SM6661A

Post-amplifier for Gyroscope

OVERVIEW

The SM6661A is a post-amplifier for use in combination with gyroscope ICs. The SM6661A has a built-in 2-system post-amplifier, so that it can amplify two output signals of gyroscope IC with a single SM6661A. It features a simple method to change the different image stabilizing gain and frequency characteristics depending on the models. It also has a built-in sleep function making it easy to connect the output signal of gyroscope IC to A/D converter.

FEATURES

- Supply voltage range: 3.0 to 3.6V
- Operating ambient temperature range: −20 to +80°C
- 2-system input and output (reverse phase output)
- Corresponds to 2-axis of gyroscope output
- Adjustable output gain and frequency characteristics by external components
- Output gain: 30 to 50dB (variable amplification control)
- Zero-rate voltage compensation function for simple interface to A/D converter connected to subsequent stage
- Sleep function built-in
- Small package: 16-pin QFN

APPLICATIONS

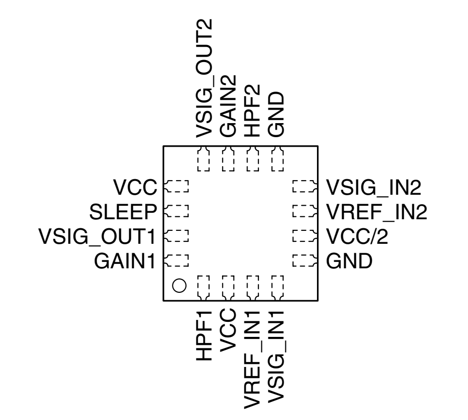
- DVC
- DSC

ORDERING INFORMATION

Device	Package
SM6661AB	16-pin QFN

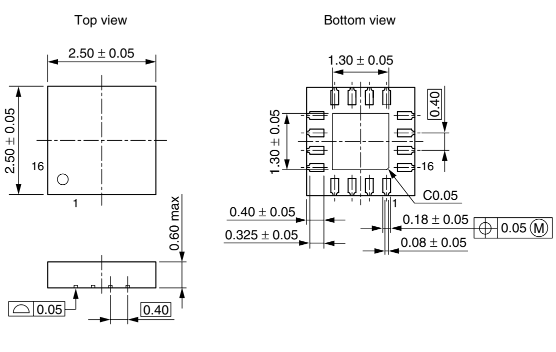
PINOUT

(Top view)

