KSD

Photon Counting Integrated Circuit for Intelligent Particulate Sensor

Product Specification

General Description

The KSD is a mixed-signal ASIC for an Intelligent Particulate Sensor (IPS). This ultra-low noise, low power circuit will provide mass concentration/count data of various sized ultrafine particulates (PM0.1 - PM10) in the ambient air with high-accuracy.

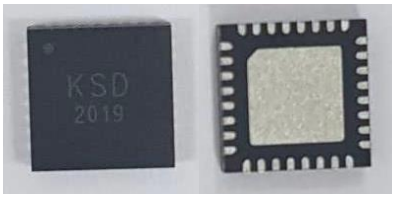
The KSD adopts a new photon packet counting architecture to process small photoelectric currents generated by reflected light due to submicron particles, ranging between a few femto to a few pico amperes.

Unlike the conventional scheme of chips, the KSD has an electronic common noise cancellation pre-amplifier to increase SNR. The chip is able to effectively identify actual signals originated from particles that are embedded in noise, which can be a hundred times larger.

The KSD also features five internal discriminators to detect amplitudes of signals proportional to photon energies, and outputs 16-bit binary digital signals to an application system. By using the information of amplitude, width and number of pulses, the chip can provide accurate data to show the mass concentration of particles, their sizes in real-time.

The chip operates at a high frequency (wide bandwidth) to distinguish clustered ultrafine particles, reducing the probability of falsely registering them as a much larger particle.

The KSD is one of the three different versions of Piera System's PCICs (Particle Counting IC).



KSD (5mm x 5mm, 32-pin QFN)

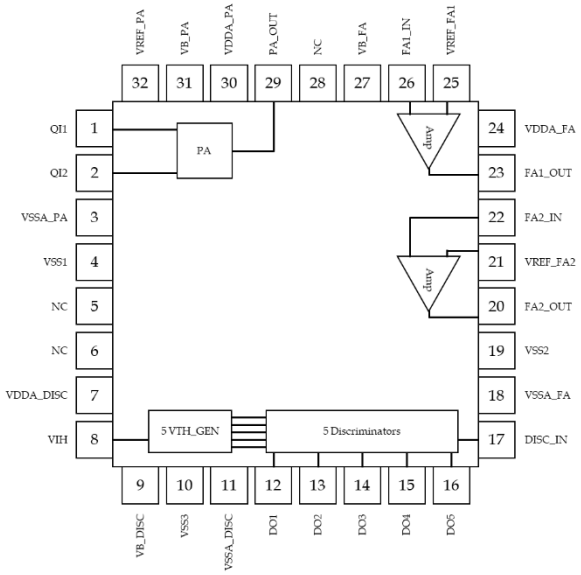
Features

- 11mW low power dissipation
- 3.3V single power supply
- Gain control (150 – 240dB)
- High Sensitivity (0.1pA – 10pA)
- 5-bin digital outputs & 1 analog output (amplified raw signal from photodiode – can be connected to other discrete amps depending on application
- Binning threshold control (0~3.3V)
- High sampling rate ~1MHz
- Internal noise cancellation

Applications

- Particulate sensor
- Dust sensor
- Noxious gas Spectrum analyzers

Pin Configuration & Functional Block Diagram



Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit
Supply Voltage	VDDA_DISC, VDDA_FA, VDDA_PA	3.0	3.3	3.6	Volt
Operating Temperature	T_{OP}	0	-	85	℃
Storage Temperature	T_{STG}	-40	-	125	℃

Electrical Characteristics

Parameter	Condition	Min	Typ	Max	Unit
Total Current	VDDA_PA: 2.22mA VDDA_FA: 0.46mA VDDA_DISC: 0.66mA	-	3.34	-	mA
PA Gain[1)]	Parasitic Input Capacitance: 100pF	144	150-	156	dB
FA1 Gain[2)]	R2: 5.1kΩ, R2: 510kΩ		40	-	dB
FA2 Gain[2)]	R4: 5.1kΩ, R5: 510kΩ	-	40	-	dB
VTH[3)]	-	0		2.5	V
Data Out	Load capacitance 3pF	0	-	3.3	V
Vtrp(+/-)	-	46	50	55	mV

