AK5736 User's Guide

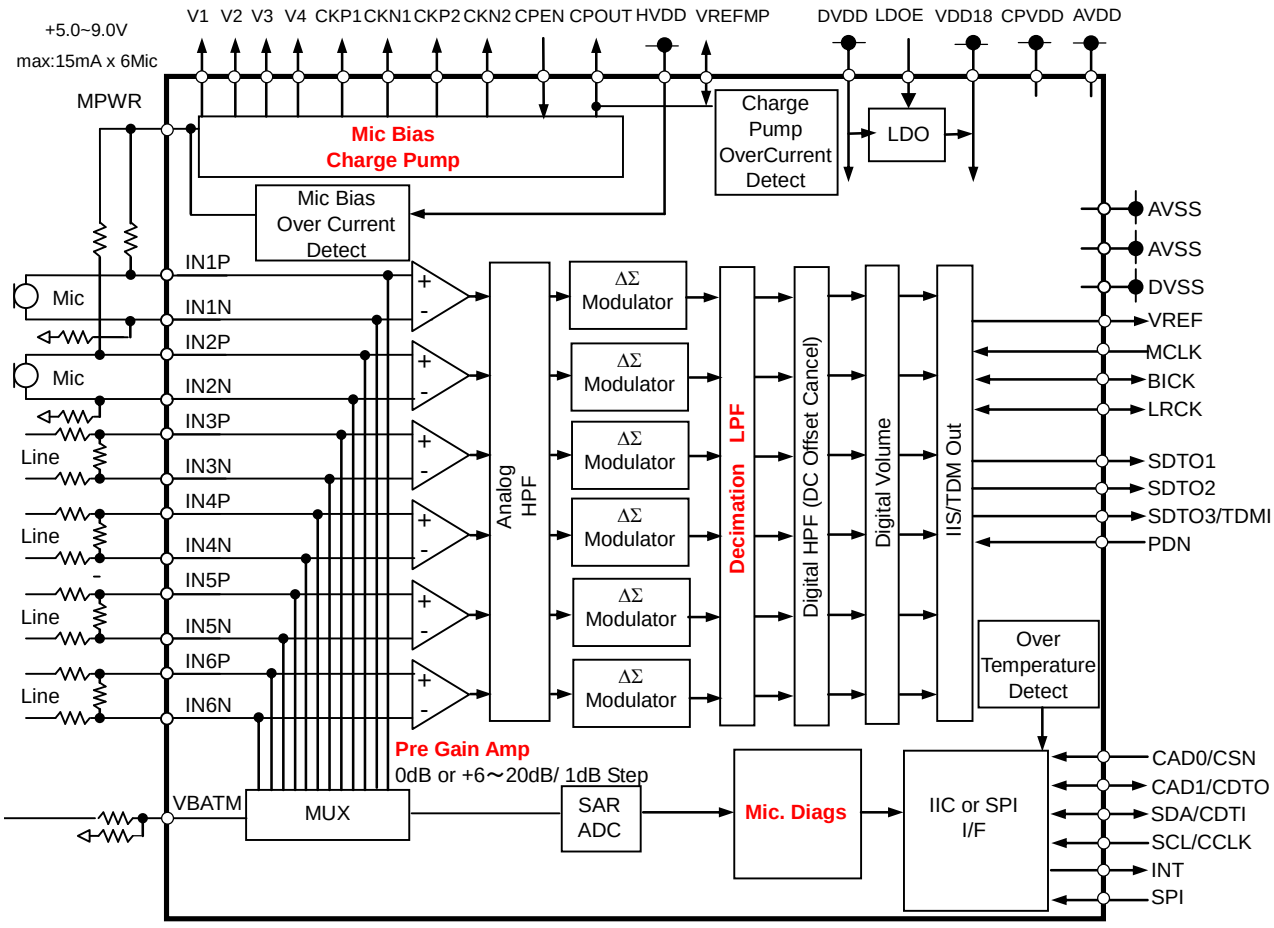
Function Setting of AK5736

1. General Description

The AK5736 is a 6ch ADC (Analog to Digital Converter) equipped with the diagnostic function which can monitor connection state of a microphone and input harness. This product can be operated with very low latency and is perfect for ANC (Active Noise Canceller) that needs high speed operation.
In this application note, features, setting methods and notes for functions below are mentioned.