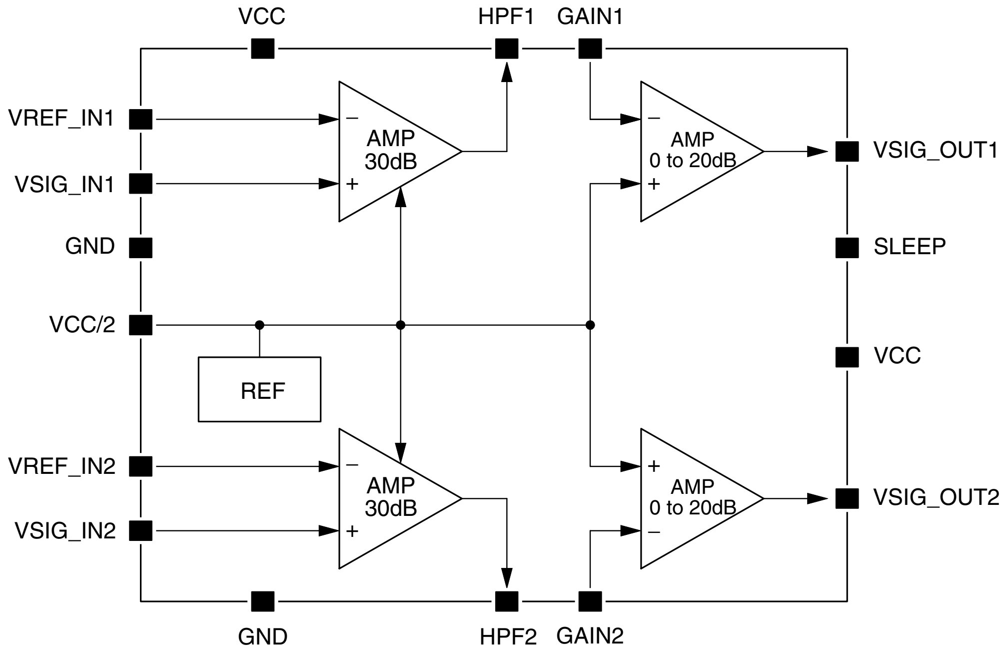


PACKAGE DIMENSIONS

(Unit: mm)
Weight: 9mg



BLOCK DIAGRAM

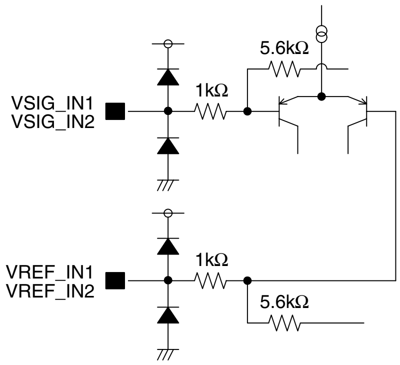
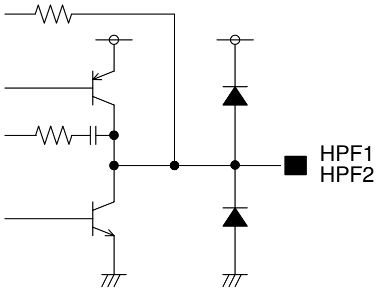
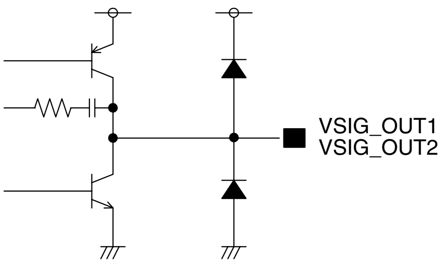
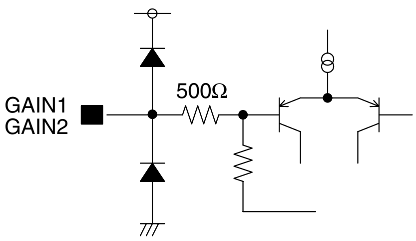


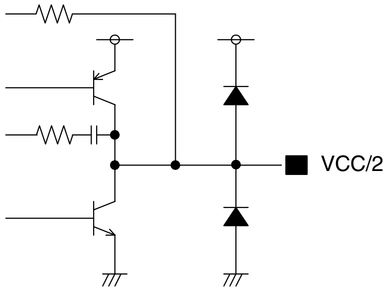
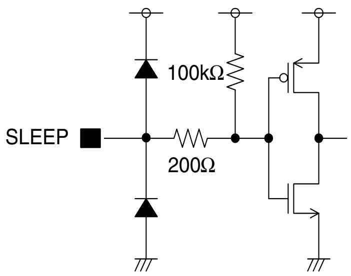
PIN DESCRIPTION

Number	Name	I/O*1	Type*2	Description
1	HPF1	O	A	30dB amplifier output pin 1
2	VCC	–	–	Supply pin
3	VREF_IN1	I	A	Gyroscope IC reference voltage input pin 1
4	VSIG_IN1	I	A	Gyroscope IC signal input pin 1
5	GND	–	–	Ground pin
6	VCC/2	O	A	Reference voltage pin Note. Connect smoothing capacitors.
7	VREF_IN2	I	A	Gyroscope IC reference voltage input pin 2
8	VSIG_IN2	I	A	Gyroscope IC signal input pin 2
9	GND	–	–	Ground pin
10	HPF2	O	A	30dB amplifier output pin 2
11	GAIN2	I	A	Variable gain amplifier input pin 2
12	VSIG_OUT2	O	A	Signal output pin 2
13	VCC	–	–	Supply pin
14	SLEEP	Ip	D	Sleep mode control pin with built-in pull-up resistor HIGH: sleep mode, LOW: normal operation
15	VSIG_OUT1	O	A	Signal output pin 1
16	GAIN1	I	A	Variable gain amplifier input pin 1

*1. I: input, Ip: input with built-in pull-up resistor, O: output
*2. A: analog, D: digital

PIN EQUIVALENT CIRCUITS

Number	Name	I/O*1	Equivalent circuit
3 4 7 8	VREF_IN1 VSIG_IN1 VREF_IN2 VSIG_IN2	I	
1 10	HPF1 HPF2	O	
12 15	VSIG_OUT2 VSIG_OUT1	O	
11 16	GAIN2 GAIN1	I	

Number	Name	I/O[*1]	Equivalent circuit
6	VCC/2	O	
14	SLEEP	Ip	

*1. I: input, Ip: input with built-in pull-up resistor, O: output

Note. Resistance values indicate design values.