Note 1): Trans-impedance Amplifier Gain (Vo/Ii)
Note 2): Voltage Gain (Vo/Vi) adjustable by changing the resistors R2 and R5
Note 3): VTH1 ~ VTH5 were evenly spaced, i.e. VTH1 0.5V, VTH2 1.0V, VTH3 1.5V, VTH4 2.0V, and VTH5 2.5V at VTH 2.5V

Pin Description

Pad No.	Pad Name	Function	Value		
			Min(V)	Typ.(V)	Max(V)
1	QI1	Should be connected to an anode of a photodiode (w/ IO).		-	
2	QI2	Should be connected to a cathode of a photodiode (w/ IO).		-	
3	VSSA_PA	Ground pin for preamplifier. Must be connected to 0V.		0	
4	VSS1	Ground pin. Must be connected to 0V.		0	
5	NC	Should not be connected to anything.		-	
6	NC	Should not be connected to anything.		-	
7	VDDA_DISC	Power supply input for discriminator.	3.0	3.3	3.6
8	VIH	Threshold voltage setup input voltage. 5 bin threshold voltage control.	1	3	3
9	VB_DISC	Bias voltage input for discriminators.	0.8	1	1.2
10	VSS3	Ground pin. Must be connected to 0V.		0	
11	VSSA_DISC	Ground pin for discriminators. Must be connected to 0V.		0	
12	DO1	1st Discriminator output – digital.	0		VDDA_DISC
13	DO2	2nd Discriminator output – digital.	0		VDDA_DISC
14	DO3	3rd Discriminator output – digital.	0		VDDA_DISC
15	DO4	4th Discriminator output – digital.	0		VDDA_DISC
16	DO5	5th Discriminator output – digital.	0		VDDA_DISC
17	DISC_IN	Discriminator input.	0.2		3.3
18	VSSA_FA	Ground pin for amplifier. Must be connected to 0V.		0	
19	VSS2	Ground pin. Must be connected to 0V.		0	
20	FA2_OUT	2nd Filter & Amplifier output.	0.1		3.2
21	VREF_FA2	Reference voltage input for 2nd Filter & Amplifier.	0.1	0.5	2.5
22	FA2_IN	2nd Filter & Amplifier input.	0.1		3.2
23	FA1_OUT	1st Filter & Amplifier output.	0.1		3.2
24	VDDA_FA	Power supply input for Filter & Amplifier.	3.0	3.3	3.6
25	VREF_FA1	Reference voltage input for 1st Filter & Amplifier.	0.1	0.5	2.5
26	FA1_IN	1st Filter & Amplifier input.	0.1		3.2
27	VB_FA	Bias voltage input for Filter & Amplifier	0.8	1	1.2
28	NC	Should not be connected to anything		-	
29	PA_OUT	Pre-amplifier output (w/ IO)	1		3.2
30	VDDA_PA	Power supply input for preamplifier	3.0	3.3	3.6
31	VB_PA	Bias voltage input for preamplifier	0.8	1	1.2
32	VREF_PA	Reference voltage input for preamplifier	1.24	1.26	1.28

Application Note for Particulate Sensor

Recommended front-end photoelectronic parts

- Laser diode or Infrared diode (IR diode): 800nm – 950nm, 5mW – 10mW
- Photodiode: matching wavelength to laser diode or Infrared diode (IR diode), < 3mm x 3mm

An application block diagram with an MCU is shown in Fig.1. The analog output VO and digital outputs DO1~DO5, can be used to analyze the number and sizes of particles in the air.

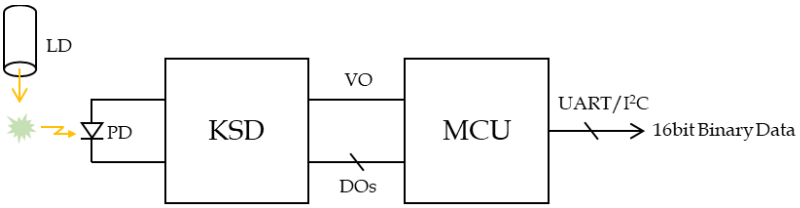


Fig. 1. Application circuit with an MCU

PA (Preamplifier)

The preamplifier receives photocurrent resulting from reflected light on particles from a photodiode. The current gets amplified by the preamplifier which outputs voltage signal. Customer has freedom to choose a photodiode depending on application. An IR LED or laser diode with wave length of 850nm-940nm is recommended for a typical particle sensor application.

