



AK2347B

Two-way Radio Audio & Sub-Audio Processor

1. Features

- Audio processing
 - TX and RX amplifier
 - Pre/De-emphasis circuit
 - Compressor and Expander with no external components
 - Scrambler and De-scrambler in frequency inversion type (3.388kHz or 3.290kHz)
 - Limiter with level adjuster
 - Splatter filter for wide and narrow band
 - Digital controlled amplifier for microphone, modulator and demodulator sensitivity
- Sub-Audio filter with level adjuster for CTCSS and DCS
- Low power supply operation: 2.7 to 3.3V
- Wide range operating for temperature: -40 to 85 °C
- Oscillator circuit for 3.6864MHz and 3.579545MHz crystal
- Serial control interface operation
- Compact plastic packaging, 24-pin SSOP

2. Description

AK2347B includes audio filter, limiter, splatter filter, compandor, scrambler, which is highly integrated two-way radio baseband functions for FRS and LMR.

Audio high-pass filter shows a high attenuation in magnitude response characteristics under 250Hz that supports to eliminate a subaudio tone clearly.

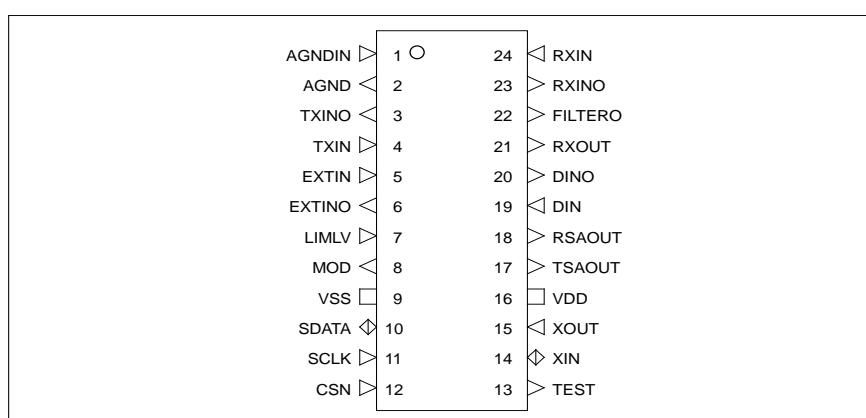
TX limiter for deviation control has a limiting level adjuster by applying a DC voltage via external components. Splatter filter has the magnitude response for narrowband($f_c=2.55\text{kHz}$) and wideband(3.0kHz) to meet various regulatory agencies in the world wide.

Compandor is no adjustment type because it includes all parametric components inside the chip. Scrambler circuit is composed of frequency inversion circuit by double balanced mixer that has 3.388kHz and 3.290kHz carrier clock.

Sub-Audio filter with level adjuster is available for pre- or post-filter for CTCSS and DCS.

There are four signal level adjusters for microphone, modulator and demodulator sensitivity by digital controlled amplifier (volume).

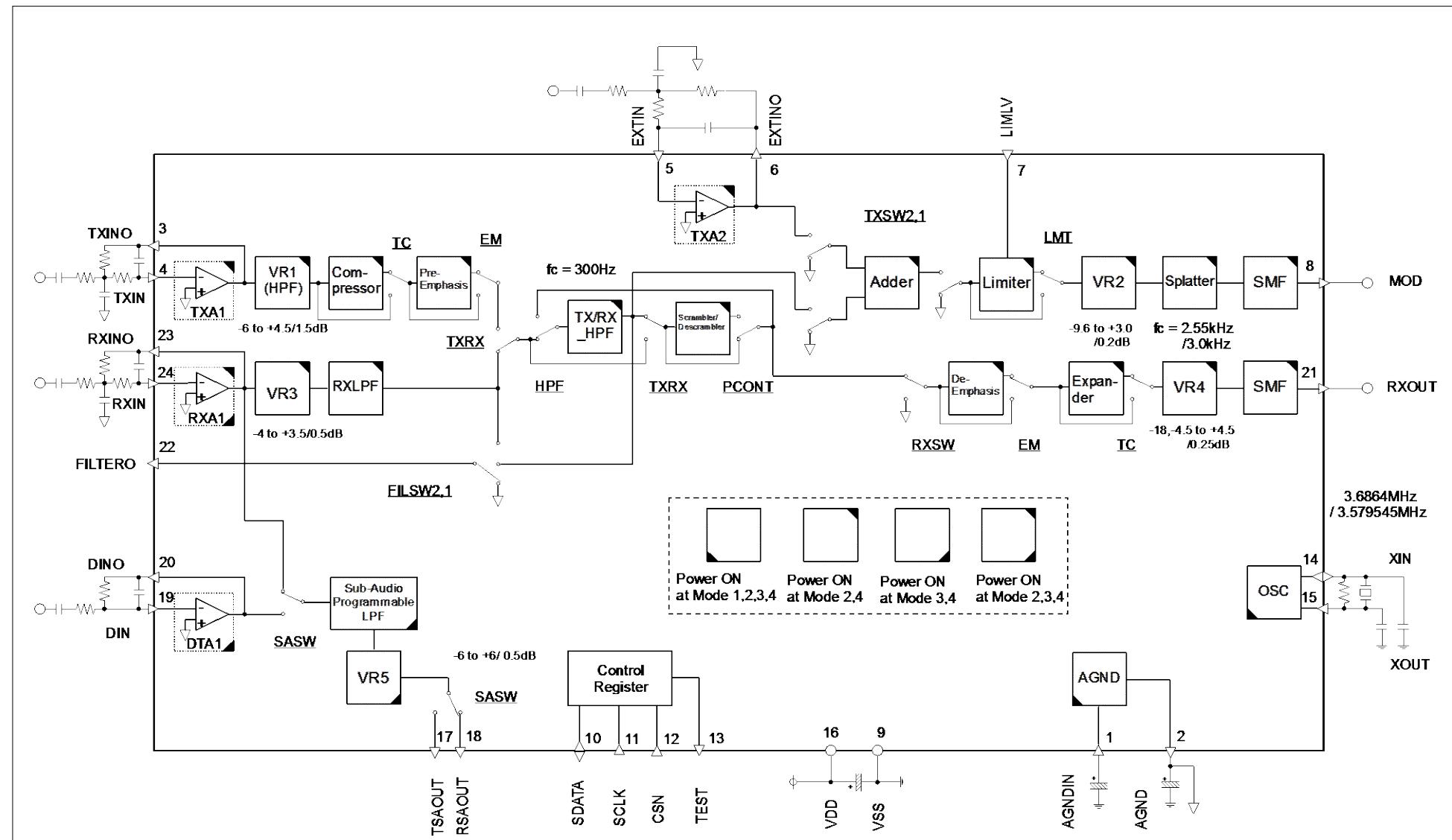
- Pin Assignment (Top view)



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4. Block Diagram



5. Block Functions

| Block | Function |
|---------------------------|--|
| TXA1 | Operational amplifier for gain adjustment of transmit audio signal and for the filter for preventing aliasing noise of the SCF circuit in the subsequent stage. Use external resistors and capacitors to set the gain to 30dB or less and the cut-off frequency to around 10kHz. |
| VR1 (HPF) | This circuit controls the volume for adjusting the input level of transmit audio signal. Setting registers: VR12 to VR10, adjustment range: -6.0dB to +4.5dB in 1.5dB steps |
| Compressor | This circuit compresses the amplitude of transmit audio signal by 1/2 in dB scale. Cross-point: -10dBx. This circuit is turned on and off by the TC register. |
| Pre-emphasis | This circuit emphasizes the high-frequency component of transmit audio signal to improve the S/N ratio of the modulation signal. |
| TX/RX_HPF | High-pass filter to eliminate low-frequency components lower than 250Hz which are included in transmit and receive audio signals. This circuit is turned on and off by the HPF register. |
| Scrambler/ Descrambler | This circuit inverts the spectrum distribution of transmit and receive audio signals with respect to the carrier frequency. The carrier frequency is 3.388kHz or 3.290kHz. The Scrambler/Descrambler or emphasis circuit can be selected using the EM and PCONT registers. These circuits cannot be used at the same time. |
| TXA2 | Operational amplifier for gain adjustment of external tone signal. Use external resistors and capacitors to set the gain to 0dB or less and the cut-off frequency to around 10kHz. |
| Adder | This circuit adds together the audio signal and external tone input signal. This circuit is controlled by the TXSW2 and TXSW1 register. |
| Limiter | Amplitude limiting circuit to suppress frequency deviation in the modulation signal. The limit level can be adjusted by applying a DC voltage to the LIMLV pin. When the pin is left open, the level predetermined within the device is output. This circuit is turned on and off by the LMT register. |
| VR2 | This circuit controls the volume for adjusting the output level on the MOD pin. Setting registers: VR25 to VR20, adjustment range: -3.2dB to +3.0dB in 0.2dB steps. For coarse adjustment, switching between -6.4dB and 0dB is possible. |
| Splatter | Low-pass filter to eliminate high-frequency components higher than 3kHz which are included in the limiter output signal. The cut-off frequency can be adjusted with the SPL register. |
| SMF | Smoothing filter to eliminate the high-frequency and clock components generated in the SCF circuit. |
| RXA1 | Operational amplifier for gain adjustment of the receive demodulation signal and for the filter for preventing aliasing noise in the SCF circuit in the subsequent stage. Use external resistors and capacitors to set the gain to 20dB or less and the cut-off frequency to around 40kHz. |
| VR3 | This circuit controls the volume for adjusting the input level of the receive demodulation signal. Setting registers: VR33 to VR30, adjustment range: -4.0dB to +3.5dB in 0.5dB steps |
| RXLPF | Low-pass filter to eliminate high-frequency components higher than 3kHz which are included in the receive demodulation signal. |
| De-emphasis | This circuit restores the original state of the signal of which high-frequency component has been emphasized by the Pre-emphasis. |
| Expander | This circuit expands the signal compressed twice by the Compressor in dB scale to restore the original signal state. Cross-point: -10dBx. The Expander is turned on and off with the TC register. |
| VR4 | This circuit controls the volume for adjusting the RX output level. Setting registers: VR45 to VR40 Adjustment range: -18.0dB, -4.5dB to +4.5dB in 0.25dB steps |

| Block | Function |
|----------------------------|--|
| DTA1 | Operational amplifier for gain adjustment of the Sub-Audio LPF input signal and for the filter for preventing aliasing noise in the SCF circuit in the subsequent stage. Use external resistors and capacitors to set the gain to 0dB or less and the cut-off frequency to around 10kHz. |
| Sub-Audio Programmable LPF | Low-pass filter to eliminate components of the DAT1 signal in the transmit operation and of RXA1 signal in the receive. This circuit is controlled by the SASW register for transmit or receive and by the SA5 to SA0 for cut-off frequency. |
| VR5 | This circuit controls the volume for adjusting the output level from the Sub-Audio LPF signal. Setting registers: VR54 to VR50, adjustment range: -6.0dB to +6.0dB in 0.5dB steps |
| AGND | This circuit generates the reference voltage (1/2VDD) for internal analog signals. |
| OSC | This circuit generates a 3.6864MHz or 3.579545MHz reference clock signal from an external resistor and crystal oscillator. This circuit is controlled by the MCKSL register. |
| Control Register | Control registers set the switch status and volume for level adjustment inside the IC according to the serial input data consisting of 1-bit instruction and 4-bit address and 8-bit data. At power-up, the registers are set to the power-down values by the power-on reset circuit. This circuit has a software reset named RSTN register. (See the description of the registers) |

