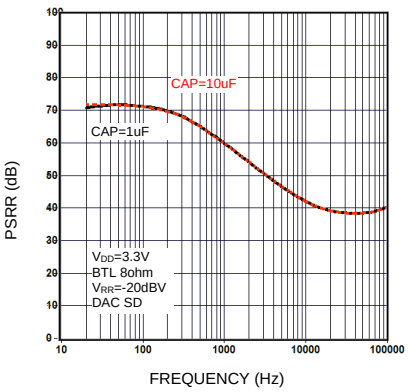
PSRR（3.3V）vs. frequency



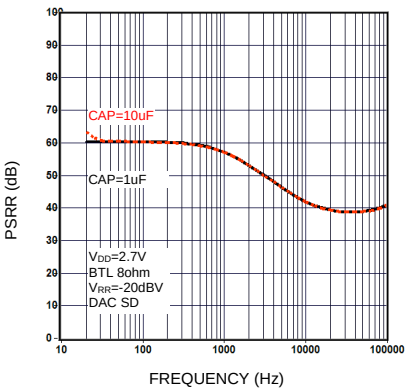
PSRR（2.7V）vs. frequency



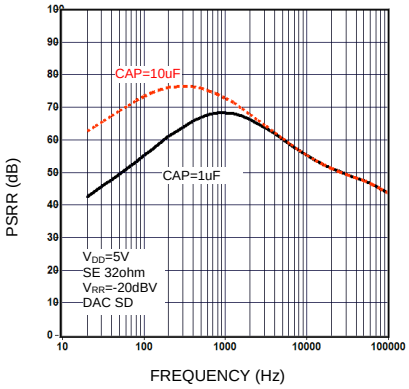
PSRR（5V） vs. frequency



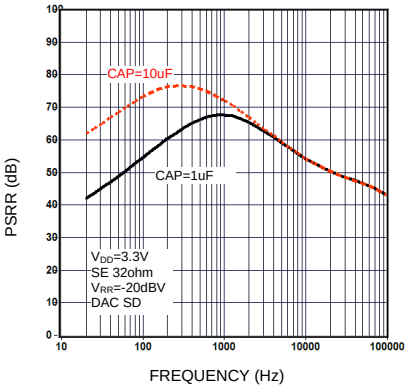
PSRR（3.3V）vs. frequency



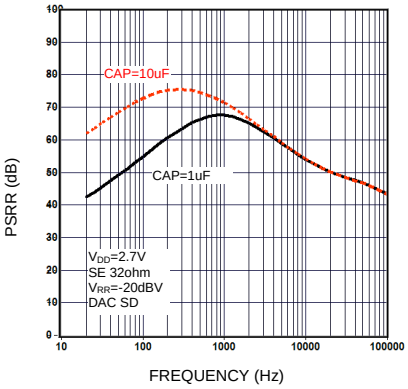
PSRR（2.7V）vs. frequency



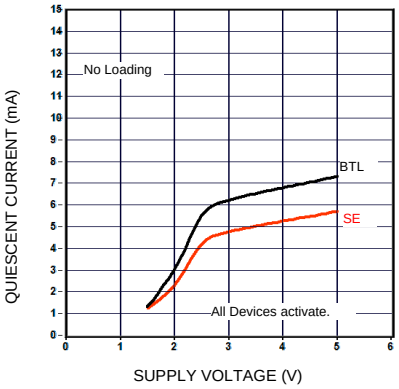
PSRR（5V） vs. frequency



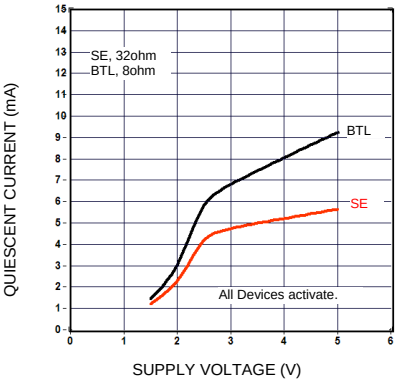
PSRR（3.3V）vs. frequency



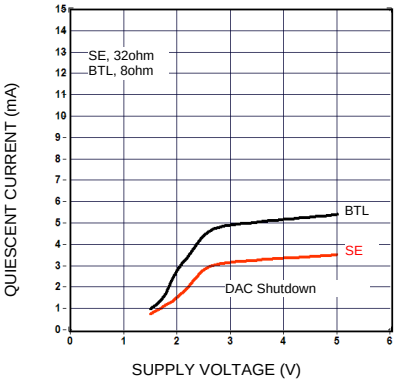
PSRR（2.7V）vs. frequency



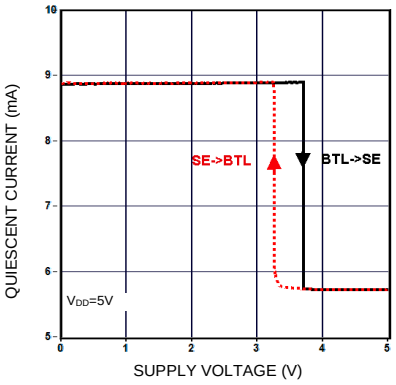
Quiescent current vs. supply voltage



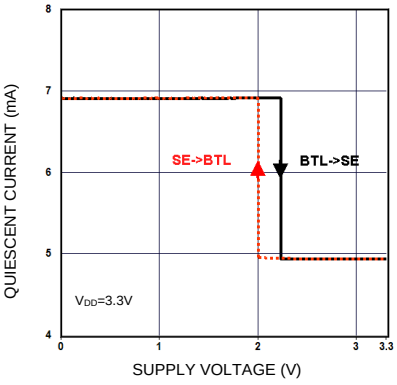
Quiescent current vs. supply voltage



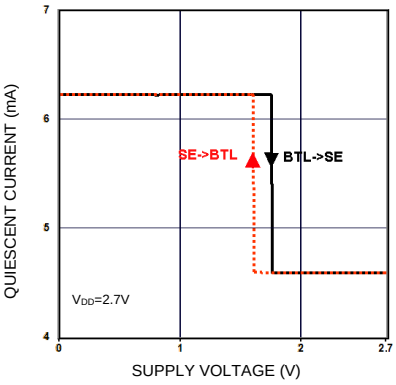
Quiescent current vs. supply voltage



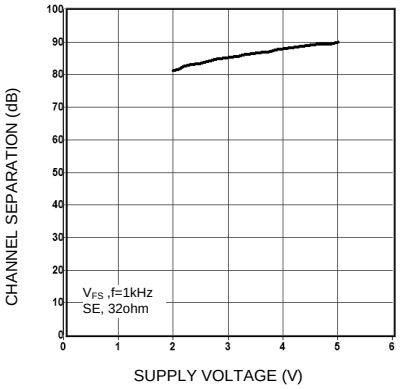
Mode vs. HP-IN votage



Mode vs. HP-IN votage



Mode vs. HP-IN votage



Channel separation vs. supply voltage

TIMING AND DATA FORMAT

The MS6337 accepts input serial data formats of 16-bit word length. Left and right data words are time multiplexed can also be input format, single channel. The MSB must always be first.

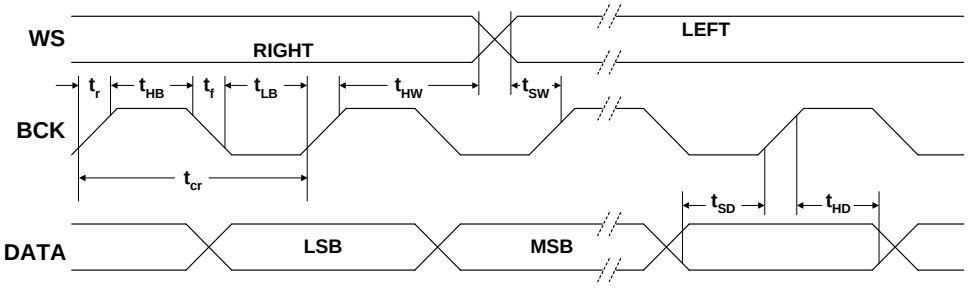


Fig.1 Timing and input signals.（Stereo）

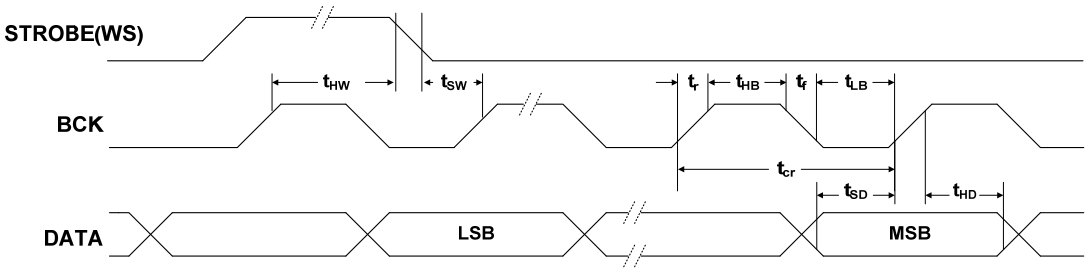


Fig.2 Timing and input signals.（Mono）

Data format (BCK, WS and DATA)