2. Table of content

3. Block Diagram



4. Pre Gain Amp

The AK5736 is capable of keeping high S/N while setting the gain by using an internal PGA (Pre Amplifier Gain). The internal PGA can set the gain to 0dB and from +6dB to +20dB by 1dB step. Therefore, it is recommended to set the gain from 0dB to 20dB by PGA, and for over +20 dB Digital Volume is preferable to set the gain.

Figure 1 shows two type of S/N. The red one is the S/N vs gain set by the PGA and the digital volume. The gain from 0dB to 20dB is set by PGA, and the digital volume used from 20dB.

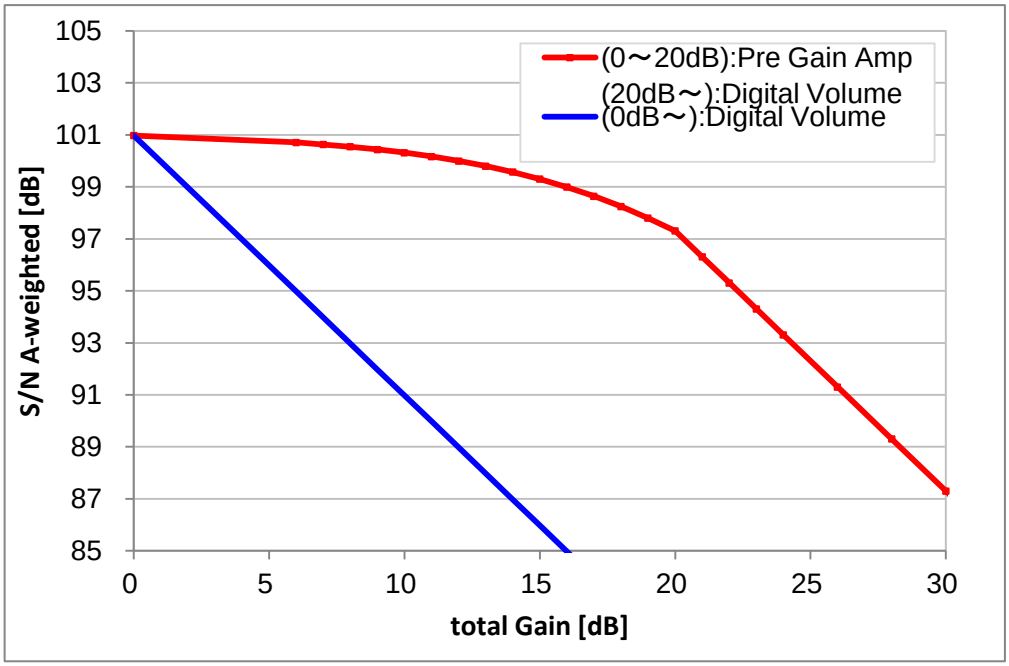


Figure 1. S/N vs Gain(Measurement value)

The PGA is located before ADC blocks. Set the gain by PG13-10 bits (1ch), PG23-20 bits (2ch), …, PG63-60 bits (6ch) so that the maximum input voltage to the ADC block becomes under 2Vrms.

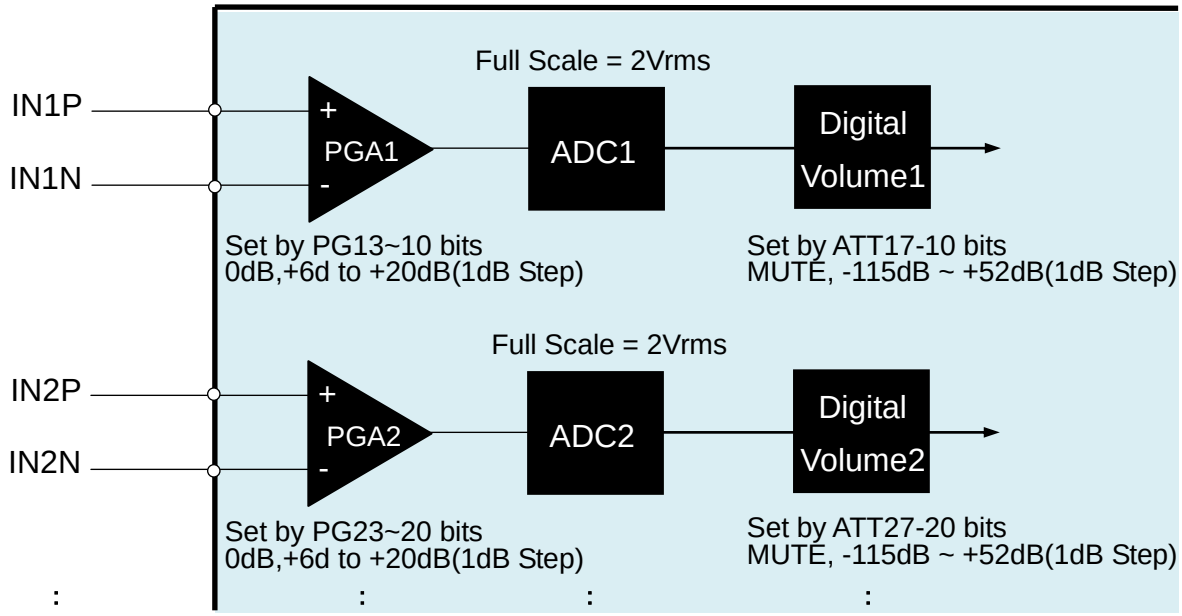


Figure 2. Internal gain circuits in AK5736

5. Digital Filter

The AK5736 has 4 types of digital filters. Short Delay Slow Roll-Off Filter (SD bit = “1”, SLOW bit = “1”) is suitable for ANC that requires high speed operation. There are two reasons for that, the one is Group Delay (GD) is the minimum among the four filters, and the other is that Group Delay Distortion (ΔGD) representing the difference in the GD at input signal 0kHz to 20kHz is very small as 1.2 fs (Figure 3) therefore there is almost no ΔGD in the low frequency area used for ANC.
When using the AK5736 for audio system, Sharp Roll-Off Filter (SD bit = “0”, SLOW bit = “0”) is the most suitable because the passband ripple is very low. This steep LPF makes the AK5736 possible to reproduce the original sound realistically when playing-back.

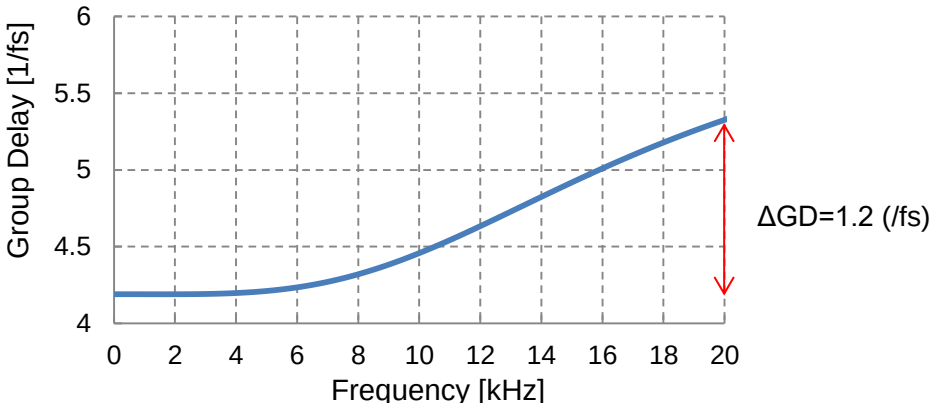


Figure 3. Group Delay Distortion
(SD bit = “1”, SLOW bit = “1”, fs = 48kHz)

【Reference】The filter characteristic of the two filter, SHORT DELAY SLOW ROLL-OFF FILTER and SHARP ROLL-OFF FILTER.
(Ta= -40~+105°C; AVDD =4.75~5.25V, DVDD=1.7~1.98V (LDOE pin = “L”), 3.0~3.6V (LDOE pin = “H”), VDD18= 1.7~1.98V (LDOE pin = “L”))

Digital Filter (Decimation LPF): SHORT DELAY SLOW ROLL-OFF (Figure 4) (SD bit=”1”, SLOW bit=”1”)						
Passband (Note 1)	±0.034dB –6.0dB	PB -	0 -	- 21.9	12.5 -	kHz kHz
Stopband (Note 1)		SB	36.5	-	-	kHz
Stopband Attenuation		SA	85	-	-	dB
Group Delay Distortion 0 ~ 20.0kHz		ΔGD	-	-	1.2	1/fs
Group Delay (Note 2)		GD	-	4.3	-	1/fs

Digital Filter (Decimation LPF): SHARP ROLL-OFF (Figure 5) (SD bit = “0”, SLOW bit = “0”)						
Passband (Note 1)	+0.001/–0.06dB –6.0dB	PB	0 -	- 24.4	22.0 -	kHz kHz
Stopband (Note 1)		SB	27.9	-	-	kHz
Stopband Attenuation		SA	85	-	-	dB
Group Delay Distortion 0 ~ 20.0kHz		ΔGD	-	0	-	1/fs
Group Delay (Note 2)		GD	-	18.8	-	1/fs

Note 1. The passband and stopband frequencies scale with fs.
For example, PB (+0.001dB/–0.06dB) =0.46 × fs (SHARP ROLL-OFF).
For example, PB (+0.001dB/–0.076dB) =0.26 × fs (SLOW ROLL-OFF).
Note 2. The digital filter’s delay is calculated as the time from inputting analog signal until an MSB output timing of SDTO L channel at the ADC block. It may cause +1/32 fs difference at the maximum when outputting the signal by an audio interface.

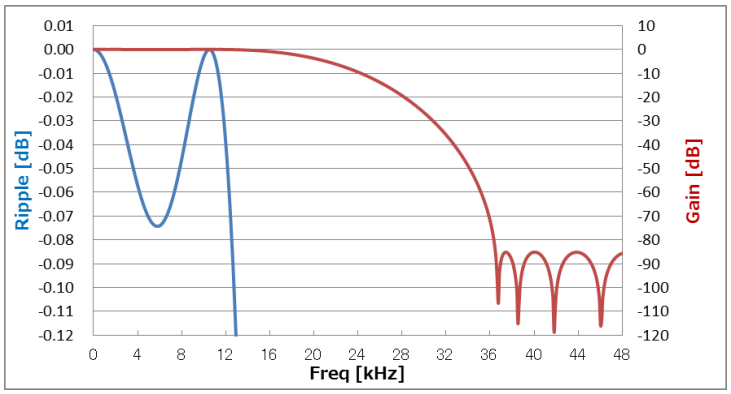


Figure 4. SHORT DELAY SLOW ROLL-OFF (fs=48kHz)

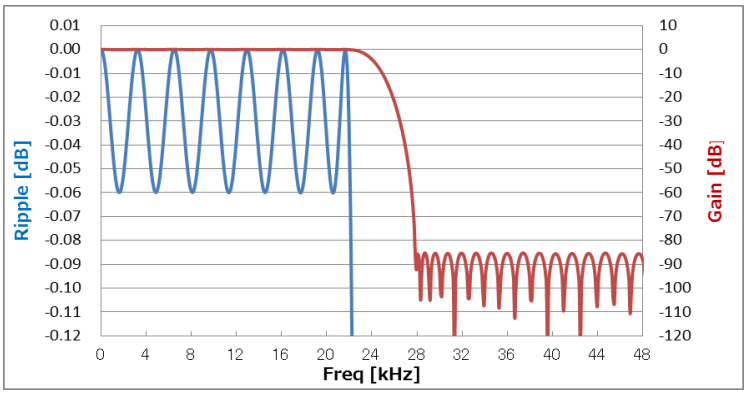


Figure 5. SHARP ROLL-OFF (fs=48kHz)

6. Charge Pump

For preventing interference to a radio IC by the charge pump frequency, the AK5736 has two operation mode, "**Internal Generation Mode(CPEN pin = "L")**" using the charge pump, and "**Outside Supply Mode(CPEN pin ="H")**" not using it. In this section, features and cautions of each mode are described.

Table 1. Comparison table of each mode

Item	Internal Generation Mode	Outside Supply Mode
Charge Pump Frequency	512kHz or 768kHz	-
Capacitors for Charge Pump	Necessary	Not necessary
Protection for HVDD pin (Connected to Battery)	Not necessary	Necessary 12~16V(Load Dump Suppressed)
Current Supply of MIC bias	80mA (Max.)	90mA (Max.)
Application	Single 3.3V power supply system	1. Multi power supply syetem, 3.3V and battery. 2. System using radio IC.