6. Pin Functions

| Pin number | Pin name | Pin type | Power-down status | Function |
|------------|----------|----------|-------------------|---|
| 1 | AGNDIN | AI | *3) | Analog ground input pin This pin is connected to a capacitor to stabilize the analog ground level. |
| 2 | AGND | AO | *3) | Analog ground output pin This pin is connected to a capacitor to stabilize the analog ground level. |
| 3 | TXINO | AO | Z | Output pin of TXA1 *1) |
| 4 | TXIN | AI | Z | Transmit audio signal input pin This pin is the inverting input pin of TXA1. This pin, with resistors and capacitors externally connected, forms a microphone amplifier. |
| 5 | EXTIN | AI | Z | External input pin This pin is the inverting input pin of TXA2. This pin, with resistors and capacitors externally connected, forms a amplifier. An external signal such as a tone signal other than the audio signal can be input. |
| 6 | EXTINO | AO | *3) | Output pin of TXA2 *1) |
| 7 | LIMLV | AI | *4) | Limit level adjustment pin The limit level can be adjusted by applying a DC voltage to this pin. When this pin is left open, the limit level predetermined within the device is set. |
| 8 | MOD | AO | Z | Modulated transmit signal output pin *2) |
| 9 | VSS | PWR | - | Negative power supply pin Normally, apply 0V. |
| 10 | SDATA | DB | Z | Serial data input and output control pin |

| Pin number | Pin name | Pin type | Power-down status | Function |
|------------|----------|----------|-------------------|---|
| 11 | SCLK | DI | Z | Serial data clock input pin |
| 12 | CSN | DI | Z | Serial data chip select input This signal is active low. |
| 13 | TEST | DO | L | Output pin for testing This pin is assigned to test pin for pre-delivery inspection in factory. Do not connect anything in normal operation. |
| 14 | XIN | DB | *5) | Pin for connecting a crystal oscillator A reference clock used within this IC is generated by connecting a 3.6864MHz or 3.579545MHz oscillator between this pin and the adjacent XOUT pin. For detailed information about the connection method and the method for supplying an external clock, see "Recommended External Application Circuits". |
| 15 | XOUT | DI | *5) | Pin for connecting a crystal oscillator |
| 16 | VDD | PWR | — | Positive power supply pin Connect this pin to a power supply ranging from 2.7V to 3.3V with less noise. Connect a bypass capacitor of 0.1μF or higher between this pin and the VSS pin. |
| 17 | TSAOUT | AO | Z | Transmit Sub-Audio signal output pin *2) |
| 18 | RSAOUT | AO | Z | Receive Sub-Audio signal output pin *2) |
| 19 | DIN | AI | Z | Data input pin This pin is the inverting input pin of DTA1. This pin, with resistors and capacitors externally connected, forms a amplifier. An external signal such as a tone signal through CPU port can be input. |
| 20 | DINO | AO | Z | Output pin of DTA1 *1) |
| 21 | RXOUT | AO | Z | Receive audio signal output pin *2) |
| 22 | FILTERO | AO | Z | RXLPF or TX/RX_HPF block output pin This pin can be used as a monitor pin for a signal such as a tone signal. The output signal on this pin includes a 57.6kHz sampling-clock component. So, perform waveform processing externally as required. *2) |
| 23 | RXINO | AO | Z | Output pin of RXA1 *1) |
| 24 | RXIN | AI | Z | Demodulated receive signal input pin Inverting input pin of RXA1. This pin, with resistors and capacitors externally connected, forms a pre-filter. |

Note) A: Analog, D: Digital, PWR: Power, I: Input, O: Output, B: Bi-directional, Z: High-Z, L: Low

*1) Output load requirement: [load impedance] > 30kΩ, [load capacitance] < 50pF

*2) Output load requirement: [load impedance] > 10kΩ, [load capacitance] < 50pF

*3) AGND (=1/2VDD) level

*4) AGND + 0.256(VDD-AGND) level

*5) When XOUT pin is set to low level, XIN pin goes to High-Z.
When XOUT pin is set to high level, XIN pin outputs low level.

7. Absolute Maximum Ratings

| Parameter | Symbol | Min. | Max. | Units |
|--|------------------|------|---------|-------|
| Power Supply Voltage | VDD | -0.3 | 4.6 | V |
| Ground Level | VSS | 0 | 0 | V |
| Input Voltage | V _{IN} | -0.3 | VDD+0.3 | V |
| Input Current (Except power supply pin) | I _{IN} | -10 | +10 | mA |
| Storage Temperature | T _{stg} | -55 | 130 | °C |

Note) All voltages are relative to the VSS pin.

Caution) If the device is used in conditions exceeding these values, the device may be destroyed. Normal operations are not guaranteed in such extreme conditions.

8. Recommended Operating Conditions

| Parameter | Symbol | Condition | Min. | Typ. | Max. | Units |
|--------------------------|----------------|-----------|------|--------|------|-------|
| Operating Temperature | T _a | | -40 | | 85 | °C |
| Power Supply Voltage | VDD | | 2.7 | 3.0 | 3.3 | V |
| Analog Reference Voltage | AGND | | | 1/2VDD | | V |

Note) All voltages are relative to the VSS pin.

9. Digital DC Characteristics

| Parameter | Symbol | Condition | Min. | Typ. | Max. | Units |
|---------------------------|------------------|--|---------|------|--------|-------|
| High level input voltage | V _{IH1} | SDATA | 0.7VDD | | | V |
| | V _{IH2} | SCLK, CSN | 0.8VDD | | | |
| Low level input voltage | V _{IL1} | SDATA | | | 0.3VDD | V |
| | V _{IL2} | SCLK, CSN | | | 0.2VDD | |
| High level input current | I _{IH} | V _{IH} =VDD SDATA, SCLK, CSN | | | 10 | µA |
| Low level input current | I _{IL} | V _{IL} =0V SDATA, SCLK, CSN | -10 | | | µA |
| High level output voltage | V _{OH} | I _{OH} =+0.2mA SDATA | VDD-0.4 | | VDD | V |
| Low level output voltage | V _{OL} | I _{OL} =-0.4mA SDATA | 0.0 | | 0.4 | V |

10. Clock Input Characteristics

| Parameter | Symbol | Condition | Min. | Typ. | Max. | Units | Remarks |
|--------------------------|----------------|--------------|------|--------------------|------|----------|---------|
| Master Clock Frequency | MCK | XIN, XOUT | | 3.6864 3.579545 | | MHz | |
| High level input voltage | V_{MCK1_IH} | XIN | 1.5 | | | V | *1) |
| Low level input voltage | V_{MCK1_IL} | XIN | | | 0.4 | V | *1) |
| Input amplitude | V_{MCK2} | XIN | 0.2 | | 1.0 | V_{PP} | *2) |

*1) When directly connects to XIN pin, refer to “Recommended External Application” 7) Oscillator circuit Fig. 7.

*2) When connects to XIN pin via capacitor, refer to “Recommended External Application” 7) Oscillator circuit Fig. 8.

11. Current Consumption

| Parameter | Symbol | Condition | Min. | Typ. | Max. | Units |
|---------------------|--------|--|------|------|------|-------|
| Current Consumption | IDD0 | Mode 0 OSC:OFF, Audio: OFF, Sub-Audio: OFF | | 0.08 | 0.14 | mA |
| | IDD1 | Mode 1 OSC: ON , Audio: OFF, Sub-Audio: OFF | | 0.7 | 1.0 | |
| | IDD2 | Mode 2 OSC: ON , Audio: ON , Sub-Audio: OFF | | 4.5 | 5.8 | |
| | IDD3 | Mode 3 OSC: ON , Audio: OFF, Sub-Audio: ON | | 1.6 | 2.1 | |
| | IDD4 | Mode 4 OSC: ON , Audio: ON , Sub-Audio: ON | | 5.3 | 6.7 | |

12. Analog Characteristics

Unless otherwise specified, the following apply: MCK=3.6864MHz, f=1kHz, Emphasis: on, Compandor: on, Scrambler: off, VR1=VR2=VR3=VR4=0dB, HPF=LMT=1 with the external circuit shown in page.28 to 32.

"dBx" is a standardized notation to match the operating voltage and is defined by equation $0\text{dBx} = -5 + 20\log(\text{VDD}/2)\text{dBm}$. $0\text{dBm} = 0.775\text{Vrms}$.

1) TX Audio system characteristics

| Parameter | Condition | Min. | Typ. | Max. | Units | Remarks |
|----------------------------------|--|----------------|----------------|----------------|-------|---------|
| Standard input level | @TXINO, EXTINO | | -10 | | dBx | |
| Absolute gain | TXINO to MOD | -1.5 | 0 | +1.5 | dB | |
| | EXTIN to MOD | -1.5 | 0 | +1.5 | dB | |
| Distortion | EXTIN to MOD, EXTINO=-3dBx When LMT is set to 0 30kHz Low-pass filtering | | | -35 | dB | |
| Limit level | EXTIN to MOD Without external R adjustment With external R adjustment | -8.6 | -7.6 | -6.6 -6.6 | dBx | |
| Compressor linearity | TXINO to MOD TXINO=-44dBx TXINO=-50dBx Relative value to 0dB for MOD level of -10dBx TXINO. | -20.0 -24.0 | -17.0 -20.0 | -14.0 -16.0 | dB | |
| Compressor distortion | TXINO to MOD TXINO=-10dBx 30kHz Low-pass filtering | | | -35 | dB | |
| Noise level with no signal input | TXINO to MOD C-Message filtering | | | -36.5 | dBm | |
| VR1 Attenuation error | TXINO to MOD -6.0 dB to 4.5dB, 1.5dB/step | -1.5 | | +1.5 | dB | |
| VR2 ATT error (VR24,23,22,21,20) | TXINO to MOD -3.2dB to +3.0dB, 0.2dB/step | -0.2 | | +0.2 | dB | |
| VR2 ATT error (VR25=0) | TXINO to MOD Relative value when -6.4/0dB is set | -6.8 | -6.4 | -6.0 | dB | |

2) RX Audio system characteristics

| Parameter | Condition | Min. | Typ. | Max. | Units | Remarks |
|----------------------------------|---|----------------|----------------|----------------|-------|---------|
| Standard Input Level | @RXINO | | -10 | | dBx | |
| Absolute gain | RXINO to FILTERO | -1.5 | 0 | +1.5 | dB | |
| | RXINO to RXOUT | -1.5 | 0 | +1.5 | dB | |
| Expander linearity | RXINO to RXOUT RXINO=-25dBx RXINO=-30dBx Relative value to 0dB for RXOUT level of -10dBx RXINO | -33.0 -45.0 | -30.0 -40.0 | -27.0 -35.0 | dB | |
| Expander distortion | RXINO to RXOUT RXINO=-5dBx 30kHz Low-pass filtering | | | -35 | dB | |
| Noise level with no signal input | RXINO to RXOUT C-Message Filtering | | | -70 | dBm | |

| Parameter | Condition | Min. | Typ. | Max. | Units | Remarks |
|--|---|-------|------|-------|-------|---------|
| VR3 Attenuation error | RXIN0 to RXOUT -4.0dB to +3.5dB, 0.5dB/step | -0.5 | | +0.5 | dB | |
| VR4 Attenuation error | RXIN0 to RXOUT -4.5 to +4.5dB, 1.5dB/step | -0.25 | | +0.25 | dB | |
| VR4 ATT error (VR45...40=0,0,0,0,0, 0) | RXIN0 to RXOUT Relative value when -18/0dB is set | -20 | -18 | -16 | dB | |

3) Audio Filter Characteristics

3.1) Emphasis: on, Compandor: off, Scrambler: off

| Parameter | Condition | Min. | Typ. | Max. | Units | Remarks |
|-------------------------------|-----------------------------------|--------|-------|-------|-------|-----------------------|
| TX overall characteristics | TXINO to MOD | 250Hz | -57 | -40 | dB | |
| | | 300Hz | -12.5 | -9.5 | | |
| | | 2.5kHz | +6.0 | +9.0 | | |
| | | 3.0kHz | +4.5 | +8.5 | | |
| | | 6.0kHz | -23 | -18 | | |
| | Relative value to gain at 1kHz | 300Hz | -12.5 | -9.5 | | SPL=0 fc=2.55 K |
| | | 2.5kHz | +6.0 | +9.0 | | |
| | | 3.0kHz | +7.0 | +10.5 | | |
| | | 6.0kHz | -17 | -12 | | |
| RX overall characteristics | RXINO to RXAF | 250Hz | -38 | -26 | dB | |
| | | 300Hz | +8.5 | +11.5 | | |
| | | 3.0kHz | -11.5 | -8.5 | | |
| | | 6.0kHz | -52 | -40 | | |

