SM3600AP

Magnetic Sensor Module

OVERVIEW

The SM3600AP is a magnetic sensor module incorporating magnetic sensor elements, amplifier IC, and bias magnet in a compact package. The sensor functions are integrated into a compact package to help reduce the effects of external noise. The magnetic sensor elements employ ultra-small nanogranular tunnel magnetoresistance (TMR[*1]) elements for high-sensitivity magnetic field detection. The SM3600AP includes a built-in auto-bias function to achieve stable output characteristics. The SM3600AP supports non-contact, magnetic field detection, making it ideal for a diverse range of identification devices.

*1. TMR: Tunnel Magneto-Resistance

FEATURES

- Non-contact magnetic detection function
- Magnetic sensor element, amplifier IC, and bias magnet fabricated in a single package
- Amplifier IC built-in
  Amplification factor (Gain): 60dB, DC output
- Auto-bias function built-in
  Amplified signal output of magnetic field variation with $V_{DD}/2$ reference
- High stable output independent of detection speed
- Magnetic detection width: 3.0mm
- Supply voltage range: 4.5 to 5.5V
- Output voltage range: 1.0 to 4.0V (When V_{DD} = 5.0V)
- Operating temperature range: -40 to +80°C
- Package: DIP-8 (9.4mm×6.5mm×6.8mm)

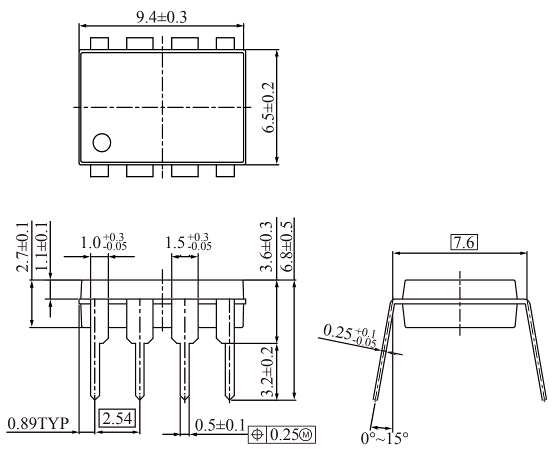
ORDERING INFORMATION

Device	Package
SM3600AP-G[*1]	8 pin DIP

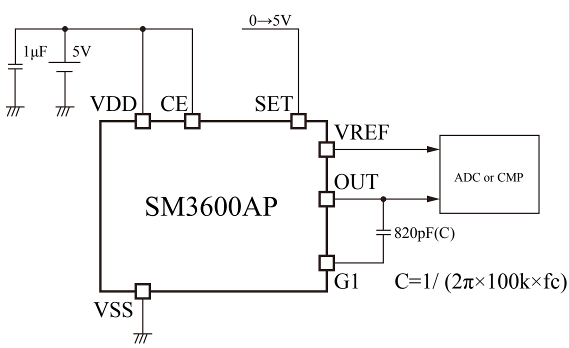
*1. "-G" option code lead-free package

PACKAGE DIMENSIONS

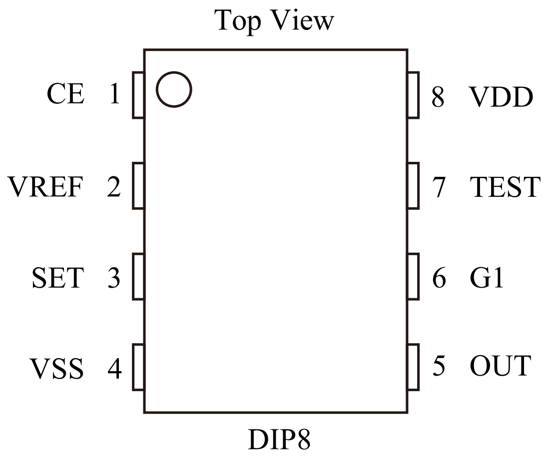
(Unit: mm)



