

# TB6066FNG

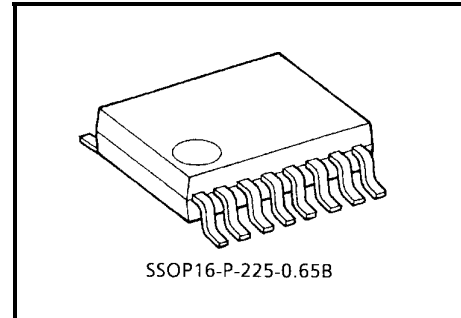
## Shock Sensor IC

TB6066FNG detects an existence of external shock through the shock sensor and output Low-level signal at 7 pin.

It has so excellent characteristic in S/N ratio that user can use Analog signal for mechanical control systems, like servo control.

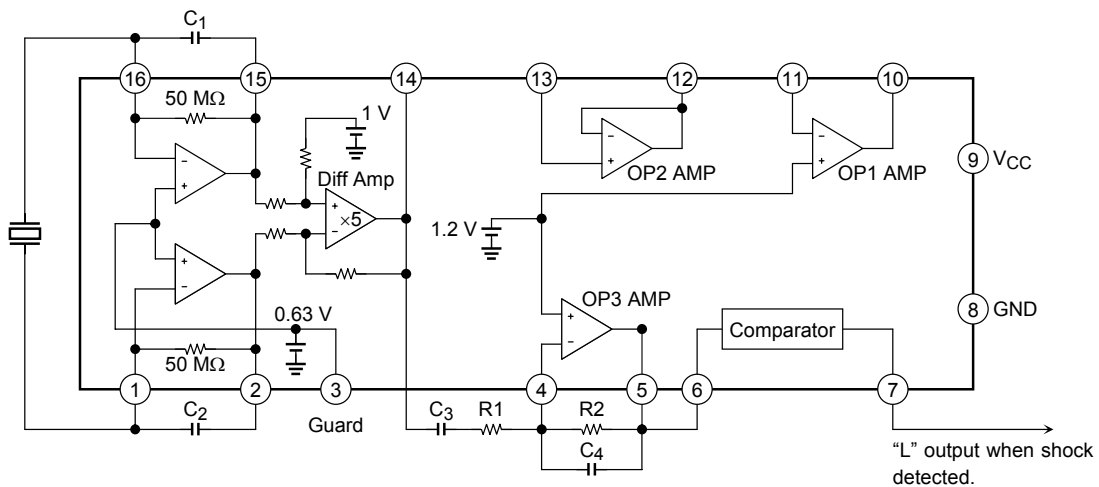
### Features

- TB6066FNG operates from 2.7 to 5.5 V DC single power supply voltage.
  - Signal from the shock sensor is amplified according to setting gain, and is detected through the internal window comparator.
  - Input terminal of sensor signal is designed high impedance. Differential input impedance = 100 MΩ (typ.)
  - Three Operational-Amplifier is built in for design flexibility. (\*Note 1)
  - Sensitivity of shock detection can be adjusted by external devices.
  - Small package: SSOP16-P-225-0.65B (0.65 mm pitch)
  - Excellent S/N ratio: Improved 10dB compared with our TA6038FN/FNG
- \*Note 1: LPF (low pass filter) circuitry is not built in. User needs to make some filter with one operational-amplifier to cancel the signal of resonant frequency of piezo sensor



Weight: 0.07 g (typ.)

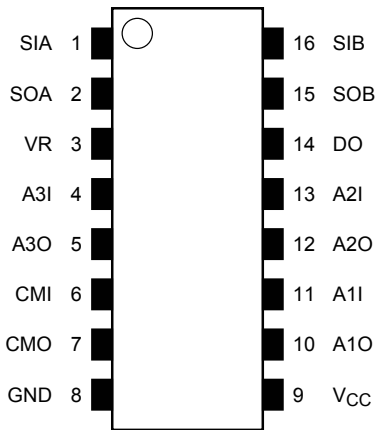
### Block Diagram



**Pin Function**

Pin No.	Pin Name	Function
1	SIA	Connection terminal of shock sensor
2	SOA	Amp (A) output terminal
3	VR	Guard terminal. Reference voltage to protect (1, 16 pin)
4	A3I	OP-AMP (3) input terminal
5	A3O	OP-AMP (3) output terminal
6	CMI	Comparator Input terminal
7	CMO	Comparator Output terminal (output = "L" when shock is detected.)
8	GND	Ground terminal
9	V <sub>CC</sub>	Power supply voltage
10	A1O	OP-AMP (1) output terminal
11	A1I	OP-AMP (1) input terminal
12	A2O	OP-AMP (2) output terminal
13	A2I	OP-AMP (2) input terminal
14	DO	Differential-Amp output terminal
15	SOB	Amp (B) output terminal
16	SIB	Connection terminal of shock sensor

