

# Dual 2W Power Amplifier

## 3 Stereo Inputs with Volume Control

### FEATURES

- Operation range: 2.4V~5.5V
- 3 stereo inputs
- Volume control range  
Gain: 0 to 21dB, 3dB/step  
Attenuation: 0 to -77.5dB, 1.25dB/step
- Output mode : Speaker( BTL)/Headphone(SE)
- BTL Output power  
 $R_L=4\Omega$ , 2W at 5V, 0.8W at 3.3V, 360mW at 2.4V  
 $R_L=8\Omega$ , 1.3W at 5V, 0.53W at 3.3V, 250mW at 2.4V
- SE Output power  
 $R_L=32\Omega$ , 93mW at 5V, 35mW at 3.3V, 15mW at 2.4V
- Control interface : I<sup>2</sup>C
- Excellent Power Supply Rejection Ratio(PSRR)
- Flexibility power management
- Component less
- Reduce pop noise circuit
- Housed in TSSOP20 package, enhanced thermal PAD

### APPLICATIONS

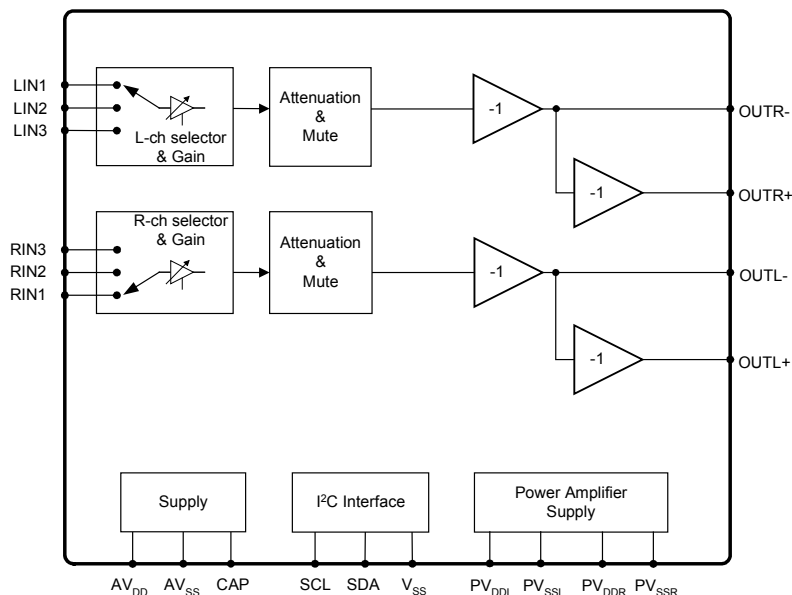
Multimedia system, Portable Digital Audio.

### DESCRIPTION

The MS6865 is low distortion stereo power amplifier that has 3 stereo inputs with volume control. It can drive 2W of continuous average power into a dual 4Ω bridged-tied (BTL) speaker or 2 \* 90mW into stereo 32Ω single ended (SE) headphone. The volume control offers wide range of gain and attenuation for stereo input. All of the functions are easy setting that can be set by I2C interface.

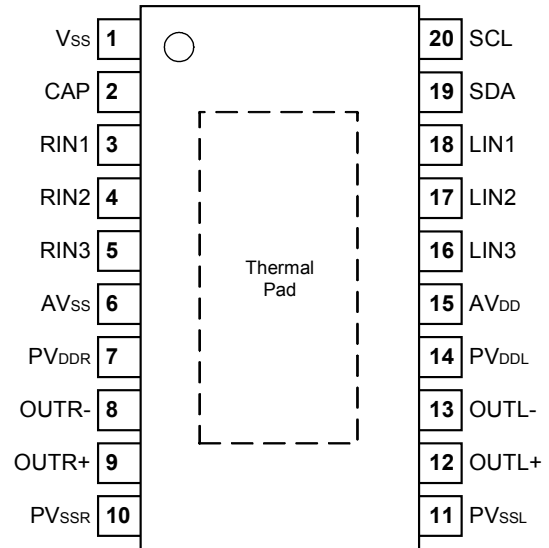
The MS6865 has good features for portable equipment, including wide voltage operation 2.4V~5.5V, low power consumption, power management, component less and small package TSSOP20, make the MS6865 ideally suitable for use in the portable digital audio equipments.

### BLOCK DIAGRAM



## PIN CONFIGURATION

Symbol	Pin	Description
V <sub>SS</sub>	1	Connected to ground
CAP	2	Capacitor connected
RIN1	3	Right channel input 1
RIN2	4	Right channel input 2
RIN3	5	Right channel input 3
AV <sub>SS</sub>	6	Negative supply voltage
PV <sub>DDR</sub>	7	Positive supply voltage for right channel of power amplifier
OUTR-	8	SE right channel output or negative output of BTL right channel
OUTR+	9	Positive output of BTL right channel
PV <sub>SSR</sub>	10	Negative supply voltage for right channel of power amplifier
PV <sub>SSL</sub>	11	Negative supply voltage for left channel of power amplifier
OUTL+	12	Positive output of BTL left channel
OUTL-	13	SE left channel output or negative output of BTL left channel
PV <sub>DDL</sub>	14	Positive supply voltage for left channel of power amplifier
AV <sub>DD</sub>	15	Positive supply voltage
LIN3	16	Left channel input 3
LIN2	17	Left channel input 2
LIN1	18	Left channel input 1
SDA	19	I <sup>2</sup> C data input
SCL	20	I <sup>2</sup> C clock input



MS6865, TSSOP20

Note: 1. SE: Single Ended. BTL: Bridged-Tied Load

## ORDERING INFORMATION

Package	Part number	Packaging Marking	Transport Media
20Pin TSSOP (lead free)	MS6865TGTR	MS6865G	2.5k Units Tape and Reel
20Pin TSSOP (lead free)	MS6865TGU	MS6865G	75 Units Tube

RoHS Compliance

## ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Rating	Unit
V <sub>DD</sub>	Supply voltage	6	V
V <sub>ESD</sub>	Electrostatic handling	2000	V
T <sub>STG</sub>	Storage temperature range	-65 to 150	°C
T <sub>A</sub>	Operating ambient temperature range	-40 to 85	°C
T <sub>J</sub>	Maximum junction temperature	150	°C
T <sub>S</sub>	Soldering temperature, 10 seconds	260	°C
R <sub>THJA</sub>	Thermal resistance from junction to ambient in free air TSSOP20 (enhanced thermal pad)	51	°C/W