TYPICAL APPLICATION CIRCUIT



PINOUT

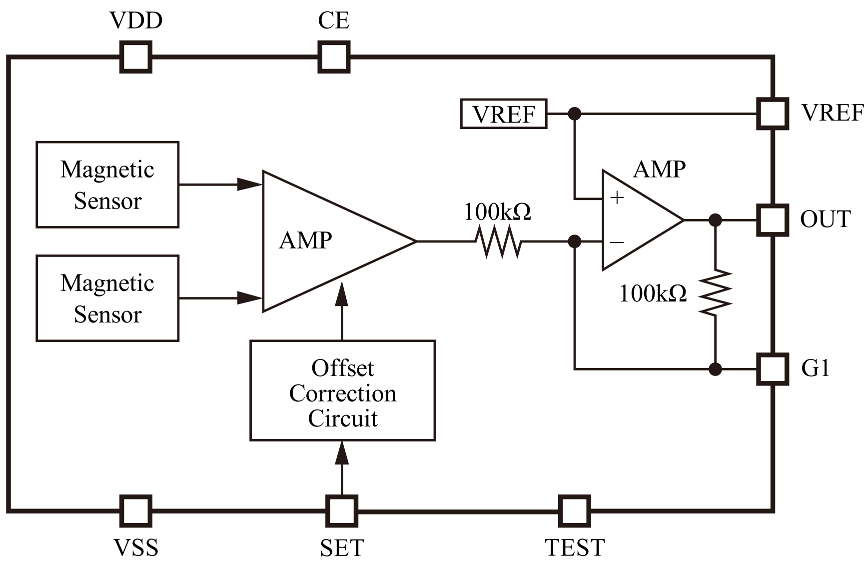


PIN DESCRIPTION

No.	Name	I/O*1	Description
1	CE	I	Chip enable (High: Normal operating mode, Low: standby mode)
2	VREF	O	Reference voltage output (output $V_{DD}/2$)
3	SET	I	Auto-bias function input. When SET goes Low → High, the voltage on OUT is adjusted to VDD/2 using the auto-bias function.
4	VSS	S	Ground
5	OUT	O	Magnetic detector signal output (output V_{SS} level when CE=Low)
6	G1	O	Low-pass filter capacitor connection A low-pass filter is formed by connecting a capacitor between G1 and OUT pins.
7	TEST	O	Test output. Leave open for normal operation
8	VDD	S	Supply voltage (normally 5V)

*1. I: Input pin O: Output pin S: Supply pin

BLOCK DIAGRAM



SPECIFICATIONS

Absolute Maximum Ratings

V_{SS}=0V

Parameter	Symbol	Conditions	Rating	Unit
Supply voltage*1	V_{DD}	VDD pin	-0.3 to +6.0	V
Input voltage*1*2	V_{IN}	CE pin, SET pin	-0.3 to V_{DD}+0.3	V
Output voltage*1*2	V_{OUT}	VREF pin, OUT pin, G1 pin, TEST pin	-0.3 to V_{DD}+0.3	V
Storage temperature*3	T_{STG}	-	-40 to +85	°C

*1 These ratings should not be exceeded, not even momentarily. If a rating is exceeded, there is a risk of IC failure, deterioration in characteristics, and decrease in reliability.

*2 V_{DD} value satisfies the recommended operating conditions.

*3 Parameters should not exceed ratings. If a rating is exceeded, there is a risk of deterioration in characteristics and decrease in reliability.

Recommended Operating Conditions

V_{SS}=0V

Parameter	Symbol	Conditions	MIN	TYP	MAX	Unit
Supply voltage	V_{DD}	VDD pin	4.5	5.0	5.5	V
Operating ambient temperature	T_a	-	-40	+25	+80	°C

Note. Electrical characteristics are guaranteed when operated within the recommended operating conditions.

Electrical Characteristics

DC Characteristics

V_{DD}=4.5 to 5.5V, T_a=-40 to +80°C unless otherwise noted.

