AK2341

CTCSS Encoder/Decoder

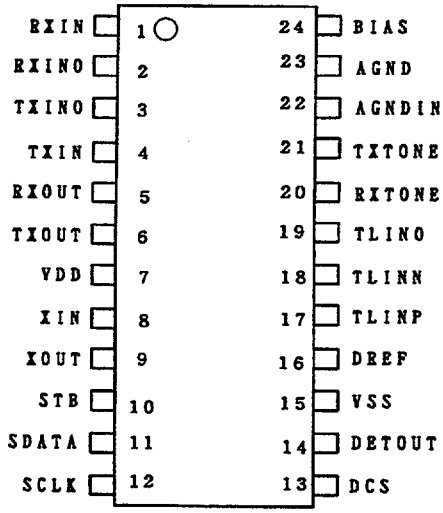
Features

- ☐ CTCSS (Continuous Tone Controlled Squelch System) Encoder/Decoder
- ☐ Can be programmed with up 50 frequencies.
- ☐ Built-in tone signal elimination filter
- ☐ Can conform to a DCS (Digitally Coded Squelch) system.
- ☐ Built-in power down function
- ☐ Built-in (3.6864 MHz) oscillator circuit with crystal oscillator
- ☐ Control register controlled via serial interface
- ☐ CMOS Process Low voltage operation (1.8~5.5 V)
- ☐ Compact plastic package is used (24 pin VSOP)