3.2) Emphasis: off, Compandor: off, Scrambler: off (Design target values)

| Parameter | Condition | Min. | Typ. | Max. | Units | Remarks |
|-------------------------------|-----------------------------------|-----------------|------|------|-------|-----------------------|
| TX overall characteristics | TXINO to MOD | 250Hz | -50 | -38 | dB | |
| | | 300Hz to 2.0kHz | -1.0 | +1.0 | | |
| | | 2.5kHz | -1.5 | +1.0 | | |
| | | 3.0kHz | -4.0 | -1.0 | | |
| | | 6.0kHz | -32 | -28 | | |
| | Relative value to gain at 1kHz | 300Hz to 2.5kHz | -1.0 | +1.0 | | SPL=0 fc=2.55 K |
| | | 3.0kHz | -1.5 | +1.0 | | |
| | | 6.0kHz | -26 | -22 | | |
| RX overall characteristics | RXINO to RXAF | 250Hz | -49 | -38 | dB | |
| | | 300Hz | -1.5 | +1.0 | | |
| | | 350Hz to 3.0kHz | -1.0 | +1.0 | | |
| | | 6.0kHz | -38 | -28 | | |

- Audio path frequency response for TX

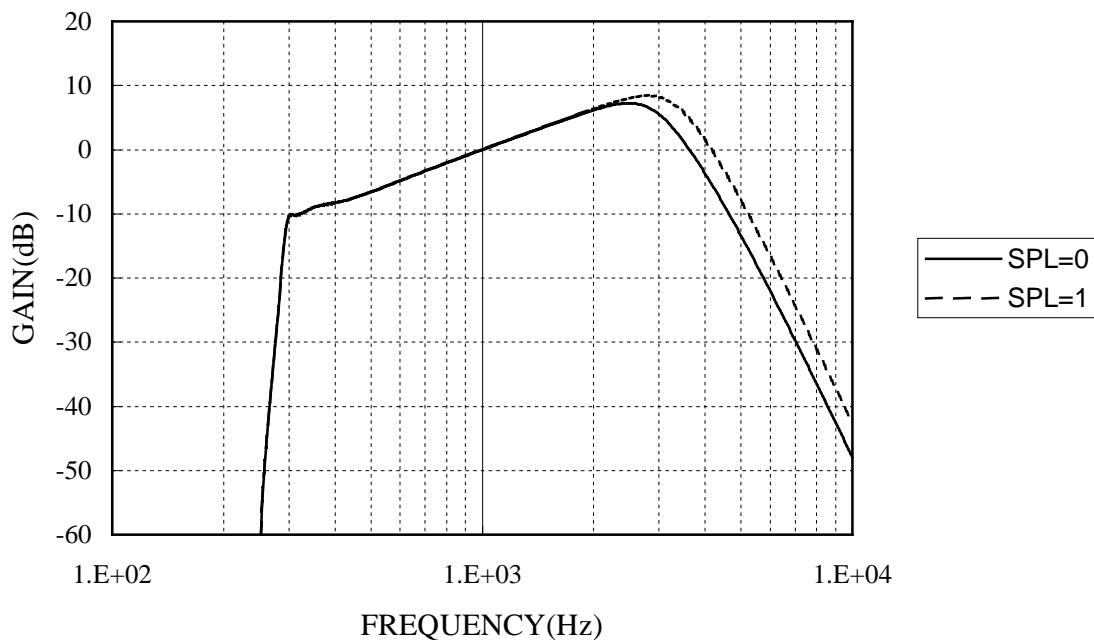


Figure 1: TX overall response with pre-emphasis.

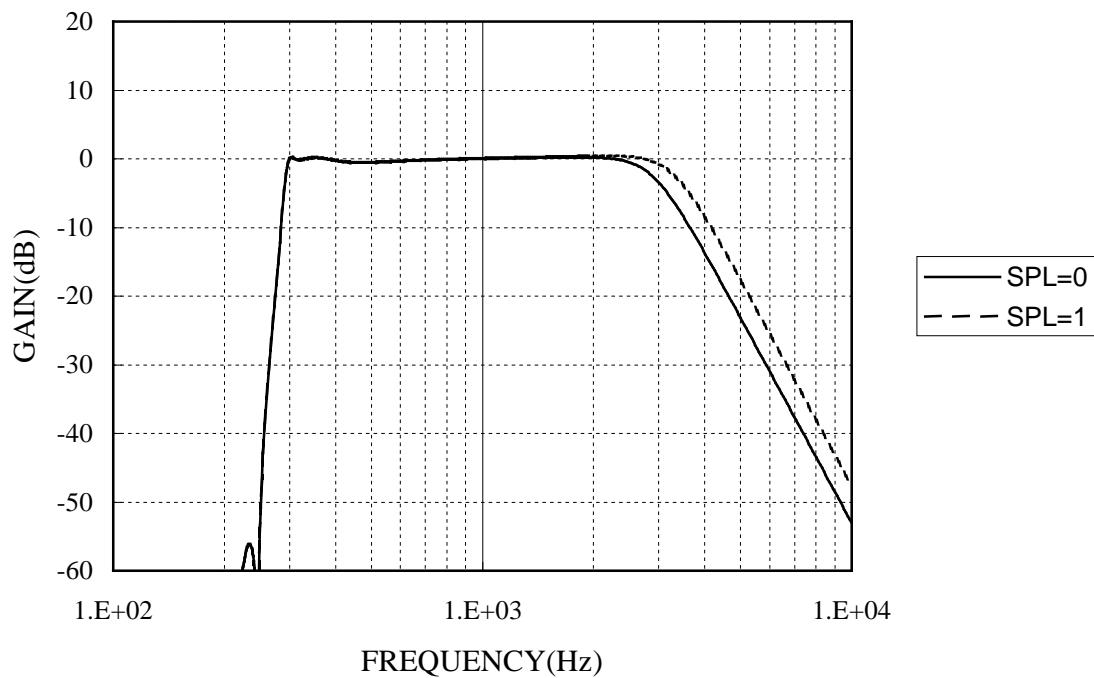


Figure 2: TX overall response without pre-emphasis.

- Audio path frequency response for RX

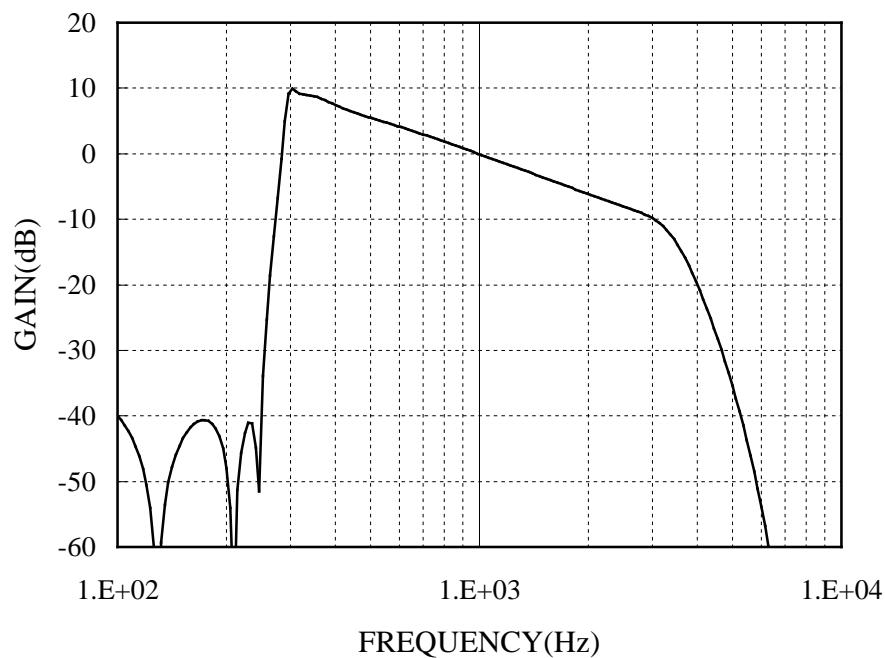


Figure 3: RX overall response with de-emphasis.

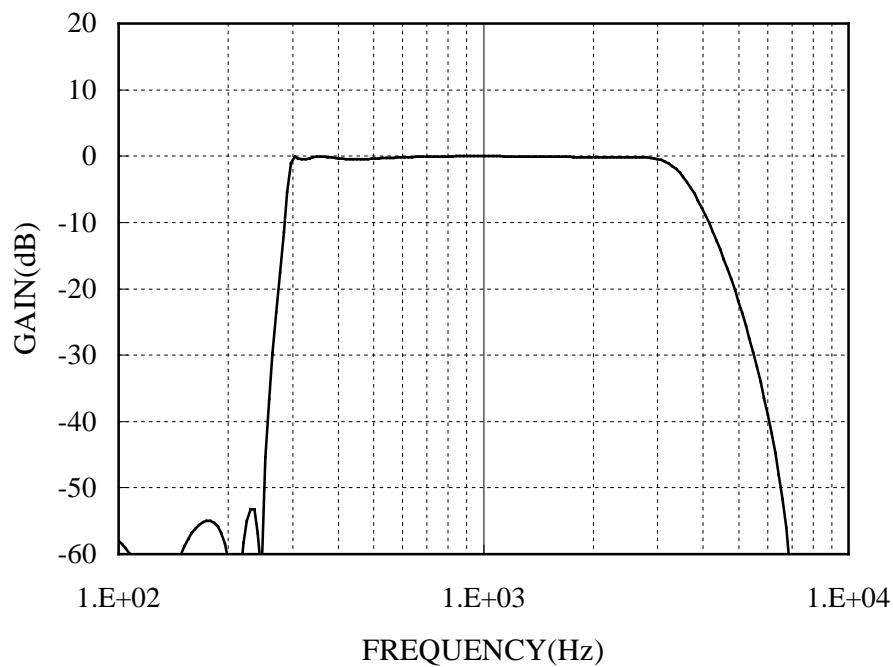


Figure 4: RX overall response without de-emphasis.

4) Scrambler Characteristics

4.1) Scrambler: **on**, Emphasis: off, Compandor: off, MCKSL=1, SCSL=0/1...3.388kHz
 MCKSL=0, SCSL=0 ...3.290kHz

| Parameter | Condition | Min. | Typ. | Max. | Units | Remarks |
|--------------------------|---|----------------|------|------|-------|---------|
| Carrier frequency | | 3.388 3.290 | | | kHz | |
| Modulated output | TXINO to MOD, RXINO to RXOUT Input level 1.0kHz -10dBx Measuring-freq. 2.388kHz (3.388kHz) Measuring-freq. 2.290kHz (3.290kHz) | -12 | -10 | -8 | dBx | |
| High frequency rejection | TXINO to MOD, RXINO to RXOUT Input level 1.0kHz -10dBx Measuring-freq. 4.388kHz (3.388kHz) Measuring-freq. 4.290kHz (3.290kHz) | | | -50 | dBx | |
| Carrier signal leakage | TXINO to MOD, RXINO to RXOUT Input level No signal Measuring-freq. 3.388kHz Measuring-freq. 3.290kHz | | | -50 | dBx | |
| Original signal leakage | TXINO to MOD, RXINO to RXOUT Input level 1.0kHz -10dBx Measuring-freq. 1.0kHz | | | -50 | dBx | |

4.2) Scrambler: **on**, Emphasis: off, Compandor: off, MCKSL=0, SCSL=1

(Design target values)

| Parameter | Condition | Min. | Typ. | Max. | Units | Remarks |
|--------------------------|---|-------|------|------|-------|---------|
| Carrier frequency | | 3.390 | | | kHz | |
| Modulated output | TXINO to MOD, RXINO to RXOUT Input level 1.0kHz -10dBx Measuring-freq. 2.390kHz | -12 | -10 | -8 | dBx | |
| High frequency rejection | TXINO to MOD, RXINO to RXOUT Input level 1.0kHz -10dBx Measuring-freq. 4.390kHz | | | -50 | dBx | |
| Carrier signal leakage | TXINO to MOD, RXINO to RXOUT Input level No signal Measuring-freq. 3.390kHz | | | -50 | dBx | |
| Original signal leakage | TXINO to MOD, RXINO to RXOUT Input level 1.0kHz -10dBx Measuring-freq. 1.0kHz | | | -25 | dBx | |

5) Sub-Audio filter Characteristics

Unless otherwise specified, the following apply: MCKSL=1, SA5=1, SA4=1, SA3=0, SA2=0, SA1=0, SA0=1(fc=260.9Hz), VR5=0dB, 250.3Hz sinusoidal wave.