Symbol	Parameter	Conditions	Min	Typ.	Max	Unit
V_{IL}	Input LOW level		-	-	0.7	V
V_{IH}	Input HIGH level		1.6	-	-	V
$\lvert I_{IL} \rvert$	Input Leakage Current LOW		-	-	10	μA
$\lvert I_{IH} \rvert$	Input Leakage Current HIGH		-	-	10	μA
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_{CR}	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

Right justified format

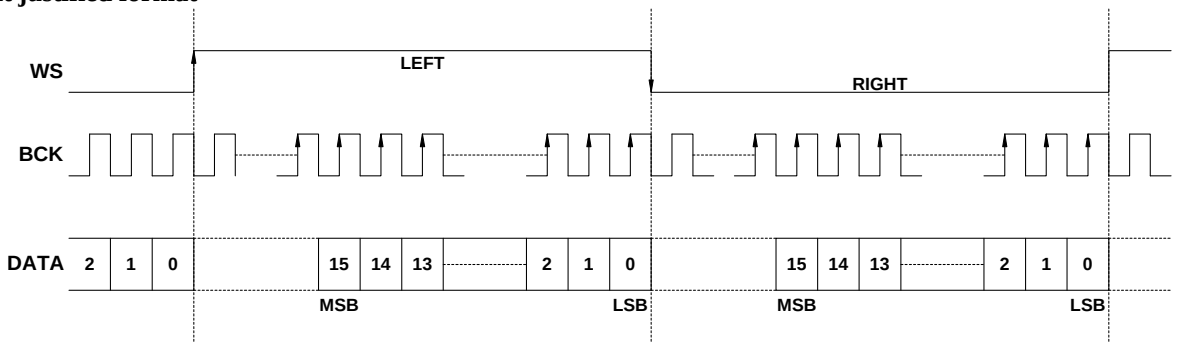


Fig.3 Right justified format（Stereo）

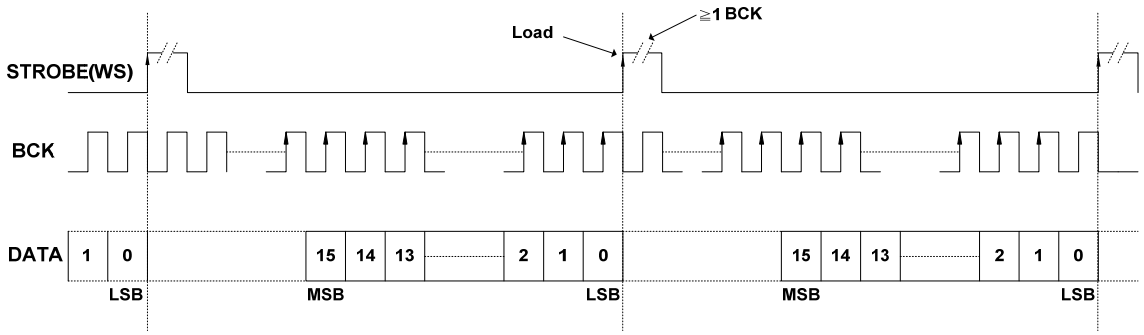