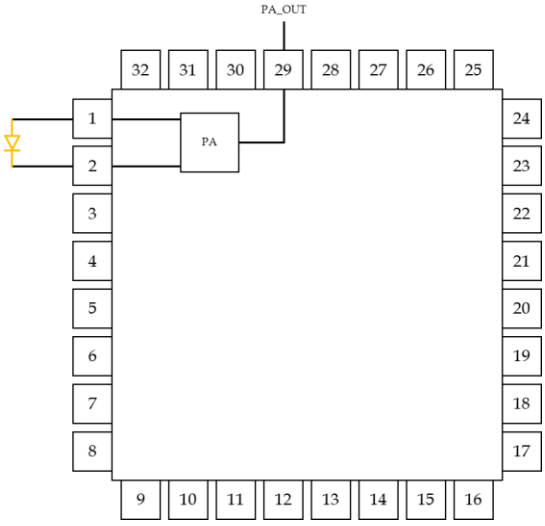


Fig. 2. Preamplifier and a photodiode connection

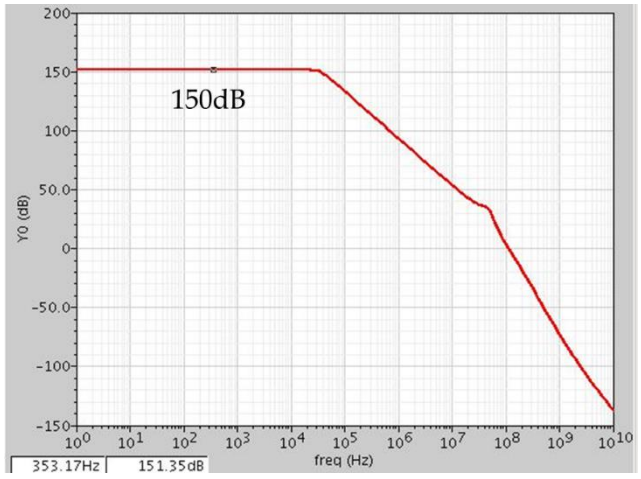


Fig. 3. The preamplifier has high gain of 150dB

The gain of the preamplifier (PA) is adjustable by varying the input voltage on VREF_PA from 1.24V-1.28V.

FA1 (1st Filter and Amplifier)

The 1st Filter & Amplifying block (FA1) amplifies the output of PA by around 40dB depending on the resistances of R3 (variable) and R4, parallel with the capacitor C3 (0.17nF). The C1 (2.2uF) between the output pin of PA and the input pin of FA1 decouples the DC voltages of PA and FA1. The R1 (10kΩ) and C1 forms a low pass filter to increase system stability. The R2 (200kΩ) is for supplying reference voltage to FA1.

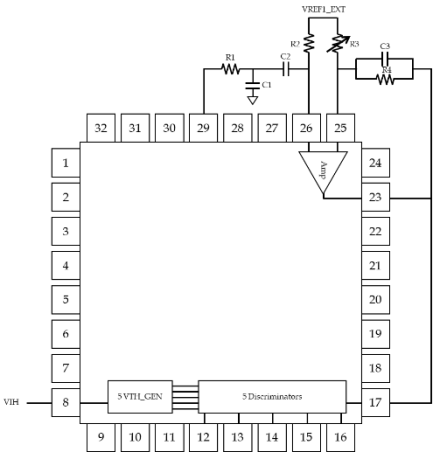


Fig. 4. Configuration of FA1

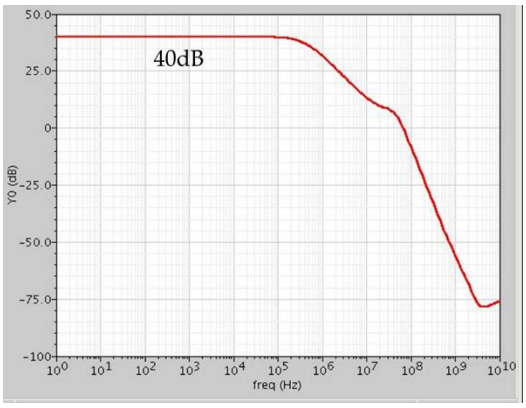


Fig. 5. Gain of FA1

FA2 (2nd Filter and Amplifier)