5.1) Analog characteristics

| Parameter | Condition | Min. | Typ. | Max. | Units | Remarks |
|----------------------------------|---|------|------|------|-------|---------|
| Standard input level | @ TSAOUT | | -10 | | dBx | |
| Transmit CTCSS signal gain | DINO to TSAOUT | -2 | 0 | +2 | dB | |
| Transmit CTCSS signal distortion | DINO to TSAOUT 250.3Hz,Duty50%, 585mVp-p(@3V)rectangular wave 30kHz Low-pass filtering | | -37 | -32 | dB | |
| Standard input level | @ RSAOUT | | -10 | | dBx | |
| Receive CTCSS signal gain | RXINO to RSAOUT | -2 | 0 | +2 | dB | |
| Receive CTCSS signal distortion | RXINO to RSAOUT RXINO=-10dBx input 30kHz Low-pass filtering | | -37 | -32 | dB | |
| VR5 Attenuation error | RXINO to RSAOUT -6.0 to +6.0dB, 0.5dB/step | -0.5 | | +0.5 | dB | |

5.2) Filter characteristics

| Parameter | Condition | Min. | Typ. | Max. | Units | Remarks |
|--|--|----------------------------|--------------|---------------------|-------|---------|
| Overall characteristics @fc=260.9Hz | DINO to TSAOUT Relative value to gain at 100Hz | 50~240Hz 250Hz 300Hz | -1.0 -1.5 | +1.0 +1.0 -38 | dB | |

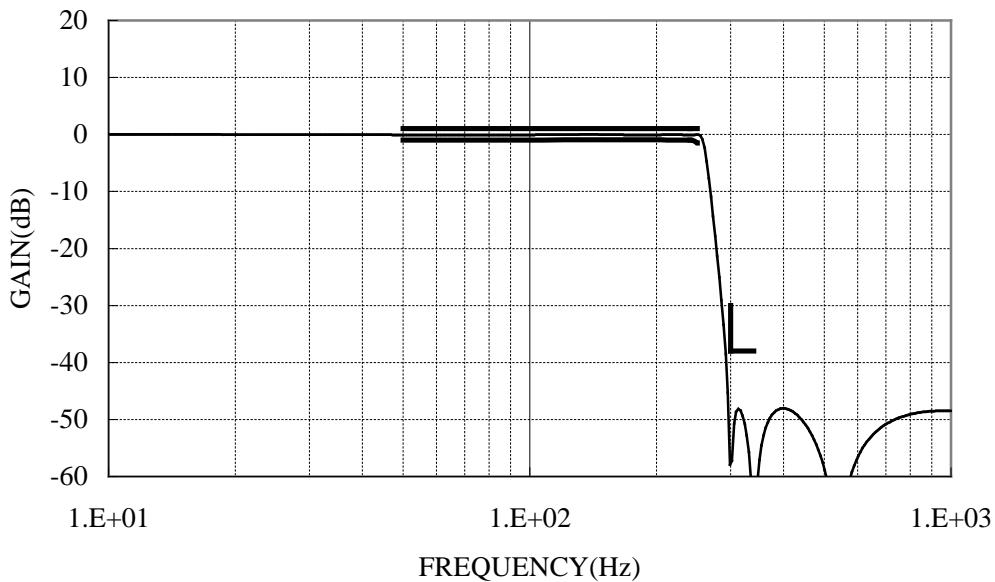
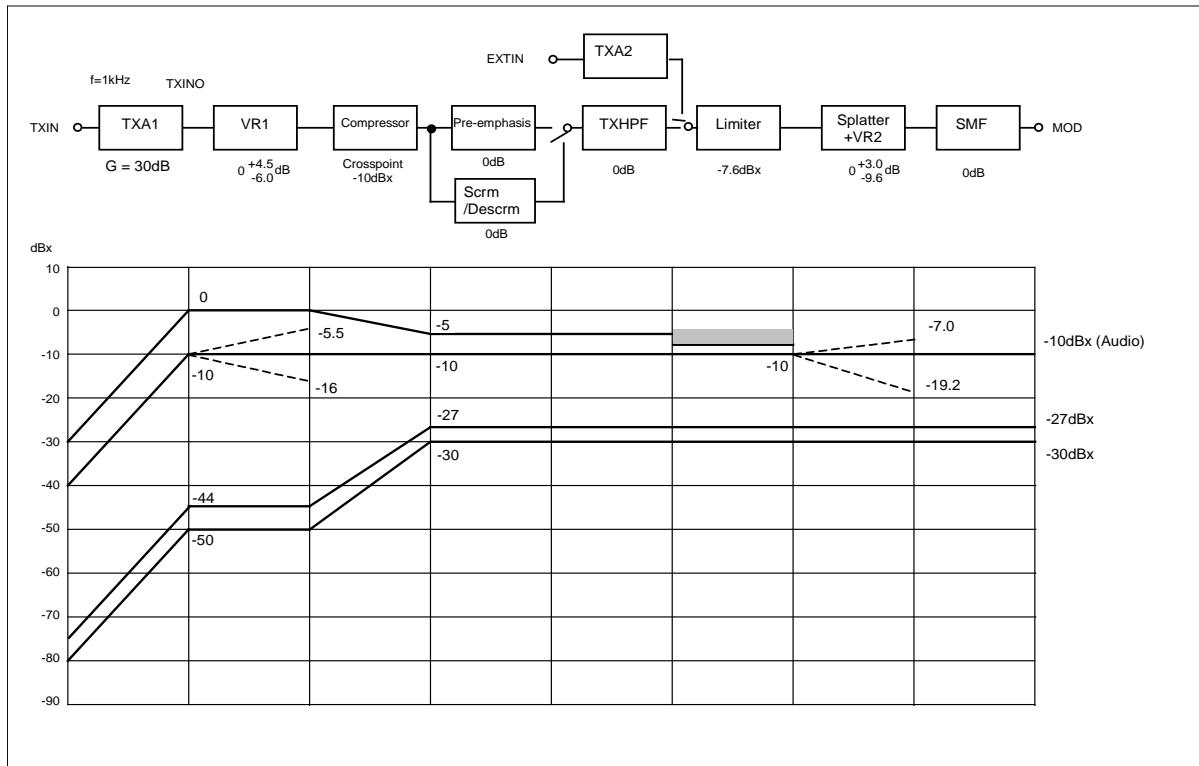


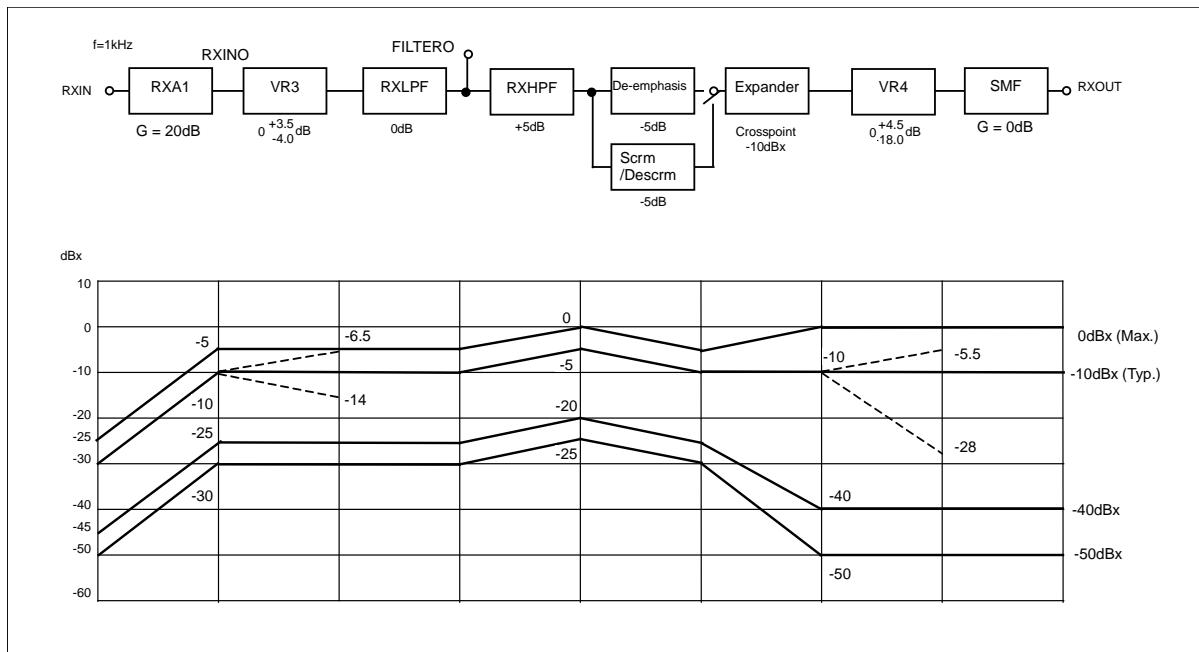
Fig.5 Sub-Audio response characteristics

13. Level Diagram

1) TX system: TXRX=0



2) RX system: TXRX=1



Note) dBx is a standardized notation to match the operating voltage and is defined by equation
 $0\text{dBx} = -5 + 20\log(\text{VDD}/2)\text{dBm}$.

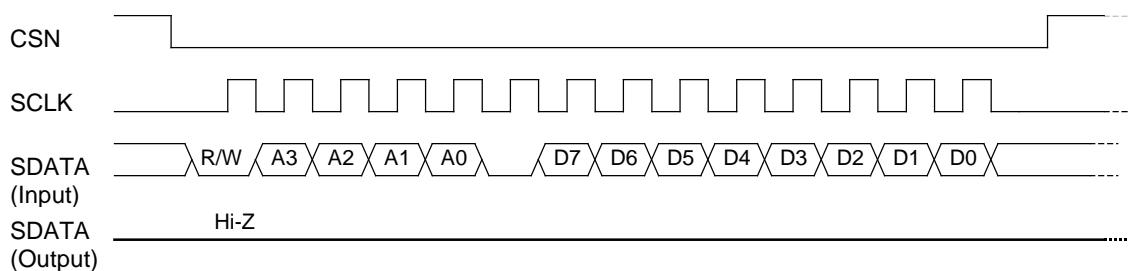
14. Digital AC Timing

1) Serial Interface Timing

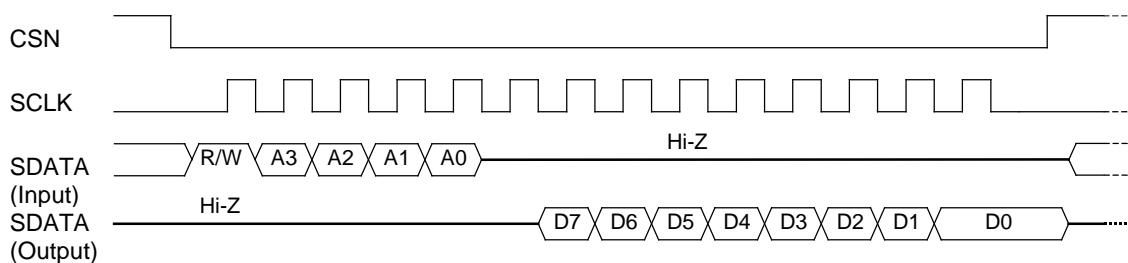
AK2347B is connected to a CPU by three-wired interface through CSN, SCLK and SDATA pins, which can make reading and writing data for control registers.

Serial data named SDATA is consist of 1-bit read and write instruction(R/W), 4-bit address (A3 to A0) and 8-bit data(D7 to D0) in one frame.

Write mode



Read mode



R/W : Instruction bit controls to write data to AK2347B or read back from it.
 When set to low, AK2347B is in write mode. When set to high, AK2347B is in read mode.