### OPERATING RATINGS

Symbol	Parameter	Min	Typ	Max	Unit
V <sub>DD</sub>	Supply voltage	2.4	5	5.5	V

### 5V ELECTRICAL CHARACTERISTICS

(T<sub>a</sub>=25°C, V<sub>DD</sub>=5V, V<sub>SS</sub>=0V, f=1kHz; unless otherwise specified)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>DC Characteristics</b>						
V <sub>CAP</sub>	Voltage at CAP		0.5V <sub>DD</sub> -0.05	0.5V <sub>DD</sub>	0.5V <sub>DD</sub> +0.05	V
V <sub>DC</sub>	Output DC level		0.5V <sub>DD</sub> -0.05	0.5V <sub>DD</sub>	0.5V <sub>DD</sub> +0.05	V
I <sub>Q</sub>	Quiescent current	All devices are active, BTL	-	10	-	mA
		All devices are active, SE		6.7		
		L-ch (R-ch) PD, BTL		5.2		
		L-ch (R-ch) PD, SE		3.4		
I <sub>PD</sub>	Power down current	All devices power down	-	-	0.3	uA
		All devices power down, except CAP=1/2 VDD		12		
ATT	Mute attenuation				-90	dB
G <sub>RAN</sub>	Gain/Attenuation range	Gain	0	-	21	dB
		Attenuation	-77.5		0	dB
G <sub>STEP</sub>	Gain step		-	3	-	dB
A <sub>STEP</sub>	Attenuation step		-	1.25	-	dB
E <sub>GA</sub>	Gain/Attenuation step error		-	0.3	-	dB
V <sub>I2CH</sub>	Serial interface high input level		2			V
V <sub>I2CL</sub>	Serial interface low input level				0.8	V
<b>AC Characteristics</b>						
PSRR	Power supply rejection ratio	BTL Mode, R <sub>L</sub> =8Ω CAP=1uF, f=200Hz	-	61	-	dB
		SE Mode, R <sub>L</sub> =32Ω CAP=1uF, f=200Hz	-	65	-	dB
CS	Channel separation	BTL Mode, R <sub>L</sub> =8Ω Po=1W	-	78	-	dB
		SE Mode, R <sub>L</sub> =32Ω Po=60mW	-	81	-	dB
THD+N	Total harmonic distortion plus Noise	SE mode, R <sub>L</sub> =32Ω, 75mW	-	-65	-	dB
			-	0.0562	-	%
S/N	Signal-to-noise ratio	SE mode, A-weighting, 75mW	-	93	-	dB
P <sub>o</sub>	Maximum output power	BTL Mode, R <sub>L</sub> = 4Ω THD+N = 1%	-	2	-	W
		BTL Mode, R <sub>L</sub> = 8Ω THD+N = 1%	-	1.3	-	W
		SE Mode, R <sub>L</sub> = 32Ω THD+N = 0.1%	-	93m	-	W

PD: Power Down

### 3.3V ELECTRICAL CHARACTERISTICS

(Ta=25°C, V<sub>DD</sub>=3.3V, V<sub>SS</sub>=0V, f=1kHz; unless otherwise specified)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>DC Characteristics</b>						
I <sub>Q</sub>	Quiescent current	All devices are active, BTL	-	9	-	mA
		All devices are active, SE	-	6	-	
		L-ch (R-ch) PD, BTL	-	4.6	-	
		L-ch (R-ch) PD, SE	-	3.0	-	
<b>AC Characteristics</b>						
THD+N	Total harmonic distortion plus Noise	SE mode, R <sub>L</sub> =32 Ω, 35mW	-	-65	60	dB
			-	0.0562	0.1	%
P <sub>o</sub>	Maximum output power	BTL Mode, R <sub>L</sub> = 4 Ω THD+N = 1%	-	0.8	-	W
		BTL Mode, R <sub>L</sub> = 8 Ω THD+N = 1%	-	0.53	-	W
		SE Mode, R <sub>L</sub> = 32 Ω THD+N = 0.1%	-	35m	-	W

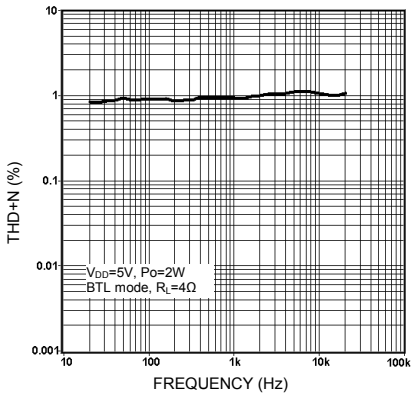
### 2.4V ELECTRICAL CHARACTERISTICS

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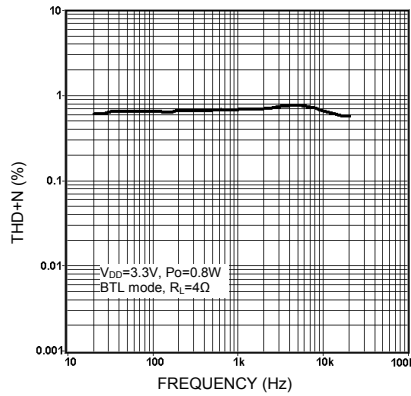
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>DC Characteristics</b>						
I <sub>Q</sub>	Quiescent current	All devices are active, BTL	-	7.6	-	mA
		All devices are active, SE	-	5.1	-	
		L-ch (R-ch) PD, BTL	-	4	-	
		L-ch (R-ch) PD, SE	-	2.6	-	
<b>AC Characteristics</b>						
THD+N	Total harmonic distortion plus Noise	SE mode, R <sub>L</sub> =32 Ω, 15mW	-	-65	-60	dB
			-	0.0562	0.1	%
P <sub>o</sub>	Maximum output power	BTL Mode, R <sub>L</sub> = 4 Ω THD+N = 1%	-	0.36	-	W
		BTL Mode, R <sub>L</sub> = 8 Ω THD+N = 1%	-	0.25	-	W
		SE Mode, R <sub>L</sub> = 32 Ω THD+N = 0.1%	-	15m	-	W

## TYPICAL PERFORMANCE CHARACTERISTICS

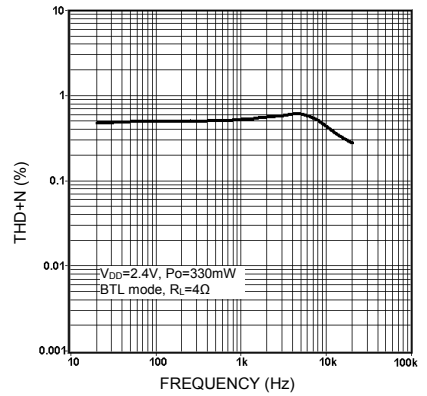
(Ta=25°C; unless otherwise specified)



