Features

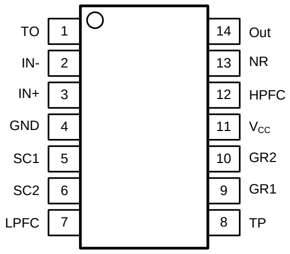
- **Ideal DC gain when Rg=20K: 4.56GΩ**
- **One resister(Rg) to set the gain**
- **Supply voltage range: 2.1-5.5V**
- **Iq: 700μA maximum**
- **Analog output**
- **Internal amplifier:**
  - **V_{OS}: ±3mV maximum**
  - **Low noise: 25 nV/$\sqrt{Hz}$**
  - **GBWP: 1.3MHz**
  - **Input Bias Current: 1pA typical**
- **ESD rating: HBM 8KV / CDM 2KV**
- **Operation temperature range: –40°C to 125°C**
- **Green, Popular Type Package**

Applications

- **Dust sensor for air quality monitoring (PM2.5, PM10)**
- **Photodiode interface**
- **Sensor interface for current output sensor**

Pin Configuration

TPA8801B
14-Pin TSSOP
(-T Suffixes)



Description

TPA8801B is a high sensitivity current input interface, which can covert the pA to nA range current signal to 5V range output.

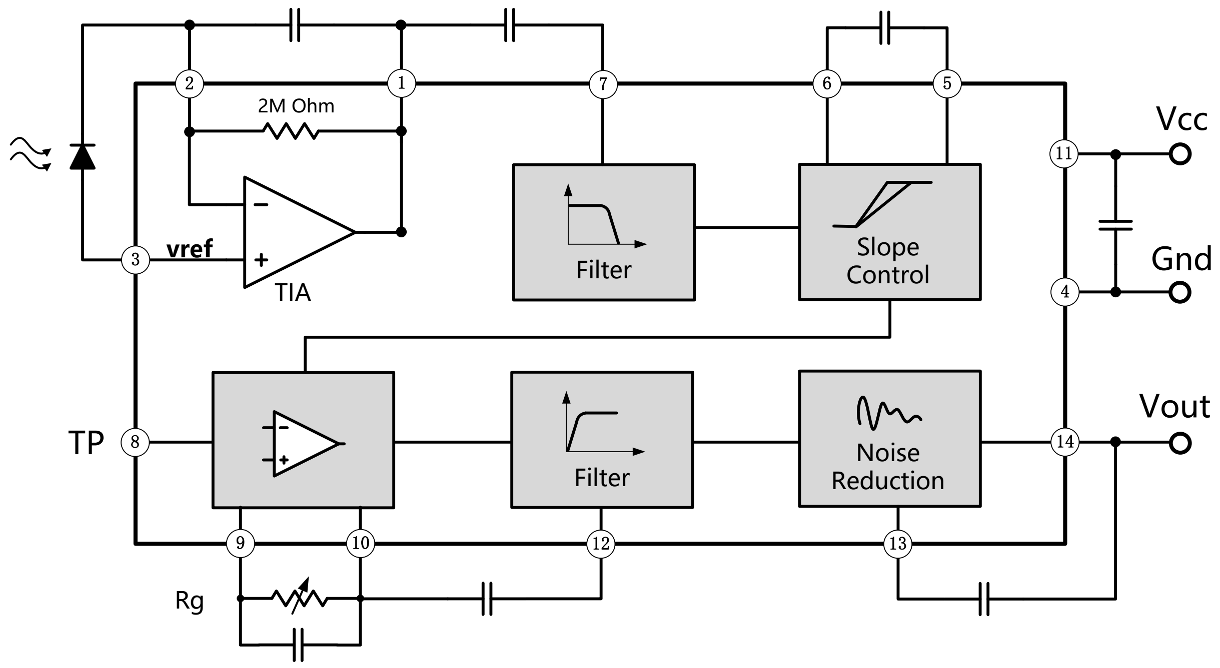
TPA8801B use one resister to set the transduce gain, can provide ideal 4.56GΩ current to voltage DC gain when the resister is 20KΩ. As the output is saturated in the real application by offset voltage of internal amplifier, AC coupled mode is used to remove DC offset voltage and bias current impaction, so the real AC gain in the application is less than ideal DC gain depend on the capacitor values.