A DC decoupling capacitor C4, 0.22uF should be connected in between FA1 and FA2. The FA2 Further provides more gain. With R6 and R7 (5.1kΩ and 510kΩ respectively), connected in parallel with the capacitor C5, 0.34nF, the gain of FA2 is 40dB.

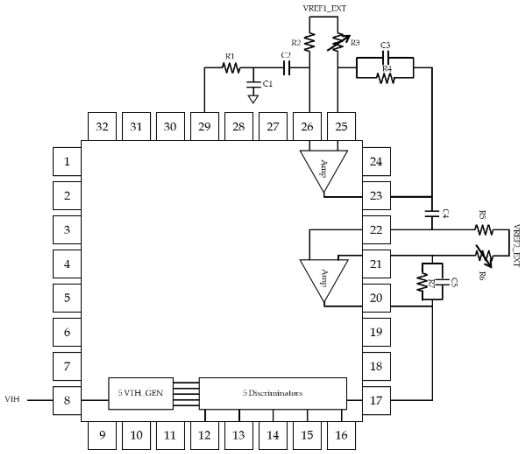


Fig. 6. Configuration of FA2

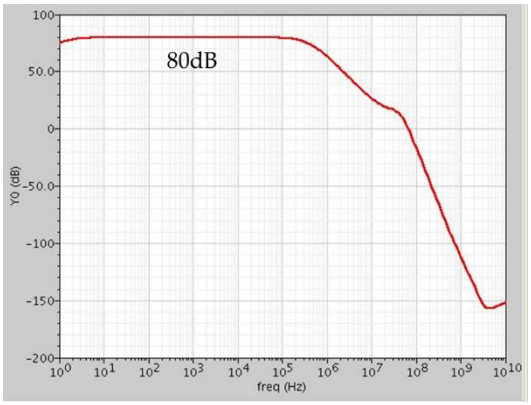


Fig. 7. Gain of FA1 and FA2 combined

VTH

The VTH sets the internal threshold voltage for the 5 discriminators. The 5 VTH_GEN block generates five different threshold voltages of VTH1-VTH5 that are equally spaced. Digital output pulses are shown in Fig. 8.

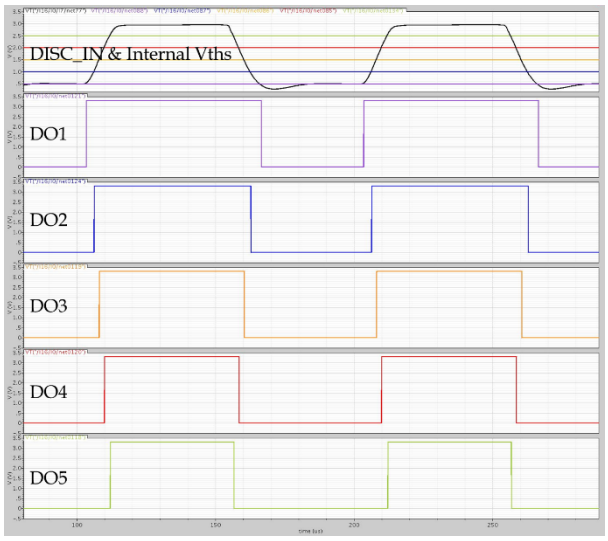


Fig. 8. Discriminator output examples

Hysteresis

KSD has internal hysteresis control to effectively reduce signal transition noise at the threshold point. Fig. 9 shows the trip voltage.