Parameter	Symbol	Conditions	MIN	TYP	MAX	Unit
Standby mode current consumption	I_{DDS}	CE=Low (standby mode), Ta=25°C	-	100	300	µA
Operating mode current consumption	I_{DDO}	CE=SET=High (operating mode)	-	3.5	7.0	mA
Logic input voltage	V_{IH}	CE Pin, SET Pin	$0.8V_{DD}$	-	-	V
	V_{IL}		-	-	$0.2V_{DD}$	V
Logic input current	I_{LI}	CE Pin, SET Pin T_a=25°C	-1	0	1	µA
Output voltage range	V_O	OUT Pin	1	-	V_{DD}-1	V
Output reference voltage	V_{REF}	VREF Pin	$0.49V_{DD}$	$0.50V_{DD}$	$0.51V_{DD}$	V
Auto-bias accuracy	V_{O2}	OUT Pin	$0.46V_{DD}$	$0.50V_{DD}$	$0.54V_{DD}$	V
Maximum load resistance	R_L	OUT Pin	100	-	-	kΩ

AC Characteristics

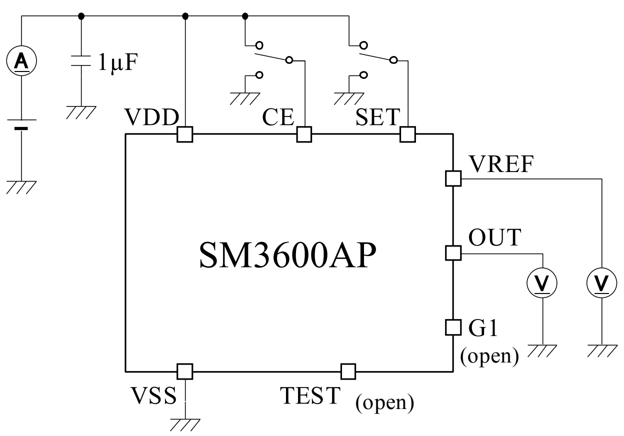
V_{DD}=4.5 to 5.5V, T_a=-40 to +80°C unless otherwise noted.

Parameter	Symbol	Conditions	MIN	TYP	MAX	Unit
Output noise*1	V_{NOISE}	OUT Pin Cutoff frequency: 2kHz, T_a=25°C	-	25	-	mV_{p-p}

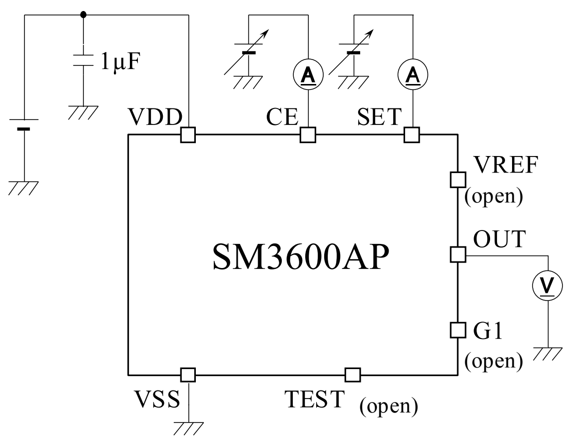
*1. Typical noise value.

Measurement circuit diagrams

Measurement Parameters: I_{DDS}, I_{DDO}, V_O, V_{REF}, V_{O2}



Measurement Parameters: V_{IH}, V_{IL}, I_{LI}



Magnetic Characteristics

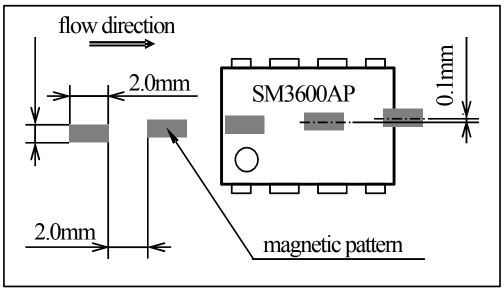
V_{DD}=4.5 to 5.5V, T_a=25°C unless otherwise noted.

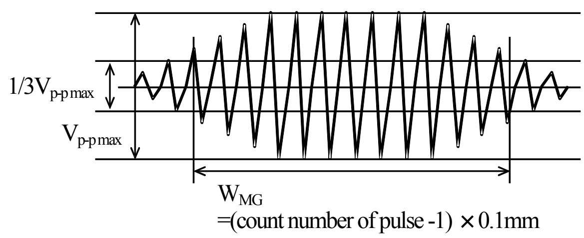
Parameter	Symbol	Conditions	MIN	TYP	MAX	Unit
Magnetic sensitivity	V_{MG}	OUT pin After auto-bias setting, H=0Oe, V_{DD}=5.0V	3.0	4.0	-	V/Oe
			0.037	0.050	-	V/(A/m)
Magnetic detection width*1	W_{MG}	OUT pin Width of magnetic material detected by sensor, Detection range of −9.54dB (1/3) to maximum amplitude, Gap=0.5mm	3.0	3.5	-	mm
Spatial resolution*2	R_{MG}	OUT pin Clearance between magnetic materials detected by sensor, Detection range of −9.54dB (1/3) to maximum amplitude, Gap=0.5mm	-	0.8	1.2	mm
Surface magnetic flux density	B_{MG}	Magnetic flux density at package surface	-	60*	-	mT