The internal precision amplifier has 1pA input bias current is good to transduce down to 100pA signal, 0.4mV offset voltage to expand the input range for DC signal, 1.3MHz GBW to meet the requirement of AC signal which is used in some type of dust sensor application.

TPA8801B is specified for operation over the -40°C to 125°C range.

TPA8801B is available in 5mm*6mm 14-lead TSSOP package. TPA8801B possibly in 3mm*2mm 14-lead DFN package, 1/5 size versus TSSOP-14 package, to meet the size limitation application, the sample can be provided in one month.

Block Diagram



Pin Functions

No.	Mnemonic	Description	No.	Mnemonic	Description
1	TO	TIA Output	**8**	TP	Test Point
2	IN-	Amplifier IN- , Sensor Input	**9**	GR1	Voltage Gain Setting
3	IN+	Amplifier IN+ , Sensor Input	**10**	GR2	Voltage Gain Setting
4	GND	Ground	**11**	V_{CC}	Power Supply
5	SC1	Slope Control Cap Input	**12**	HPFC	High Pass Filter Cap
6	SC2	Slope Control Cap Output	**13**	NR	Noise Reduction
7	LPFC	Low Pass Filter Cap	**14**	OUT	Signal Output

Order Information

Model Name	Order Number	Package	Transport Media, Quantity	Marking Information
TPA8801B	TPA8801B-TR	TSSOP-14	Tape and Reel, 3,000	TPA8801B

Absolute Maximum Ratings Note 1

Supply Voltage: $V^+ - V^-$....................................7.0V

Input Voltage............................ $V^- - 0.3$ to $V^+ + 0.3$

Input Current: Note 2....................................... ±10mA

Output Short-Circuit Duration Note 3.............. Infinite

Operating Temperature Range.......–40°C to 125°C

Maximum Junction Temperature................... 150°C

Storage Temperature Range.......... –65°C to 150°C

Lead Temperature (Soldering, 10 sec) .... 260°C

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 inputs are protected by ESD protection diodes to each power supply. If the input extends more than 500mV beyond the power supply, the input current should be limited to less than 10mA.

Note 3: A heat sink may be required to keep the junction temperature below the absolute maximum. This depends on the power supply voltage and how many amplifiers are shorted. Thermal resistance varies with the amount of PC board metal connected to the package. The specified values are for short traces connected to the leads.

ESD, Electrostatic Discharge Protection

Symbol	Parameter	Condition	Minimum Level	Unit
HBM	Human Body Model ESD	MIL-STD-883H Method 3015.8	8	kV
MM	Machine Model ESD	JEDEC-EIA/JESD22-A115	500	V
CDM	Charged Device Model ESD	JEDEC-EIA/JESD22-C101E	2	kV

Electrical Characteristics

The specifications are at TA = 27°C. V_{CC} = 5V, unless otherwise noted.

Symbol	Parameter	Limits			Unit
		Min	Typ	Max	
V_{CC}	Power supply	2.1		5.5	V
I_Q	Supply current		390	700	µA
TIA R_F	TIA Feedback Resister		2		MΩ
DG	Theory DC Gain Note 1, Note 2		228,000		V/V
DGE	DC Gain Error Note 3	-1		1	%
V_{REF}	Voltage Reference		0.8	0.9	V
Internal Amplifier					
GBWP	Gain-Bandwidth Product		1.3		MHz
I_B	Input Bias Current		1	10	pA
V_{OS}	Amplifier Offset Voltage			3	mV
e_N	Input Voltage Noise Density		25		nV/√Hz
I_{SC}	Output Short-Circuit Current		100		mA
I_O	Output Current		50		mA

Note 1: The theory loop gain is Voltage of Output = DG * Rg

Note 2: The theory DC gain is calculated exclude the V_{OS} of internal amplifier, the AC gain in the real application is less than theory DC gain, the value is depended on pass band setup.