Fig.4 Right justified format（Mono）

I2S format

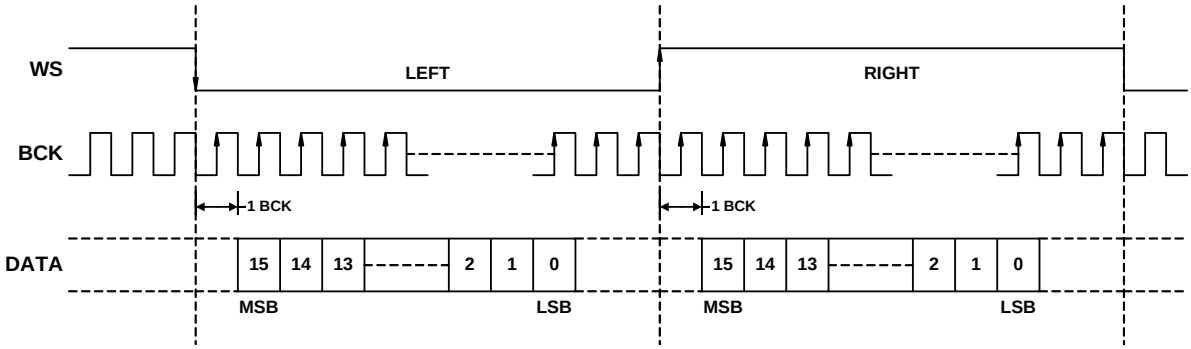


Fig.3 I2S format（Stereo）

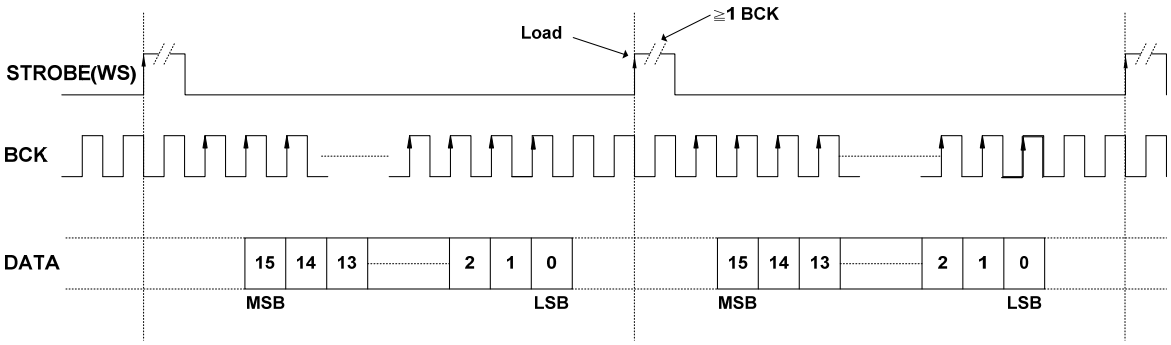
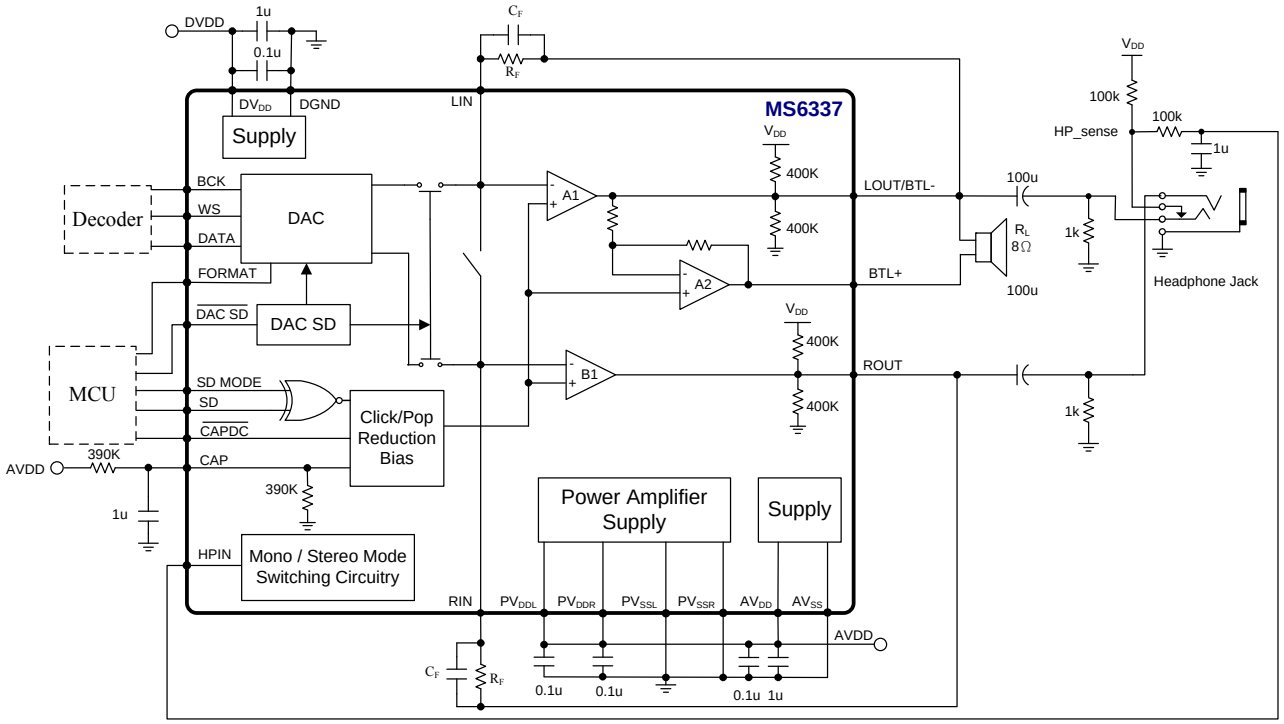


Fig.3 I2S format（Mono）

APPLICATION INFORMATION

Basic application example



Note: $V_{DAC\ out}$=0.015775*R_F*V_{DD}（Vpp）
R_F//C_F to decide –3dB point
For V_{DD}=3V, R_L=32Ω, R_F =24k, C_F =390pF, $V_{DAC\ out}$ =1.134Vpp
R_L=16Ω, R_F =22k, C_F =470pF, $V_{DAC\ out}$ =1.04Vpp

Fig.4 Basic application circuit.

SE mode and BTL mode operation

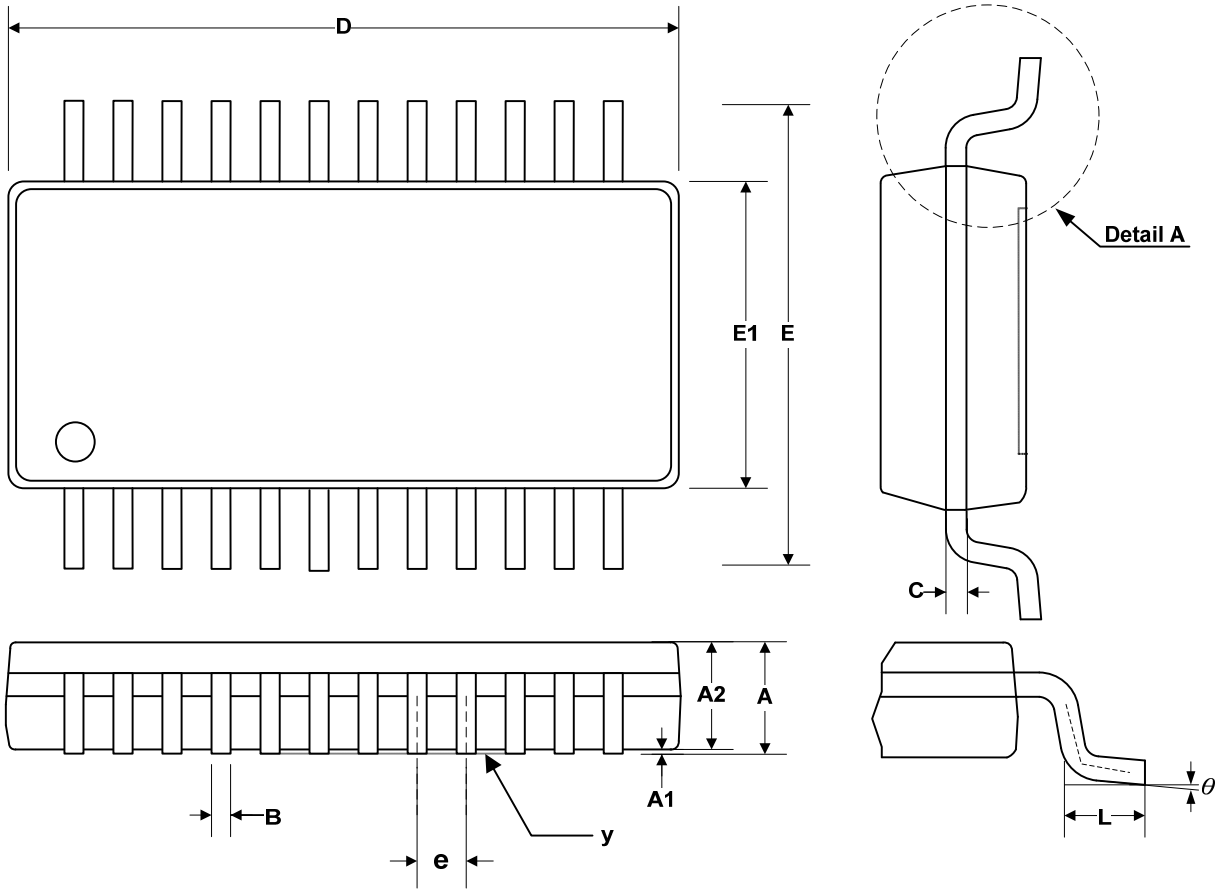
As shown in the block diagram (Page.1), for the SE mode, the MS6337 operates as a high drive dual operational amplifiers.
Amplifier A1 and B1 are independent amplifiers with an externally configured gain of A_V = - R_F/R_{IN}. Amplifier A2 is shutdown to a high output impedance state. That is, the mono speaker is muted.

For the BTL mode, the audio signal from the RIN pin is connected directly to the inverting input of A1. As a result, the L-IN and R-IN audio signals, either from DAC or Line in, are summed together at the input of A1. A2 is then activated with a closed-loop gain of A_V = -1 fixed by two internal resistors. The outputs of A1 and A2 are then used to drive the mono bridged-tied load.

Also in the BTL mode, the amplifier B1 functions as an unit gain buffer. The output voltage of B1 will follow Vcap, in which no current goes through the feedback resistor R_F of B1. This will insure that as HPIN goes low there is no transient of Rout for the BTL mode.

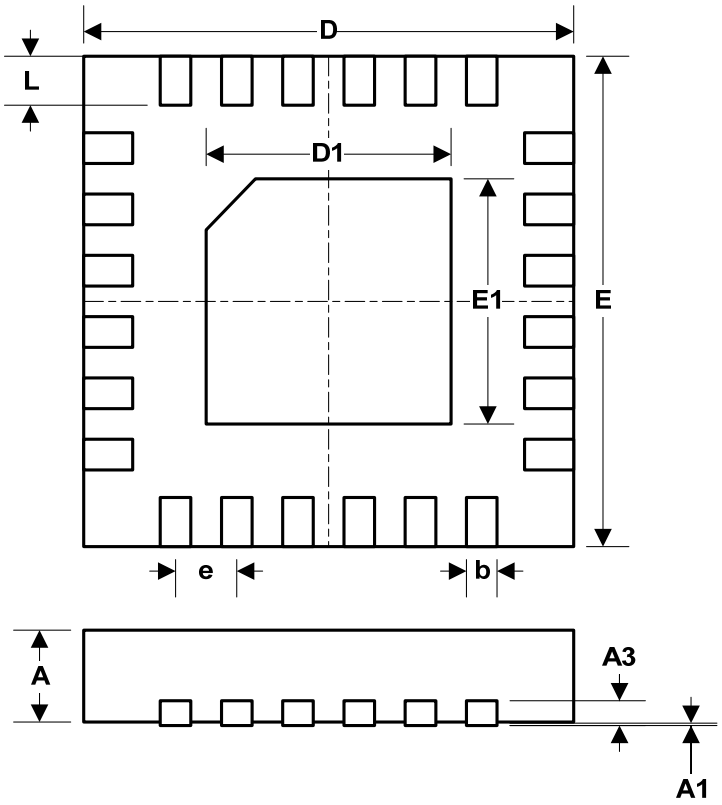
EXTERNAL DIMENSIONS

SSOP24



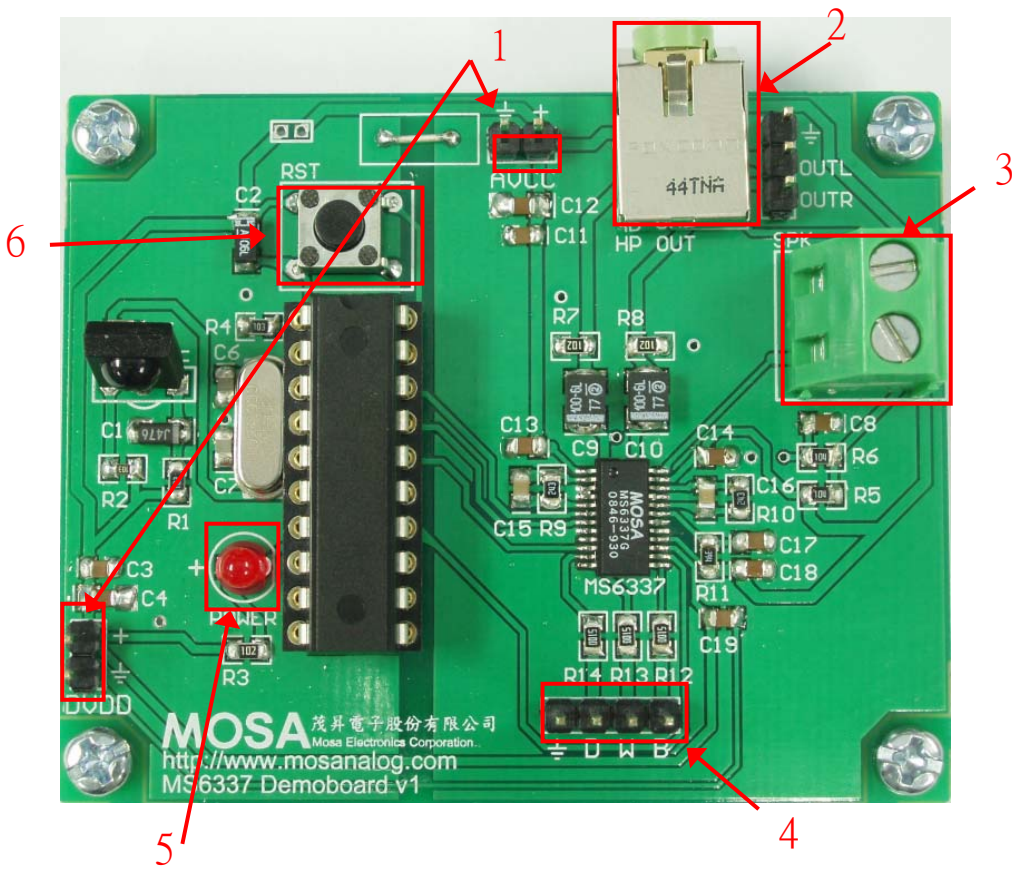
Symbol	Dimension in mm			Dimension in inches		
	Min	Nom	Max	Min	Nom	Max
A	1.35	1.6	1.75	0.053	0.064	0.069
A1	0.1	-	0.25	0.004	-	0.010
A2	-	1.45	-	-	0.057	-
B	0.2	0.25	0.30	0.008	0.010	0.012
C	0.19	-	0.25	0.007	-	0.010
D	8.55	-	8.75	0.337	-	0.344
E	5.8	6.0	6.2	0.228	0.236	0.244
E1	3.8	3.9	4.0	0.150	0.153	0.157
e	0.640 BASIC			0.025 BASIC		
L	0.40	-	1.27	0.016	-	0.05
θ	0^o	-	8^o	0^o	-	8^o
y	-	-	0.10	-	-	0.004

QFN24 (4x4mm)



Symbol	Dimension in mm			Dimension in inch		
	Min	Nom	Max	Min	Nom	Max
A	0.70	0.75	0.80	0.02756	0.02953	0.03150
A1	0	0.02	0.05	0	0.00079	0.00197
A3	0.203REF			0.008REF		
b	0.18	0.25	0.30	0.00709	0.00984	0.01181
D	3.90	4.00	4.10	0.1535	0.1575	0.161.4
D1	1.90	2.00	2.10	0.0748	0.0787	0.0827
E	3.90	4.00	4.10	0.1535	0.1575	0.1614
E1	1.90	2.00	2.10	0.0748	0.0787	0.0827
e	0.50BSC			0.01969BSC		
L	0.30	0.40	0.50	0.0118	0.0157	0.0197

Demo board



Function description

Label 1: Supply Input
Supply voltage range is 2.7V to 6.5V.

Label 2: Headphone Jack
Used 3.5mm diameter of headphone with 32ohm

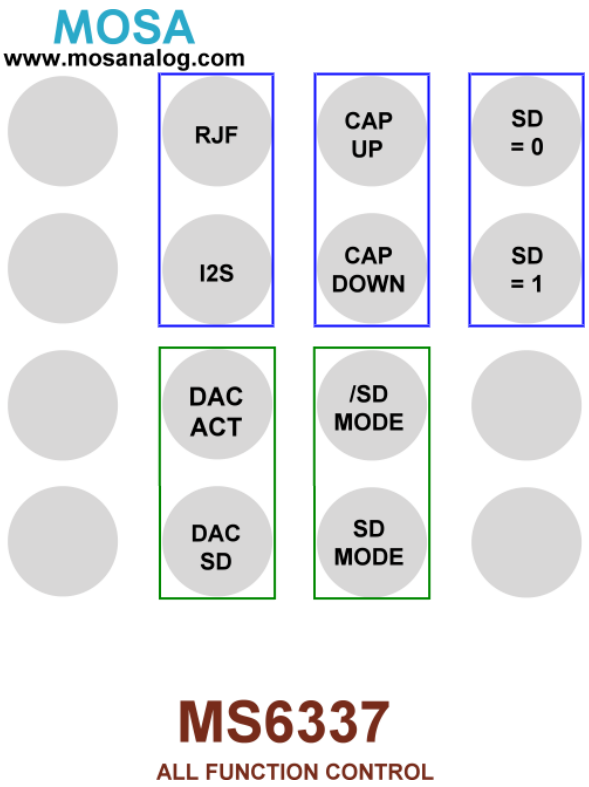
Label 3: Speaker Output
Connected to speaker with 8ohm or 4 ohm

Label 4: Digital Signal Input
Connected to digital audio formats as I2S, Right Justified.

Label 5: LED Indicator
The LEDs indicate the chip status and IR received status. It is red-dark blink once when the MCU has received the function code correctly.

Label 6: Reset
All I/O pins are reset to default values.（Initial state: RJF, CAP_UP, DAC_SD, /SD_MODE, SD = 0.）

IR Controller



Initial state: RJF, CAP_UP, DAC_SD, /SD_MODE, SD = 0.

I2S, RJF: The digital input format keys.
There are two formats can be selected that is I2S and Right justified.