5-1 Internal Generation Mode（CPEN pin = "L"）

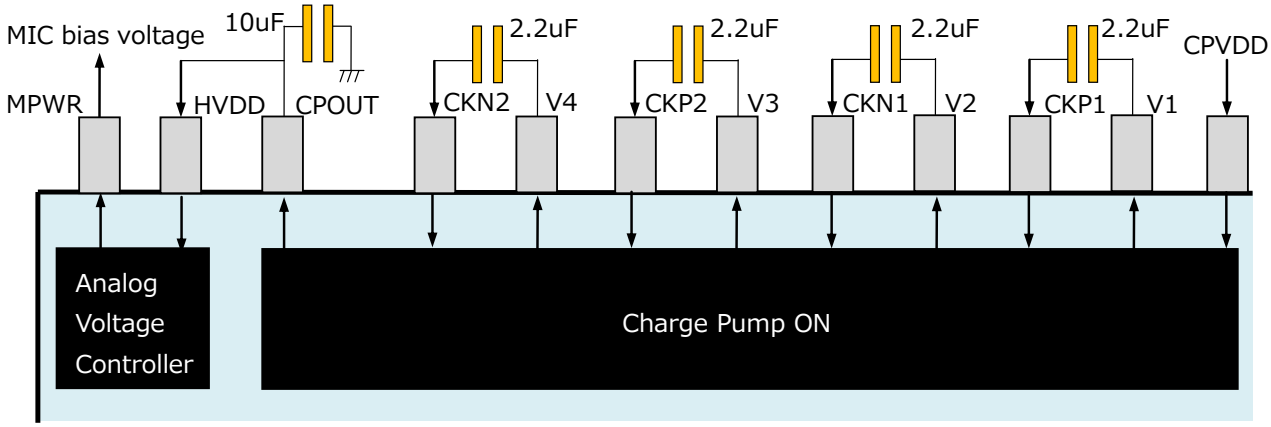


Figure 6. Internal Generation Mode(CPEN pin = "L")

MIC bias is generated by an internal charge pump. Single 3.3V power supply operation is enabled in this mode. A protection diode to the HVDD pin is not necessary since it does not have to connect the battery voltage unlike external supply mode. EMI by switching operation of the charge pump is generated when using the charge pump (Table 2). It is recommended to place radio IC and antenna wiring far from AK5736 in this mode .The current supply of MIC bias is shown below.
(Ta = 25°C; AVDD = DVDD = CPVDD = 3.0~3.6V; AVSS = DVSS = CPVSS = 0V; MCLK = 512fs, fs = 48kHz, BCLK = 64fs, CPEN pin = "L")

Parameter		min	typ	max	Unit
MIC Power Supply:					
Microphone Current (for 6 channels)	MBS3-0 bits = "0000"	-	-	50	mA
	MBS3-0 bits = "0001"	-	-	55	mA
	MBS3-0 bits = "0010"	-	-	60	mA
	MBS3-0 bits = "0011"	-	-	65	mA
	MBS3-0 bits = "0100"	-	-	70	mA
	MBS3-0 bits = "0101"	-	-	75	mA
	MBS3-0 bits = "0110"	-	-	80	mA
	MBS3-0 bits = "0111"	-	-	78	mA
	MBS3-0 bits = "1000"	-	-	66	mA

Note 3. Voltage difference between CPVDD and AVDD should be less than 0.1V.

Table 2. Relationship of LRCK, MCLK and Charge Pump Frequency

LRCK	MCLK(MHz)					Charge Pump Frequency
fs	128fs	192fs	256fs	384fs	512fs	
8kHz	-	-	-	-	4.096	512kHz
12kHz	-	-	-	-	6.144	768kHz
16kHz	-	-	4.096	6.144	8.192	512kHz
24kHz	-	-	6.144	9.216	12.288	768kHz
32kHz	-	-	8.192	12.288	16.384	512kHz
44.1kHz	-	-	11.2896	16.9344	22.5792	705.6kHz
48kHz	-	-	12.288	18.432	24.576	768kHz
72kHz	-	-	18.432	27.648	-	512kHz
96kHz	-	-	24.576	36.864	-	768kHz
144kHz	18.432	27.648	-	-	-	512kHz
192kHz	24.576	36.864	-	-	-	768kHz