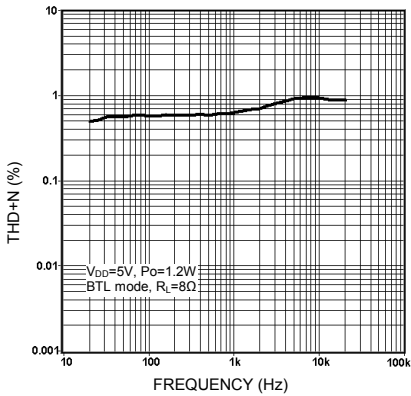
THD+N vs. frequency



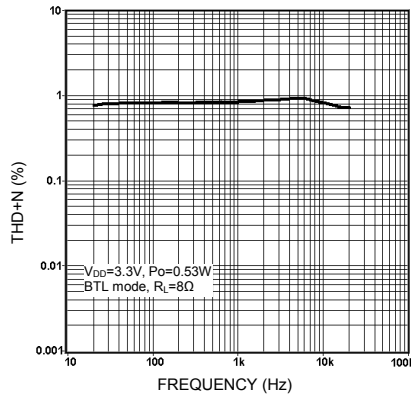
THD+N vs. frequency



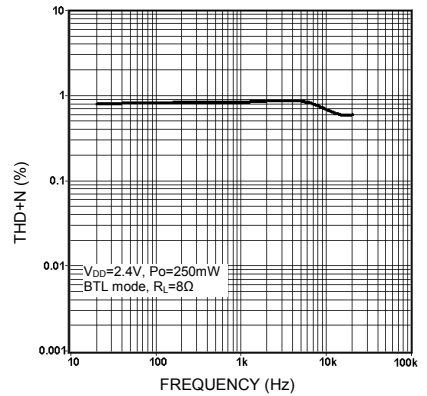
THD+N vs. frequency



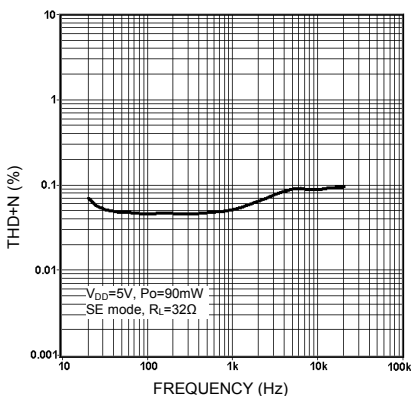
THD+N vs. frequency



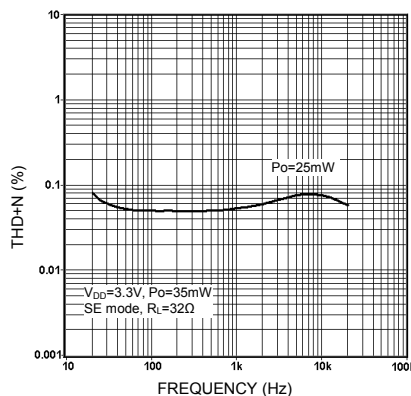
THD+N vs. frequency



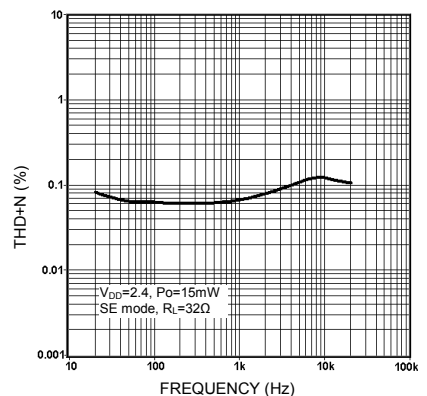
THD+N vs. frequency



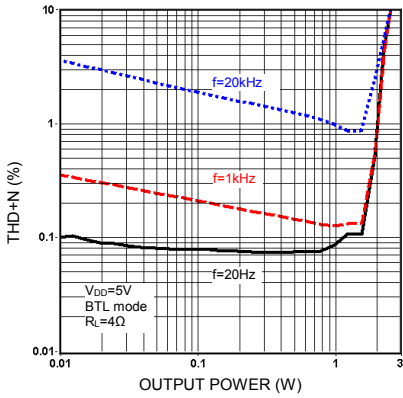
THD+N vs. frequency



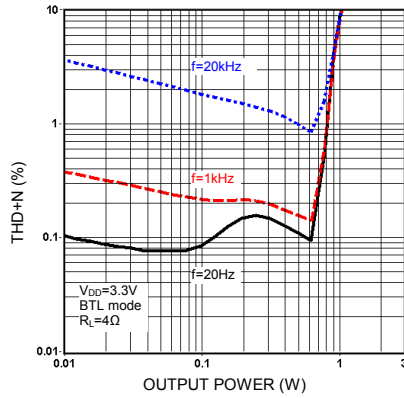
THD+N vs. frequency



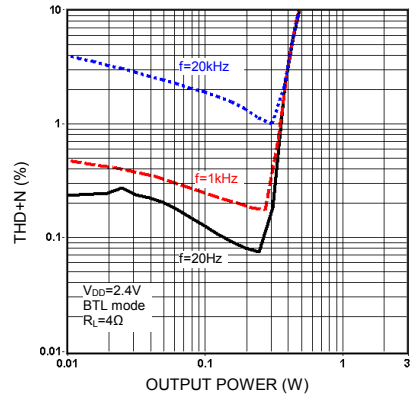
THD+N vs. frequency



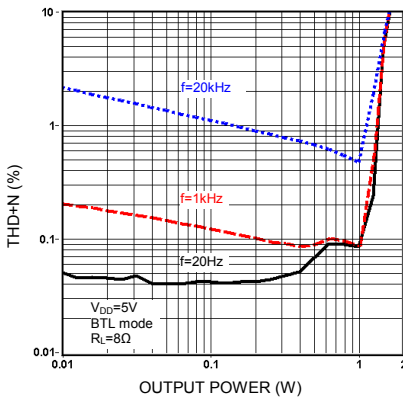
THD+N vs. output power



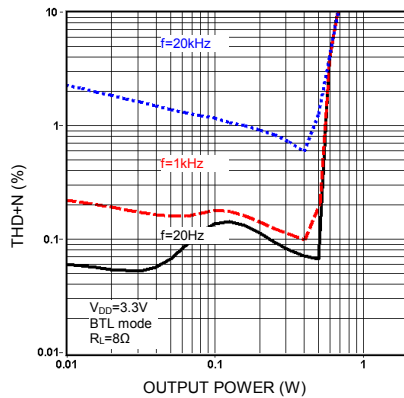
THD+N vs. output power



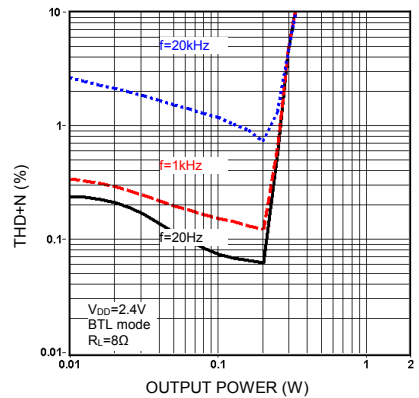
THD+N vs. output power



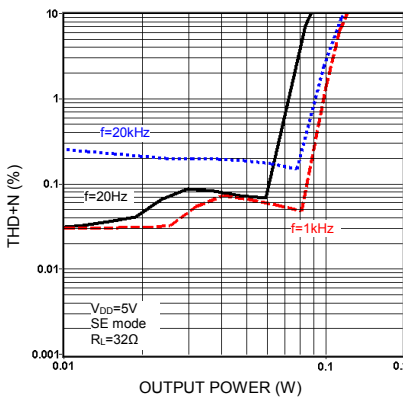
THD+N vs. output power



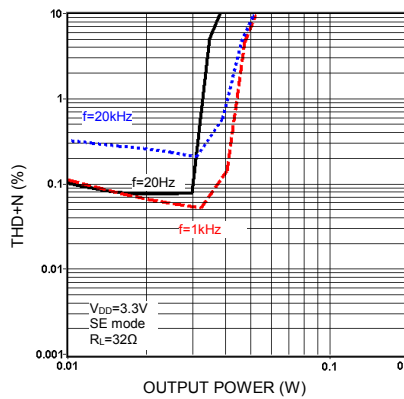
THD+N vs. output power



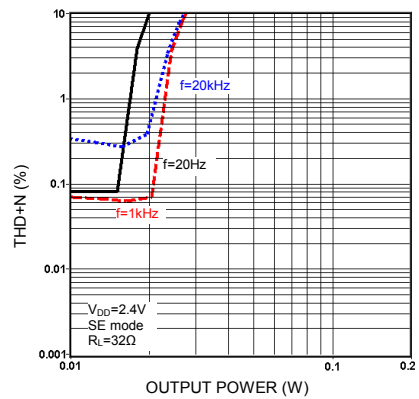
THD+N vs. output power



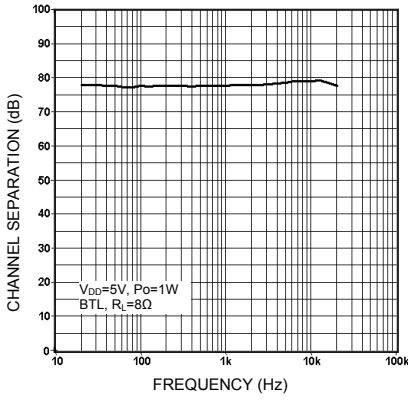
THD+N vs. output power



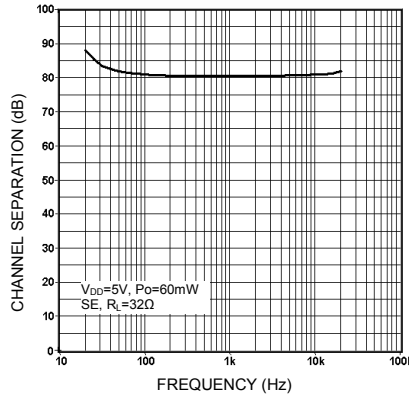
THD+N vs. output power



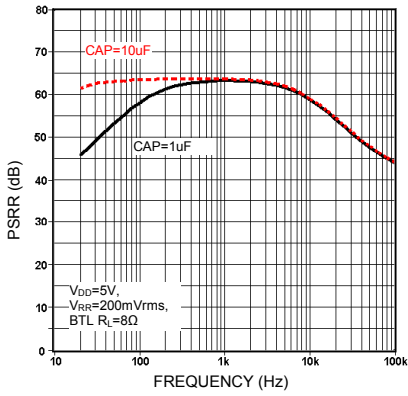
THD+N vs. output power



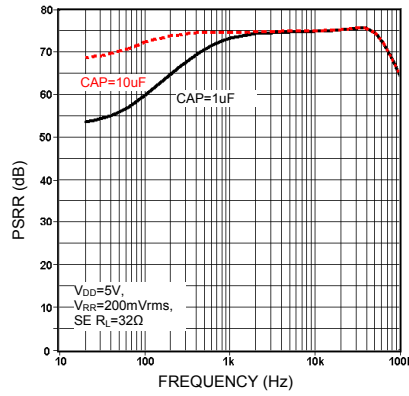
Channel separation vs. frequency



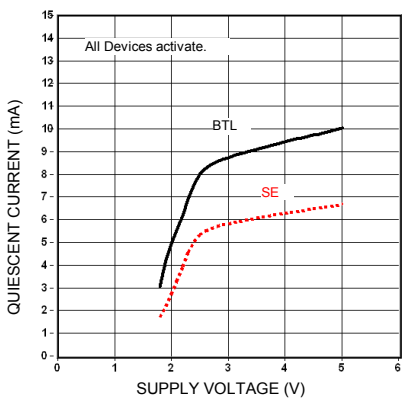
Channel separation vs. frequency



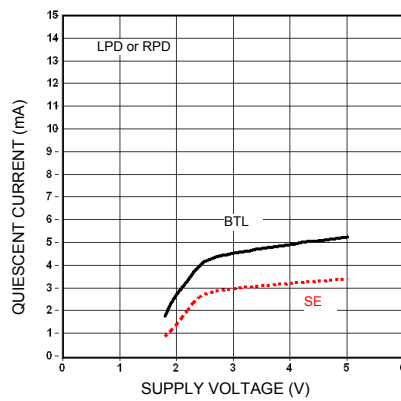
PSRR vs. frequency



PSRR vs. frequency



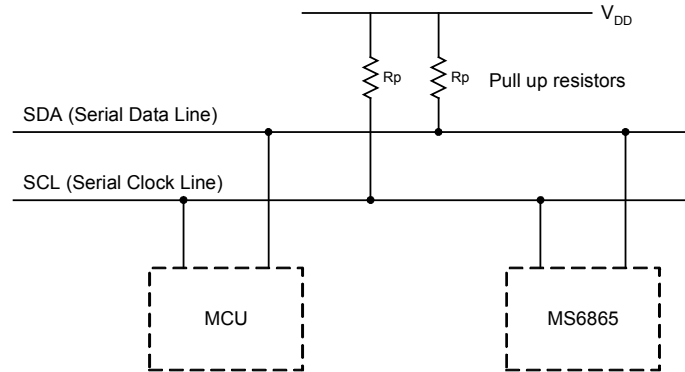
Quiescent current vs. supply voltage



Quiescent current vs. supply voltage