SPECIFICATIONS

Absolute Maximum Ratings

GND = 0V

Parameter	Pin	Symbol	Rating	Unit
Supply voltage	VCC	V_{CC}	5.0	V
Input voltage	VREF_IN1, VREF_IN2, VSIG_IN1, VSIG_IN2, HPF1, HPF2, GAIN1, GAIN2, SLEEP	V_{IN}	V_{CC} + 0.3 to GND – 0.3	V
Storage temperature range		T_{STG}	– 40 to +125	°C
Power dissipation[*1]		P_D	0.7	W
Junction temperature		T_{JMAX}	+125	°C

*1. When mounted on a NPC's standard board (76.2mm × 114.3mm, 1.6mm thickness, FR-4 glass-epoxy board).
Thermal resistance θja = 64°C/W

Recommended Operating Conditions

GND = 0V

Parameter	Pin	Symbol	Rating			Unit
			min	typ	max	
Supply voltage	VCC	V_{CC}	3.0	3.3	3.6	V
SLEEP pin applied voltage	SLEEP	V_{SLEEP}	0	–	V_{CC}	V
Operating ambient temperature		Ta	–20	25	80	°C
Reference input voltage	VREF_IN1, VREF_IN2, VSIG_IN1, VSIG_IN2	V_{REF_IN}	1.25	1.35	2.10	V
Signal input amplitude[*1]	VSIG_IN1, VSIG_IN2	$V_{SIG\_IN\_AC}$	–	–	47	mVpp
Output gain variable range	VSIG_OUT1, VSIG_OUT2	G_{RANGE}	30	–	50	dB
Variable gain amplifier feedback resistance		R_2	27	–	330	kΩ
Output load resistance	VSIG_OUT1, VSIG_OUT2	R_L	50	–	–	kΩ

*1. When V_{CC} = 3.0V, 30dB output gain setting

Electrical Characteristics

DC Characteristics

V_{CC} = 3.3V, GND = 0V, Ta = 25°C, circuit constant is same as "TYPICAL APPLICATION CIRCUIT", unless otherwise noted.

Parameter	Symbol	Condition	Rating			Unit
			min	typ	max	
Current consumption 1	I_{CC1}	SLEEP = LOW, V_{CC} = 3.3V	–	5.5	7.5	mA
		SLEEP = LOW, V_{CC} = 3.6V	–	7.0	9.0	mA
Current consumption 2	I_{CC2}	SLEEP = HIGH (sleep mode)	–	–	1.0	µA
High-level input voltage	V_{IH}	SLEEP pin, V_{CC} = 3.0 to 3.6V, Ta = –20 to +80°C	2.0	–	–	V
Low-level input voltage	V_{IL}		–	–	0.8	V
High-level input leakage current[*1]	I_{LH}	SLEEP pin, 3.3V input voltage	–	–	± 1.0	µA
Low-level input current[*1]	I_{LL}	SLEEP pin, 0.0V input voltage	–38	–33	–28	µA
Input current (SLEEP = HIGH)[*1]	I_{LEAK}	VSIG_IN1, VSIG_IN2, VREF_IN1, VREF_IN2 pins	–	–	± 0.1	mA
Input current (SLEEP = LOW)[*1]	I_{IN}	VSIG_IN1, VSIG_IN2, VREF_IN1, VREF_IN2 pins, 1.35V input voltage	–0.2	–0.045	+0	mA
High-level output voltage	V_{OH}	VSIG_OUT1, VSIG_OUT2 pins, R_L = 100kΩ	V_{CC}–0.3	V_{CC}–0.1	–	V
Low-level output voltage	V_{OL}		–	0.1	0.3	V
Offset voltage[*2]	V_{OFFSET}	VSIG_OUT1, VSIG_OUT2 pins, potential difference from VCC/2 pin, R_1 = 150kΩ, R_2 = 330kΩ	–	± 5	± 20	mV
VCC/2 pin voltage	$V_{VCC/2}$	VCC/2 pin	V_{CC}/2–0.1	V_{CC}/2	V_{CC}/2+0.1	V

*1. Sink current is defined as positive value.
*2. R_1 and R_2 indicate the values of input resistor and feedback resistor for variable gain amplifier respectively. Refer to "TYPICAL APPLICATION CIRCUIT".