5-2 External Supply Mode（CPEN pin =”H”）

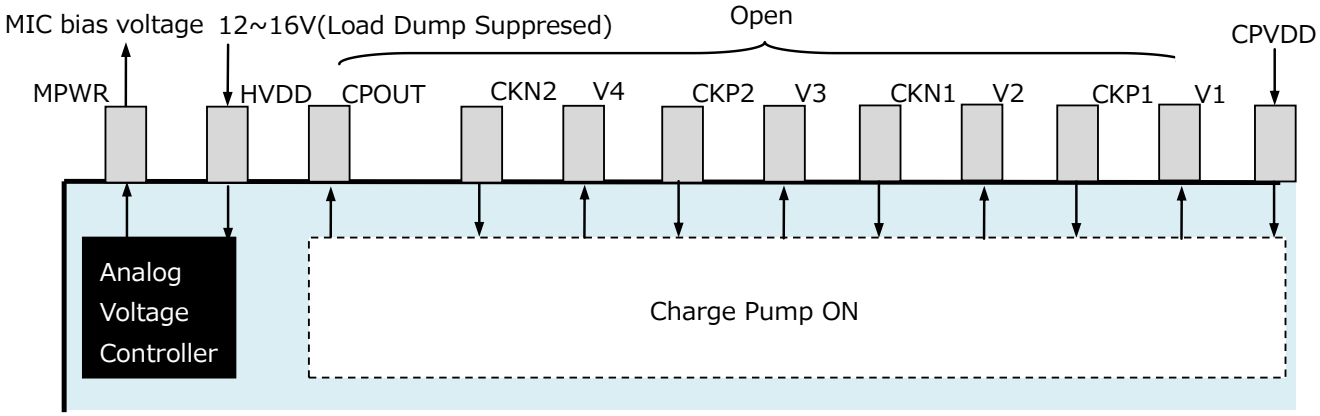


Figure 7. External Supply Mode（CPEN pin = “H”）

MIC bias is generated by battery voltage supplied to HVDD pin. There is no interference to a radio IC since the charge pump is not used and EMI is not generated.

Capacitors connected to CKP1,2 pin, CKN1,2 pin and V1~4 pin are not necessary. These pins and CPOUT pin can be opened. Connect CPVDD pin to AVDD pin.

Load dump suppressed voltage should be supplied to HVDD pin because the recommended operation conditions of HVDD is from 12V to 16V. If it falls below 12V, problems such as drop of MIC bias voltage and deterioration of diagnostics function may occur.

The current supply of MIC bias is shown below.

(Ta = 25°C; AVDD = DVDD = CPVDD = 3.0～3.6V; HVDD = 12.0~16.0V; AVSS = DVSS = CPVSS = 0V; MCLK = 512fs, fs = 48kHz, BCLK = 64fs, CPEN in = ”H”)

Parameter		min	typ	max	Unit
MIC Power Supply:					
Microphone Current (for 6 channels)	MBS3-0 bits = “0000”	-	-	50	mA
	MBS3-0 bits = “0001”	-	-	55	mA
	MBS3-0 bits = “0010”	-	-	60	mA
	MBS3-0 bits = “0011”	-	-	65	mA
	MBS3-0 bits = “0100”	-	-	70	mA
	MBS3-0 bits = “0101”	-	-	75	mA
	MBS3-0 bits = “0110”	-	-	80	mA
	MBS3-0 bits = “0111”	-	-	85	mA
	MBS3-0 bits = “1000”	-	-	90	mA

7. MIC bias

The AK5736 outputs MIC power supply (MIC bias) from the MPWR pin. In order to obtain sufficient supply current from the microphone bias voltage when the CPEN pin = "L", it is necessary to satisfy that the voltage difference between CPVDD and AVDD is less than 0.1V as specified in the datasheet. In this section, MIC bias current supply when the power supply conditions are out of specification of the AK5736 is shown.

The consumption current of the AK5736 can be greatly reduced when supplying MIC bias voltage externally instead of using internal MIC bias voltage.
In this section, cautions when MIC bias voltage of the AK5736 is not connected to the MIC are also written.

7-1 MIC bias current when the potential difference between CPVDD and AVDD becomes out of specification

When the CPEN pin =”L”, MIC bias current of the AK5736 depends on a potential difference between CPVDD and AVDD, and it decreases as the potential difference gets bigger. In the following table, MIC bias current when |CPVDD-AVDD| = 0.1V/0.2V/0.3V (0.2V and 0.3V are out of specification) is shown.