Note 3: Guaranteed by design

Typical Application Circuit

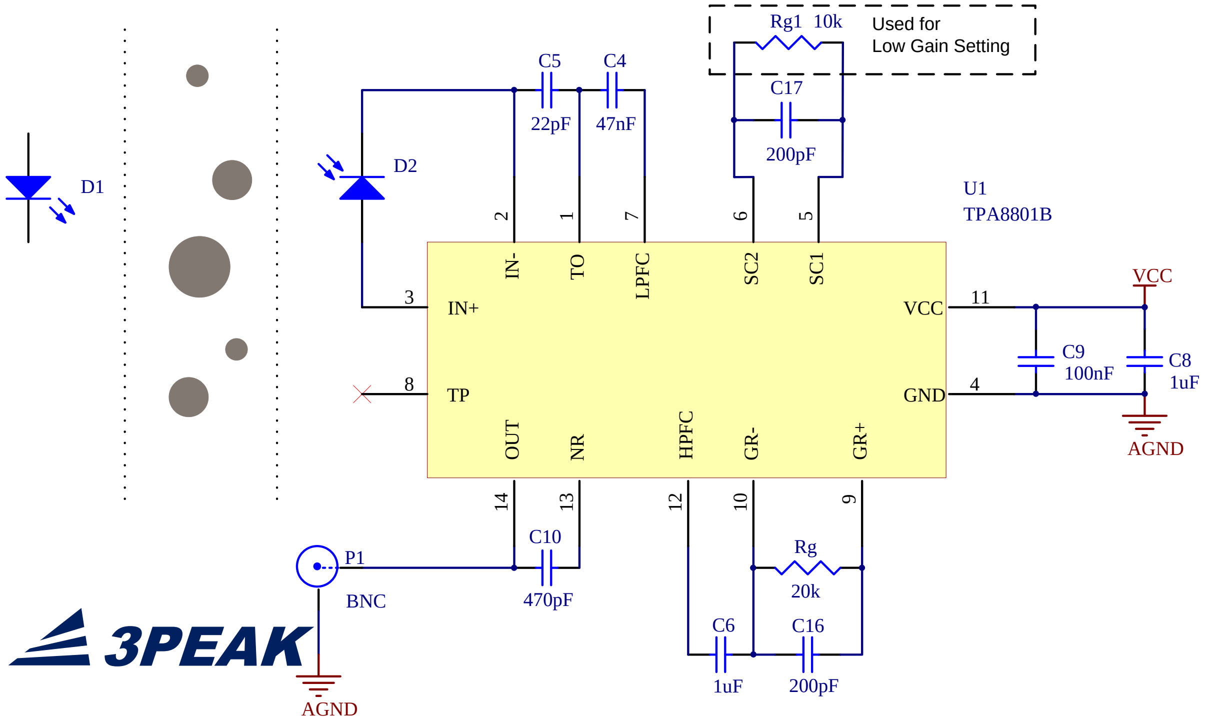


Figure 1 Typical configuration of dust detection by infrared pulse stimulation

Clean Air (Y: LED Switch 2V/DIV G: Vout 200mV/DIV)

Dirty Air (Y: LED Switch 2V/DIV G: Vout 2V/DIV)