AC Characteristics

V_{CC} = 3.3V, GND = 0V, Ta = 25°C, circuit constant is same as "TYPICAL APPLICATION CIRCUIT", unless otherwise noted.

Parameter	Symbol	Condition	Rating			Unit
			min	typ	max	
30dB amplifier output gain	Gain1	HPF1, HPF2 pins	29	30	31	dB
Output gain[*1]	Gain2	VSIG_OUT1, VSIG_OUT2 pins,	35.7	36.8	37.9	dB
Input referred voltage noise[*2]	V_{NOISE}	At 1Hz	–	0.05	–	$\mu V_{rms}/\sqrt{Hz}$
Lower cutoff frequency[*1*3]	f_{CL}	R_1 = 150kΩ, C_1 = 22µF	–	0.05	–	Hz
Upper cutoff frequency[*1*4]	f_{CH}	R_2 = 330kΩ, C_2 = 2200pF	–	219	–	Hz

*1. As for these parameters, the characteristics are determined by external components, and the specifications are guaranteed by design and characteristics evaluation. The rating values are shown without considering variability of external components.
*2. Input referred voltage noise is a design value when short-circuiting between VSIG_IN1 and VREF_IN1 pins, VSIG_IN2 and VREF_IN2 pins, without inputting external signal.
*3. R_1 and C_1 indicate the values of input resistor and input capacitor for variable gain amplifier respectively. Refer to "TYPICAL APPLICATION CIRCUIT".
*4. R_2 and C_2 indicate the values of feedback resistor and feedback capacitor for variable gain amplifier respectively. Refer to "TYPICAL APPLICATION CIRCUIT".

FUNCTIONAL DESCRIPTION

Sensor Signal Input and Output

The signal output of gyroscope IC is connected to VSIG_IN1 pin. The first stage amplifier of SM6661A is differential input, so that VREF_IN1 pin is input zero-rate voltage of gyroscope IC.
(Normally, the reference voltage output pin of gyroscope IC should be connected to VREF_IN1 pin.)

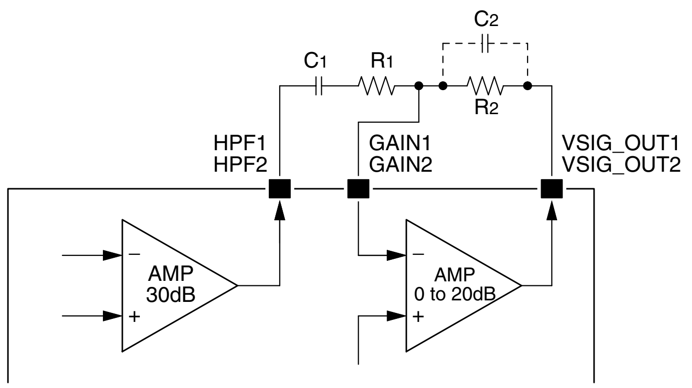
The amplified signal is output from VSIG_OUT1 pin. Note that the output signal is reverse phase of input signal from VSIG_IN1 pin. The zero-rate voltage of output signal is $V_{CC}/2V$. The description of VSIG_IN2, VREF_IN2 and VSIG_OUT2 pins are the same as above VSIG_IN1, VREF_IN1 and VSIG_OUT1 pins.

VCC/2 Pin

The VCC/2 pin is a reference voltage pin. Smoothing capacitors should be connected between VCC/2 pin and GND. The recommended values of smoothing capacitors are parallel-connected 10µF electrolytic capacitor and 0.1µF ceramic capacitor.

Output Gain and Frequency Characteristics Setting

The output gain and frequency characteristics of SM6661A are adjustable with connecting external resistors and capacitors as shown below.