*Typical value

*1. Magnetic detection width measurement method

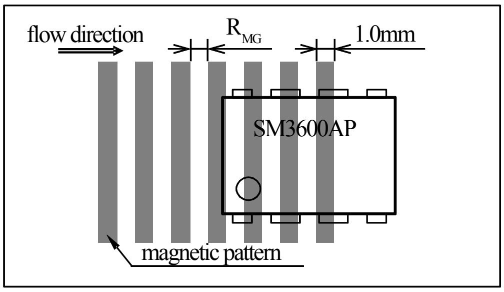
When gap (package surface to magnetic pattern separation) = 0.5mm

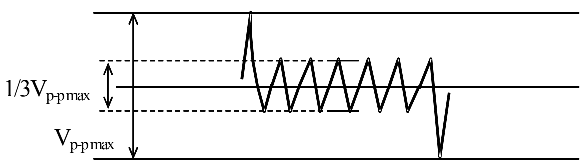




*2. Spatial resolution measurement method

When gap (package surface to magnetic pattern separation) = 0.5mm





Note: Magnetism units

Parameter	SI Units			CGS Units		Note
	Name	Symbol	other	Name	Symbol	
Magnetic flux	Weber	Wb	V·s	Maxwell	Mx	1[Mx] = 10^{-8}[Wb]
Mgnetic flux density	Tesla	T	Wb/m^2	Gauss	G	1[G] = 10^{-4}[T]
Magnetic field strength	-	-	A/m	Oersted	Oe	1[Oe] = $10^3/(4\pi)$[A/m]

The magnetic field strength is expressed in [Oe] or [A/m] units, and the magnetic flux density per unit surface area (flux density of magnetic field lines) is expressed in [G] or [T] units.

There is no proportional relationship between magnetic field strength and flux density between in-vacuo and in magnetic materials due to the difference in the definition of the units, but for normal measurement in the atmosphere (or vacuo), 1 [Oe] can be converted as approximately 1 [G].

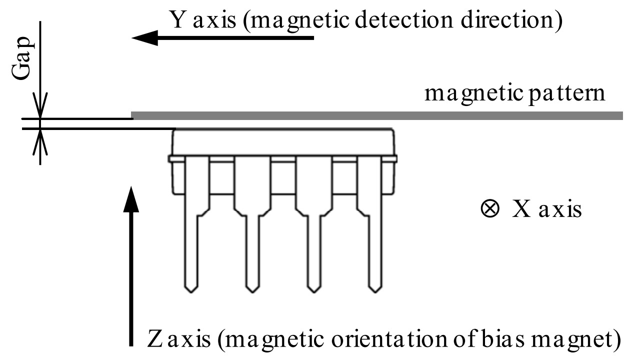
FUNCTIONAL DESCRIPTION

Function Overview

The SM3600AP is a magnetic sensor module that incorporates magnetic sensor elements, a bias magnet, and an amplifier IC in a compact DIP package, required to detect magnetism.

The magnetic sensor elements in the SM3600AP detect changes in the magnetic field along the Y axis as shown in the following figure. The sensor detect the magnetic pattern of measurement objects by detecting changes in the magnetic field, using a bias magnet, as the object moves across the upper surface of the module package in the Y-axis direction. The SM3600AP package surface is not designed to withstand wear, hence the measurement mechanism should be designed so that the measurement object does not come into contact with the surface of the package. The recommended gap (separation between package surface and magnetic pattern) is 0.5 mm.

The magnetic field of the bias magnet is aligned so that the Z-axis component in the figure is strongest, with a magnetic flux density at the package surface of 110mT (max).