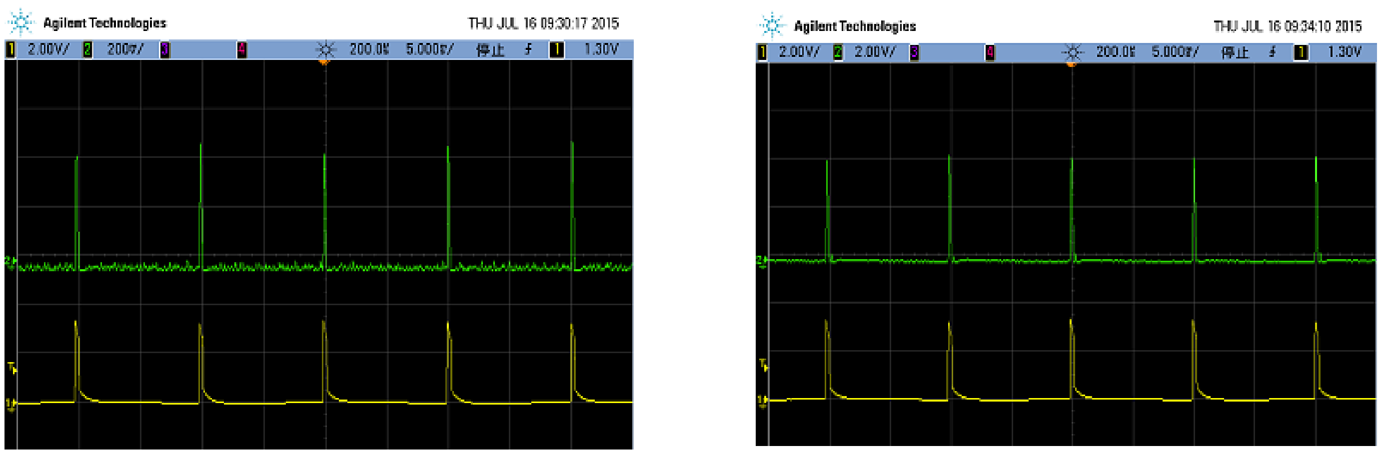


Figure 2 Performance of dust detection by infrared pulse stimulation

Applications Information

Application for dust detection by infrared pulse stimulation

The Figure 1 and Figure 2 show the popular way to detect dust or PM2.5, PM10 particle by infrared pulse stimulation. Comparing to laser solution, the infrared solution has low cost by sensor, mechanical design. The response of infrared photodiode is very small, in 0.1nA to 1nA output, so it needs very high transduce gain to covert the signal to voltage. To remove the DC impaction like dark current of photodiode, offset voltage and bias current of internal amplifier, the pulse stimulation is used for the emitting diode, and the high pass filter is used in the TPA8801b.

Gain and pass band calculation of the typical application circuit for infrared

The TPA8801B tools.xlsx is a tool can calculate the circuit setting

1. Calculate the frequency of pulse
   The typical period of infrared pulse is 10ms, the typical width of the infrared pulse is 300µs. The 1/(pulse width) is the frequency where most of energy of pulse is in, so the low pass frequency is 1/300µs = 3.3KHz.

2. Set the gain in the pass band
   Gain = DG * Rg = 4.56G when Rg = 20K, the result show TPA8801B can convert 0.22nA into 1V output

DG	Rg - kΩ	Loop Gain - GΩ	Equal input current for 1V output - nA
228000	20	4.56	0.22

   Please note that the high pass filter will reduce the amplitude of response, so the calculation only give a guide to set the gain in the real application, it should be adjusted by different sensor design including emitting diode, photodiode, optical channel and mechanical design.
   As the internal DG is 1% accuracy in full temperature range by internal matching resister, the system gain error is decided by Rg and system level design.

3. Set the pass band

Passband Setting, set a small value when you want to remove it				
Symbol	**Filter type**	**Value**	**Unit**	**f(-3dB) - kHz**
C5	Low pass	22	pF	3.62
C4	High pass	47	nF	1.69
C17	Low pass	200	pF	7.96
C16	Low pass	200	pF	39.79
C6	High pass	1	uF	0.02
C10	Low pass	200	pF	16.93

   Basically the configuration of typical circuit provide a pass band between 1.7KHz and 3.6KHz which can build the balance from pass the pulse and block the DC signal.

Gain and pass band calculation of the application circuit for laser

Comparing to infrared, laser solution to detect dust has better resolution. The signal of laser sensor is strong and fast than infrared sensor, so the configuration of TPA8801B must be set to smaller gain and faster bandwidth. Typical laser pulse is about 40µs which provide 1/40µs = 25KHz.

The solution is to add a resistor Rg1 to C17 in parallel, the equivalent resistor with the 100K internal gain control resister will reduce the gain and expand pass band of internal amplifier. Other capacitor need be adjusted to fit the higher pass frequency.

Here is an example for laser solution in the TPA8801B tool, The setting give 1V/2.41nA transduces gain in 2K to 80K pass band with 10K parallel to C17.

Gain Setting

DG	Rg1 - kΩ	Rg1_Eq -kΩ	Rg -kΩ	Loop Gain - GΩ	Equal input current for 1V output -nA
228000	10	9.09	20	0.41	2.41

Passband from Pulse

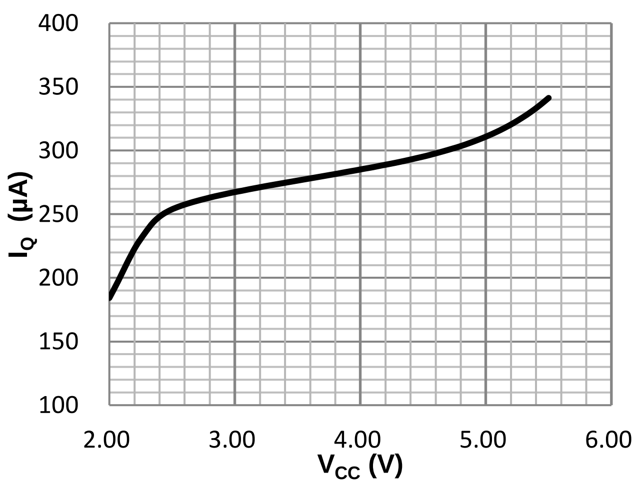
Pulse width - us	Low pass frequency - kHz
40	25.00