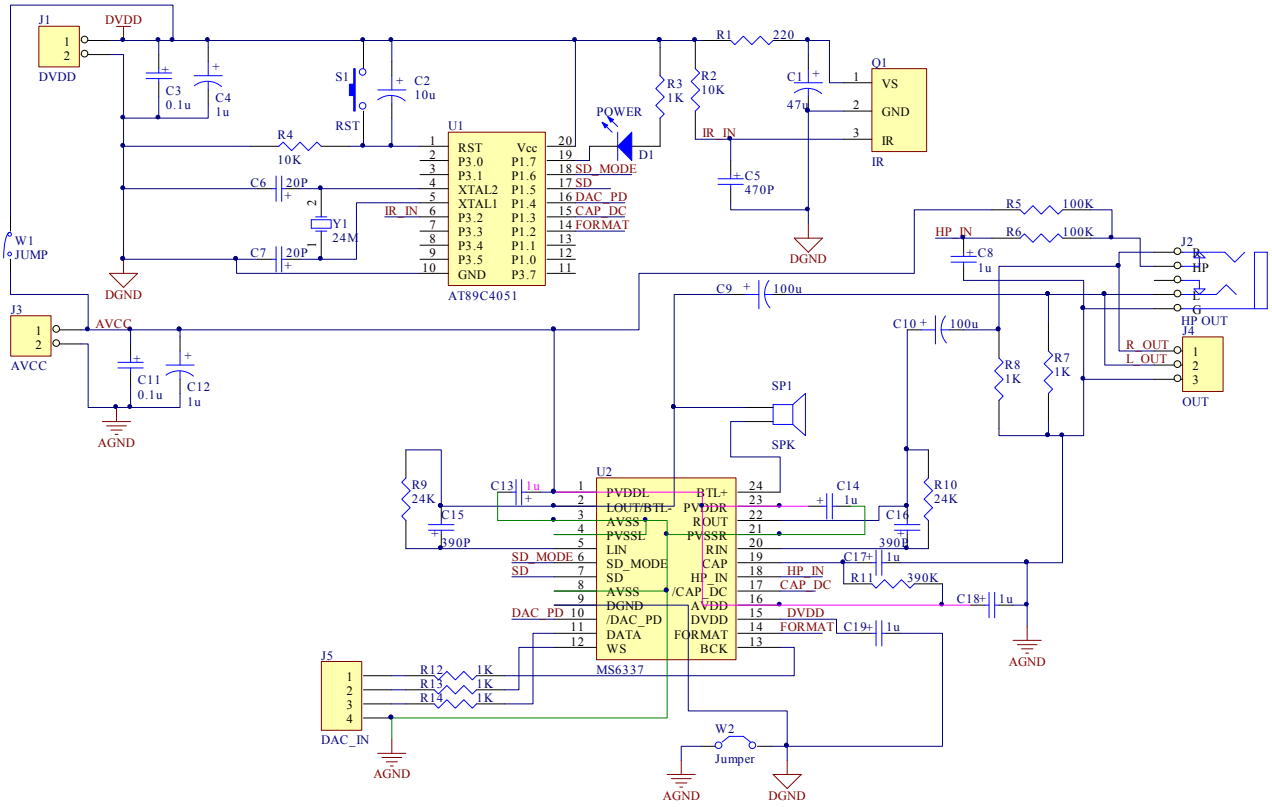
CAP_UP/CAP DOWN : The CAP control key. (This pin is functional only as the system is shutdown.)
CAP_UP : CAP charge.
CAP_DOWN : CAP discharge.

DAC_ACT, DAC_SD : The DAC Shutdown keys.
DAC_ACT : DAC is active.
DAC_SD : DAC is shutdown.

SD_MODE, /SD_MODE: The shutdown mode select keys.
The shutdown mode selects the shutdown logic level

SD=0, SD=1: The shutdown level control keys.
SD_MODE , the device is shutdown when SD = 0.
/SD_MODE , the device is shutdown when SD =1.

Circuit


J1
DVDD
C3 0.1u
C4 1u
S1
RST
C2 10u
R4 10K
C6 20P
C7 20P
Y1 24M
U1
AT89C4051
RST
P3.0
P3.1
XTAL2
XTAL1
P3.2
P3.3
P3.4
P3.5
GND
Vcc
P1.7
P1.6
P1.5
P1.4
P1.3
P1.2
P1.1
P1.0
P3.7
SD_MODE
SD
DAC_PD
CAP_DC
FORMAT
IR_IN
POWER
D1
R3 1K
R2 10K
R1 220
C1 47u
Q1
VS
GND
IR
C5 470P
W1 JUMP
J3
AVCC
C11 0.1u
C12 1u
AGND
DGND
R5 100K
R6 100K
HP_IN
C8 1u
C9 100u
C10 100u
J2
HP OUT
J4
OUT
R_OUT
L_OUT
R8 1K
R7 1K
SP1
SPK
U2
MS6337
PVDDL
LOUT/BTL-
AVSS
PVSSL
LIN
SD_MODE
SD
AVSS
DGND
/DAC_PD
DATA
WS
BTL+
PVDDR
ROUT
PVSSR
RIN
CAP
HP_IN
/CAP_DC
AVDD
DVDD
FORMAT
BCK
R9 24K
C13 1u
C15 390P
C14 1u
C16 390P
R10 24K
C17+ 1u
R11 390K
C18+ 1u
C19+ 1u
J5
DAC_IN
R12 1K
R13 1K
R14 1K
W2
Jumper