Table 3. MIC bias current when |CPVDD-AVDD| = 0.1V, 0.2V and 0.3V

	MIC bias current (max)		
MIC bias	AVDD=3.1V CPVDD=3.0V	AVDD=3.2V CPVDD=3.0V	AVDD=3.3V CPVDD=3.0V
5.0V	50mA	50mA	50mA
5.5V	55mA	55mA	55mA
6.0V	60mA	60mA	60mA
6.5V	65mA	65mA	65mA
7.0V	70mA	70mA	70mA
7.5V	75mA	75mA	75mA
8.0V	80mA	80mA	78mA
8.5V	78mA	70mA	64mA
9.0V	66mA	60mA	50mA

7-2 Cautions in supplying MIC power supply from external IC

The MIC bias voltage that the AK5736 generates internally is used for not only the power supply for a microphone, but also the criteria of diagnostics function of the AK5736 (Figure 8). Therefore when using an external power supply IC for a microphone, the accuracy of diagnostics will degrade since there is a voltage difference between the MIC bias of the external IC and the internal MIC bias for diagnostics thresholds.

When the MIC power bias is supplied by an external IC, criteria setting for diagnosis should be changed to the setting for external MIC bias by REFSEL bit (Table 4). In this case, the external MIC bias voltage must be input to the VBATM pin instead of battery voltage. (Figure 9)
Internal MIC bias voltage generator circuit should be powered down when using an external IC (PDMP_N bit = “0”). The power consumption current of the AK5736 can be greatly reduced by setting this (Table 5, Table 6). In addition, a resistor and a capacitor at the MPWR pin and a capacitor at the VREFMP pin can be eliminated. The MPWR and the VREFMP pins can be open.

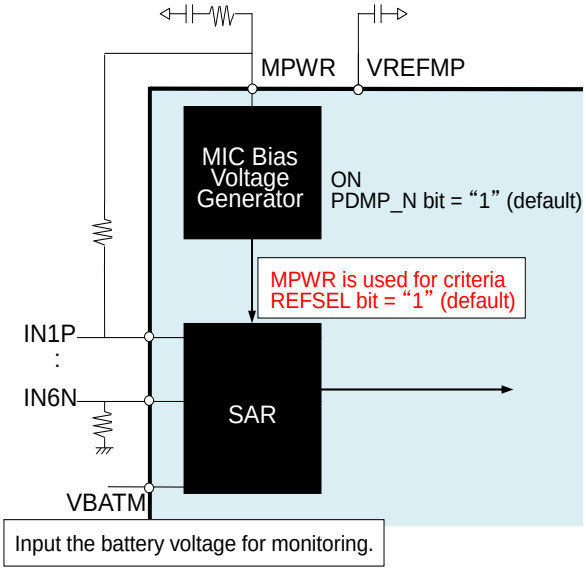


Figure 8. Using Internal MIC bias of AK5736

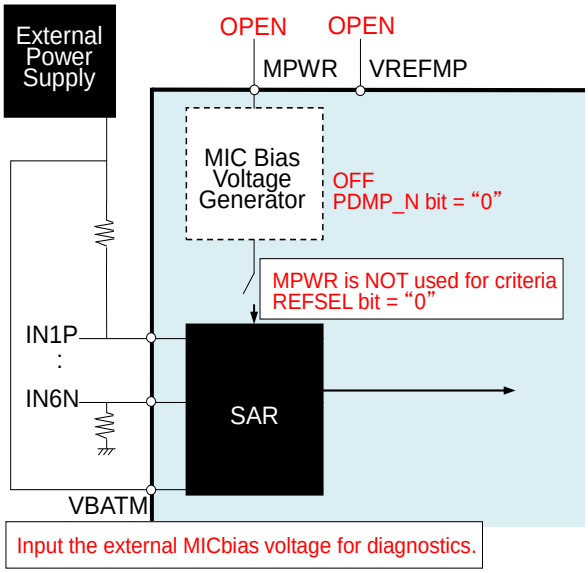


Figure 9. Using External MIC bias

Table 4. REFSEL Bit and the Criteria

No.	Error status	Error Criteria	
		Using Internal AK5736 MIC Bias Voltage for MIC MPWR Based REFSEL bit = “1”(default)	**Using External MIC Bias for MIC** VBATM Based REFSEL bit = “0”
1	OPEN	MPWR - Vth ≤ IN*P ≤ MPWR + Vth and IN*N ≤ Vth	VBATM - Vth ≤ IN*P ≤ VBATM + Vth and IN*N ≤ Vth
2	SHTD	IN*P ≤ Vth or IN*N ≤ Vth	IN*P ≤ Vth or IN*N ≤ Vth
3	SHTG	IN*P ≤ Vth or IN*N ≤ Vth	IN*P ≤ Vth or IN*N ≤ Vth
4	SHMB	IN*P/N ≥ MPWR - Vth	IN*P/N ≥ VBATM - Vth
5	SHTV	IN*P/N ≥ MPWR + Vth	IN*P/N ≥ VBATM + Vth
6	OVDET:	11.9V(typ)	11.9V(typ)
7	OIDET	350mA(typ)	350mA(typ)
8	OVCP	CPOUT = 5 ~7V(typ)	CPOUT = 5 ~7V(typ)
9	OVTP	160°C or more	160°C or more