Passband Setting, set a small value when you want to remove it

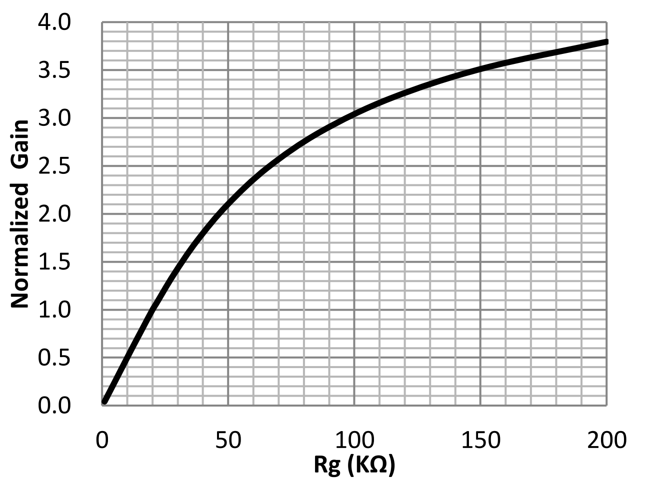
	Filter type	Value	Unit	f(-3dB) - kHz
C5	Low pass	1	pF	79.58
C4	High pass	47	nF	1.69
C17	Low pass	200	pF	87.56
C16	Low pass	100	pF	79.58
C6	High pass	0.01	uF	2.00
C10	Low pass	22	pF	153.91

Typical Performance Characteristics

Supply Current vs. Supply Voltage

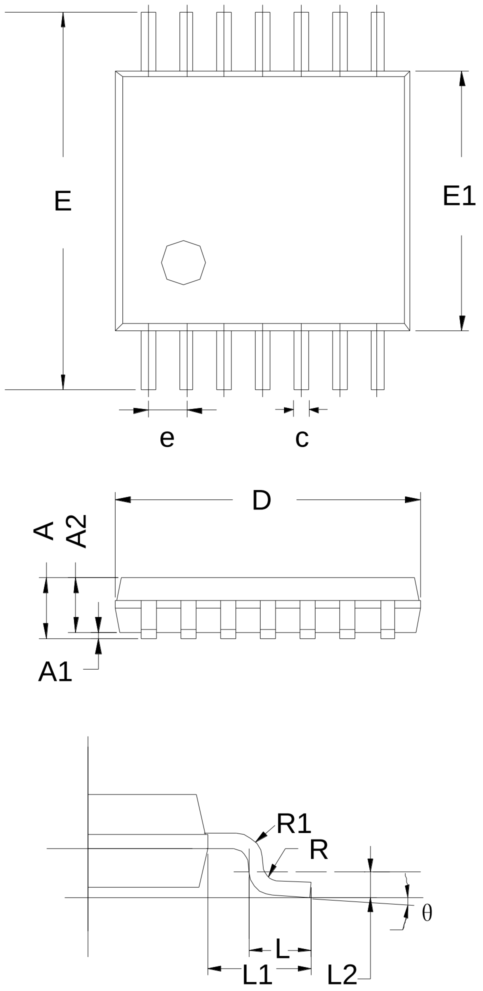


Normalized Gain vs. Rg



Package Outline Dimensions

TSSOP-14



Symbol	Dimensions In Millimeters		
	MIN	TYP	MAX
A	-	-	1.20
A1	0.05	-	0.15
A2	0.90	1.00	1.05
b	0.20	-	0.28
c	0.10	-	0.19
D	4.86	4.96	5.06
E	6.20	6.40	6.60
E1	4.30	4.40	4.50
e	0.65 BSC		
L	0.45	0.60	0.75
L1	1.00 REF		
L2	0.25 BSC		
R	0.09	-	-
θ	0°	-	8°

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