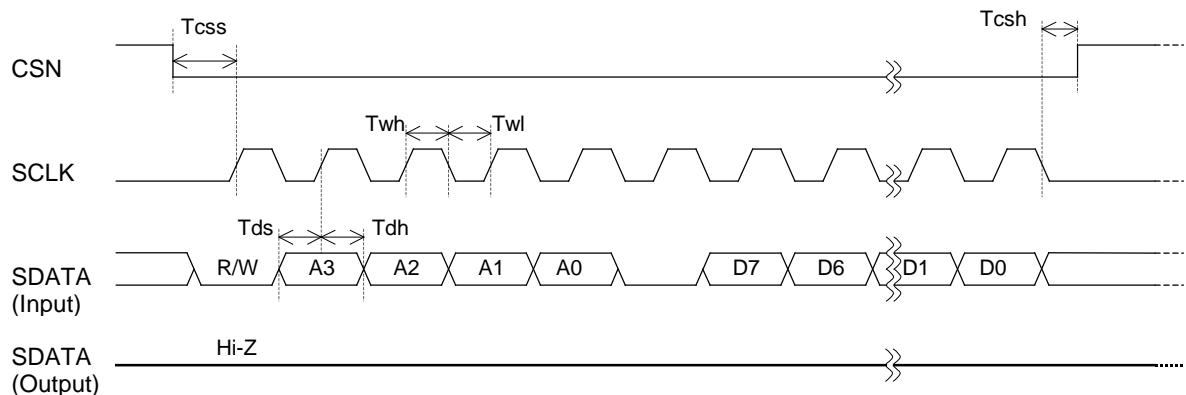
A3 to A0: Register address to be accessed.

D7 to D0: Write or read date to be accessed.

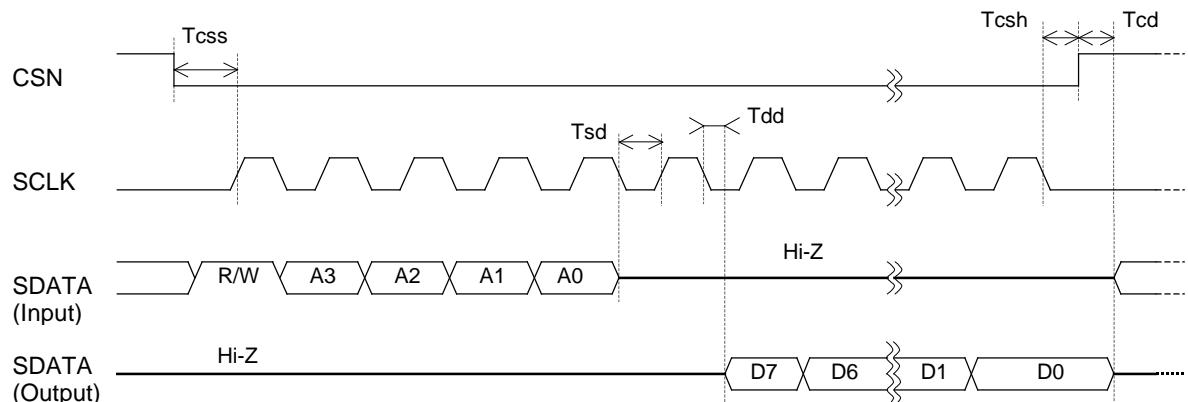
- (1) CSN(Chip select) is normally selected high for disable.
 When CSN is set to low, serial interface becomes active.
- (2) In write mode, instruction, address and data input from SDATA pin are synchronized and latched with the rising edge of 14 iterations of SCLK clock. Set to low between address A0 and data D7.
 In read mode, instruction and address are synchronized and latched with the rising edge of 5 iterations of SCLK clock. And the register data are output from SDATA pin synchronized with the falling edge of 9 iterations of SCLK clock. The date between address A0 and data D7 is unstable.
 A CPU port to SDATA pin is fixed to High-Z during the interval that SDATA outputs the read data.
- (3) AK2347B assumes that write and read is set by 14 iterations SCLK clock while CSN sets to Low. If SCLK iterations are less or more than 14 clocks, serial data would not set properly.

2) Detail Timing Chart

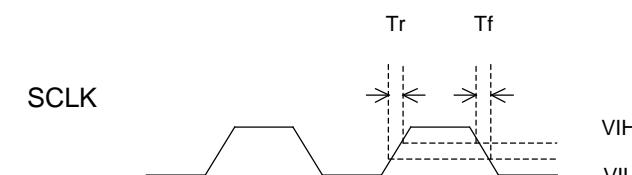
Write mode



Read mode



Rising and falling time



| Parameter | Symbol | Condition | Min. | Typ. | Max. | Unit |
|--------------------------|--------|-----------|------|------|------|------|
| CSN setup time | Tcss | | 100 | | | ns |
| SDATA setup time | Tds | | 100 | | | ns |
| SDATA hold time | Tdh | | 100 | | | ns |
| SCLK high time | Twh | | 500 | | | ns |
| SCLK low time | Twl | | 500 | | | ns |
| CSN hold time | Tcsh | | 100 | | | ns |
| SDATA Hi-Z setup time | Tsd | | 500 | | | ns |
| SCLK to SDATA delay time | Tdd | 20pF load | | | 500 | ns |
| CSN to SDATA delay time | Tcd | 20pF load | | 100 | | ns |
| SCLK rising time | Tr | | | | 100 | ns |
| SCLK falling time | Tf | | | | 100 | ns |

Note) In digital input timing, rising time is relative to VIH and falling time is relative to VIL.
 In digital output timing, rising time is relative to VOH and falling time is relative to VOL.

15. Register Function Description

1) Register configuration

| Address | | | | Function | Data | | | | | | | |
|---------|-----|-----|-----|------------------------------------|--------|--------|-------|------|-------------|-------|------|-------|
| A3 | A2 | A1 | A0 | | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
| 0 | 0 | 0 | 0 | Control register 1 | BS3 | BS2 | BS1 | TXRX | TXSW2 | TXSW1 | RXSW | MCKSL |
| 0 | 0 | 0 | 1 | Control register 2 | TC | EM | PCONT | SPL | SCSL | LMT | HPF | SASW |
| 0 | 0 | 1 | 0 | Volume register 1 | VR54 | VR53 | VR52 | VR51 | VR50 | VR12 | VR11 | VR10 |
| 0 | 0 | 1 | 1 | Volume register 2 | FILSW2 | FILSW1 | VR25 | VR24 | VR23 | VR22 | VR21 | VR20 |
| 0 | 1 | 0 | 0 | Volume register 3 | – | – | – | – | VR33 | VR32 | VR31 | VR30 |
| 0 | 1 | 0 | 1 | Volume register 4 | – | – | VR45 | VR44 | VR43 | VR42 | VR41 | VR40 |
| 0 | 1 | 1 | 0 | Sub-Audio frequency | – | – | SA5 | SA4 | SA3 | SA2 | SA1 | SA0 |
| 0 | 1 | 1 | 1 | Software-reset & Revision register | – | – | – | RSTN | REVNUM[3:0] | | | |
| 1 | 0/1 | 0/1 | 0/1 | Reserved | X | X | X | X | X | X | X | X |

Note1) The mark “–” means that a write to those bits does not have any influence on the LSI operation and read back the writing data.

Note2) All registers except address 0111 are write and readable registers.

Caution) Never access the mark “X” test register and unlisted bits of VR33 to VR30, VR45 to VR40 and SA5 to SA1. If an access is made to these addresses inadvertently, the LSI operation is not guaranteed.

2) Descriptions of registers

2.1) Control register 1

| Address | | | | Data | | | | | | | | |
|-----------------|----|----|----|------|-----|-----|------|-------|-------|------|-------|--|
| A3 | A2 | A1 | A0 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | |
| 0 | 0 | 0 | 0 | BS3 | BS2 | BS1 | TXRX | TXSW2 | TXSW1 | RXSW | MCKSL | |
| When power-down | | | | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | |

2.1.1) Operation mode setting

| BS3 | BS2 | BS1 | Mode name | OSC and AGND system | TX and RX audio system | Sub-Audio system |
|-----|-----|-----|------------------------|---------------------|------------------------|------------------|
| 0 | 0 | 0 | Mode 0 (Power-down) | OFF | OFF | OFF |
| 0 | 0 | 1 | Mode 1 (standby) | ON | OFF | OFF |
| 0 | 1 | 0 | Mode 2 | ON | ON | OFF |
| 0 | 1 | 1 | Mode 3 | ON | OFF | ON |
| 1 | 0/1 | 0/1 | Mode 4 | ON | ON | ON |

2.1.2) TX and RX setting

| Data | Item | Function | | Remarks |
|-------|------------------------|---------------------|---------------------|---------|
| | | 0 | 1 | |
| TXRX | TX-RX switch | TX operation *1) | RX operation *2) | *3) |
| RXSW | RX audio mute | Mute | Normal operation | *4) |
| MCKSL | Master clock frequency | 3.579545MHz | 3.6864MHz | |

2.1.3) TX path setting

| TXSW2 | TXSW1 | Function | Remarks |
|-------|-------|---|---------|
| 1 | 1 | Mute (AGND → Limiter → Splatter) | |
| 0 | 1 | Audio system operation (HPF → Limiter → Splatter) | |
| 1 | 0 | External signal operation (EXTIN pin → Limiter → Splatter) | |
| 0 | 0 | Audio signal and external signal added together (HPF+EXTIN pin → Adder → Limiter → Splatter) | |

*1) When TXRX is set to 0 and RXSW is set to 1, the signal input from the TXIN pin can be output to the RXOUT pin. In this case, because use of the Scrambler/Descrambler is inhibited, be sure to set PCONT to 1.

When RXSW is set to 0, the RXOUT pin output is muted.

*2) When TXRX is set to 1 and TXSW2 and TXSW1 are set to 0 and 1 respectively, the signal input from the RXIN pin can be output to the MOD pin. In this case, because use of the Scrambler/Descrambler is inhibited, be sure to set PCONT to 1. When TXSW2 and TXSW1 are set to 1 and 1 respectively, the MOD pin output is muted.

*3) Set the gain level for each circuit block properly according to the level diagrams on page 15.

*4) If RXSW is set to 0, the FILTERO pin output is not muted.

2.2) Control register 2

| Address | | | | Data | | | | | | | |
|-----------------|----|----|----|------|----|-------|-----|------|-----|-----|------|
| A3 | A2 | A1 | A0 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
| 0 | 0 | 0 | 1 | TC | EM | PCONT | SPL | SCSL | LMT | HPF | SASW |
| When power-down | | | | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |

| Data | Item | Function | | Remarks |
|------|--|----------------------|-----------------------|---------|
| | | 0 | 1 | |
| TC | Companopr | OFF (Bypass) | ON (Active) | |
| SPL | Splatter Cut-off frequency | 2.55kHz | 3.0kHz | |
| SCSL | Scrambler carrier frequency MCKSL is set to 0 | 3.290kHz | 3.390kHz | |
| | MCKSL is set to 1 | 3.388kHz | 3.388kHz | |
| LMT | Limiter | OFF (Bypass) | ON (Active) | |
| HPF | TX/RX HPF | OFF (Bypass) | ON (Active) | |
| SASW | Sub-Audio operation | DIN pin → TSAOUT pin | RXIN pin → RSAOUT pin | |

| EM | PCONT | Function | Remarks |
|-----|-------|---|---------|
| 1 | 1 | Emphasis: ON (Active), Scrambler/Descrambler: OFF (Bypass) | |
| 0 | 1 | Emphasis: OFF (Bypass), Scrambler/Descrambler: OFF (Bypass) | |
| 0/1 | 0 | Emphasis: OFF (Bypass), Scrambler/Descrambler: ON (Active) | |