**Pin Connection (top view)**



**Maximum Ratings (Ta = 25°C)**

Characteristics	Symbol	Rating	Unit
Power supply voltage	V <sub>CC</sub>	6	V
Input voltage	V <sub>IN</sub>	-0.3 to V <sub>CC</sub> + 0.3	V
Power dissipation	P <sub>D</sub>	300	mW
Storage temperature	T <sub>stg</sub>	-55 to 150	°C

**Recommend Operating Condition**

Characteristics	Symbol	Rating	Unit
Power supply voltage	V <sub>CC</sub>	2.7 to 5.5	V
Operating temperature	T <sub>opr</sub>	-25 to 85	°C

Note: The IC may be destroyed due to short circuit between adjacent pins, incorrect orientation of device's mounting, connecting positive and negative power supply pins wrong way round, air contamination fault, or fault by improper grounding.

## Electrical Characteristics (1) --- Guaranteed data (unless otherwise specified, $V_{CC} = 3.3\text{ V}$ , $T_a = 25^\circ\text{C}$ )

Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Supply voltage	$V_{CC}$	—	—	2.7	3.3	5.5	V
Supply current	$I_{CC}$	1	$V_{CC} = 3.3\text{ V}$	—	3.5	5	mA
			$V_{CC} = 5.0\text{ V}$	—	3.6	5	

### (DIFF-AMP)

Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Gain	$G_{vBuf}$	2	—	13.6	14	14.4	dB
Output DC voltage	$V_{oBuf}$	3	Connect C = 1000 pF between 1 pin and 2 pin, 15 pin and 16 pin,	0.7	1	1.3	V
Output source current	$I_{B_{so}}$	4	$V_{oh} = V_{CC} - 1\text{ V}$	0.6	1.9	—	mA
Output sink current	$I_{B_{si}}$	5	$V_{ol} = 0.3\text{ V}$	70	150	—	$\mu\text{A}$

### (OP-AMP1)

Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Input voltage 1	$V_{in1}$	6	—	1.135	1.2	1.265	V
Input current	$I_{in}$	7	—	—	40	100	nA
Output voltage range (Low side)	$V_{ol}$	—	—	0.3	—	—	V
Output voltage range (High side)	$V_{oh}$	—	—	—	—	$V_{CC} - 1$	V
Output source current	$I_{A_{so}}$	8	$V_{oh} = V_{CC} - 1\text{ V}$	200	800	—	$\mu\text{A}$
Output sink current	$I_{A_{si}}$	9	$V_{ol} = 0.3\text{ V}$	100	200	—	$\mu\text{A}$

### (OP-AMP2)

Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Input voltage range (Low side)	$V_{il}$	—	—	0	—	—	V
Input voltage range (High side)	$V_{ih}$	—	—	—	—	$V_{CC} - 1$	V
Input current	$I_{in}$	10	Input voltage 1.0 V	-100	—	100	nA
Output voltage range (Low side)	$V_{ol}$	—	—	0.3	—	—	V
Output voltage range (High side)	$V_{oh}$	—	—	—	—	$V_{CC} - 1$	V
Output source current	$I_{A_{so}}$	11	$V_{oh} = V_{CC} - 1\text{ V}$	200	800	—	$\mu\text{A}$
Output sink current	$I_{A_{si}}$	12	$V_{ol} = 0.3\text{ V}$	100	200	—	$\mu\text{A}$

**(OP-AMP3)**

Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Input voltage 1	V <sub>in1</sub>	13	—	1.135	1.2	1.265	V
Input current	I <sub>in</sub>	14	—	—	40	100	nA
Output voltage range (Low side)	V <sub>ol</sub>	—	—	0.3	—	—	V
Output voltage range (High side)	V <sub>oh</sub>	—	—	—	—	V <sub>CC</sub> - 1	V
Output source current	I <sub>Aso</sub>	15	V <sub>oh</sub> = V <sub>CC</sub> - 1 V	200	800	—	μA
Output sink current	I <sub>Asi</sub>	16	V <sub>ol</sub> = 0.3 V	100	200	—	μA

**(Window-Comparator)**

Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Output pull-up resistance	R <sub>Wu</sub>	17	—	21	27	33	kΩ
Output sink current	I <sub>Wsi</sub>	18	V <sub>ol</sub> = 0.3 V	1.0	3.0	—	mA

**(Guard Terminal)**

Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Reference Voltage	V <sub>ref</sub>	—	—	0.50	0.63	0.80	V

Note: This terminal should be used to make guard ring for (1, 16 pin). Please don't use for any other usage.