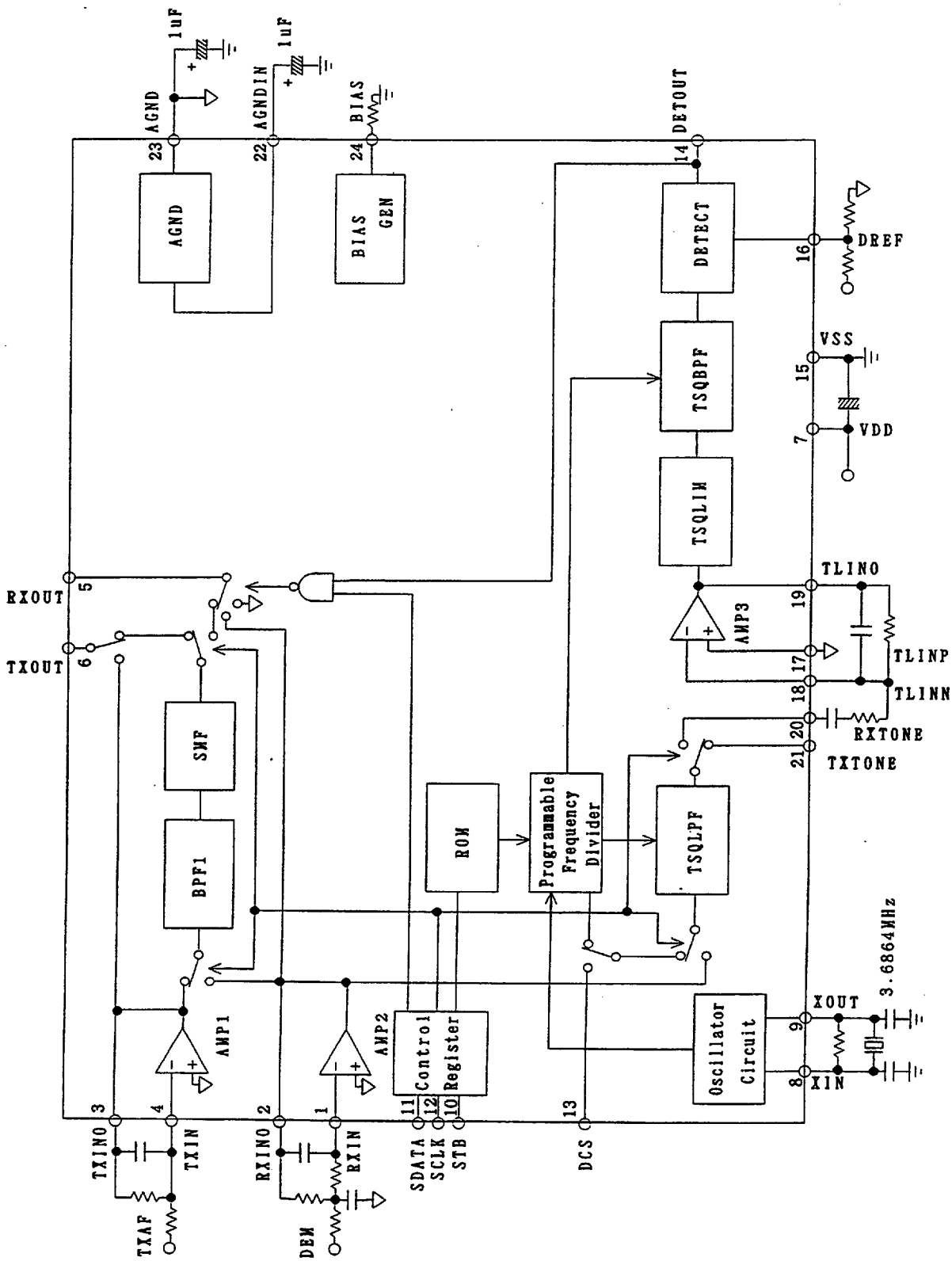
Outline

The AK2341 is an IC which supports CTCSS (Continuous Tone Controlled Squelch System), compatible with EIA RS220A standards.
One tone out of 50 frequencies between 67 and 254.1 Hz can be selected and that tone can be sent simultaneously with the voice signal during transmission.
During reception, by making the audio circuit operative only when a tone at that frequency is detected, it is possible to carry on multiple communications at the same wireless frequency.
A built-in tone signal elimination filter is included. This can be used to prevent the leakage of the tone to the voice signal during reception and CTCSS malfunction due to the voice signal during transmission.

■ Pin Arrangement



Block Diagram



Circuit Configuration

Block	Function
AMP 1	This is an operational amplifier used as a filter to adjust transmission voice signal gain and prevent SCF aliasing noise at later stages. Add external resistors and capacitors to lower the gain to 30 dB or lower and the cutoff frequency at about 10 kHz.
AMP 2	This is an operational amplifier used as a filter to adjust the reception voice and tone signal gain and prevent SCF aliasing noise at later stages. Add external resistors and capacitors to set the gain to 30 dB or lower and the cutoff frequency at about 10 kHz.
BPF1	This is a SCF circuit which limits signals input from AMP 1 and AMP 2 to the 300~3000 Hz band. This prevents voice signals at or below 300 Hz from being adversely affected by the tone signal during transmission. During reception, the tone signal is eliminated and only the voice signal is output to RXOUT.
SMF	This eliminates the high frequency component and clock component generated by BPF1.
Control Register	This is a storing circuit for CTCSS tone frequencies and control signals for switching between transmit and receive.
ROM	This circuit supplies frequency dividing ratios for the programmable frequency divider in order create 50 different tone signal frequencies according to the control signals stored in the control register.
Programmable Frequency Divider	This circuit generates the necessary clock for generating and detecting the 50 different tone signal frequencies.
Oscillatory Circuit	This circuit generates a 3.6864 MHz reference clock through the use of an external crystal oscillator and resistors and capacitor.
TSQLPF	This is a programmable filter which changes rectangular waves to sine waves. During reception, only the tone signal is extracted from the received signal. While in the DCS transmitting mode, digital code signals input to the DCS pin are limited by band-pass filtering and output to the TXTONE pin.
AMP3	This is an operational amplifier which amplifies the tone signal from TSQLPF and supplies it to TSQLIM. Set the final receiving tone detection level by adding external resistors and capacitors. It can also be used as a hysteresis comparator by changing the external circuit.
TSQLIM	This circuit limits the amplitude of the tone signal.
TSQBPF	This is a narrow band band-pass filter for differentiating the 50 tone signal frequencies. The center frequency is changed by a clock from a programmable frequency divider.
DETECT	This circuit uses the signals output by TSQBPF to judge whether there is a tone or not.
AGND	This circuit generates reference voltage for the internal analog circuit.
BIAS GEN	This circuit determines the operating current of the operational amplifier used internally.

Pin/Function

Pin No.	Pin Name	I/O	Function
1	RXIN	I	Receive demodulation signal input pin. This is the inverted input of AMP2. A prefilter is configured by connecting resistors and capacitors externally.
2	RXINO	O	AMP2 output pin. This pin can drive a 30kΩ (AC resistance) or higher load.
3	TXINO	O	AMP1 output pin. This pin can drive a 30kΩ (AC resistance) or higher load.
4	TXIN	I	Transmit voice input pin. This is the inverted input of AMP1. A mic amp is configured by connecting resistors and capacitors externally.
5	RXOUT	O	Receiving voice signal output pin. It can drive a 10 kΩ (AC resistance) or higher load. When in the transmit mode, the potential at AGND is output. When in the standby state, the impedance at this pin becomes high. When in the voice through mode, it is connected to the AMP 1 output.
6	TXOUT	O	Transmitting voice signal output pin. It can drive a 10 kΩ (AC resistance) or higher load. When in the receive mode, the potential at AGND is output. When in the standby state, the impedance at this pin becomes high. When in the voice through mode, it is connected to the AMP 1 output.
7	VDD	–	Positive power supply pin. A 1.8~5.5 V voltage is applied.
8 9	XIN XOUT	I O	Crystal oscillator connection pins. By connecting a 3.6864 MHz oscillator between these 2 pins, a reference clock used internally by the IC is created. If a clock is supplied externally, XOUT is left open and the clock signal is applied to XIN.
10	STB	I	Serial data strobe signal input pin.
11	SDATA	I	Serial data input pin. 8 bit serial data are input for setting operating modes or CTCSS tone frequencies, etc.
12	SCLK	I	Clock input pin for serial data.
13	DCS	I	DCS signal input pin. When in the DCS transmit mode, the DCS (Digitally Coded Squelch) signal, generated by the microprocessor, is input.
14	DETOUT	O	Tone detect signal output pin. (open drain output) When in the receive mode, if a tone at the frequency set by serial data is detected, this signal goes "L". In the transmit mode, it is high impedance at all times.
15	VSS	–	Negative power supply pin. A voltage of 0 V is applied.