## I<sup>2</sup>C CONTROL INTERFACE

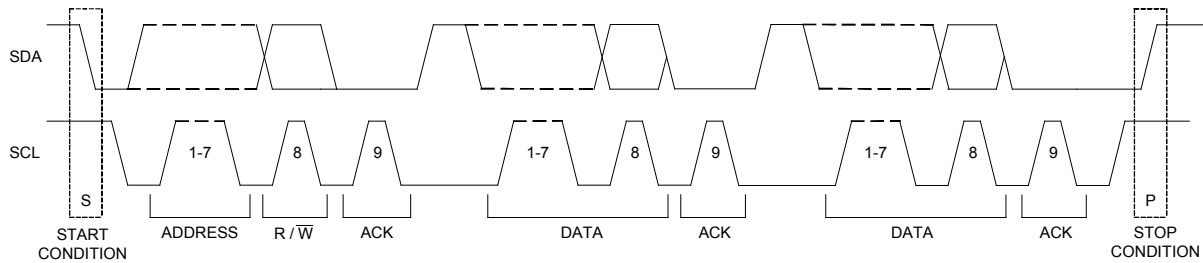
Data are transmitted to and from the MCU and MS6865 via the SDA and SCL. The SDA and SCL make up the BUS interface. It should be noted that pull-up resistors must be connected to the positive supply voltage.



### I<sup>2</sup>C interface protocol

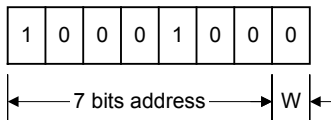
The format consists of the following:

- A START condition
- A chip address byte including the chip address. (7bits)
- The 8<sup>th</sup> 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



### I<sup>2</sup>C chip address

**88H**



### I<sup>2</sup>C data bytes description

MSB		LSB						Function
0	0	B2	B1	B0	A2	A1	A0	L-ch, Attenuation and Mute
0	1	B2	B1	B0	A2	A1	A0	R-ch, Attenuation and Mute
1	0	0	G2	G1	G0	S1	S0	L-ch, Input Gain and line Selection
1	0	1	G2	G1	G0	S1	S0	R-ch, Input Gain and line Selection
1	1	0	1	RPD	LPD	PDPR	CAP PD	Power Down Mode
1	1	1	S/B	0	0	0	0	Output mode (SE/BTL)

Where Ax = 1.25dB/step; Bx = 10dB/step; Gx = 3dB/step

Attenuation and Mute								
MSB		LSB						Function
0	0	B2	B1	B0	A2	A1	A0	L-ch, Attenuation and Mute
0	1							R-ch, Attenuation and Mute
					0	0	0	0 dB
					0	0	1	-1.25 dB
					0	1	0	-2.5 dB
					0	1	1	-3.75 dB
					1	0	0	-5 dB
					1	0	1	-6.25 dB
					1	1	0	-7.5 dB
					1	1	1	-8.75 dB
		0	0	0				0 dB
		0	0	1				-10 dB
		0	1	0				-20 dB
		0	1	1				-30 dB
		1	0	0				-40 dB
		1	0	1				-50 dB
		1	1	0				-60 dB
		1	1	1				-70 dB
		1	1	1	1	1	1	Mute

Initial state: Both L-ch and R-ch are mute-on.