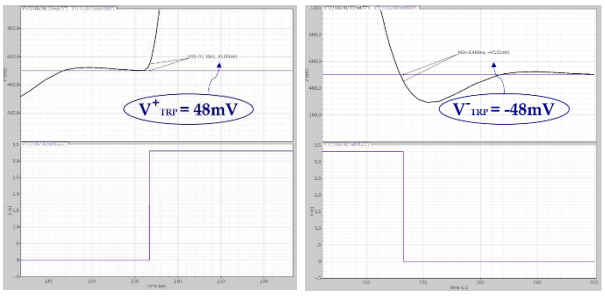


Fig. 9. Discriminator output examples

Complete Application Circuit Configuration

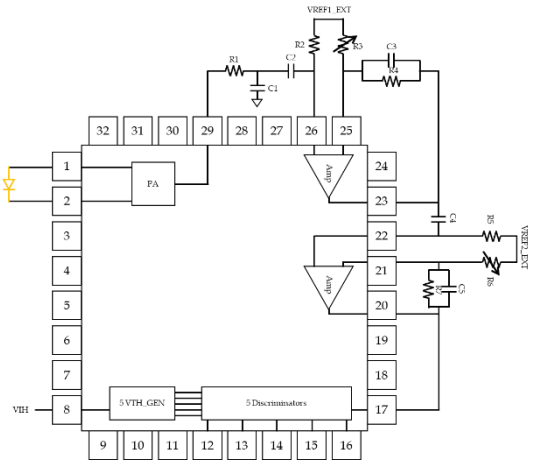
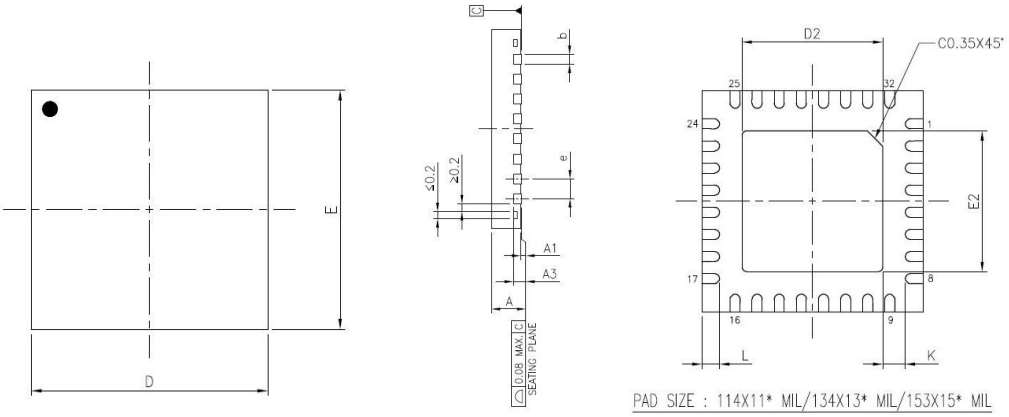


Fig. 10. Complete IC configuration

Fig. 11. Total Gain

Package Information



	PACKAGE TYPE					
JEDEC OUTLINE	MO-220			MO-220		
PKG CODE	WQFN(X532)			VQFN(Y532)		
SYMBOLS	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.70	0.75	0.80	0.80	0.85	0.90
A1	0.00	0.02	0.05	0.00	0.02	0.05
A3	0.203 REF.			0.203 REF.		
b	0.18	0.25	0.30	0.18	0.25	0.30
D	5.00 BSC			5.00 BSC		
E	5.00 BSC			5.00 BSC		
e	0.50 BSC			0.50 BSC		
L	0.35	0.40	0.45	0.35	0.40	0.45
K	0.20	—	—	0.20	—	—

PAD SIZE	D2			E2			LEAD FINISH		JEDEC CODE
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	Pure Tin	PPF	
114X11* MIL	2.65	2.70	2.75	2.65	2.70	2.75	X	V	W(V)HHD-2
134X13* MIL	3.15	3.20	3.25	3.15	3.20	3.25	V	V	W(V)HHD-2
150X15* MIL	3.45	3.50	3.55	3.45	3.50	3.55	V	V	W(V)HHD-5
R150X15* MIL	3.45	3.50	3.55	3.45	3.50	3.55	V	X	W(V)HHD-5
153X15* MIL	3.20	3.25	3.30	3.20	3.25	3.30	V	V	W(V)HHD-5

"*" is an universal character, which means maybe replaced by specific character, the actual character please refers to the bonding diagram.