Pin No.	Pin Name	I/O	Function
16	DREF	I	Tone detect level adjust pin. The tone decoder's threshold level is determined by applying a DC voltage greater than the AGND potential to this pin. Normally, a voltage of approximately 1.16 V is applied when the VDD = 2.0 V.
17	TLINP	I	Receive tone signal reference voltage input pin. This is the noninverted input of AMP3. Normally, it is connected to the AGND pin. By changing the external circuit, AMP 3 can be used as a comparator.
18	TLINN	I	Receive tone signal input pin. This is the inverted input of AMP3. By using external resistors and capacitors, the receive tone minimum detection level is set.
19	TLINO	O	AMP3 output pin. This pin can drive a 10kΩ (AC resistance) or higher load.
20	RXTONE	O	Receive ton signal output pin. This is the TSQLPF output pin. When in the receive mode, only the tone signal is output from among the voice and tone signals input from DEM. It can drive a 5kΩ (AC resistance) or higher load.
21	TXTONE	O	Transmit tone signal output pin. When in the transmit mode, a tone of the frequency set by serial data is output from this pin. When in the receive mode, the AGND potential is output. When in the standby state, the impedance at this terminal becomes high. It can drive a 10 kΩ (AC resistance) or higher load.
22	AGNDIN	I	Analog ground input pin. Connect a condenser to stabilize the analog ground.
23	AGND	O	Analog ground pin. A 1/2 VDD voltage, which becomes the reference for the analog circuit, is output. Connect a capacitor to stabilize the analog ground.
24	BIAS	I	Bias resistor connection pin. Connect a resistor with a resistance value determined by the power supply voltage between this pin and VSS.

Absolute Maximum Ratings

Parameter	Symbol	min	max	units
Power Supply Voltage: (VDD)	VDD	-0.3	7	V
Ground Level	VSS	0	0	V
Input Current (except power supply pin)	I_{IN}	-10	+10	mA
Analog input voltage	V_{AIN}	-0.3	VDD+0.3	V
Digital input voltage	V_{DIN}	-0.3	VDD+0.3	V
Storage temperature	Tstg	-55	130	℃

Note: All voltages are with respect to the VSS pin.
Caution: If this device is used in conditions which exceed these values, the device may be destroyed. In addition, normal operation cannot be assured.

Recommended Operating Conditions

Parameter	Symbol	min	typ	max	units
Operating temperature	Ta	-30		70	℃
Power supply voltage: R_{BIAS}= 75kΩ	VDD	1.8	2.0	2.5	V
(VDD) R_{BIAS}=330kΩ		4.5	5.0	5.5	
Analog reference voltage	AGND		1/2VDD		V
Current consumption					
DCS=1, STBY=1 (Mode 0)	Idd0		0.03	0.1	
DCS=0, STBY=1 (Mode 1)	Idd1		1.0	2	mA
STBY=0 (Mode 3)	Idd2		3.4	7	

Note: All voltages are with respect to the VSS pin.

Digital Characteristics

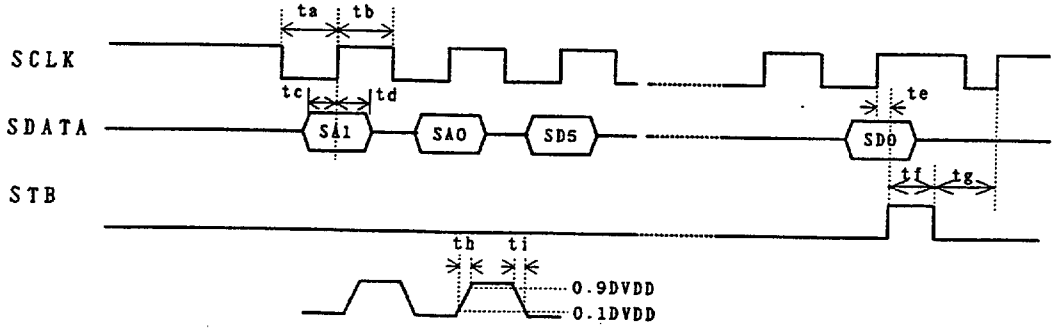
1. DC Characteristics

Parameter	Terminal	Symbol	min	typ	max	units
High level input voltage	(1)	V_{IH}	70%VD+			V
Low level input voltage	(1)	V_{IL}			30%VD+	V
High level input current V_{IH}=VD+	(1)	I_{IH}			10	μA
Low level input current V_{IL}=0V	(1)	I_{IL}	-10			μA
Low level output voltage I_{OL}=0.8mA	(2)	V_{OL}			0.3	V