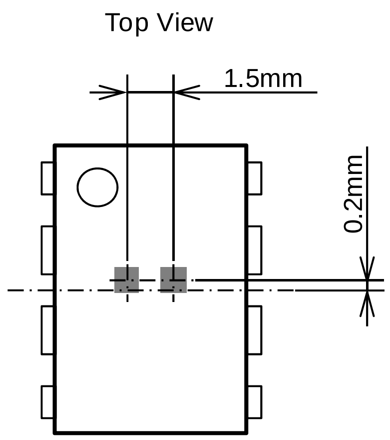


Magnetic detection direction (Y axis), bias magnet magnetic direction (Z axis)

The detected magnetic field signal is converted to a voltage, then amplified by 60dB (1000 times amplification) by an internal amplifier, and then output as an analog voltage on the OUT pin. An auto bias function is built-in to help obtain the appropriate DC voltage output signal.

Magnetic Sensor Element Layout

The magnetic sensor elements are located as shown in the following figure. The measurement object must be aligned with the magnetic sensor elements in order to detect the magnetic pattern.

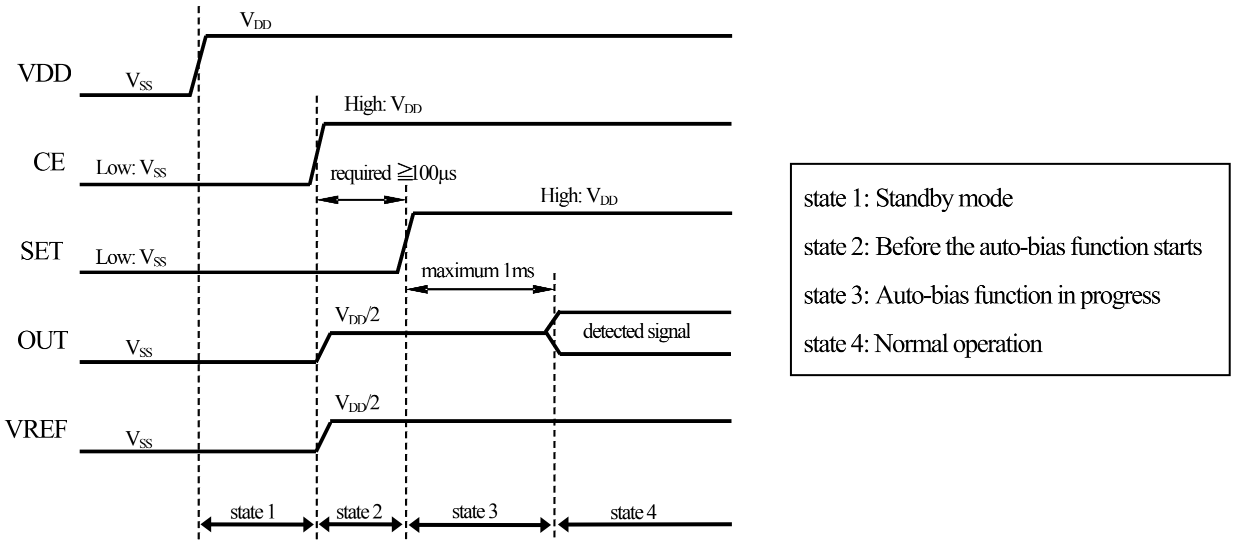


Sensor layout

Location of sensors only. The figure does not represent an accurate depiction of sensor size and shape.

Operating Procedure

When CE is HIGH and SET is LOW, a $V_{DD}/2$ DC voltage is output on the OUT pin (state 2). Switch the SET pin from LOW to HIGH under conditions of stable magnetic field near the SM3600AP. Bias voltage correction is then performed for 1 ms (max) using the auto bias function (described below). The $V_{DD}/2$ DC voltage output is maintained during the correction interval (state 3). After correction finishes, the magnetic detection signal is output on the $V_{DD}/2$ reference voltage on the OUT pin (state 4).



Timing diagram

Auto-Bias Function

The auto-bias function corrects the bias voltage of the internal amplifier of the SM3600AP to set the DC output voltage of the magnetic detection signal to the $V_{DD}/2$ reference voltage.