2.3) Volume Register 1

| Address | | | | Data | | | | | | | |
|-----------------|----|----|----|------|------|------|------|------|------|------|------|
| A3 | A2 | A1 | A0 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
| 0 | 0 | 1 | 0 | VR54 | VR53 | VR52 | VR51 | VR50 | VR12 | VR11 | VR10 |
| When power-down | | | | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 |

| VR54 | VR53 | VR52 | VR51 | VR50 | VR5 gain (dB) |
|------|------|------|------|------|---------------|
| 0 | 0 | 0 | 0 | 0 | -6.0 |
| 0 | 0 | 0 | 0 | 1 | -5.5 |
| 0 | 0 | 0 | 1 | 0 | -5.0 |
| 0 | 0 | 0 | 1 | 1 | -4.5 |
| 0 | 0 | 1 | 0 | 0 | -4.0 |
| 0 | 0 | 1 | 0 | 1 | -3.5 |
| 0 | 0 | 1 | 1 | 0 | -3.0 |
| 0 | 0 | 1 | 1 | 1 | -2.5 |
| 0 | 1 | 0 | 0 | 0 | -2.0 |
| 0 | 1 | 0 | 0 | 1 | -1.5 |
| 0 | 1 | 0 | 1 | 0 | -1.0 |
| 0 | 1 | 0 | 1 | 1 | -0.5 |
| 0 | 1 | 1 | 0 | 0 | 0.0 |
| 0 | 1 | 1 | 0 | 1 | +0.5 |
| 0 | 1 | 1 | 1 | 0 | +1.0 |
| 0 | 1 | 1 | 1 | 1 | +1.5 |
| 1 | 0 | 0 | 0 | 0 | +2.0 |
| 1 | 0 | 0 | 0 | 1 | +2.5 |
| 1 | 0 | 0 | 1 | 0 | +3.0 |
| 1 | 0 | 0 | 1 | 1 | +3.5 |
| 1 | 0 | 1 | 0 | 0 | +4.0 |
| 1 | 0 | 1 | 0 | 1 | +4.5 |
| 1 | 0 | 1 | 1 | 0 | +5.0 |
| 1 | 0 | 1 | 1 | 1 | +5.5 |
| 1 | 1 | 0 | 0 | 0 | +6.0 |

| VR12 | VR11 | VR10 | VR1 gain (dB) |
|------|------|------|---------------|
| 0 | 0 | 0 | -6.0 |
| 0 | 0 | 1 | -4.5 |
| 0 | 1 | 0 | -3.0 |
| 0 | 1 | 1 | -1.5 |
| 1 | 0 | 0 | 0.0 |
| 1 | 0 | 1 | +1.5 |
| 1 | 1 | 0 | +3.0 |
| 1 | 1 | 1 | +4.5 |

2.4) Volume Register 2

| Address | | | | Data | | | | | | | |
|-----------------|----|----|----|--------|--------|------|------|------|------|------|------|
| A3 | A2 | A1 | A0 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
| 0 | 0 | 1 | 1 | FILSW2 | FILSW1 | VR25 | VR24 | VR23 | VR22 | VR21 | VR20 |
| When power-down | | | | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |

| FILSW2 | FILSW1 | Function | Remarks |
|--------|--------|--|---------|
| 1 | 1 | FILTERO pin output is muted. | |
| 0 | 1 | RXLPF circuit signal is output on FILTERO pin. | |
| 0/1 | 0 | TX/RX_HPF circuit signal is output on FILTERO pin. | |

| VR25 | VR2 gain (dB) |
|------|---------------|
| 0 | -6.4 |
| 1 | 0.0 |

| VR24 | VR23 | VR22 | VR21 | VR20 | VR2 gain (dB) |
|------|------|------|------|------|---------------|
| 0 | 0 | 0 | 0 | 0 | -3.2 |
| 0 | 0 | 0 | 0 | 1 | -3.0 |
| 0 | 0 | 0 | 1 | 0 | -2.8 |
| 0 | 0 | 0 | 1 | 1 | -2.6 |
| 0 | 0 | 1 | 0 | 0 | -2.4 |
| 0 | 0 | 1 | 0 | 1 | -2.2 |
| 0 | 0 | 1 | 1 | 0 | -2.0 |
| 0 | 0 | 1 | 1 | 1 | -1.8 |
| 0 | 1 | 0 | 0 | 0 | -1.6 |
| 0 | 1 | 0 | 0 | 1 | -1.4 |
| 0 | 1 | 0 | 1 | 0 | -1.2 |
| 0 | 1 | 0 | 1 | 1 | -1.0 |
| 0 | 1 | 1 | 0 | 0 | -0.8 |
| 0 | 1 | 1 | 0 | 1 | -0.6 |
| 0 | 1 | 1 | 1 | 0 | -0.4 |
| 0 | 1 | 1 | 1 | 1 | -0.2 |
| 1 | 0 | 0 | 0 | 0 | 0.0 |
| 1 | 0 | 0 | 0 | 1 | +0.2 |
| 1 | 0 | 0 | 1 | 0 | +0.4 |
| 1 | 0 | 0 | 1 | 1 | +0.6 |
| 1 | 0 | 1 | 0 | 0 | +0.8 |
| 1 | 0 | 1 | 0 | 1 | +1.0 |
| 1 | 0 | 1 | 1 | 0 | +1.2 |
| 1 | 0 | 1 | 1 | 1 | +1.4 |
| 1 | 1 | 0 | 0 | 0 | +1.6 |
| 1 | 1 | 0 | 0 | 1 | +1.8 |
| 1 | 1 | 0 | 1 | 0 | +2.0 |
| 1 | 1 | 0 | 1 | 1 | +2.2 |
| 1 | 1 | 1 | 0 | 0 | +2.4 |
| 1 | 1 | 1 | 0 | 1 | +2.6 |
| 1 | 1 | 1 | 1 | 0 | +2.8 |
| 1 | 1 | 1 | 1 | 1 | +3.0 |

2.5) Volume Register 3

| Address | | | | Data | | | | | | | |
|-----------------|----|----|----|------|----|----|----|------|------|------|------|
| A3 | A2 | A1 | A0 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
| 0 | 1 | 0 | 0 | – | – | – | – | VR33 | VR32 | VR31 | VR30 |
| When power-down | | | | – | – | – | – | 1 | 0 | 0 | 0 |

| VR33 | VR32 | VR31 | VR30 | VR3 gain (dB) |
|------|------|------|------|---------------|
| 0 | 0 | 0 | 0 | -4.0 |
| 0 | 0 | 0 | 1 | -3.5 |
| 0 | 0 | 1 | 0 | -3.0 |
| 0 | 0 | 1 | 1 | -2.5 |
| 0 | 1 | 0 | 0 | -2.0 |
| 0 | 1 | 0 | 1 | -1.5 |
| 0 | 1 | 1 | 0 | -1.0 |
| 0 | 1 | 1 | 1 | -0.5 |
| 1 | 0 | 0 | 0 | 0.0 |
| 1 | 0 | 0 | 1 | +0.5 |
| 1 | 0 | 1 | 0 | +1.0 |
| 1 | 0 | 1 | 1 | +1.5 |
| 1 | 1 | 0 | 0 | +2.0 |
| 1 | 1 | 0 | 1 | +2.5 |
| 1 | 1 | 1 | 0 | +3.0 |
| 1 | 1 | 1 | 1 | +3.5 |

2.6) Volume Register 4

| Address | | | | Data | | | | | | | |
|-----------------|----|----|----|------|----|------|------|------|------|------|------|
| A3 | A2 | A1 | A0 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
| 0 | 1 | 0 | 1 | – | – | VR45 | VR44 | VR43 | VR42 | VR41 | VR40 |
| When power-down | | | | – | – | 0 | 1 | 0 | 0 | 1 | 1 |

| VR45 | VR44 | VR43 | VR42 | VR41 | VR40 | VR4 gain (dB) |
|------|------|------|------|------|------|---------------|
| 0 | 0 | 0 | 0 | 0 | 0 | -18.0 |
| 0 | 0 | 0 | 0 | 0 | 1 | -4.50 |
| 0 | 0 | 0 | 0 | 1 | 0 | -4.25 |
| 0 | 0 | 0 | 0 | 1 | 1 | -4.00 |
| 0 | 0 | 0 | 1 | 0 | 0 | -3.75 |
| 0 | 0 | 0 | 1 | 0 | 1 | -3.50 |
| 0 | 0 | 0 | 1 | 1 | 0 | -3.25 |
| 0 | 0 | 0 | 1 | 1 | 1 | -3.00 |
| 0 | 0 | 1 | 0 | 0 | 0 | -2.75 |
| 0 | 0 | 1 | 0 | 0 | 1 | -2.50 |
| 0 | 0 | 1 | 0 | 1 | 0 | -2.25 |
| 0 | 0 | 1 | 0 | 1 | 1 | -2.00 |
| 0 | 0 | 1 | 1 | 0 | 0 | -1.75 |
| 0 | 0 | 1 | 1 | 0 | 1 | -1.50 |
| 0 | 0 | 1 | 1 | 1 | 0 | -1.25 |
| 0 | 0 | 1 | 1 | 1 | 1 | -1.00 |
| 0 | 1 | 0 | 0 | 0 | 0 | -0.75 |
| 0 | 1 | 0 | 0 | 0 | 1 | -0.50 |
| 0 | 1 | 0 | 0 | 1 | 0 | -0.25 |
| 0 | 1 | 0 | 0 | 1 | 1 | 0.00 |
| 0 | 1 | 0 | 1 | 0 | 0 | +0.25 |
| 0 | 1 | 0 | 1 | 0 | 1 | +0.50 |
| 0 | 1 | 0 | 1 | 1 | 0 | +0.75 |
| 0 | 1 | 0 | 1 | 1 | 1 | +1.00 |
| 0 | 1 | 1 | 0 | 0 | 0 | +1.25 |
| 0 | 1 | 1 | 0 | 0 | 1 | +1.50 |
| 0 | 1 | 1 | 0 | 1 | 0 | +1.75 |
| 0 | 1 | 1 | 0 | 1 | 1 | +2.00 |
| 0 | 1 | 1 | 1 | 0 | 0 | +2.25 |
| 0 | 1 | 1 | 1 | 0 | 1 | +2.50 |
| 0 | 1 | 1 | 1 | 1 | 0 | +2.75 |
| 0 | 1 | 1 | 1 | 1 | 1 | +3.00 |
| 1 | 0 | 0 | 0 | 0 | 0 | +3.25 |
| 1 | 0 | 0 | 0 | 0 | 1 | +3.50 |
| 1 | 0 | 0 | 0 | 1 | 0 | +3.75 |
| 1 | 0 | 0 | 1 | 0 | 1 | +4.00 |
| 1 | 0 | 0 | 1 | 0 | 0 | +4.25 |
| 1 | 0 | 0 | 1 | 0 | 1 | +4.50 |

2.7) Sub-Audio LPF frequency

| Address | | | | Data | | | | | | | | |
|-----------------|----|----|----|------|----|-----|-----|-----|-----|-----|-----|--|
| A3 | A2 | A1 | A0 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | |
| 0 | 1 | 1 | 0 | - | - | SA5 | SA4 | SA3 | SA2 | SA1 | SA0 | |
| When power-down | | | | - | - | 1 | 1 | 0 | 0 | 0 | 1 | |

| SA5 | SA4 | SA3 | SA2 | SA1 | SA0 | Divide *1) | MCKSL=0(3.579545M) | | MCKSL=1(3.6864MHz) | |
|-----|-----|-----|-----|-----|-----|---------------|------------------------------|-------------------------|------------------------------|-------------------------|
| | | | | | | | Cut-off Frequency (Hz) | Target CTCSS (Hz) | Cut-off Frequency (Hz) | Target CTCSS (Hz) |
| 0 | 0 | 0 | 0 | 0 | 0 | 640 | 59.4 | - | 61.1 | - |
| 0 | 0 | 0 | 0 | 0 | 1 | 630 | 60.3 | - | 62.1 | - |
| 0 | 0 | 0 | 0 | 1 | 0 | 620 | 61.3 | - | 63.1 | - |
| 0 | 0 | 0 | 0 | 1 | 1 | 610 | 62.3 | - | 64.1 | - |
| 0 | 0 | 0 | 1 | 0 | 0 | 600 | 63.3 | - | 65.2 | - |
| 0 | 0 | 0 | 1 | 0 | 1 | 590 | 64.4 | - | 66.3 | - |
| 0 | 0 | 0 | 1 | 1 | 0 | 580 | 65.5 | - | 67.5 | - |
| 0 | 0 | 0 | 1 | 1 | 1 | 570 | 66.7 | - | 68.6 | - |
| 0 | 0 | 1 | 0 | 0 | 0 | 560 | 67.8 | - | 69.9 | - |
| 0 | 0 | 1 | 0 | 0 | 1 | 550 | 69.1 | - | 71.1 | - |
| 0 | 0 | 1 | 0 | 1 | 0 | 540 | 70.3 | - | 72.5 | 67.0 |
| 0 | 0 | 1 | 0 | 1 | 1 | 530 | 71.7 | 67.0 | 73.8 | - |
| 0 | 0 | 1 | 1 | 0 | 0 | 520 | 73.1 | - | 75.2 | 69.3 |
| 0 | 0 | 1 | 1 | 0 | 1 | 510 | 74.5 | 69.3 | 76.7 | 71.9 |
| 0 | 0 | 1 | 1 | 1 | 0 | 500 | 76.0 | - | 78.3 | - |
| 0 | 0 | 1 | 1 | 1 | 1 | 490 | 77.6 | 71.9 | 79.8 | 74.4 |
| 0 | 1 | 0 | 0 | 0 | 0 | 480 | 79.2 | - | 81.5 | - |
| 0 | 1 | 0 | 0 | 0 | 1 | 470 | 80.6 | 74.4 | 83.3 | 77.0 |
| 0 | 1 | 0 | 0 | 1 | 0 | 460 | 82.6 | 77.0 | 85.1 | 79.7 |
| 0 | 1 | 0 | 0 | 1 | 1 | 450 | 84.4 | - | 87.0 | - |
| 0 | 1 | 0 | 1 | 0 | 0 | 440 | 86.3 | 79.7 | 89.0 | 82.5 |
| 0 | 1 | 0 | 1 | 0 | 1 | 430 | 88.4 | 82.5 | 91.0 | 85.4 |
| 0 | 1 | 0 | 1 | 1 | 0 | 420 | 90.4 | - | 93.2 | - |
| 0 | 1 | 0 | 1 | 1 | 1 | 410 | 92.7 | 85.4 | 95.5 | 88.5 |
| 0 | 1 | 1 | 0 | 0 | 0 | 400 | 95.0 | 88.5 | 97.8 | 91.5 |
| 0 | 1 | 1 | 0 | 0 | 1 | 390 | 97.4 | 91.5 | 100.3 | - |
| 0 | 1 | 1 | 0 | 1 | 0 | 380 | 100.0 | - | 103.0 | 94.8 |
| 0 | 1 | 1 | 0 | 1 | 1 | 370 | 102.7 | 94.8 | 105.8 | 97.4 |
| 0 | 1 | 1 | 1 | 0 | 0 | 360 | 105.6 | 97.4 | 108.7 | 100.0 |
| 0 | 1 | 1 | 1 | 0 | 1 | 350 | 108.6 | 100.0 | 111.8 | 103.5 |
| 0 | 1 | 1 | 1 | 1 | 0 | 340 | 111.8 | 103.5 | 115.1 | 107.2 |
| 0 | 1 | 1 | 1 | 1 | 1 | 330 | 115.1 | 107.2 | 118.6 | 110.9 |