(1)SDATA, SCLK, STB
(2)DETOUT

2. AC Characteristics

Parameter	Symbol	min	typ	max	units
Master Clock Frequency	fclk		3.6864		MHz
Serial data input timing					
Clock pulse width 1	ta	500			ns
Clock pulse width 2	tb	500			ns
SDATA Set Up time	tc	100			ns
SDATA Hold time	td	100			ns
STROBE Set up time	te	100			ns
STROBE pulse width	tf	100			ns
STROBE dehold time	tg	100			ns
digital input rising time	th			250	ns
digital input falling time	ti			250	ns



Serial Data Input

Analog Characteristics

0dBm=0.775Vrms
0dBx=-5dBm at AVDD=2V
Note 5)

1) TX System

Parameter		min	typ	max	units
Reference input level	@TXINO		-10		dBx
Absolute gain	TXINO→TXOUT 1kHz	-5	-4	-3	dB
Maximum output level	@TXOUT	-4			dBx
Noise level	@TXOUT Note 1)			-62	dBm
Transmit tone output level	@TXTONE	-12	-10	-8	dBx
Transmit tone frequency deviation	@TXTONE	-0.3		+0.3	%
Transmit tone distortion	@TXTONE		-35	-26	dB
DCS signal gain	DCS→TXTONE	-2	0	+2	dB
Maximum DCS signal input level	@DCS	0			dBx

2) RX System

Parameter		min	typ	max	units
Reference input level	@RXINO		-10		dBx
Absolute gain	RXINO→RXOUT 1kHz	-5	-4	-3	dB
Maximum output level	@RXOUT	-4			dBx
Noise level	@RXOUT Note 1)			-62	dBm
Receive tone detect level	RXINO→DETOUT Note 2)	-38			dBx
Receive tone nondetect level	RXINO→DETOUT Note 3)			-18	dBx
Receive tone detect time	RXINO→DETOUT Note 4)			200	ms

3) Operational Amplifier

Parameter			min	typ	max	units
Gain Error	AMP1 AMP2 AMP3	60Hz～3.4kHz Set Gain 0～30dB	-1	0	1	dB

4) Filter Characteristics

Parameter		min	typ	max	units
Voice filter characteristics	250Hz		-42	-38	dB
(see Fig. 1) TXINO→TXOUT	300Hz	-2.5		0.5	dB
Absolute value when	350Hz	-1		1	dB
the gain at 1 kHz	3kHz	-1		1	dB
is 0 dB.	3.6kHz			-40	dB

Note 1) After passing the 30 kHz LPF, Tone frequency setting : "11000000" (OFF)
Note 2) Frequency deviation within ± 0.5%. See the external circuit example.
Note 3) Frequency deviation ± 3.0% or greater.(TSQBPF Q value is "H") See the external circuit example.
Note 4) During -20 dBx, 162.2 Hz input. See the external circuit example.
Note 5) dBx is standardized so that it can handle all voltages between 1.9～5.5 V. When the voltage is 2 V, 0 dBx = -5 dBm. If we let the voltage be X [V],

$$0\ \text{dBx} = -5 + 20 \log (X/2)\ \text{[dBm]}$$

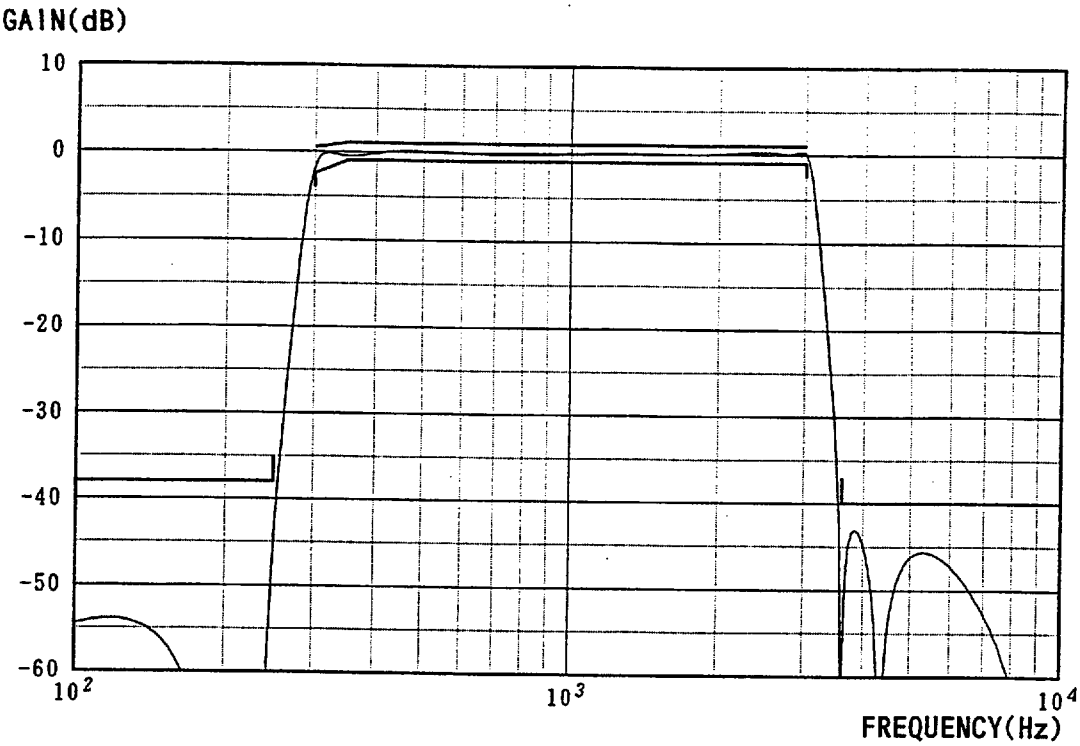


Fig. 1 Voice Filter Characteristics

Serial Interface Configuration

The AK2341 can be set on various modes and the CTCSS tone frequency can be set by writing serial data to the control registor from the serial interface pins (SDATA, SCLK, STB). Serialdata are configured from 2 address bits and 6 data bits, for a total of 8 bits.

■Register Configuration

Address		Data					
SA1	SA0	SD5	SD4	SD3	SD2	SD1	SD0
0	0	Mode setting, internal switch setting					
0	1	Not used.					
1	0	Not used.					
1	1	Tone frequency setting					

■Register Map

1) Mode setting, internal switch setting

Address		Data					
SA1	SA0	SD5	SD4	SD3	SD2	SD1	SD0
0	0	TST	DCS	RVTN	RXON	RX/TX	STBY

Data Name	Function	
STBY	STBY Standby mode control	"1" : Standby mode "0" : Normal operation
RX/TX	Switching between transmit and receive mode	"1" : Transmit mode "0" : Receive mode
RXON	Receive voice signal control	"1" : ON/OFF according to presence of receive tone "0" : ON at all times
RVTN	Transmit tone phase control	"1" : Positive-phase (0°) "0" : Negative-phase (180°)
DCS	CTCSS/DCS switching	"1" : CTCSS mode "0" : DCS mode
TST	Test mode control	"1" : Normal operation "0" : Test mode

2) Tone Frequency Setting

Address		Data						Tone Frequency (Hz)	TSQBPF Q Value
SA1	SA0	SD5	SD4	SD3	SD2	SD1	SD0		
1	1	0	0	0	0	0	1	67.0	L
		0	0	0	0	1	0	71.9	L
		0	0	0	0	1	1	77.0	L
		0	0	0	1	0	0	82.5	L
		0	0	0	1	0	1	88.5	L
		0	0	0	1	1	0	94.8	H
		0	0	0	1	1	1	100.0	H
		0	0	1	0	0	0	103.5	H
		0	0	1	0	0	1	107.2	H
		0	0	1	0	1	0	110.9	H
		0	0	1	0	1	1	114.8	H
		0	0	1	1	0	0	118.8	H
		0	0	1	1	0	1	123.0	H
		0	0	1	1	1	0	127.3	H
		0	0	1	1	1	1	131.8	H
		0	1	0	0	0	0	136.5	H
		0	1	0	0	0	1	141.3	H
		0	1	0	0	1	0	146.2	H
		0	1	0	0	1	1	151.4	H
		0	1	0	1	0	0	156.7	H
		0	1	0	1	0	1	162.2	H
		0	1	0	1	1	0	167.9	H
		0	1	0	1	1	1	173.8	H
		0	1	1	0	0	0	179.9	H
		0	1	1	0	0	1	186.2	H
		0	1	1	0	1	0	192.8	H
		0	1	1	0	1	1	203.5	H
		0	1	1	1	0	0	210.7	H
		0	1	1	1	0	1	218.1	H

Address		Data						Tone Frequency (Hz)	TSQBPF Q Value
SA1	SA0	SD5	SD4	SD3	SD2	SD1	SD0		
1	1	0	1	1	1	1	0	225.7	H
		0	1	1	1	1	1	233.6	H
		1	0	0	0	0	0	241.8	H
		1	0	0	0	0	1	250.3	H
		1	0	0	0	1	0	67.0	H
		1	0	0	0	1	1	71.9	H
		1	0	0	1	0	0	74.4	H
		1	0	0	1	0	1	77.0	H
		1	0	0	1	1	0	79.7	H
		1	0	0	1	1	1	82.5	H
		1	0	1	0	0	0	85.4	H
		1	0	1	0	0	1	88.5	H
		1	0	1	0	1	0	91.5	H
		1	0	1	0	1	1	97.4	H
		1	0	1	1	0	0	69.4	H
		1	0	1	1	0	1	159.8	H
		1	0	1	1	1	0	165.5	H
		1	0	1	1	1	1	171.3	H
		1	1	0	0	0	0	177.3	H
		1	1	0	0	0	1	183.5	H
		1	1	0	0	1	0	189.9	H
		1	1	0	0	1	1	196.6	H
		1	1	0	1	0	0	199.5	H
		1	1	0	1	0	1	206.5	H
		1	1	0	1	1	0	229.1	H
		1	1	0	1	1	1	254.1	H
		1	1	1	0	0	0	注1)	–

Note 1) Enabled only when in the DCS transmit mode. The TSQLPF cutoff frequency is 3.24 kHz.

Note 2) When a code other than the above is input, the TXTONE when in the transmit mode becomes the AGND potential and DETOUT goes "L" when in the receive mode.

Explanation of Operation

1) Operation Mode

The AK2341 operation mode is determined by 4 bit logic of STBY, RX/TX, DCS and TST from 6 bit serial data selected according to address "00". (See Table 1) In addition, regarding the transmit mode and receive mode, voice signal output and tone signal output can be controlled by the 3 bits RXON, RVTN and DCS. (See Table 2 and Table 3.)

TST	DCS	RVTN	RXON	RX/TX	STBY	Operation Mode	Explanation of Operation
0	×	×	×	×	×	Test Mode	This mode is used to test when the IC is shipped.
1	1	×	×	×	1	Standby Mode (Mode 0)	The oscillator circuit stops and the analog output enters the high impedance state, reducing the power consumption.
1	0	×	×	×	1	Voice Through Mode (Mode 1)	The outputs of AMP1 and AMP2 are connected to TXOUT and RXOUT, respectively. CTCSS circuit operation is stopped and power consumption drops.
1	×	×	×	0	0	Transmit Mode (Mode 2)	Voice signals from TXAF are band-pass filtered by BPF1 and output to TXOUT. A tone signal set by the tone frequency setting code or a DCS signal is output to TXTONE. DETOUT goes "H".
1	×	×	×	1	0	Receive Mode (Mode 3)	When the tone signal set by the tone frequency setting code is detected from the signal input from DEM, DETOUT goes "L". The tone signal is cut off from RXOUT and only the voice signal is output.

Table 1

Signal Control in the Transmit Mode

Data Name	Function
RXON	Controls the RXOUT pin. "1" : AGND potential (mute) "0" : AMP2 output signal (receive through)
RVTN	Controls the TXTONE pin's phase. "1" : Positive-phase (0°) "0" : Negative-phase (180°)
DCS	Controls the TXTONE pin's signal. "1" : CTCSS signal "0" : DCS signal

Table 2

Signal Control in the Receive Mode

Data Name	Function
RXON	Controls the RXOUT pin. "1" : Goes ON/OFF according to the presence of the receive tone. "0" : Always ON

Table 3

2) Tone Frequency

50 tone frequencies can be selected from a frequency range of 67.0~254.1 Hz. Of these, selection of either "L" or "H" can be made of the TSQBPF Q value for 5 frequencies, 67.0, 71.9, 77.0, 82.5 and 88.5 Hz. If "L" is selected, detection time can be shortened, but distinguishing between neighboring frequencies (when 88.5 Hz, between that and 84.5 Hz and 91.5 Hz) becomes more difficult. The Q value becomes "H" for the other frequencies. To stop a transmit tone signal, select a code other than the values shown in the tone frequency setting table. (Example: Set "0" in each bit of SD0~SD5.)

3) Voice Filter (BPF1) Power Down

The test mode can be used and the voice filter can be powered down. In the power down state, the impedance of the TXOUT and RXOUT pins becomes high in all operation modes.

Address		Data						Voice Filter
SA1	SA0	SD5	SD4	SD3	SD2	SD1	SD0	
0	0	0	1	0	0	0	0	Power Down
		0	0	0	0	0	0	Power Down Releas

4) Initialization When the Power is Switched On

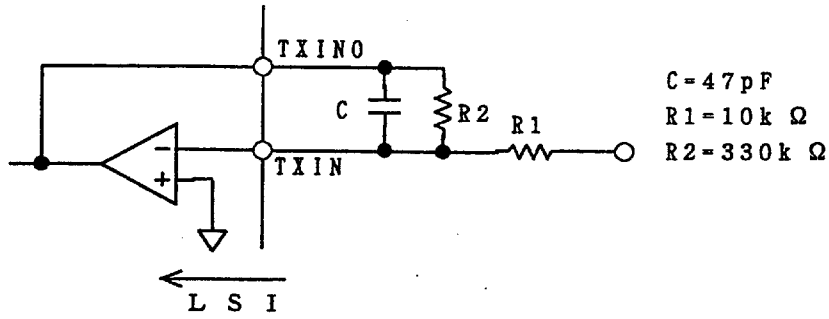
The AK2341 does not include a rest pin, so the values in the internal register are not fixed when the power is switched on. These values should be are initialized after the power is switched on, so write data 2 times from the serial register, "00111111" (stabdby mode) and "00000000" (voice filter power down release).

Examples of Application Circuits

■ Example of External Circuits

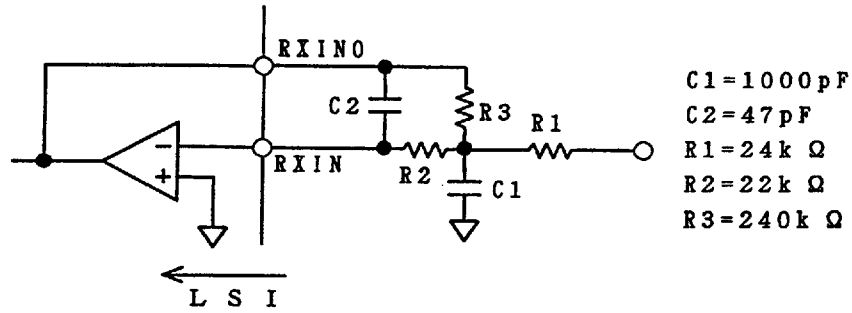
◎AMP1

This device can be used as a transmitting mic amp. Set the gain at 30 dB or lower. In cases where there is a possibility that frequency band-pass niose below 80 kHz will be input, configure a antialiasing filter. The following diagram shows an example of a primary low-pass filter with a gain of 30 dB and a cutoff frequency of 10 kHz.



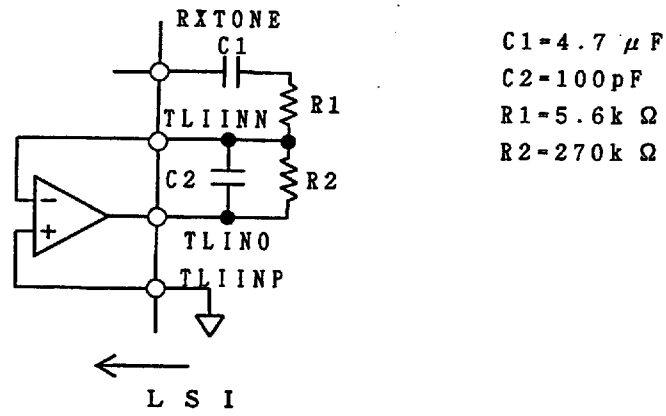
◎AMP2

This is an amp which can be used to configure a filter to adjust the gain of the receive signal and prevent aliasing so as to cut noise at or above 80 kHz. The following diagram shows an example of a secondaly low pass filter configuration with a gain of 20 dB and a cutoff frequency of 10 kHz.



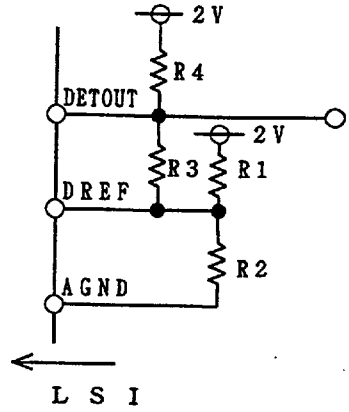
◎AMP3

The minimum detection level of the receive tone detection circuit can be changed by changing this amp's gain. To satisfy the specifications in the data sheet, use the constants shown in the following diagram.



◎Threshold Level of Receive Tone Detection Circuit

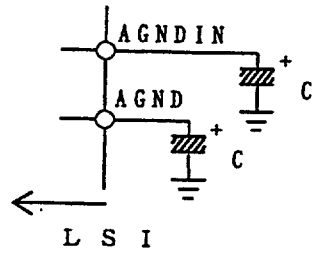
By inputting a DC signal to the DREF pin which is higher than the AGND potential, the threshold level of the receive tone detection circuit is determined. If VDD = 2.0 V, apply a voltage of approximately 1.16 V. If hysteresis is desired in the detection sensitivity, feed back the signal at the TNDET pin. The following diagram shows an example of a receive tone detection circuit with an approximately 3 dB hysteresis.



R1=22k Ω
R2=3.9k Ω
R3=150k Ω
R4=15k Ω

◎AGND Stabilization Capacitor

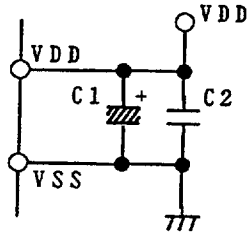
Connect a 0.3 μF or larger capacitor between the AGND pin and VSS to stabilize the AGND signal. Also, in order to eliminate the effect of the ripple in the power supply, connect a capacitor of the appropriate value between AGNDIN-VSS. A connection example is shown in the following diagram.