**Electrical Characteristics (2) --- Reference data for application (Note)**

**(DIFF-AMP)**

Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Input impedance	Zin	—	—	30	100	—	MΩ

**(OP-AMP1/2/3)**

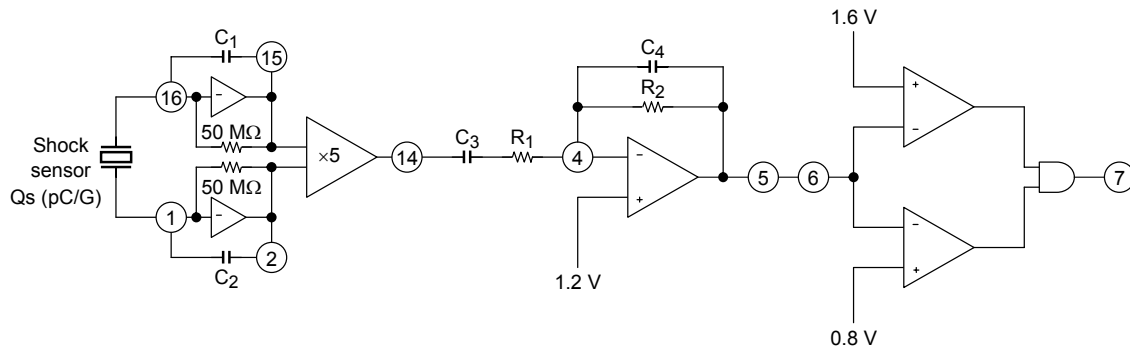
Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Cut-off frequency	fT	—	—	500	—	—	kHz
Openloop gain	Gvo	—	—	80	90	—	dB
Offset voltage (OP-AMP1/3)	Voff	—	—	-5	0	5	mV
Offset voltage (OP-AMP2)	Voff	—	—	-15	0	15	mV

**(Window-Comparator)**

Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Trip voltage 1	Vtrp1	—	—	Vin1 ±0.37	Vin1 ±0.4	Vin1 ±0.43	V

Note: Toshiba can not test these tables of characteristics for all samples. Therefore Toshiba does not guarantee the data. Please use the data as reference data for customer's application.

**Application Note**



**Figure 1 The Configuration of G-Force Sensor Amplifier**

Figure 1 shows the configuration of G-Force sensor amplifier.  
The shock sensor is connected between the pins 1 and 16.

< How to output 0 or 1 from the pin 7 to detect whether there is a shock or not. >  
– Using a sensor with the sensitivity  $Q_s$  (pC/G) to detect the shock  $g$  (G). –

a. Setting gain:  $C_1 = C_2$  (pF),  $R_1$  (k $\Omega$ ),  $R_2$  (k $\Omega$ )

$$\frac{Q_s \times g}{C_1} \times 2 \times 5 \times \frac{R_2}{R_1} = 0.4 \text{ (V)}$$

$$C_1 = C_2 = \frac{Q_s \times g}{0.04} \times \frac{R_2}{R_1}$$

Example: Detecting 5 (G)-shock using a sensor with  $Q_s = 0.34$  (pC/G),  $R_1 = 10$  (k $\Omega$ ),  $R_2 = 100$  (k $\Omega$ ).

$$C_1 = C_2 = \frac{0.34 \times 5}{0.04} \times \frac{100}{10} = 425 \text{ (pF)}$$

b. Setting the frequency (Hz) of HPF: Setting  $C_3$  ( $\mu$ F),  $R_1$  (k $\Omega$ )

$$f_c \text{ (Hz)} = \frac{1}{2 \times \pi \times R_1 \times C_3} \times 10^3$$

Example: Setting the frequency to 20 Hz with  $R_1 = 10$  (k $\Omega$ ).

$$C_3 = \frac{1}{2 \times \pi \times 10 \times 20} \times 10^3 = 0.8 \text{ (\mu F)}$$

c. Setting the frequency (kHz) of LPF: Setting  $C_4$  (pF),  $R_2$  (k $\Omega$ )

$$f_c \text{ (kHz)} = \frac{1}{2 \times \pi \times R_2 \times C_4} \times 10^6$$

Example: Setting the frequency to 5 kHz with  $R_2 = 100$  (k $\Omega$ ).

$$C_4 = \frac{1}{2 \times \pi \times 100 \times 5} \times 10^6 = 318 \text{ (pF)}$$

< How to output the voltage according to the shock through the pin 5. >

– Using a sensor with the sensitivity  $Q_s$  (pC/G), and assuming the shock sensitivity of the system is  $V_{\text{system}}$  (mV/G). –

a. Setting gain:  $C_1 = C_2$  (pF),  $R_1$  (k $\Omega$ ),  $R_2$  (k $\Omega$ )

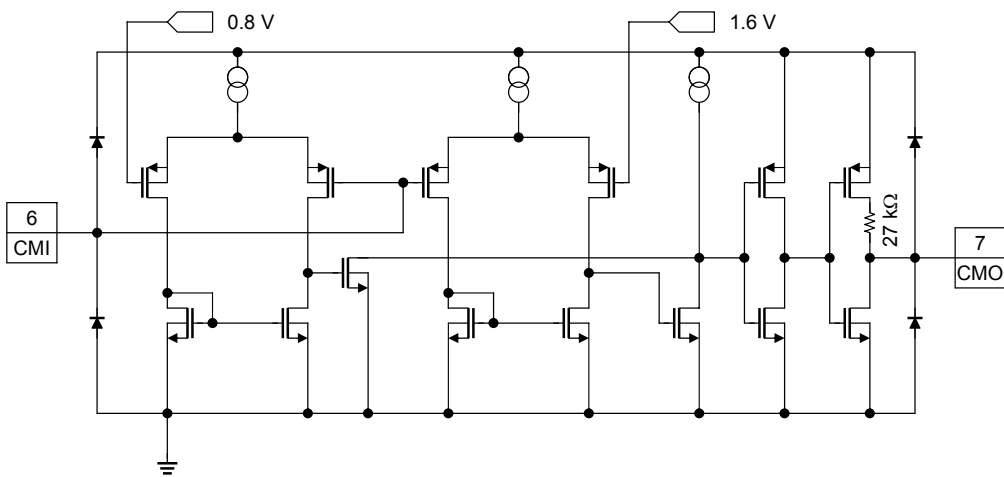
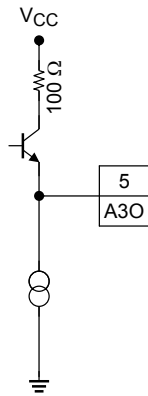
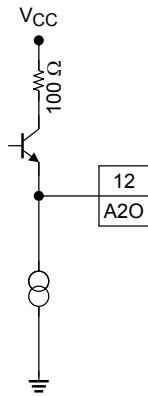
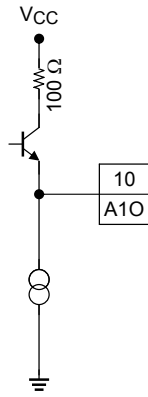
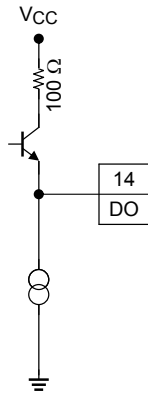
$$\frac{Q_s}{C_1} \times 2 \times 5 \times \frac{R_2}{R_1} = V_{\text{system}} \times 10^3 \text{ (mV/G)}$$

Example: Designing the system with 200 (mV/G) by using a sensor that  $Q_s = 0.34$  (pC/G),  $R_1 = 10$  (k $\Omega$ ),  $R_2 = 100$  (k $\Omega$ ).

$$C_1 = C_2 = \frac{Q_s}{V_{\text{system}}} \times \frac{R_2}{R_1} \times 10^4 \text{ (pF)}$$

$$C_1 = C_2 = \frac{0.34}{200} \times \frac{100}{10} \times 10^4 = 170 \text{ (pF)}$$

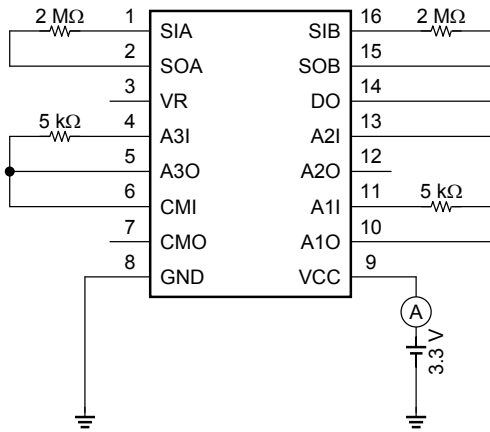
Equivalent Circuit





## Test Circuit

(1) Supply current: **ICC**



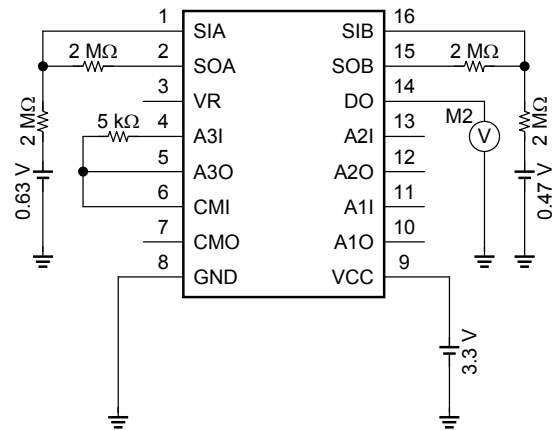
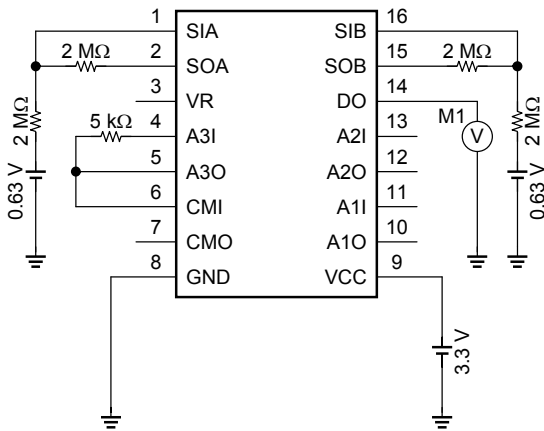
(2) DIFF-AMP

Gain: **GvBuf**

Step 1

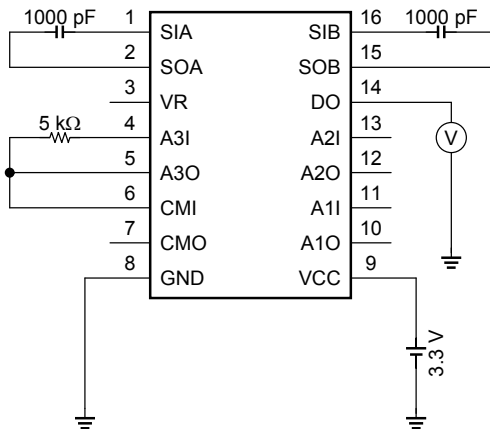
$$\text{Gain} = (M2 \cdot M1) / (0.63 - 0.47)$$

Step 2

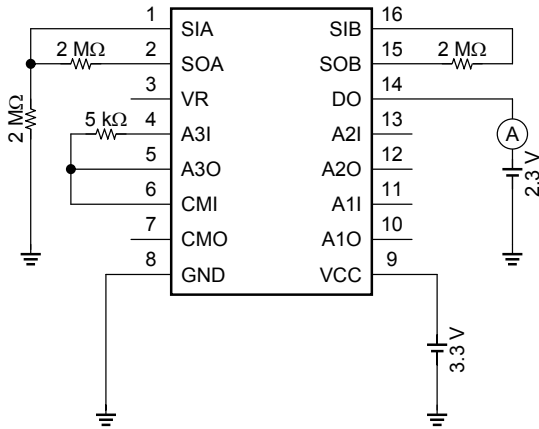


(3) DIFF-AMP

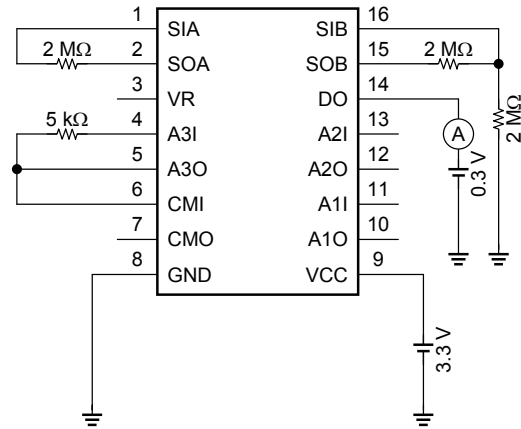
Output DC voltage: **VoBuf**



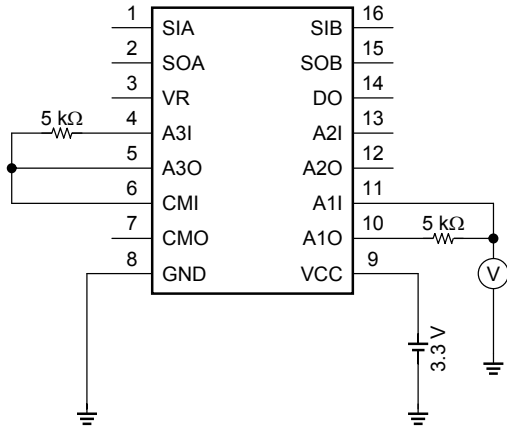
(4) DIFF-AMP  
Output source current: **IBso**



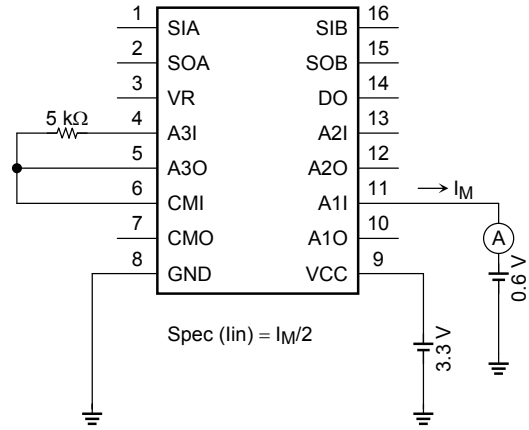
(5) DIFF-AMP  
Output sink current: **IBsi**



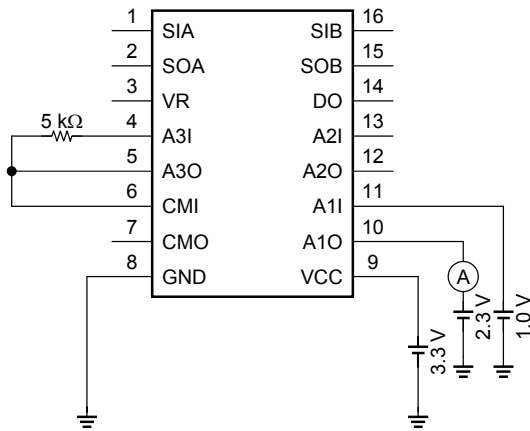
(6) OP-AMP1  
Input voltage 1: **Vin1**



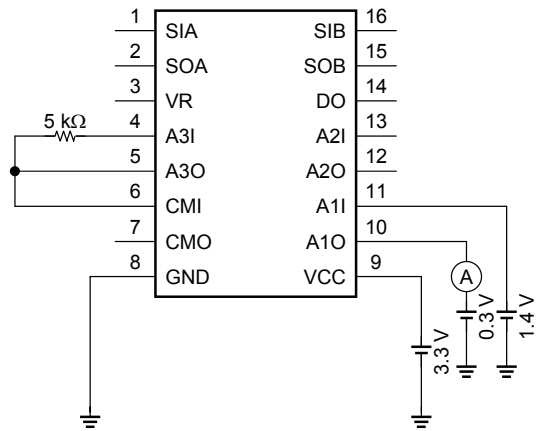
(7) OP-AMP1  
Input current: **Iin**



(8) OP-AMP1  
Output source current: **IAso**

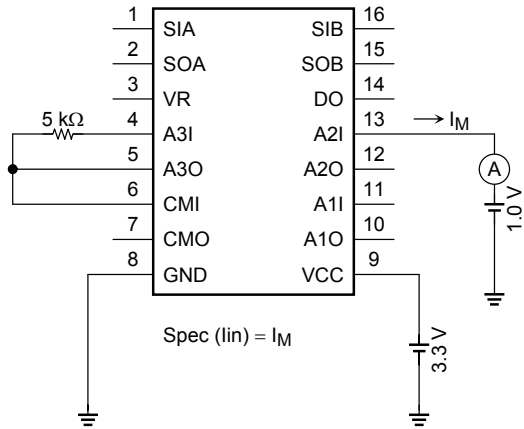


(9) OP-AMP1  
Output sink current: **IAsi**



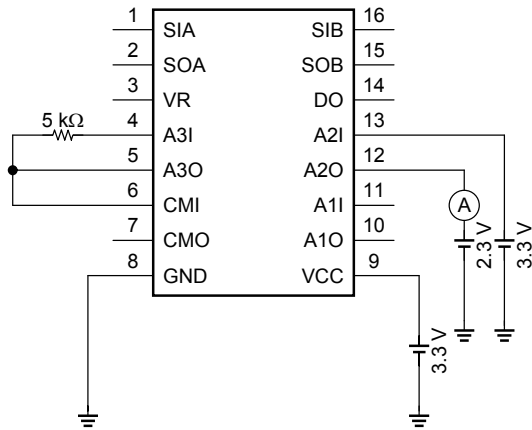
(10) OP-AMP2

Input current:  $I_{in}$



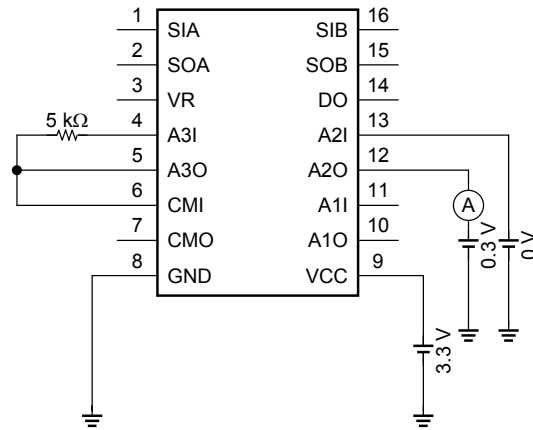
(11) OP-AMP2

Output source current:  $I_{Aso}$



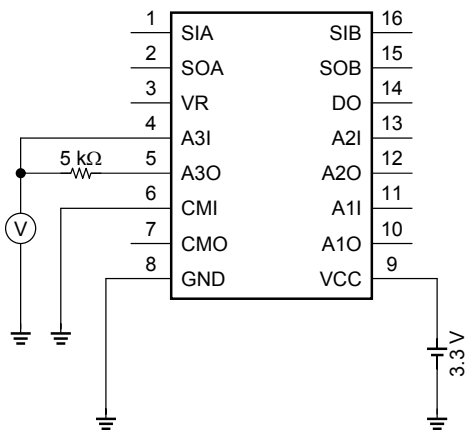
(12) OP-AMP2

Output sink current:  $I_{Asi}$



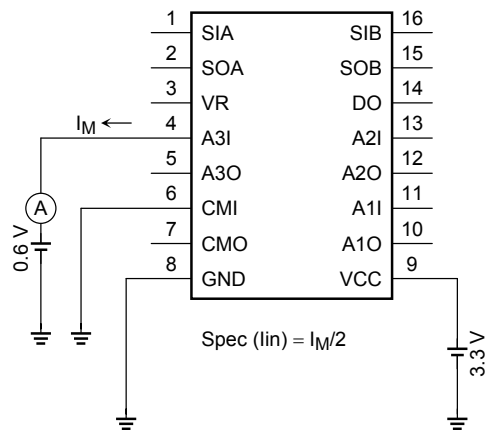
(13) OP-AMP3

Input voltage 1:  $V_{in1}$



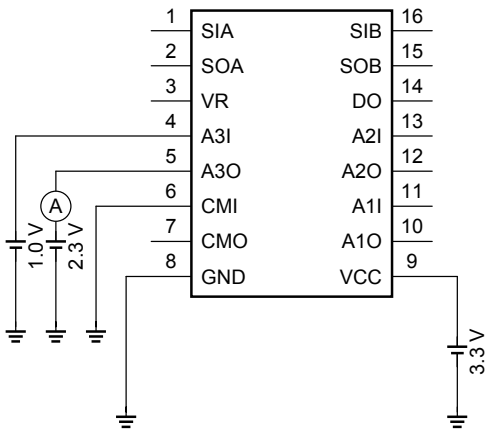
(14) OP-AMP3

Input current:  $I_{in}$



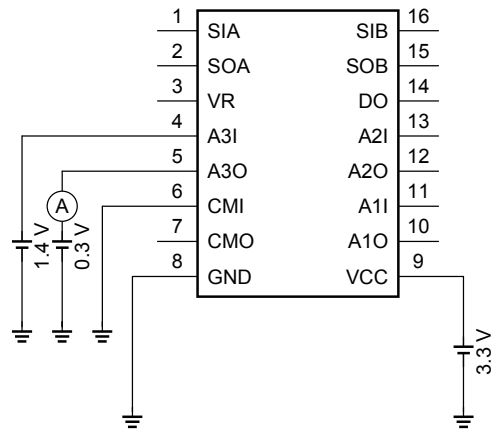
(15) OP-AMP3

Output source current: **I<sub>Aso</sub>**



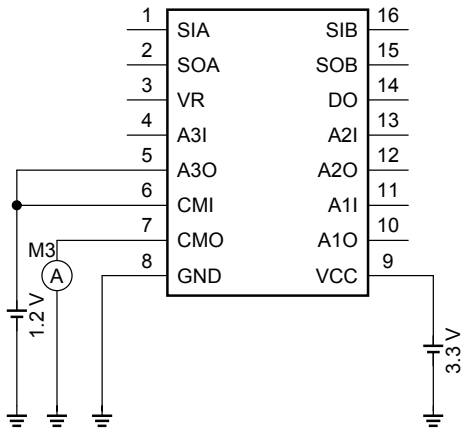
(16) OP-AMP3