Output gain setting

The output gain of SM6661A is adjustable by changing the value of external resistors R_1 and R_2. The SM6661A has a built-in 30dB amplifier, so that the output gain “Gain2” is determined by the formula below;

$$Gain2 = 20 \times \log\left(\frac{R_2}{R_1}\right) + 30\ [\mathrm{dB}]$$

Frequency characteristics setting

The frequency characteristics of SM6661A is adjustable by changing the value of external capacitors C_1 and C_2. The lower cutoff frequency “f_{CL}” and upper cutoff frequency “f_{CH}” are determined by the formula below; (These values should be set to meet the condition “$f_{CL} < f_{CH}$”, in order to construct the band-pass filter.)

$$f_{CL} = \frac{1}{(2\pi \times R_1 \times C_1)} \ \text{[Hz]}$$

$$f_{CH} = \frac{1}{(2\pi \times R_2 \times C_2)} \ \text{[Hz]}$$

External components setting

The values of R_1 and C_1 should be set considering the time constant (τ) that is determined by the formula below;

$$\tau = R_1 \times C_1 \ \text{[s]}$$

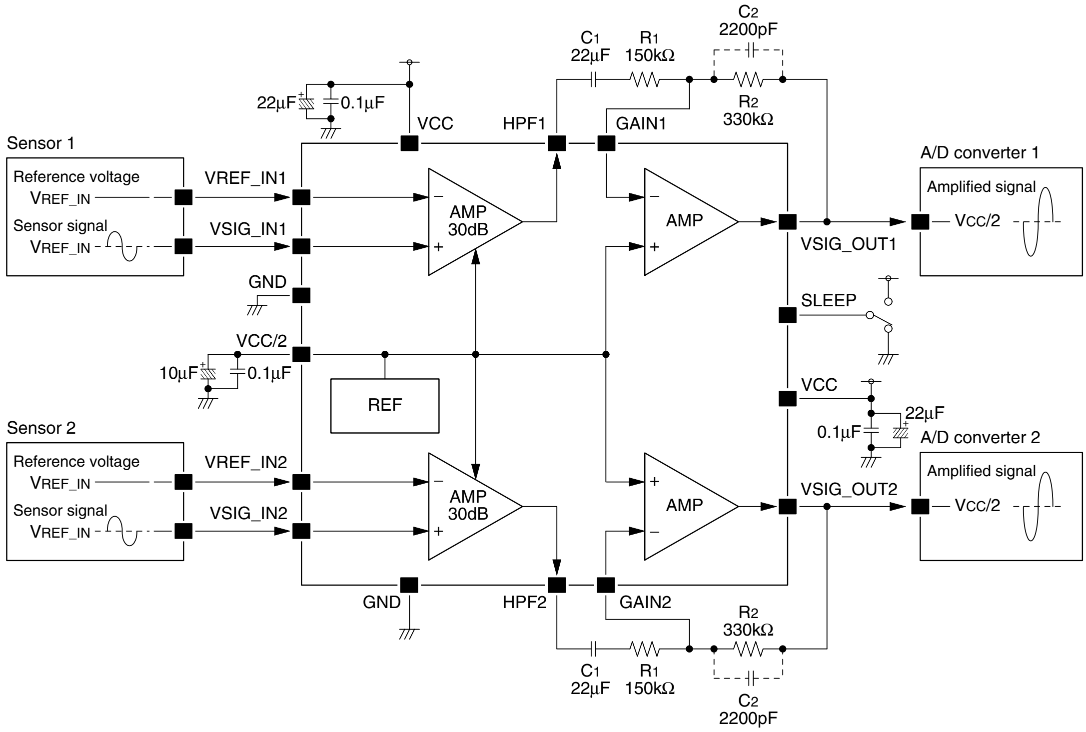
The R_2 resistor value is determined by R_1 resistor value and output gain setting. Note that the offset voltage increases as the R_2 value increases. The R_2 recommended value is 27kΩ to 330kΩ.

Sleep Mode Function

The SM6661A has the sleep mode function. When SLEEP pin set to “High”, the SM6661A operation becomes sleep mode. In sleep mode operation, the current consumption becomes up to 1.0µA and VSIG_OUT1 and VSIG_OUT2 pins are setting high-impedance.

Control pin	SM6661A operation
SLEEP	
LOW	Normal operation
HIGH	Sleep mode

TYPICAL APPLICATION CIRCUIT



Total gain	36.8dB
f_{CL}	0.05Hz
f_{CH}	219Hz

TYPICAL PERFORMANCES

V_{CC} = 3.3V, GND = 0V, Ta = 25°C, circuit constant is same as “TYPICAL APPLICATION CIRCUIT”, unless otherwise noted.