C=1 μF

◎Power Supply Stabilization Capacitor

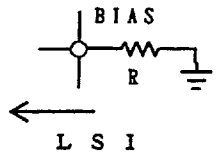
Connect a capacitor between VDD and VSS to reduce the influence of power supply noise. Place the capacitor as close to the power supply pin as possible.



C1=22 μF (electrolytic capacitor)
C2=0.1 μF (ceramic capacitor)

◎Bias Current Setting Resistor

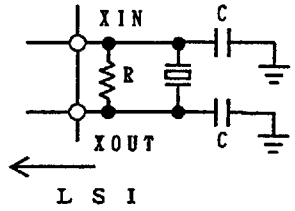
Connecting a resistor between BIAS and VSS sets the bias current of an operational amplifier. When VDD = 2V, use a 75 k resistor, when VDD = 3V, use a 160 k resistor and when VDD = 5V, use a 330 k resistor.



R= 75k Ω (VDD=2V)
R=160k Ω (VDD=3V)
R=330k Ω (VDD=5V)

◎Crystal Oscillator

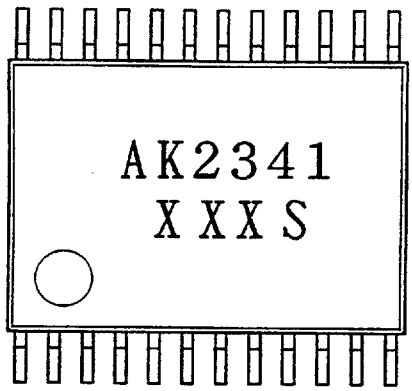
If the built-in oscillator circuit is used, connect a crystal oscillator and resistor as shown in the following diagram. If an external clock is used, leave XOUT open and connect the clock to XIN. Be careful to keep the clock amplitude from exceeding the absolute maximum rating.



Oscillator Frequency : 3.6864MHz
R=1M Ω
C=22pF

Package

■ Marking



[XXXS Content]

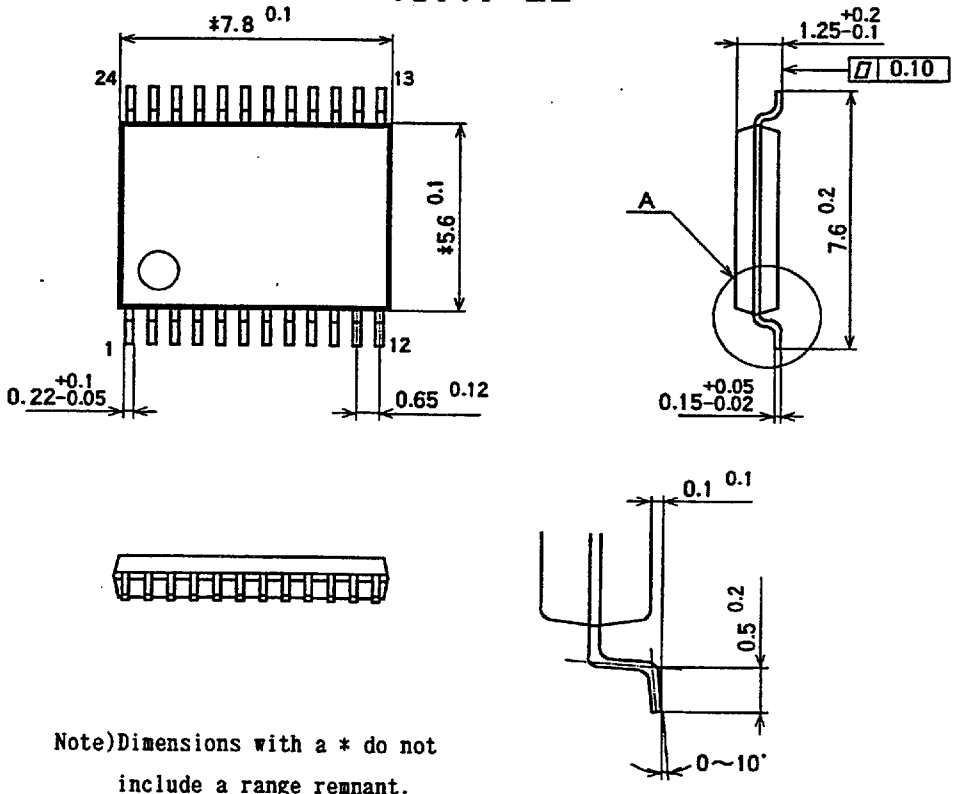
XXX: Manufacturing Data
Last digit of AD year, 2 digits of week number.

S: Assembly Plant Code

■ Package External Dimensions

24PinVSOP

Units : mm



Detail of Portion A

Note)Dimensions with a * do not include a range remnant.

[Material] Resin :Low Stress Type Epoxy Resin
Lead Frame: 42 Alloy