Output sink current: **I<sub>A<sub>si</sub></sub>**



(17) Window comparator

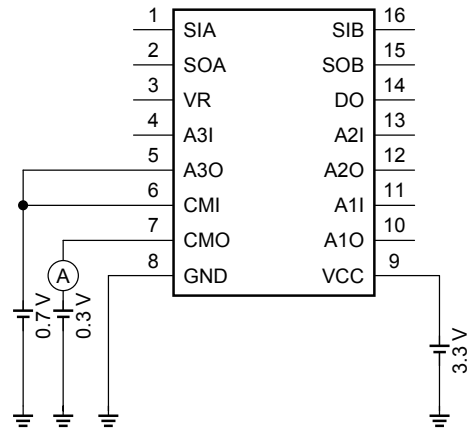
Output pull-up resistance: **R<sub>Wu</sub>**



$R_{Wu} = 3.3/M3$

(18) Window comparator

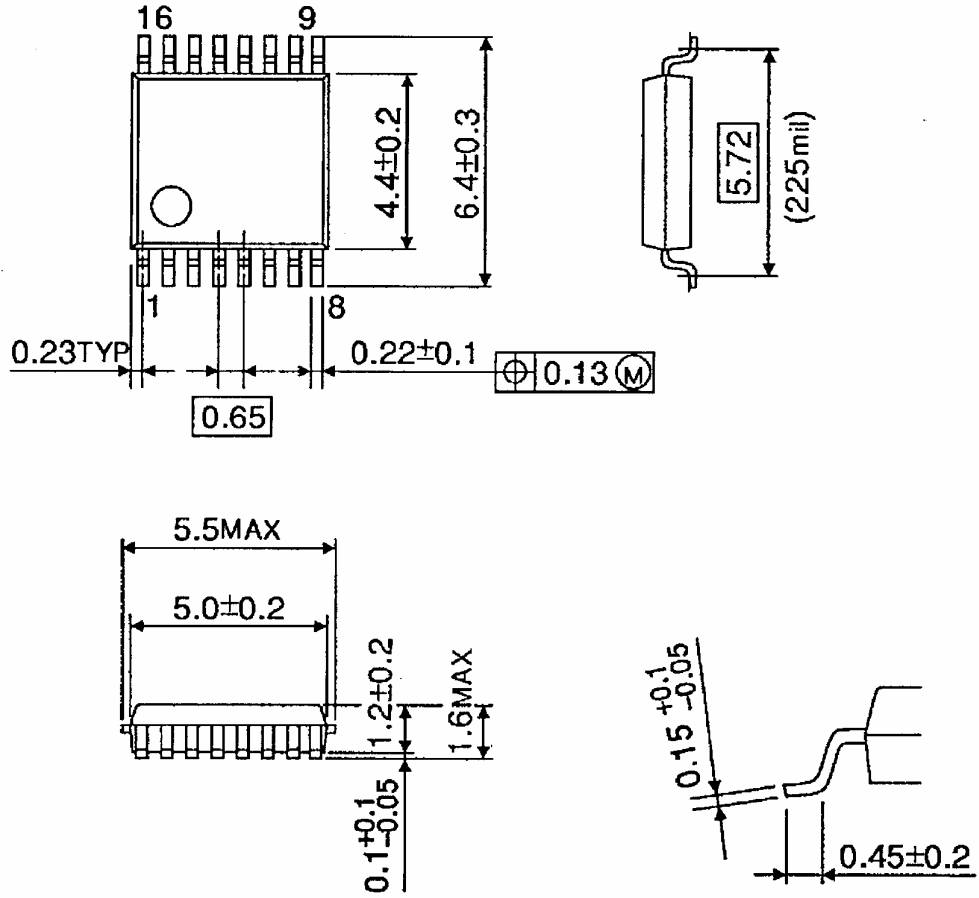
Output sink current: **I<sub>w<sub>si</sub></sub>**



Package Dimensions

SSOP16-P-225-0.65B

Unit : mm



Weight: 0.07 g (typ.)

**RESTRICTIONS ON PRODUCT USE**

000707EAA

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