AIS2001

Analog Microphone Interface With Feature Extraction for Machine Learning

Features:

- Low active power consumption of < 250 µW average power when running full Analog Signal Conditioning and Feature Extraction.
- Supports 32 frequency bins in Feature Extraction image.
- Allows for use of preset coefficients in ROM or for custom coefficients to be loaded into SRAM.
- Directly interfaces to analog MEMS microphone.
- SPI Interface (load coefficients, read audio and flags)
- On board ultra-low power regulator and clock.
- Supply operating range supports common analog MEMs microphone ranges.
  - VIN: 1.5V to 3.6V
  - AVDD: 1.2V
  - DVDD: 0.9V to 1.2V
- Direct powering of 1.2V regulated pins is supported for lowest power requirements.
- Small footprint in a 32 pin 5x5 QFN package.

Applications:

- Wake-word recognition
- Acoustic Anomaly/Event Detections
- Event based classifier templates

Description:

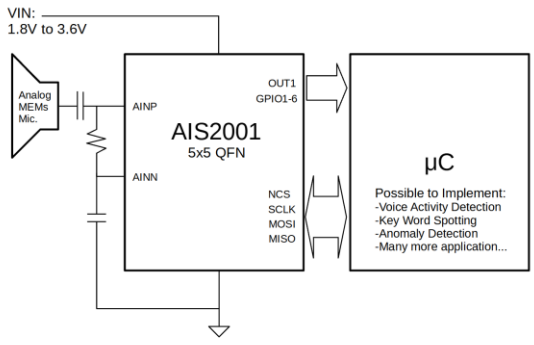
The AIS2001 is a smart analog MEMS microphone interface with included feature extraction. Ultra-low "always on" power consumption of < 250 µW, with proper dataset training, accuracy levels greater than 95% are possible for speech and anomaly detection.

The proprietary charge domain feature extraction engine eliminates the need for data conversion and complex power-hungry DSP while generating the appropriate form of spectrogram for neural network word and sound classification input. This results in superior ultra-low power performance with no compromise in accuracy.

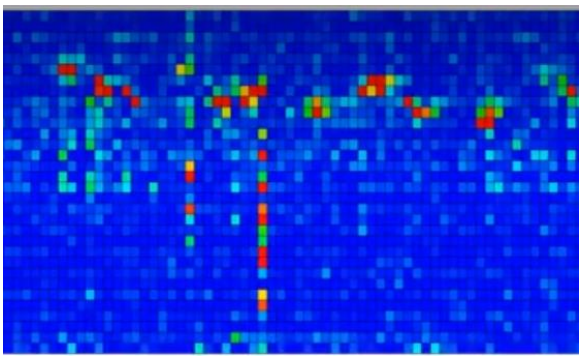
The analog front-end amplifier interfaces directly to single-ended analog MEMs microphones with minimum additional components. This allows for a significant power benefit compared to digital microphones. The AIS2001 can be easily interfaced to various other types of sensors such as accelerometers and heart rate monitors thanks to the variable gain input amplifier with high input impedance.

The AIS2001 development environment supports standard flows such as TensorFlow lite. The trained and quantized parameters can be stored directly in the on-chip SRAM. This provides ultimate flexibility for ultra-low power standalone applications.

Typical Application:



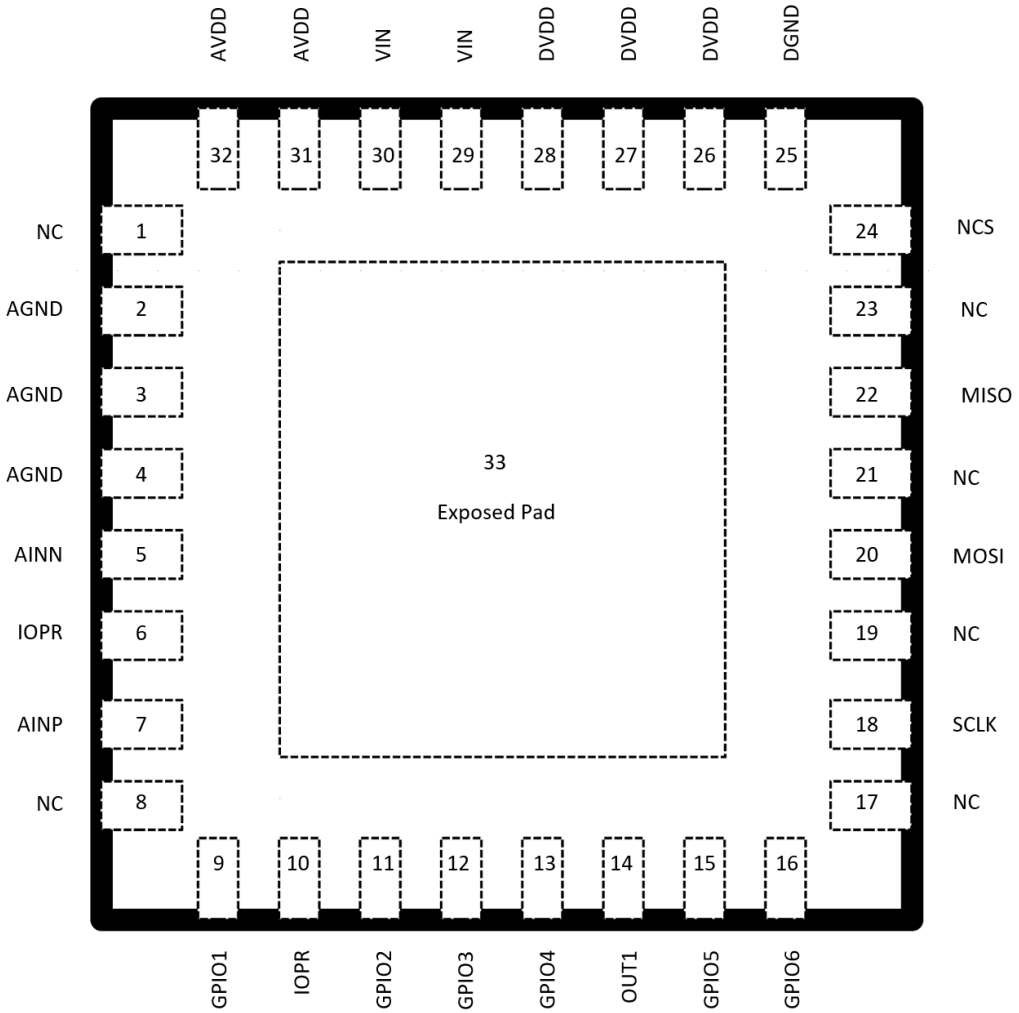
Example PSD Output:



Absolute Maximum Ratings: (Note1)

VIN Voltage .....-0.3V to 4.3V
AINP, AINN Voltage .....-0.3V to VIN+0.3V
IOPR, IOPL Voltage.....-0.3V to VIN+0.3V
NCS, SCLK, MOSI, MISO Voltage...-0.3V to VIN+0.3V
OUT1, GPIO1, GPIO2 Voltage .....-0.3V to VIN+0.3V
GPIO3, GPIO4, GPIO5 Voltage .....-0.3V to VIN+0.3V
GPIO6 Voltage.....-0.3V to VIN+0.3V
AVDD, DVDD Voltage..... -0.3V to 1.35V
AGND, DGND, Exposed Pad Voltage ....-0.3V to 0.3V
Operating Junction Temperature Range
(Note 2)..... 0°C to 55°C
Storage Temperature Range.....-65°C to 150°C

Pin Configuration:



Pin Descriptions:

AGND (Pins 2,3,4): Analog ground pins. Connect all three pins together at the AIS2001, and kelvin all AVDD, VIN, and AINN bypass capacitors to these pins. Make a single connection from these pins to board ground for the best noise performance.

AINN (Pin 5): Inverting input of the input audio amplifier. Bypass this pin to AGND with a recommended 44µF of capacitance and connect a recommended 4.7kΩ resistor between this pin and AINP.

IOPL (Pin 6): Analog output of the input audio amplifier that can be used for RMS level detection or Automatic Gain Control. See the Applications Information section for details.