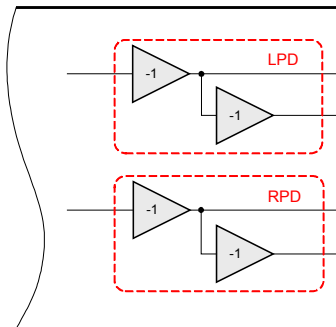
Input Selector and Input Gain									
MSB							LSB		Function
1	0	0	G2	G1	G0	S1	S0	L-ch, Input Gain and line Selection	
1	0	1						R-ch, Input Gain and line Selection	
						0	0	Line 1 (L-ch or R-ch)	
						0	1	Line 2 (L-ch or R-ch)	
						1	0	Line 3 (L-ch or R-ch)	
			0	0	0			0 dB	
			0	0	1			3 dB	
			0	1	0			6 dB	
			0	1	1			9 dB	
			1	0	0			12 dB	
			1	0	1			15 dB	
			1	1	0			18 dB	
			1	1	1			21 dB	

Initial state: L-ch1, R-ch1, Input gain is 0dB.

Power Down Mode									
MSB							LSB		Function
1	1	0	1	RPD	LPD	PDPR	CAP PD	Power mode selection and power management	
				0				R-ch PA output is active mode	
				1				R-ch PA output is power down mode	
					0			L-ch PA output is active mode	
					1			L-ch PA output is power down mode	
						0		Disable preparation for power off	
						1		Enable preparation for power off	
							0	Set the voltage of CAP to middle of supply voltage	
							1	Pull down CAP pin to ground	

Initial state: All are the power down modes.

Enable the power down preparation before the chip will be shut down.



Output mode (SE/BTL)								
MSB							LSB	Function
1	1	1	S/B	0	0	0	0	Output mode, mixer control and audio format
			0					Output mode is BTL
			1					Output mode is SE

Initial state: Output mode is BTL mode.

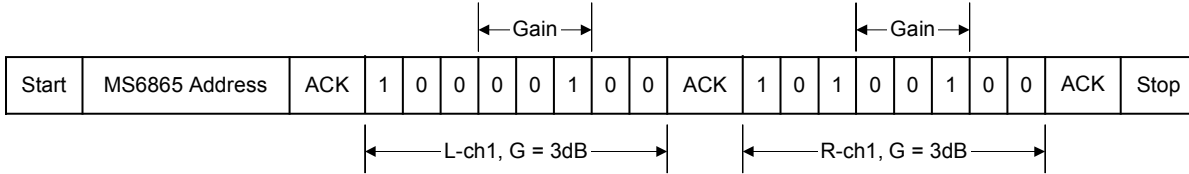
### I<sup>2</sup>C Initial code and status

MSB	LSB							Function	Initial status
0	0	1	1	1	1	1	1	L-ch, Attenuation and Mute	Mute On
0	1	1	1	1	1	1	1	R-ch, Attenuation and Mute	Mute On
1	0	0	0	0	0	0	0	L-ch, Input Gain and line Selection	Line1, 0dB
1	0	1	0	0	0	0	0	R-ch, Input Gain and line Selection	Line1, 0dB
1	1	0	1	1	1	1	1	Power Down Mode	All devices are power down
1	1	1	0	0	0	0	0	Output mode (SE/BTL)	BTL

## I<sup>2</sup>C CODE EXAMPLE

### Input gain

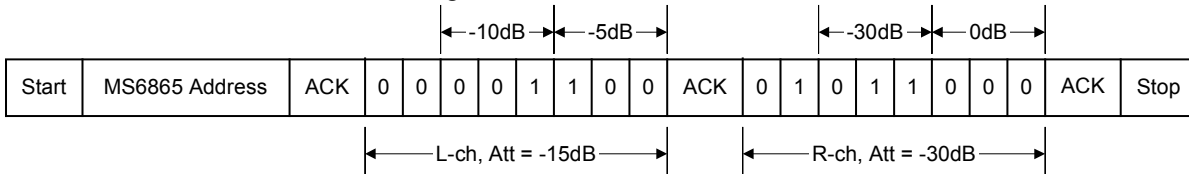
Set the left channel gain to be 3dB and the right channel gain to be 3dB



The left and right input channels are independent.

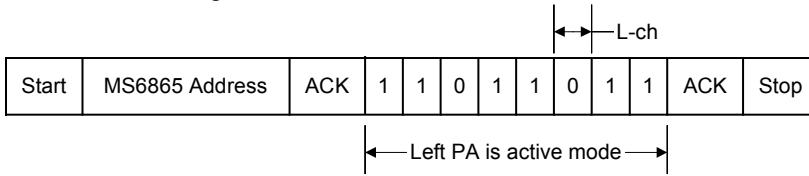
### Input Attenuation

Set the left channel to be -15dB and the right channel to be -30dB



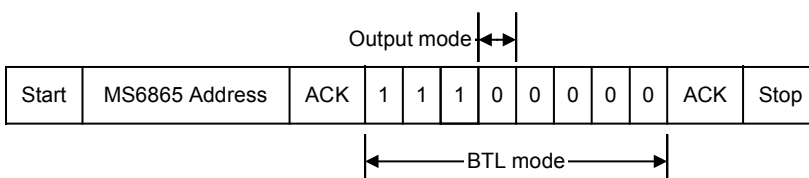
### Power down mode

Set the L-ch PA output to be active mode.



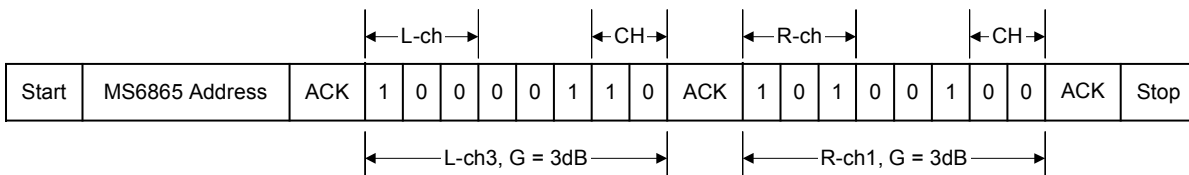
### Output mode

Set the output mode to be BTL mode



### Input Selector

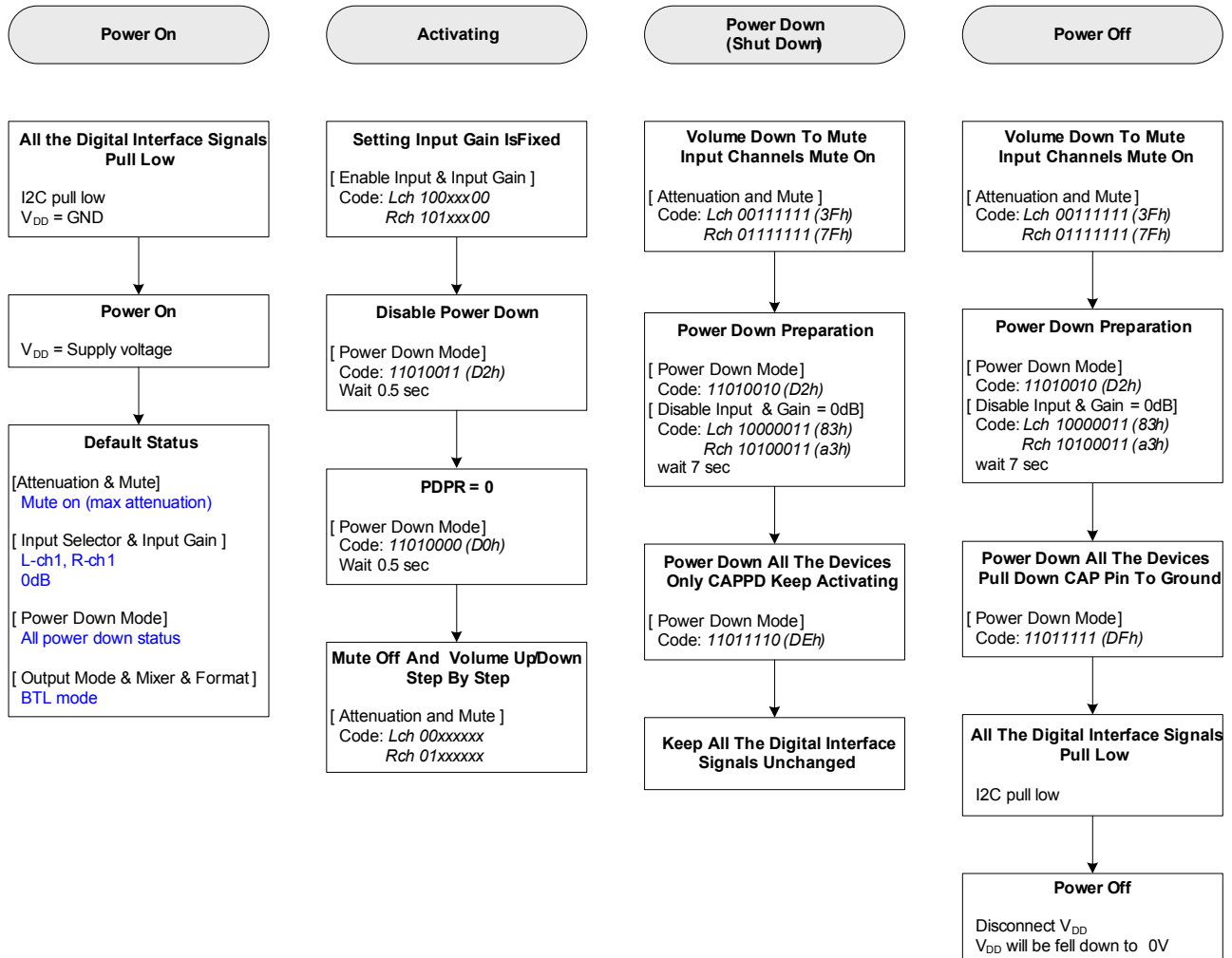
Set the left input channel to be LIN3 and the right input channel to be RIN1



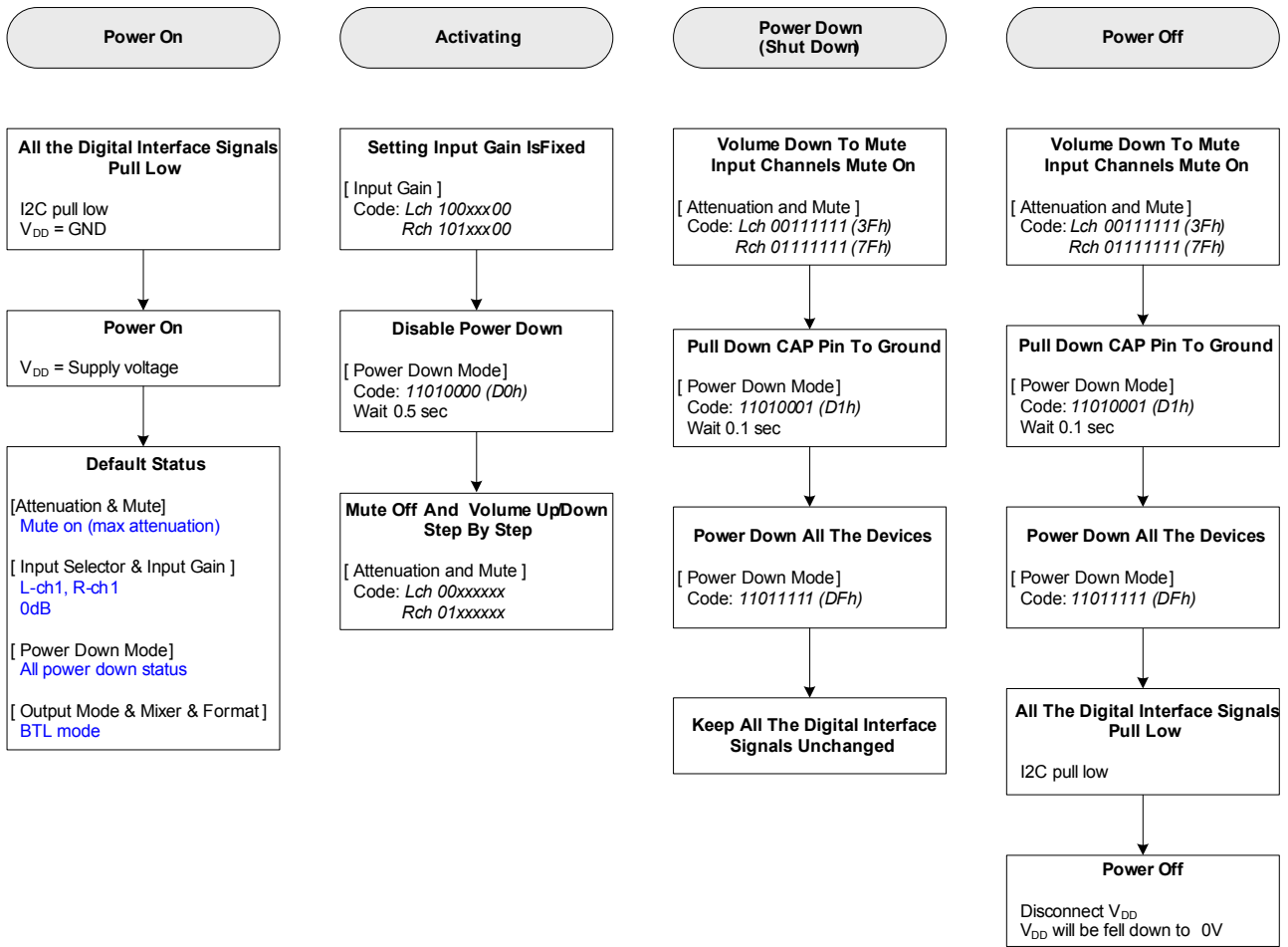
### OPERATION PROCEDURE

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

For HP mode and HP/BTL mode

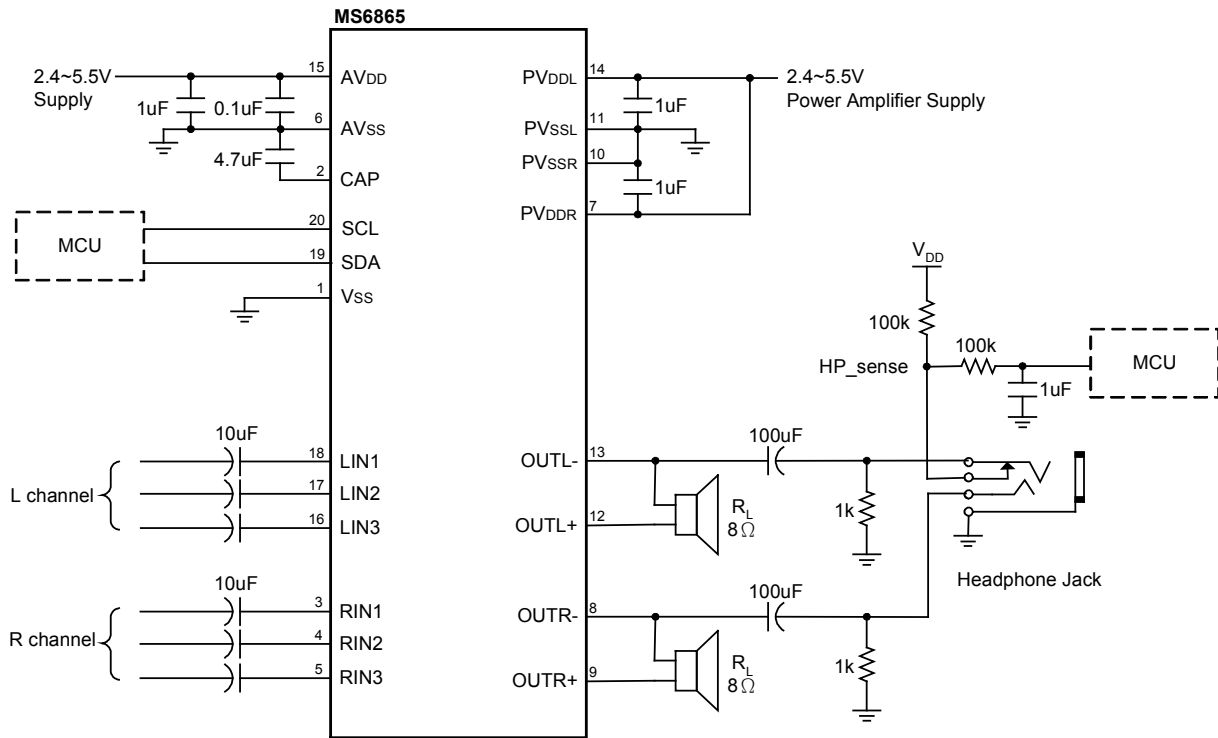


For BTL mode only



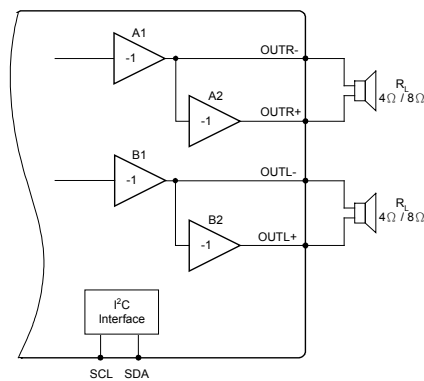
## APPLICATION INFORMATION

### A base application circuit

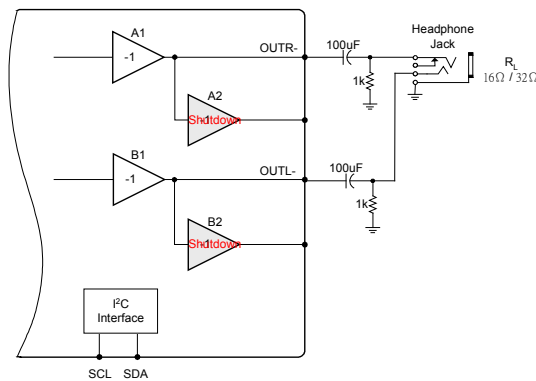


### Output mode operation -- SE mode and BTL mode

The output has two modes, SE mode and BTL mode. The mode is selected by I2C code via MCU. In BTL mode, the outputs of A1(B1) and A2(B2) are then used to drive the speakers(4Ω/8Ω).

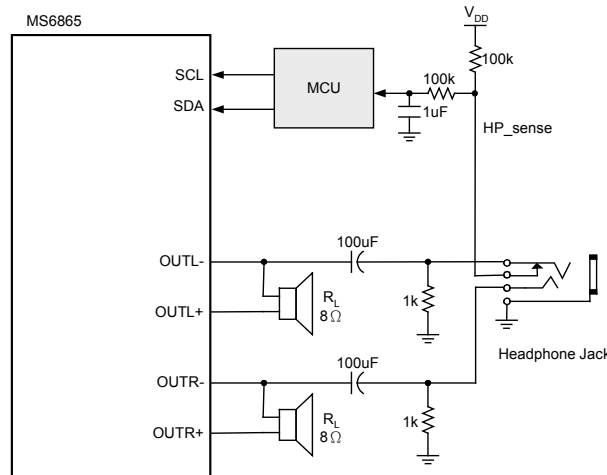


In the SE mode, the amplifiers A2 and B2 are shutdown, and become the high output impedance states.



### Headphone sense

The output mode is SE or BTL that is decided by a headphone. It has to be set SE mode when a headphone is plug-in status. The output mode is selected by I2C command code by MCU. Please note that the MS6865 don't detect a headphone automatically. Thus a detect function is executed via MCU. An operation diagram is shown as follows:



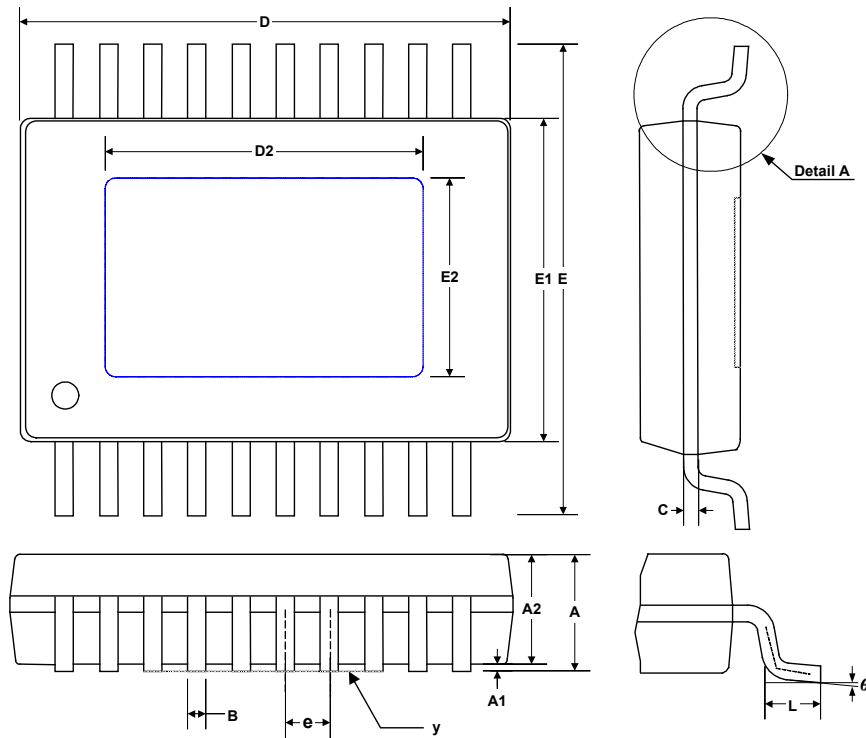
The HP\_sense pin is high when a headphone is plug-in.  
 The HP\_sense pin is low when a headphone is not plug-in.