Table 5. CPVDD Consumption Current with MIC Bias Connection Status to External MIC (CPEN pin="L")

	CPVDD Consumption Current (max)	
External Microphone	PDMP bit = "0"	PDMP bit = "1"
Connected (Iout = 80mA)	-	550mA
Not Connected (Iout = 0mA)	140mA	-

Note 4. MBS3-0 bits are set to "0110". The value written in "Not Connected" is the reference value in room temperature.

Table 6. HVDD Consumption Current with MIC Bias Connection Status to External MIC (CPEN pin = "H")

	HVDD Consumption Current (max)	
External Microphone	PDMP bit = "0"	PDMP bit = "1"
Connected (Iout = 90mA)	-	116mA
Not Connected (Iout = 0mA)	24mA	-

Note 5. MBS3-0 bits are set to"1000". The value written in "Not Connected" is the reference value in room temperature.

8. Diagnostics Function

The AK5736 has diagnostics function that monitors whether the analog input pins are correctly connected to a MIC module and its harness. The harness may short to the battery or the ground and the AK5736 detects error status of the harness.
In DC connection mode, errors 1~9 shown below can be detected. In AC connection mode, errors 6~9 can be detected.
In this section, the method to detect short to ground error in single-ended mode is described, it needs a special register setting. Please see the datasheet of the AK5736 to check the method to detect the other errors.

Table 7. Detectable error state (N/A: Not available)

No.	Error State	DC connection (Differential/Single-end)	AC connection (Differential/Single-end)
1	OPEN (Input Open)	Yes	N/A
2	SHTD (Short between Positive and Negative Inputs)	Yes	N/A
3	SHTG (Short to Ground)	Yes (Note 6)	N/A
4	SHMB(Short to MIC bias)	Yes	N/A
5	SHTV(Short to Battery)	Yes	N/A
6	OVDET(MIC Bias Overvoltage)	Yes	Yes
7	OIDET(MIC Bias Overcurrent)	Yes	Yes
8	OVCP(Charge Pump Under Voltage)	Yes	Yes
9	OVTP (Over temperature)	Yes	Yes

Note 6. Short to ground error is detected as SHTD in single-end mode.

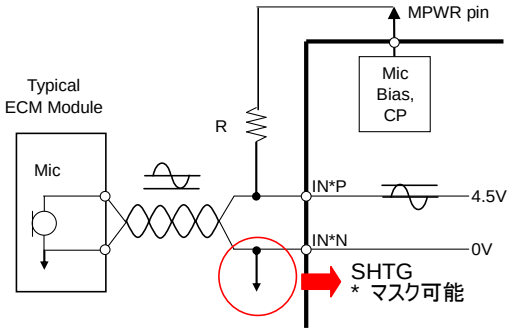


Figure 10. Single-end input (Normal)

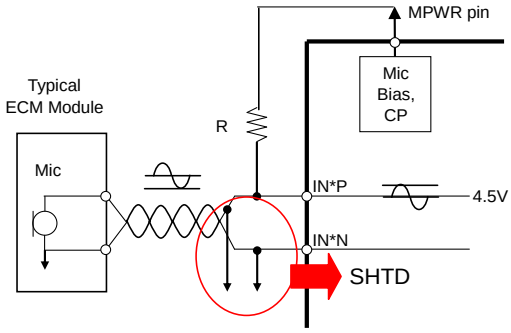


Figure 11. Single-end input (IN*P is short to ground)

In single-end mode, SHTG is always detected in IN*N pins because they are short to the ground(Figure 10). This error can be masked by MSHTG* bit =”1” assigned from address18H to 1DH.
If IN*P pins are short to ground in this mode, the voltage of IN*P pins became around ground level. Therefore when SHTG is masked, the error short to the ground is detected as SHTD (Short between Positive and Negative Input) . (Figure 11)。

9. Revision History

Date (Y/M/D)	Revision	Reason	Page	Contents
2018/06/14	01	First Revision		

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