The auto-bias function starts when the SET pin is switched from LOW to HIGH. The bias voltage of the internal amplifier is automatically corrected so that the DC voltage output under the existing magnetic field condition is the $V_{DD}/2$ reference voltage. After correction is finished (1 ms max.), the magnetic detection signal amplified by the internal amplifier is superimposed on the $V_{DD}/2$ reference voltage on the OUT pin.

The SM3600AP is sensitive to changes in magnetic field, including the geomagnetic field. The auto-bias function should be used at regular intervals if the magnetic field near the sensor modules changes or if the sensor is used continuously for extended periods. To start the auto-bias function, switch the SET pin LOW and then HIGH again.

Standby Mode

Switch the CE pin to LOW to enter standby mode (state 1). In this mode, the OUT pin output is at VSS level and the current consumption falls to 100 µA (typ). When restarting operation from standby mode, always run the auto-bias function after switching the CE pin to HIGH.

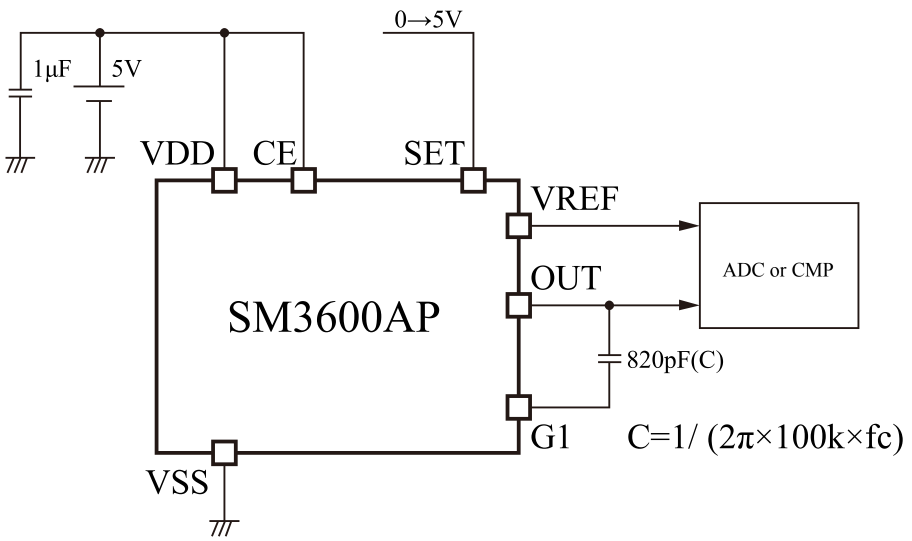
TYPICAL APPLICATION CIRCUIT

It is necessary to take the difference between VREF and OUT to cancel the power-supply voltage fluctuation.