### Thermal pad considerations

The thermal pad must be connected to ground. The package with thermal pad of the MS6865 requires the special attention on thermal design. The thermal pad on the bottom of the MS6865 should be soldered down to a copper pad on the circuit board. Heat can be conducted away from the thermal pad through the copper plane to ambient. If the copper plane is not on the top surface of the circuit board, 9 vias of 13 mil or smaller in diameter should be used to thermally couple the thermal pad to the bottom plane. For good thermal conduction, the vias must be plated through and solder filled.

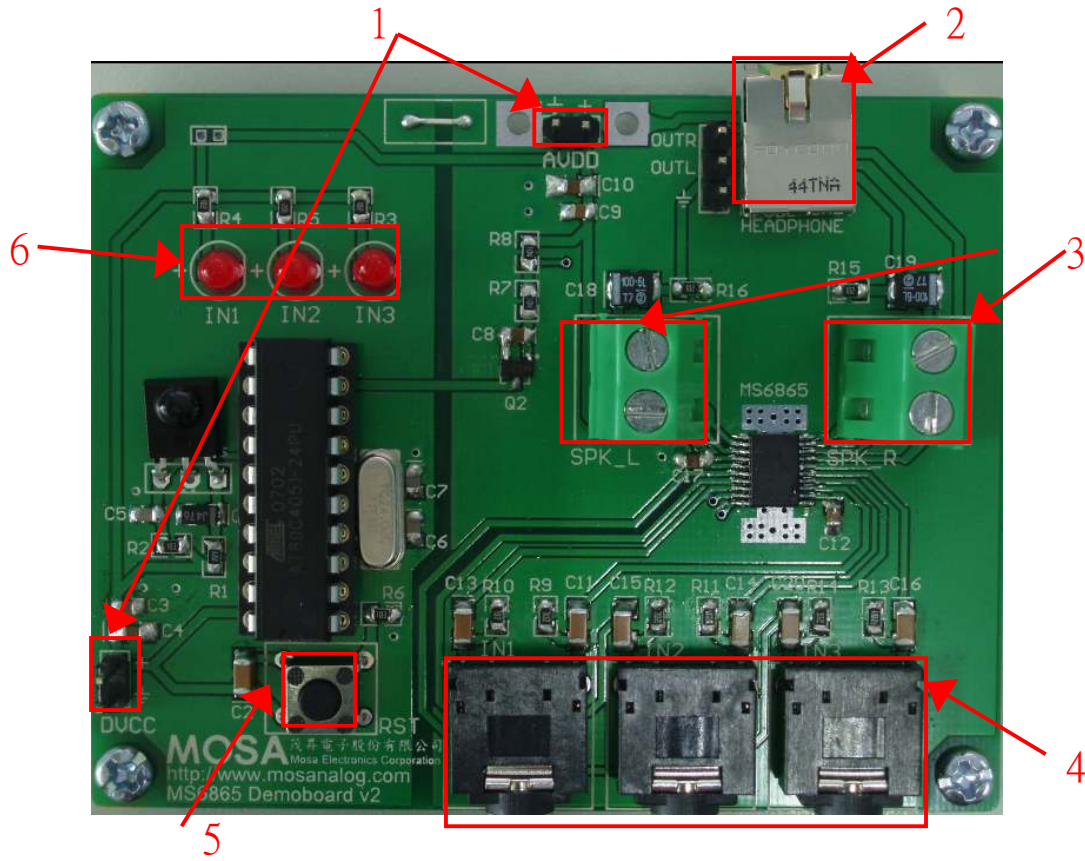
## EXTERNAL DIMENSIONS

### TSSOP20 (Thermal Pad)



Symbol	Dimension in mm			Dimension in inches		
	Min	Nom	Max	Min	Nom	Max
A	0.80	-	1.15	0.031	-	0.045
A1	0.00	-	0.10	0.000	-	0.004
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19	-	0.30	0.007	-	0.012
C	0.09	-	0.20	0.004	-	0.008
D	6.40	6.50	6.60	0.252	0.256	0.260
D2	3.70	3.80	3.90	0.146	0.150	0.154
E	6.20	6.40	6.60	0.244	0.252	0.260
E1	4.30	4.40	4.50	0.169	0.173	0.177
E2	2.70	2.80	2.90	0.106	0.110	0.114
e	0.650 BASIC			0.026 BASIC		
L	0.45	0.60	0.75	0.018	0.024	0.030
θ	0°	-	8°	0°	-	8°
y	-	-	0.10	-	-	0.004

## DEMO BOARD



### Function description

Label 1: Supply Input  
Supply voltage range is 2.4V to 5.5V.

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: Signal Input  
Connected to audio signals.

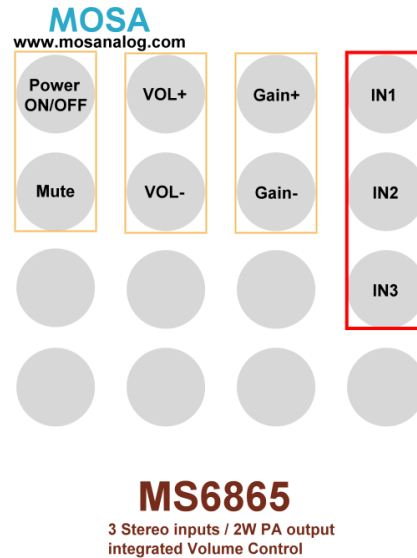
Label 5: Reset  
All I/O pins are reset to default values.

Label 6: LED Indicator  
The LEDs indicate the chip status and IR received status.  
Power ON status, it is red-dark blink twice and then keeps on a light state.  
Power OFF status, it is red-dark blink four times and then keeps on a dark state.  
It is red-dark blink once when the MCU has received the function code correctly.

### SE mode and BTL mode operation

The headphone controls operational mode. System enters SE mode when headphone jack is empty.  
When a set of headphone plugged into the jack, the system switched to BTL mode.

### IR Controller



**Power ON/OFF** : The power key.

Press the key once to set power-on or power-off for MS6865.

The default values are GAIN 0dB, ATTENUATION -20dB and MUTE-ON.

**VOL+, VOL-** : The volume control keys.

The volume control in 1.25dB/step as the switch is pressed once, the range is -78.75dB to 0dB.

**Gain+, Gain-** : The gain control keys.

The gain control in 3dB/step as the switch is pressed once, the range is 0dB to 21dB.

**PD/Active** : The power down key.

Press the key once to set power-down or activation for MS6865.

**Mute** : The mute key

Press the key once to set mute-on or mute-off.

**IN1~IN3** : Stereo input channel selection

There are three sets, stereo 1 to 3. The default channel is stereo 1 on initial status.

## Circuit