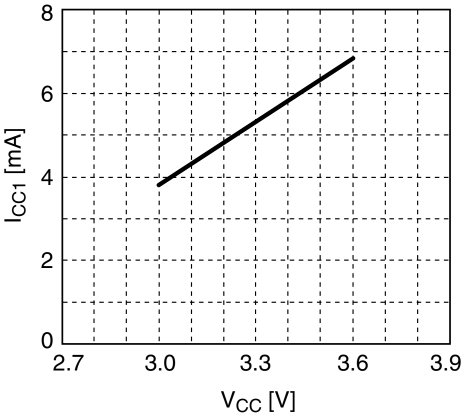


Figure 1. Current consumption 1 vs. Supply voltage

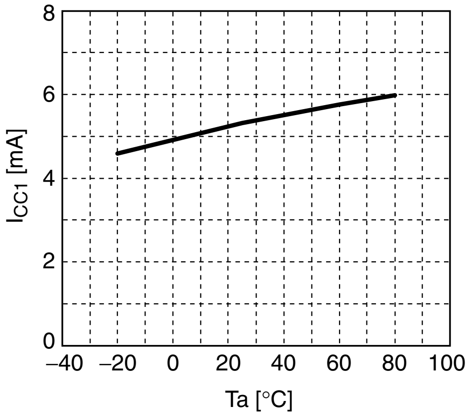


Figure 2. Current consumption 1 vs. Ambient temperature

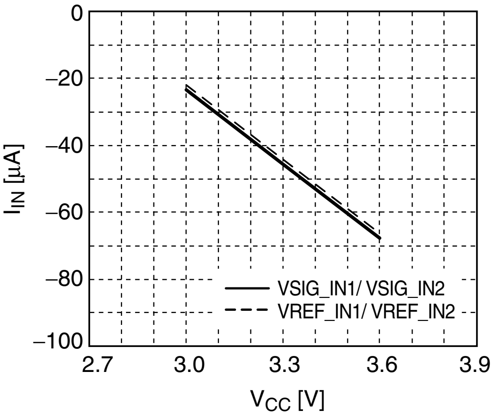


Figure 3. Input current vs. Supply voltage

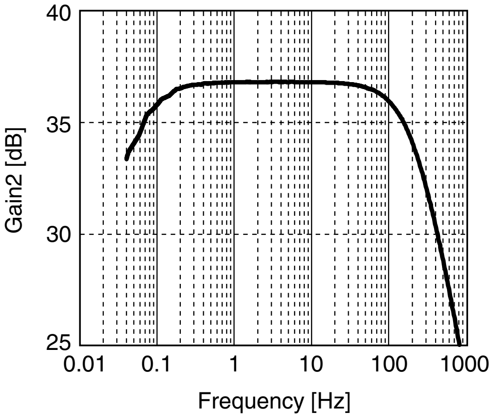


Figure 4. Output gain vs. Frequency

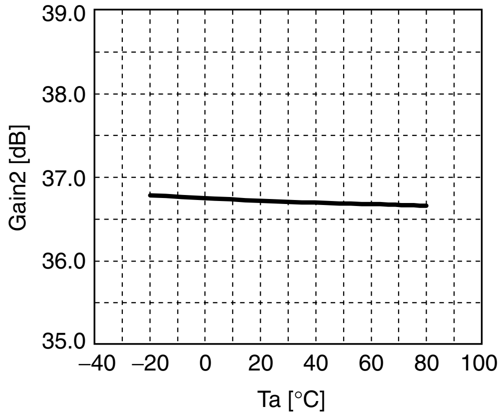


Figure 5. Output gain vs. Ambient temperature
(at 10Hz input frequency)

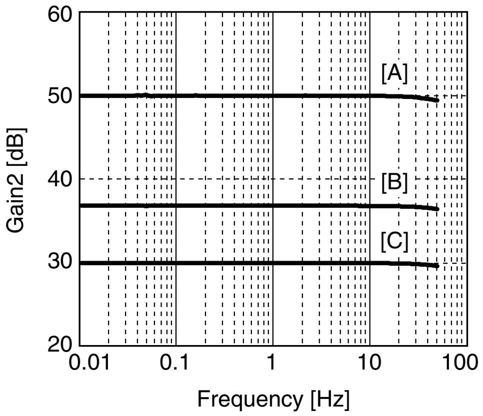


Figure 6. Output gain vs. Frequency
(when changing output gain setting*1)

*1. Each setting is measured without connecting feedback capacitor C_2 for variable gain amplifier, high-frequency bandwidth is not limited.
Output gain setting of each characteristics are shown below;
[A]: 50.0 dB setting (R_1 = 33kΩ, R_2 = 330kΩ)
[B]: 36.8 dB setting (R_1 = 150kΩ, R_2 = 330kΩ)
[C]: 30.0 dB setting (R_1 = 330kΩ, R_2 = 330kΩ)

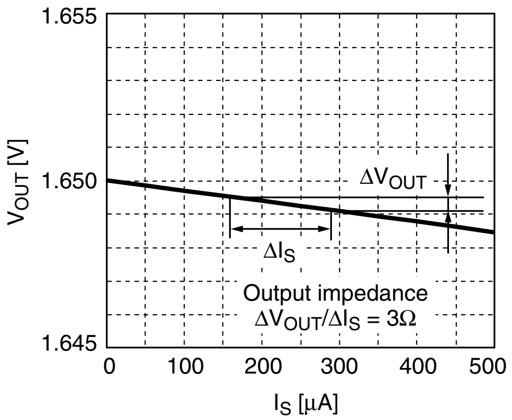


Figure 7. Output current vs. Output voltage*1
(VSIG_OUT1, VSIG_OUT2 pins)

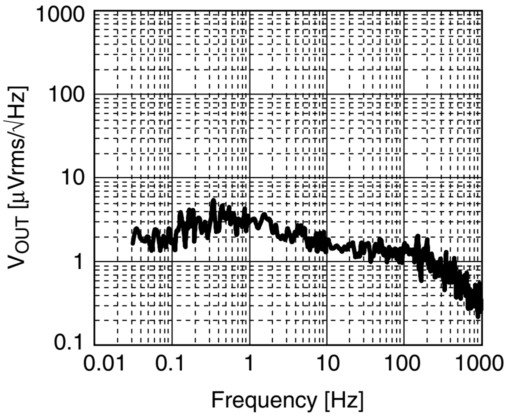


Figure 8. Output noise vs. Frequency*2

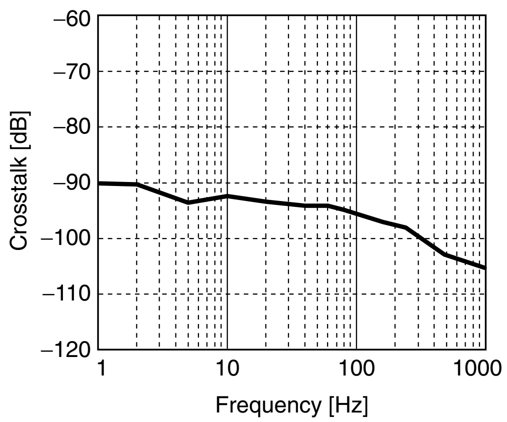


Figure 9. Crosstalk vs. Frequency*3

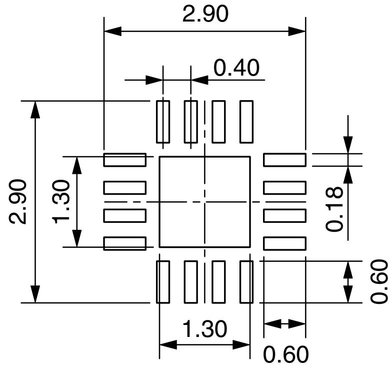
*1. I_S indicates the source current of VSIG_OUT1 or VSIG_OUT2 pins.

*2. When short-circuiting between VSIG_IN1 and VREF_IN1 pins, VSIG_IN2 and VREF_IN2 pins, without inputting external signal.
Measurement equipment: Agilent 35670A FFT Dynamic Signal Analyzer, in "FFT ANALYSIS" mode
Input referred voltage noise at 1Hz frequency: 0.05µVrms/√Hz
(calculated based on 35µVrms/√Hz output noise at 1Hz frequency and 36.8 dB output gain "Gain2")

*3. When measured without connecting feedback capacitor C_2 for variable gain amplifier, high-frequency bandwidth is not limited.

RECOMMENDED FOOTPRINT PATTERN

(Unit: mm)



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