Circuit 1

Low-pass Filter Configuration

LPF (low-pass filter) fc (cutoff frequency): 1.94kHz

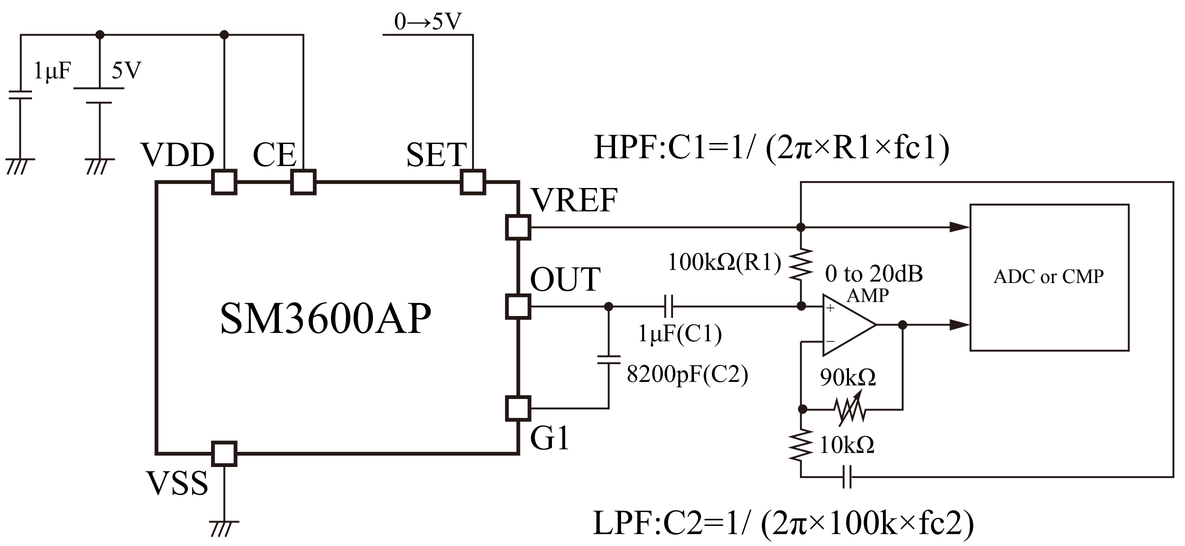


Circuit 2

Configuration with External Amplifier

HPF (high-pass filter) fc1 (cutoff frequency): 1.59Hz

LPF (low-pass filter) fc2 (cutoff frequency): 194Hz



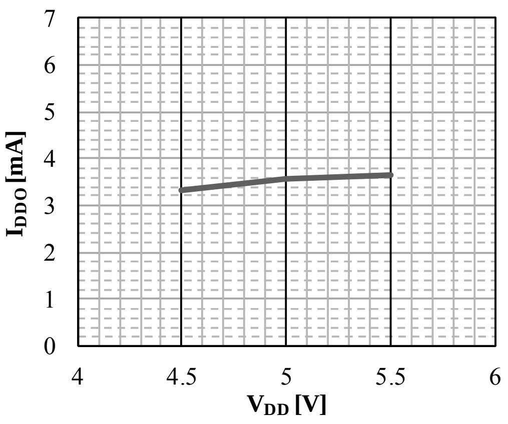
*If a low-pass filter is not used (capacitors C and C2 are not used), leave the G1 pin open-circuit.

*The typical applications circuits are for reference purposes only and correct operation using these circuits is not guaranteed. NPC accepts no responsibility for damage or loss caused by their use. Use the circuits only after thorough evaluation.

TYPICAL CHARACTERISTICS

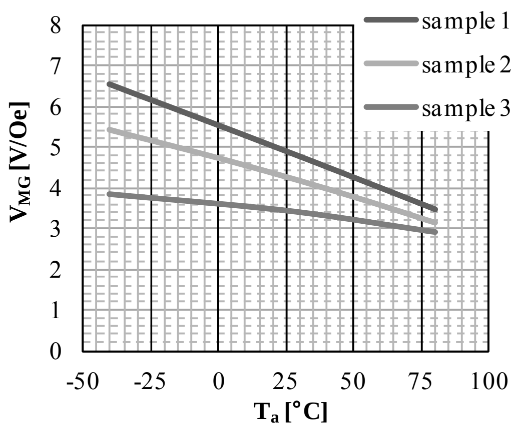
V_{DD} = 5.0V, T_a = 25°C unless otherwise noted

Current consumption (operating mode)



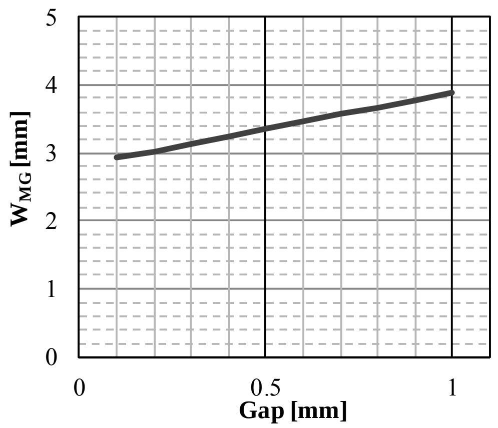
Current consumption vs. supply voltage

Magnetic sensitivity temperature characteristic



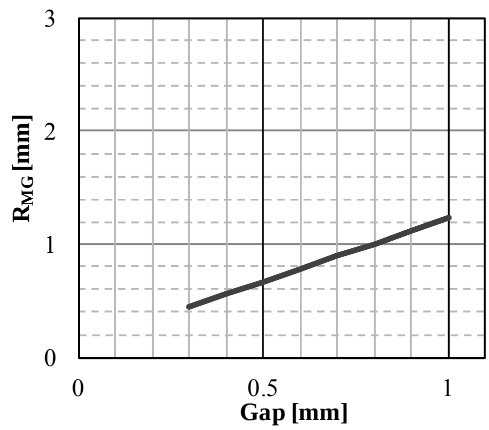
Magnetic sensitivity vs. temperature

Magnetic detection width



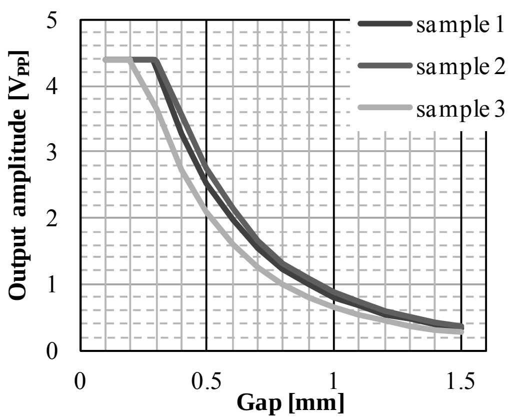
Magnetic detection width vs. gap

Spatial resolution



Spatial resolution vs. gap

Output amplitude characteristic

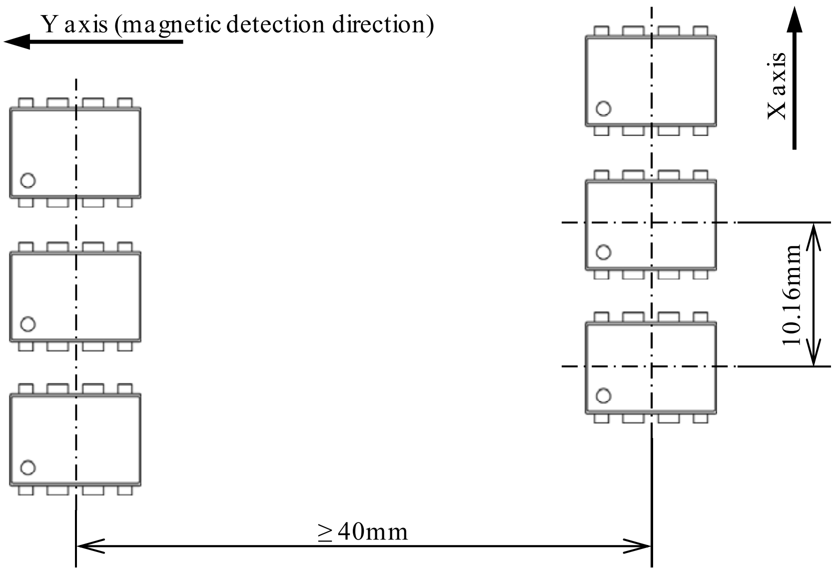


Output amplitude vs. gap
(pattern width: 1.0mm)

DESIGN PRECAUTIONS

Effect of Bias Magnet and Magnetic Field

The SM3600AP is equipped with a bias magnet. The SM3600AP functions and performance are susceptible to the effects of external magnetic fields, especially in the magnetic detection direction (Y axis in the following figure), which should be taken into consideration when designing detection mechanisms. When using a multi SM3600AP arrangement, maintain an interval of 40 mm (min) between devices along the Y axis to prevent mutual interference between the bias magnets. Devices may be placed closer along the X axis.



Multi SM3600AP arrangement example

Effect on Magnetic Field Due to Static Electricity

When the transport system is moving non-conductive objects, such as paper, across the device surface, the object may become electrostatically charged by the carrying mechanism material. The SM3600AP can detect the momentary magnetic field generated by current flowing during an electrostatic discharge, which may appear as output noise. Accordingly, anti-static measures should be taken into consideration when designing detection mechanisms. When covering the SM3600AP package surface, the use of non-insulating materials, such as conductive resin material or non-magnetic metals, is recommended.

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SEIKO NPC CORPORATION

1-9-9, Hatchobori, Chuo-ku,
Tokyo 104-0032, Japan
Telephone: +81-3-5541-6501
Facsimile: +81-3-5541-6510
http://www.npc.co.jp/
Email:sales@npc.co.jp

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