AINP (Pin 7): Non-inverting input of the input audio amplifier. Couple the single ended analog audio signal to this pin through a recommended 22µF of capacitance.

GPIO1 (Pin 9): General purpose digital output. This pin can be driven up to VIN.

IOPR (Pin 10): Analog output of the input audio amplifier that can be used for RMS level detection or Automatic Gain Control. See the Applications Information section for details.

GPIO2-4 (Pin 11-13): General purpose digital output. This pin can be driven up to VIN.

OUT1 (Pin 14): General purpose digital output. This pin can be driven up to VIN.

GPIO5, GPIO6 (Pin 15,16): General purpose digital output. This pin can be driven up to VIN.

SCLK (Pin 18): Clock input of the SPI interface.

MOSI (Pin 20): MOSI input of the SPI interface.

MISO (Pin 22): MISO input of the SPI interface.

NCS (Pin 24): Chip select of the SPI interface.

DGND (Pin 25): Digital ground pin. The DVDD bypass capacitor should be kelvined to this pin. Make a single connection from this pin to board ground for the best noise performance.

DVDD (Pins 26,27,28): AIS2001 generated digital supply voltage. Connect all pins together at the AIS2001 and bypass with a minimum of 1µF to the DGND pin.

VIN (Pins 29,30): Input voltage to the AIS2001. Connect all pins together at the AIS2001 and bypass with a minimum of 1µF to the AGND pin.

AVDD (Pins 31,32): AIS2001 generated analog supply voltage. Connect all pins together at the AIS2001 and bypass with a minimum of 1µF to the AGND pin.

NC (Pins 1,8,17,19,21,23): No connect pins. These pins have no electrical connections but must still be soldered to the PCB for mechanical strength.

Exposed Pad (Pin 33): This pin has no electrical connection but must be soldered to ground for mechanical strength and thermal performance.

Electrical Characteristics: **The • denotes specifications that apply over the specified operating junction temperature range, otherwise specifications are at T_A=25°C. (Note 2) VIN=1.5V, unless otherwise noted.**

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Input Operating Range		•	1.5		3.3	V
Input Operating Current	AIS2001 Disabled			10	100	nA
	AIS2001 Enabled, Audio Disabled			100	150	µA
	AIS2001 Enabled, Audio Enabled			250	350	µA
AVDD Regulation Voltage	T_A=25°C		1.21	1.22	1.23	V
	T_A=0°C to 55°C	•	1.19	1.22	1.25	V
DVDD Regulation Voltage	T_A=25°C, DVDD Select = 0		1.21	1.22	1.23	V
	T_A=0°C to 55°C, DVDD Select = 0	•	1.19	1.22	1.25	V
	T_A=25°C, DVDD Select = 1		1.09	1.10	1.11	V
	T_A=0°C to 55°C, DVDD Select = 1	•	1.07	1.10	1.13	V
	T_A=25°C, DVDD Select = 2		0.99	1.00	1.01	V
	T_A=0°C to 55°C, DVDD Select = 2	•	0.97	1.00	1.03	V
	T_A=0°C to 55°C, DVDD Select = 3	•	0.88	0.90	0.92	V
AINN Regulation Voltage	T_A=0°C to 55°C	•	0.88	0.9	0.92	V
AVDD and DVDD Max DC Current				1		mA
AVDD and DVDD Supply Regulation	I_{VDD} = 500µA			1.5		%
AVDD and DVDD Load Regulation	IVDD = 0µA to 1mA			1.5		%
Audio Amplifier Gain	GM Select = 0 or 8			970		µA/V
	GM Select = 1 or 9			1900		µA/V
	GM Select = 2 or 10			266		µA/V
	GM Select = 3 or 11			29.5		µA/V
	GM Select = 4 or 12			324		µA/V
	GM Select = 5 or 13			627		µA/V
	GM Select = 6 or 14			89		µA/V
	GM Select = 7 or 15			9.9		µA/V
Maximum Peak Audio Input Range (Absolute Value of V_{AINP}-V_{AINN})	GM Select = 0 or 8			309		µV
	GM Select = 1 or 9			157		µV
	GM Select = 2 or 10			1.13		mV
	GM Select = 3 or 11			10.1		mV
	GM Select = 4 or 12			926		µV
	GM Select = 5 or 13			478		µV
	GM Select = 6 or 14			3.37		mV
	GM Select = 7 or 15			30.3		mV
Audio Amplifier Bandwidth	GM Select = 0			3.9		kHz
	GM Select = 1			2.0		kHz
	GM Select = 2			12.5		kHz
	GM Select = 3			49.1		kHz
	GM Select = 4			3.8		kHz
	GM Select = 5			2.0		kHz
	GM Select = 6			12.1		kHz
	GM Select = 7			46.5		kHz
	GM Select = 8			7.8		kHz
	GM Select = 9			4.0		kHz
	GM Select = 10			25.4		kHz
	GM Select = 11			113.6		kHz
	GM Select = 12			7.2		kHz
	GM Select = 13			3.7		kHz
	GM Select = 14			23.4		kHz
	GM Select = 15			98.9		kHz
Audio Sampling Frequency	Programmed for 16kHz (Note 3)	•	15.5	16.0	16.5	kHz
	Programmed for 8kHz (Note 3)	•	7.76	8.00	8.24	kHz