| SA5 | SA4 | SA3 | SA2 | SA1 | SA0 | Divide *1) | MCKSL=0(3.579545M) | | MCKSL=1(3.6864MHz) | |
|-----|-----|-----|-----|-----|-----|---------------|------------------------------|-------------------------|------------------------------|-------------------------|
| | | | | | | | Cut-off Frequency (Hz) | Target CTCSS (Hz) | Cut-off Frequency (Hz) | Target CTCSS (Hz) |
| 1 | 0 | 0 | 0 | 0 | 0 | 320 | 118.8 | 110.9 | 122.3 | 114.8 |
| 1 | 0 | 0 | 0 | 0 | 1 | 310 | 122.5 | 114.8 | 126.2 | 118.8 |
| 1 | 0 | 0 | 0 | 1 | 0 | 300 | 126.6 | 118.8 | 130.5 | 123.0 |
| 1 | 0 | 0 | 0 | 1 | 1 | 290 | 131.0 | 123.0 | 135.0 | 127.3 |
| 1 | 0 | 0 | 1 | 0 | 0 | 280 | 135.7 | 127.3 | 139.8 | 131.8 |
| 1 | 0 | 0 | 1 | 0 | 1 | 270 | 140.7 | 131.8 | 144.9 | 136.5 |
| 1 | 0 | 0 | 1 | 1 | 0 | 260 | 146.2 | 136.5 | 150.5 | 141.3 |
| 1 | 0 | 0 | 1 | 1 | 1 | 250 | 152.0 | 141.3 | 156.5 | 146.2 |
| 1 | 0 | 1 | 0 | 0 | 0 | 240 | 158.3 | 146.2 151.4 | 163.0 | 151.4 |
| 1 | 0 | 1 | 0 | 0 | 1 | 230 | 165.2 | 156.7 | 170.1 | 156.7 162.2 |
| 1 | 0 | 1 | 0 | 1 | 0 | 220 | 172.7 | 162.2 | 177.9 | 167.9 |
| 1 | 0 | 1 | 0 | 1 | 1 | 210 | 180.9 | 167.9 173.8 | 186.4 | 173.8 |
| 1 | 0 | 1 | 1 | 0 | 0 | 200 | 190.0 | 179.9 | 195.6 | 179.9 186.2 |
| 1 | 0 | 1 | 1 | 0 | 1 | 190 | 200.0 | 186.2 192.8 | 205.9 | 192.8 |
| 1 | 0 | 1 | 1 | 1 | 0 | 180 | 211.1 | 203.5 | 217.3 | 203.5 210.7 |
| 1 | 0 | 1 | 1 | 1 | 1 | 170 | 222.9 | 210.7 | 229.6 | 218.1 |
| 1 | 1 | 0 | 0 | 0 | 0 | 160 | 237.5 | 218.1 225.7 | 244.5 | 225.7 233.6 |
| 1 | 1 | 0 | 0 | 0 | 1 | 150 | 253.2 | 233.6 241.8 | 260.9 | 241.8 250.3 |
| 1 | 1 | 0 | 0 | 1 | 0 | 140 | 271.3 | 250.3 (254.1) | 279.5 | (254.1) (268.8) |
| 1 | 1 | 0 | 0 | 1 | 1 | 130 | 292.4 | (268.8) | 300.9 | - |
| 1 | 1 | 0 | 1 | 0 | 0 | 120 | 316.7 | - | 326.0 | - |
| 1 | 1 | 0 | 1 | 0 | 1 | 110 | 345.3 | - | 355.8 | - |
| 1 | 1 | 0 | 1 | 1 | 0 | 100 | 379.9 | - | 391.3 | - |
| 1 | 1 | 0 | 1 | 1 | 1 | 90 | 422.2 | (403.2) | 434.7 | (403.2) |
| 1 | 1 | 1 | 0 | 0 | 0 | 80 | 475.0 | - | 489.0 | - |
| 1 | 1 | 1 | 0 | 0 | 1 | 70 | 542.7 | - | 559.1 | - |

*1) Divide = 10 x [64 – (register setting value)]

This equation states that Divide is divided number of master clock.

2.8) Software reset & revision register

| Address | | | | Data | | | | | | | |
|-----------------|----|----|----|------|----|----|------|-------------|----|----|----|
| A3 | A2 | A1 | A0 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
| 0 | 1 | 1 | 1 | – | – | – | RSTN | REVNUM[3:0] | | | |
| When power-down | | | | – | – | – | 1 | 0 | 0 | 1 | 0 |

2.8.1) Software rest

When D4: RSTN data is set to 0, software reset is executed and all register data is set to power-down status and. This register is a write only register and set to 1 automatic after completing software reset.

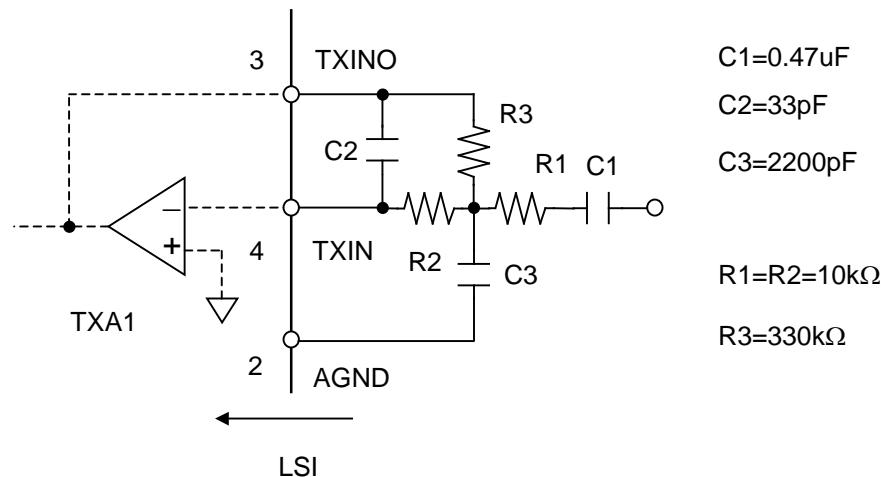
2.8.2) Revision register

When D3 to D0 data is accessed, users can read the number of mask revision. This register is a read only register.

16. Recommended External Application Circuits

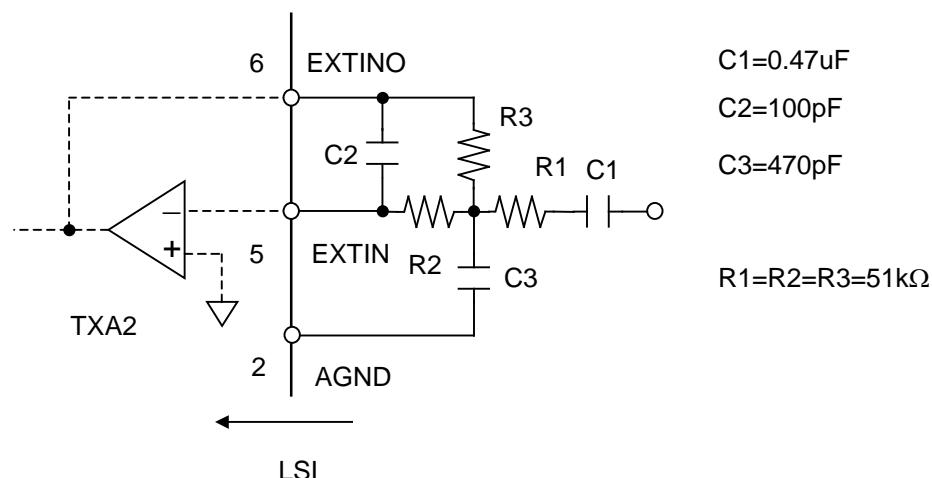
1) TXA1 amplifier

This circuit can be used as the TX microphone amplifier. Set the gain to 30dB or less. If there is a possibility that a high frequency noise component over 100kHz is input, form a first or second order anti-aliasing filter. The following gives a sample configuration of a second order LPF with a gain of 30dB and cut-off frequency of 10kHz:



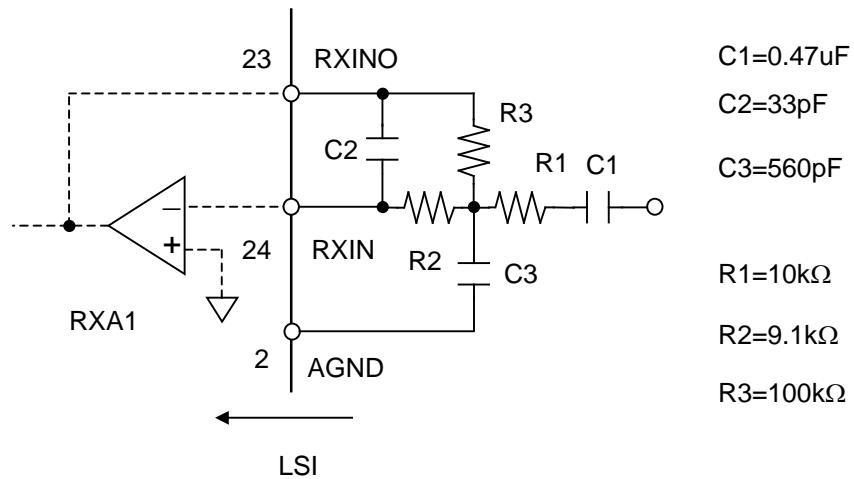
2) TXA2 amplifier

This amplifier is used for adjusting the gain of the tone signal. Set the gain to 0dB or less. For high frequency noise over 100kHz, form an anti-aliasing filter. The following gives a sample configuration of a second order LPF with a gain of 0dB and cut-off frequency of 13kHz:



3) RXA1 amplifier

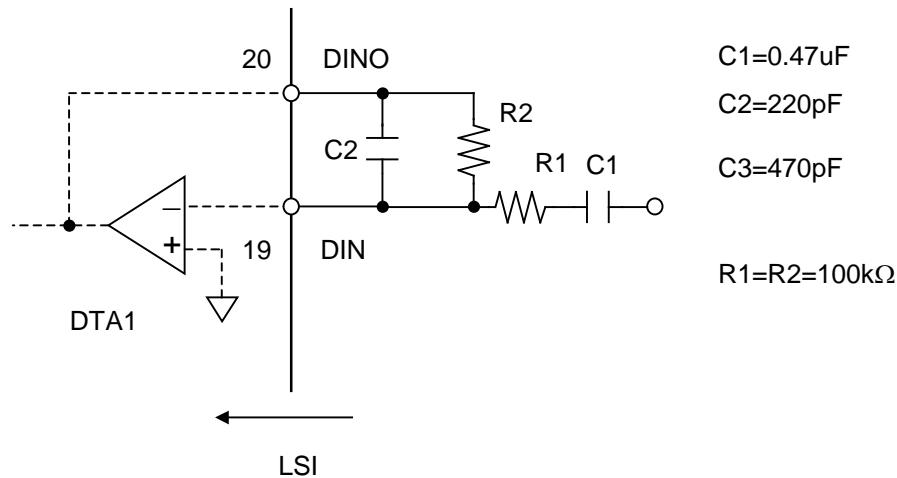
This amplifier is used for adjusting the gain of the RX signal. Set the gain to 20dB or less. For high frequency noise over 100kHz, form an anti-aliasing filter. The following gives a sample configuration of a second order LPF with a gain of 20dB and cut-off frequency of 39kHz:



4) DTA1

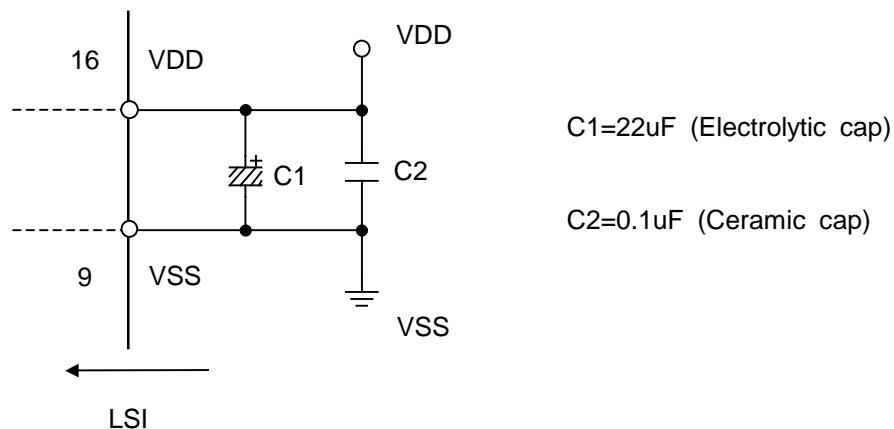
amplifier

This amplifier is used for adjusting the gain of the signal to Sub-Audio Programmable LPF. Set the gain to 0dB or less. For high frequency noise over 100kHz, form an anti-aliasing filter. The following gives a sample configuration of a second order LPF with a gain of 0dB and cut-off frequency of 7.2kHz:



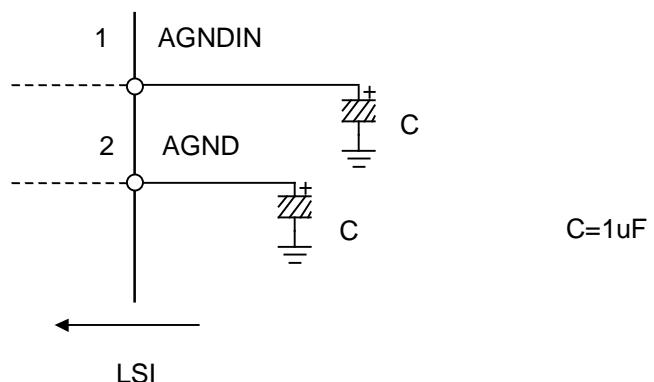
5) Power supply stabilizing capacitors

Connect capacitors between VDD and VSS pins to eliminate ripple and noise included in power supply. For maximum effect, the capacitors should be placed at a shortest distance between the pins.



6) AGND stabilizing capacitors

It is recommended that capacitors with $0.3\mu\text{F}$ or larger be connected between VSS and the AGND and AGNDIN pins to stabilize the AGND signal. The capacitors must be placed as close to the pins as possible.



7) Oscillator circuit

When the built-in oscillator circuit is to be used, connect a 3.6864MHz or 3.579545MHz crystal oscillator and a capacitor as shown in Fig. 6. The internal buffer is designed to allow stable oscillation of a crystal oscillator for the electrical equivalent circuitry with a resonance resistance of 150Ω (Max.) and a shunt capacitance of 5pF (Max.).

It is recommended that 22pF capacitors be connected externally so that the total load capacitance is 16pF (5pF + 22pF/22pF) or less. Place the oscillator, resistor, and capacitors as close to the XIN and XOUT pins as possible.

When an external clock is to be supplied, connect the clock line as shown in Fig. 7 or Fig. 8 according to the clock amplitude level.

The circuit in the first stage of the XIN pin has a constant threshold voltage (0.8V). Therefore, if the high level of the input clock is 1.5V or higher and the low level is 0.4V or lower, connect the clock signal as shown in Fig. 7. If the input clock amplitude (p-p value) is between 0.2V and 1.0V, connect the clock signal as shown in Fig. 8.

When the clock is to be shared with peripheral ICs, the clock must be input and output on the XIN pin. The clock amplitude must not exceed the absolute maximum ratings.

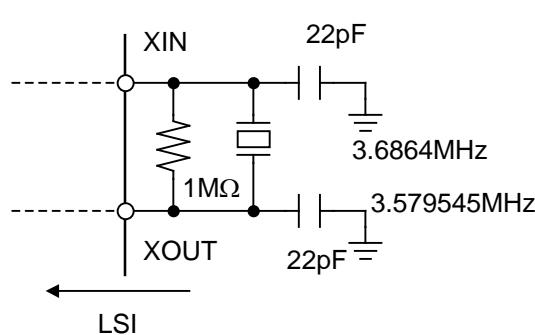


Fig. 6

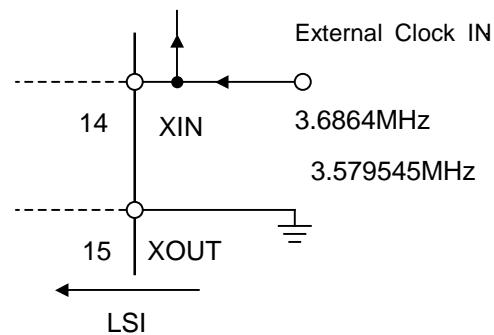


Fig. 7

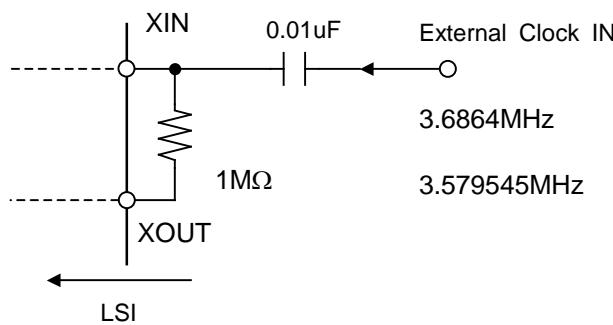


Fig. 8

8) LIMLV pin

The LIMLV pin is used for adjusting the limit level of the limiter circuit. This pin may be left open or may be used by connecting resistors as shown in the figure below.

When the pin is left open, a predetermined limit level can be obtained. The limit level is expressed as follows:

$$HV_{ref} = 0.256 \times (VDD - AGND) \quad [V_{o-p}]$$

For example, let VDD be 3V. The limit level is calculated as follows:

$$HV_{ref} = 0.256 \times (3.0 - 1.5) = 0.384V_{o-p} \quad \text{Then, } 1.5 \pm 0.384V \text{ is the typical value of the limit level.}$$

When a DC voltage higher than the AGND voltage level ($= 1/2VDD$) is applied to the pin through resistors, the limit level can be adjusted. The limit level is the difference between LIMLV and AGND and is expressed as $AGND \pm (LIMLV - AGND)$.

Let VDD be 3V. The limit level is calculated as follows:

$$LIMLV = 1.6V \rightarrow 1.5 \pm 0.1V$$

$$1.7V \rightarrow 1.5 \pm 0.2V$$

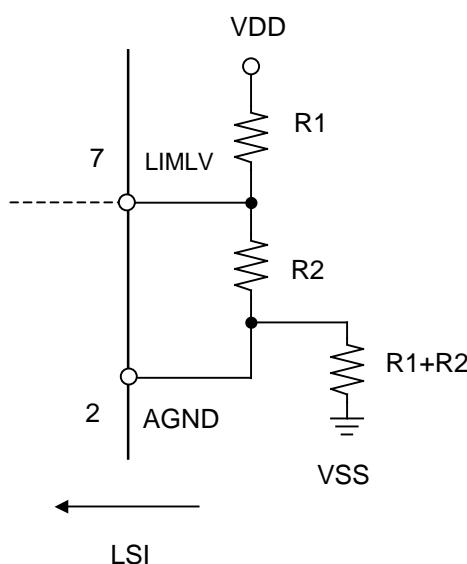
$$1.8V \rightarrow 1.5 \pm 0.3V$$

$$1.9V \rightarrow 1.5 \pm 0.4V$$

$$1.933V \rightarrow 1.5 \pm 0.433V \text{ (equivalent to } -6.6dBx \text{ (Max.)})$$

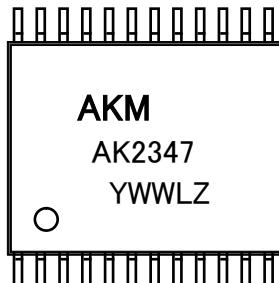
Then, the above values are obtained as the typical limit levels.

Because AGND level is used as the reference level for the limiter circuit operation as mentioned above, when resistors are connected, they should be connected so that VDD and AGND are separated by these resistors to supply a DC level to the LIMLV pin. In addition, make adjustments so that the sum of resistance ($R1 + R2$) is around $51k\Omega$.



17. Packaging

- Marking



[Contents of YWWLZ]

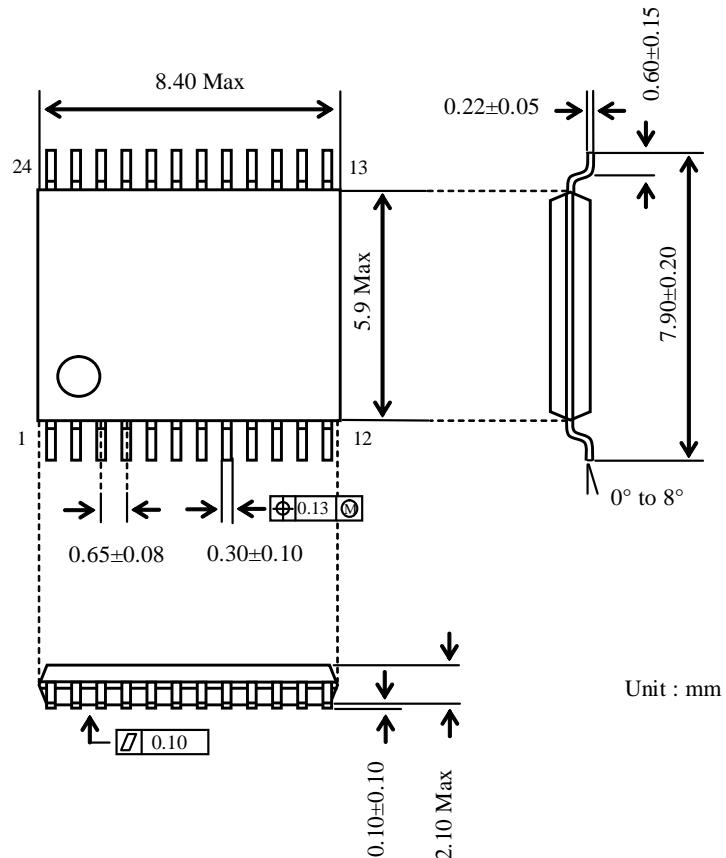
Y: Last digit of calendar year. (Year 2011->1, 2012->2)

WW: Manufacturing week number.

L: Lot identification, given to each product lot which is made in a week.
LOT ID is given in alphabetical order (A, B, C...).

Z: Assembly plant code

- 24-pin SSOP Mechanical Outline



18. Important Notice

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