Electrical Characteristics: **The • denotes specifications that apply over the specified operating junction temperature range, otherwise specifications are at T_A=25°C. (Note 2) VIN=1.5V, unless otherwise noted.**

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Feature Frame Size	(Note 3,4)			512		Samples
Feature Stride Size	(Note 3,4)			256		Samples
Pre-Programmed Feature Frequency Bins at 16kHz Sample Rate (Note 3,4)	Bin 0			62.5		Hz
	Bin 1			125.0		Hz
	Bin 3			187.5		Hz
	Bin 4			250.0		Hz
	Bin 5			312.5		Hz
	Bin 6			406.3		Hz
	Bin 7			500.0		Hz
	Bin 8			593.8		Hz
	Bin 9			687.5		Hz
	Bin 10			812.5		Hz
	Bin 11			906.3		Hz
	Bin 12			1.063		kHz
	Bin 13			1.188		kHz
	Bin 14			1.344		kHz
	Bin 15			1.500		kHz
	Bin 16			1.688		kHz
	Bin 17			1.875		kHz
	Bin 18			2.063		kHz
	Bin 19			2.531		kHz
	Bin 20			2.781		kHz
	Bin 21			3.063		kHz
	Bin 22			3.344		kHz
	Bin 23			3.688		kHz
	Bin 24			4.031		kHz
	Bin 25			4.406		kHz
	Bin 26			4.813		kHz
	Bin 27			5.250		kHz
	Bin 28			5.719		kHz
	Bin 29			6.219		kHz
	Bin 30			6.781		kHz
	Bin 31			7.375		kHz
Digital Input Rising Threshold		•			75	% VIN
Digital Input Falling Threshold		•	25			% VIN
Digital Input Leakage Current				10	30	nA
Digital Output Pull-Up Resistance	V_{VIN}-V_{GPIO}=0.2V, I_{GPIO}=1mA	•		15	50	Ω
Digital Output Pull-Down Resistance	V_{GPIO}=0.2V, I_{GPIO}=1mA	•		6	25	Ω
Maximum SPI Clock Frequency		•			8	MHz

Note 1: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

Note 2: The AIS2001 is tested under pulsed load conditions such that TJ ≈ TA. The AIS2001 is guaranteed to meet specifications from 0°C to 55°C junction temperature. Specifications over the –40°C to 85°C operating junction temperature range are assured by design, characterization and correlation with statistical process controls. The junction temperature (T_J) is calculated from the ambient temperature (T_A) and power dissipation (P_D) according to the formula: $T_J = T_A + (P_D \bullet \theta_{JA}$°C/W), where θ_{JA} is the package thermal impedance. Note that the maximum ambient temperature consistent with these specifications is determined by specific operating conditions in conjunction with board layout, the rated package thermal resistance and other environmental factors.

Note 3: Consults Applications Information section for register settings and programming details for the AIS2001.

Note 4: Guaranteed by design. Not tested.

Block Diagram: