

# HA1630Q01/02/03 Series

## Low Voltage Operation CMOS Quad Operational Amplifier

REJ03D0802-0100

Rev.1.00

Mar 10, 2006

### Description

The HA1630Q01/02/03 are dual CMOS Operational Amplifiers realizing low voltage operation, low input offset voltage and low supply current. In addition to a low operating voltage from 1.8V, these device output can achieve full swing output voltage capability extending to either supply. Available in an ultra-small TSSOP-14 package that occupies only 1/2 the area of the SOP-14 package.

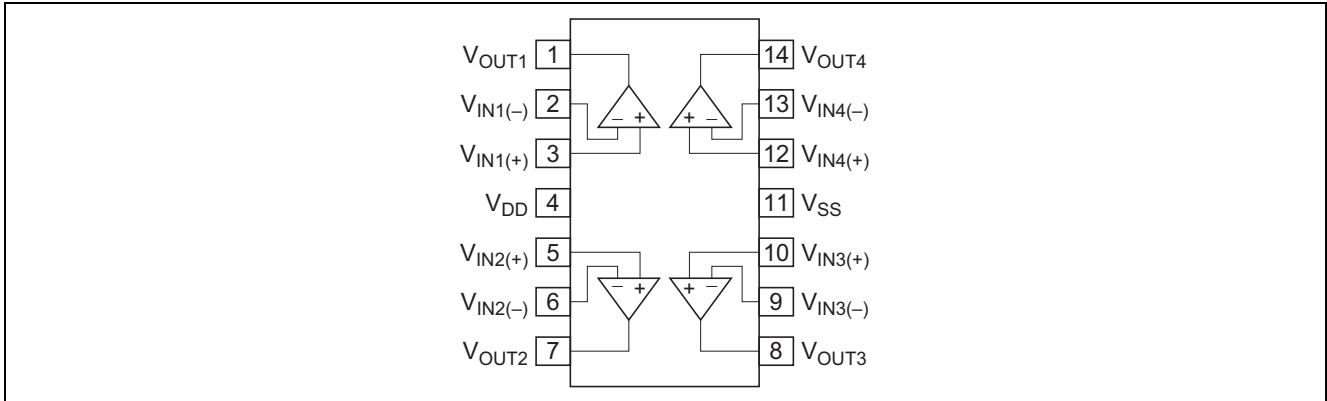
### Features

- Low power and single supply operation  $V_{DD} = 1.8$  to  $5.5$  V
- Low input offset voltage  $V_{IO} = 4.0$  mV Max
- Low supply current (per channel)
  - $I_{DD} = 15$   $\mu$ A Typ (HA1630Q01)
  - $I_{DD} = 50$   $\mu$ A Typ (HA1630Q02)
  - $I_{DD} = 100$   $\mu$ A Typ (HA1630Q03)
- Maximum output voltage  $V_{OH} = 2.9$  V Min (at  $V_{DD} = 3.0$  V)
- Low input bias current  $I_{IB} = 1$  pA Typ

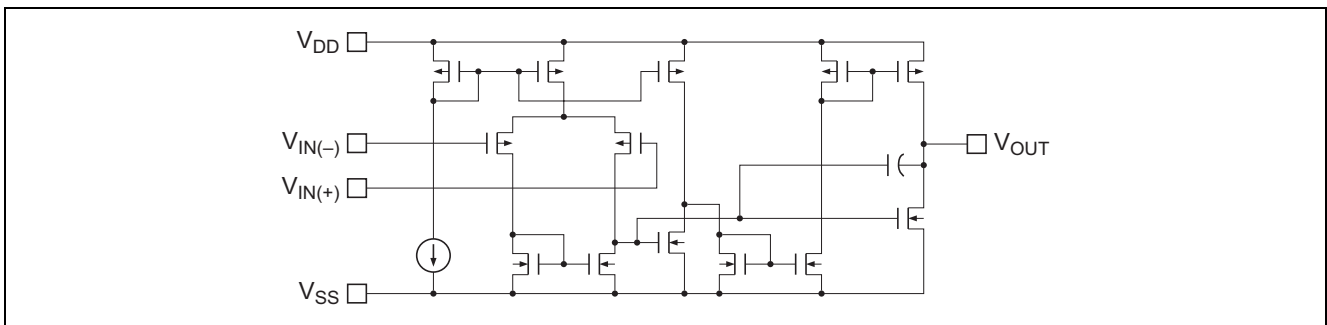
### Ordering Information

Type No.	Package Name	Package Code
HA1630Q01T	TTP-14D	PTSP0014JA-B
HA1630Q02T	TTP-14D	PTSP0014JA-B
HA1630Q03T	TTP-14D	PTSP0014JA-B

## Pin Arrangement



## Equivalent Circuit (per one channel)



## Absolute Maximum Ratings

(Ta = 25°C)

Items	Symbol	Ratings	Unit	Note
Supply voltage	V <sub>DD</sub>	7	V	
Differential input voltage	V <sub>IN(diff)</sub>	-V <sub>DD</sub> to +V <sub>DD</sub>	V	
Input voltage	V <sub>IN</sub>	-0.3 to +V <sub>DD</sub>	V	1
Power dissipation	P <sub>T</sub>	400	mW	
Operating temp. Range	Topr	-40 to +85	°C	
Storage temp. Range	Tstg	-55 to +125	°C	

Note: 1. Do not apply Input Voltage exceeding V<sub>DD</sub> or 7 V.

## Electrical Characteristics

(V<sub>DD</sub> = 3.0 V, Ta = 25°C)

Items	Symbol	Min	Typ	Max	Unit	Test Condition
Input offset voltage	V <sub>IO</sub>	—	—	4.0	mV	V <sub>in</sub> = 1.5 V
Input offset current	I <sub>IO</sub>	—	(1.0)	—	pA	V <sub>in</sub> = 1.5 V
Input bias current	I <sub>IB</sub>	—	(1.0)	—	pA	V <sub>in</sub> = 1.5 V
Output high voltage	V <sub>OH</sub>	2.9	—	—	V	R <sub>L</sub> = 1 MΩ
Output source current	I <sub>O SOURCE</sub>	6	12	—	μA	V <sub>OH</sub> = 2.5 V (HA1630Q01)
		25	50	—		V <sub>OH</sub> = 2.5 V (HA1630Q02)
		50	100	—		V <sub>OH</sub> = 2.5 V (HA1630Q03)
Output low voltage	V <sub>OL</sub>	—	—	0.1	V	R <sub>L</sub> = 1 MΩ
Output sink current	I <sub>O SINK</sub>	—	(0.8)	—	mA	V <sub>OL</sub> = 0.5 V (HA1630Q01)
		—	(1.0)	—		V <sub>OL</sub> = 0.5 V (HA1630Q02)
		—	(1.2)	—		V <sub>OL</sub> = 0.5 V (HA1630Q03)
Common mode input voltage range	V <sub>CM</sub>	-0.1 to 2.1	—	—	V	
Slew rate	SR	—	(0.125)	—	V/μs	C <sub>L</sub> = 20 pF (HA1630Q01)
		—	(0.50)	—		C <sub>L</sub> = 20 pF (HA1630Q02)
		—	(1.00)	—		C <sub>L</sub> = 20 pF (HA1630Q03)
Voltage gain	A <sub>V</sub>	60	80	—	dB	
Gain bandwidth product	BW	—	(200)	—	kHz	C <sub>L</sub> = 20 pF (HA1630Q01)
		—	(680)	—		C <sub>L</sub> = 20 pF (HA1630Q02)
		—	(1200)	—		C <sub>L</sub> = 20 pF (HA1630Q03)
Power supply rejection ratio	PSRR	60	80	—	dB	
Common mode rejection ratio	CMRR	60	80	—	dB	
Supply current	I <sub>DD</sub>	—	60	120	μA	R <sub>L</sub> = ∞ (HA1630Q01)
		—	200	400		R <sub>L</sub> = ∞ (HA1630Q02)
		—	400	800		R <sub>L</sub> = ∞ (HA1630Q03)

Note: 1. ( ) : Design specification

## Table of Graphs

Electrical Characteristics			HA1630Q01 Figure	HA1630Q02 Figure	HA1630Q03 Figure	Test Circuit
Supply current	$I_{DD}$	vs Supply voltage	1-1	2-1	3-1	2
		vs Ambient temperature	1-2	2-2	3-2	
Output high voltage	$V_{OH}$	vs Output source current	1-3	2-3	3-3	4
		vs Supply voltage	1-4	2-4	3-4	
Output source current	$I_{O\ SOURCE}$	vs Ambient temperature	1-5	2-5	3-5	6
Output low voltage	$V_{OL}$	vs Output sink current	1-6	2-6	3-6	5
Output sink current	$I_{O\ SINK}$	vs Ambient temperature	1-7	2-7	3-7	6
Input offset voltage	$V_{IO}$	Distribution	1-8	2-8	3-8	1
		vs Supply voltage	1-9	2-9	3-9	
		vs Ambient temperature	1-10	2-10	3-10	
Common mode input voltage range	$V_{CM}$	vs Ambient temperature	1-11	2-11	3-11	7
Power supply rejection ratio	PSRR	vs Frequency	1-12	2-12	3-12	1
Common mode rejection ratio	CMRR	vs Frequency	1-13	2-13	3-13	7
Voltage gain & phase angle	$A_V$	vs Frequency	1-14	2-14	3-14	10
Input bias current	$I_{IB}$	vs Ambient temperature	1-15	2-15	3-15	3
		vs Input voltage	1-16	2-16	3-16	
Slew Rate (rising)	SRr	vs Ambient temperature	1-17	2-17	3-17	9
Slew Rate (falling)	SRf	vs Ambient temperature	1-18	2-18	3-18	
Slew rate		Large signal transient response	1-19	2-19	3-19	
		Small signal transient response	1-20	2-20	3-20	
Total harmonic distortion + noise	(0 dB)	vs. Output voltage p-p	—	2-21	3-21	8
	(40 dB)	vs. Output voltage p-p	—	2-22	3-22	
Maximum p-p output voltage		vs Frequency	1-21	2-23	3-23	
Voltage noise density		vs Frequency	1-22	2-24	3-24	

Main Characteristics (HA1630Q01)

Figure 1-1. HA1630Q01  
Supply Current vs. Supply Voltage

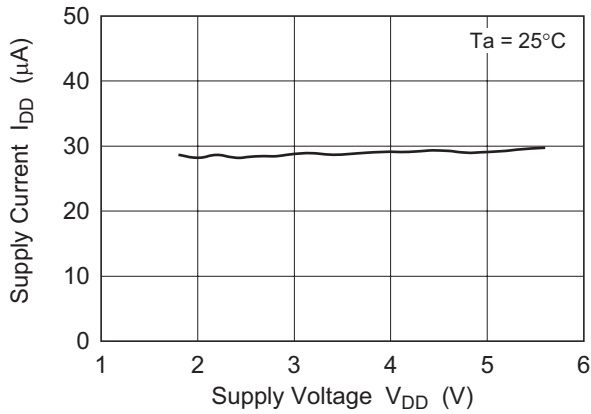


Figure 1-2. HA1630Q01  
Supply Current vs. Ambient Temperature

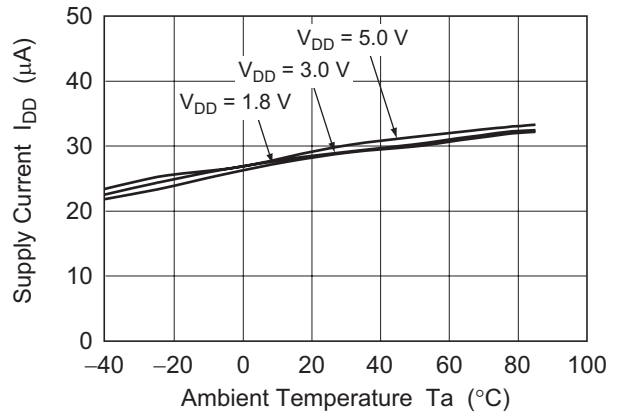


Figure 1-3. HA1630Q01  
Output High Voltage vs. Output Source Current

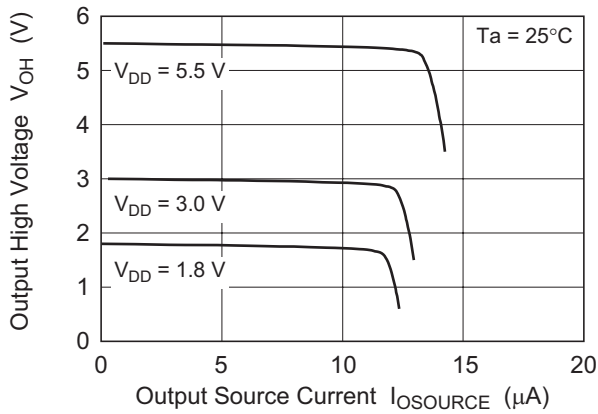


Figure 1-4. HA1630Q01  
Output High Voltage vs. Supply Voltage

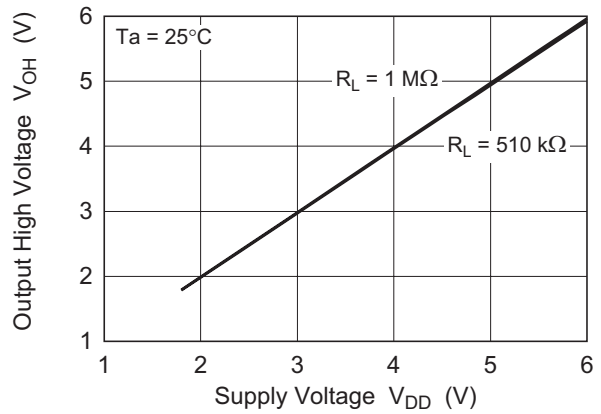
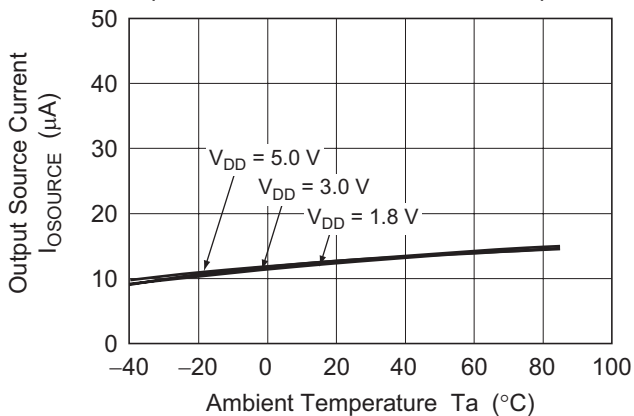


Figure 1-5. HA1630Q01  
Output Source Current vs. Ambient Temperature



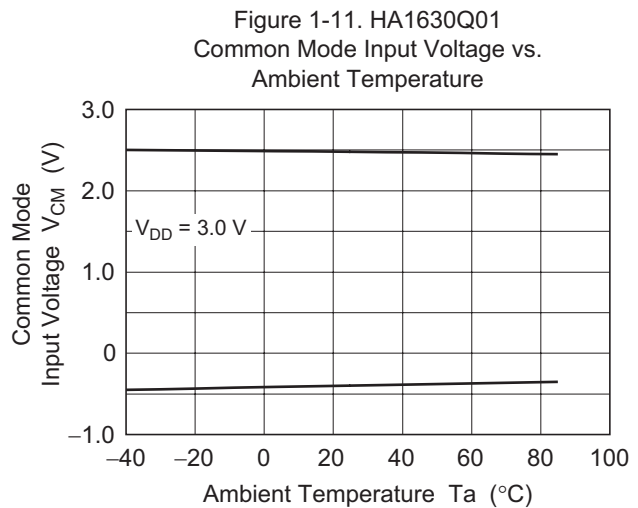
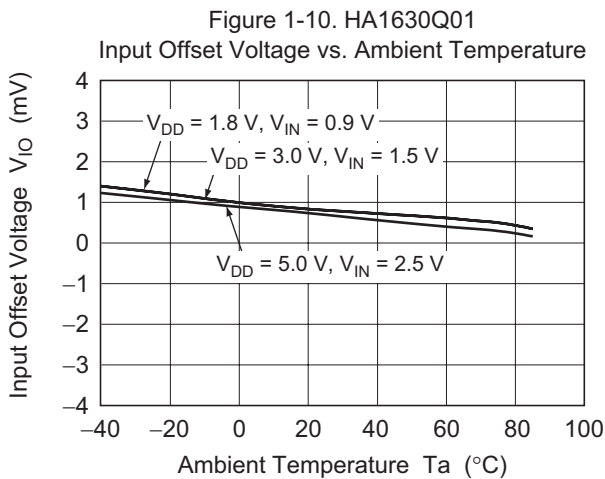
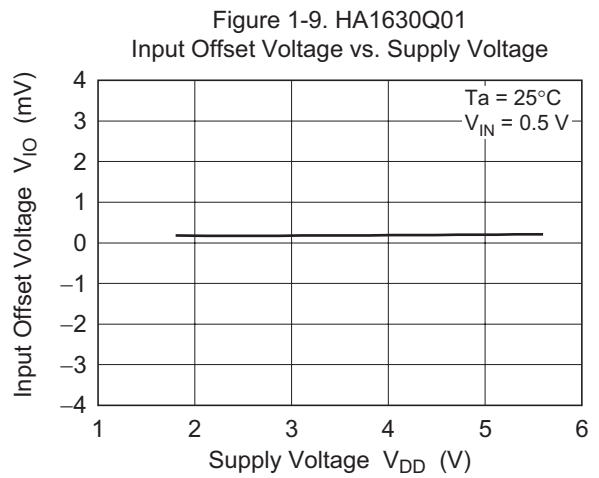
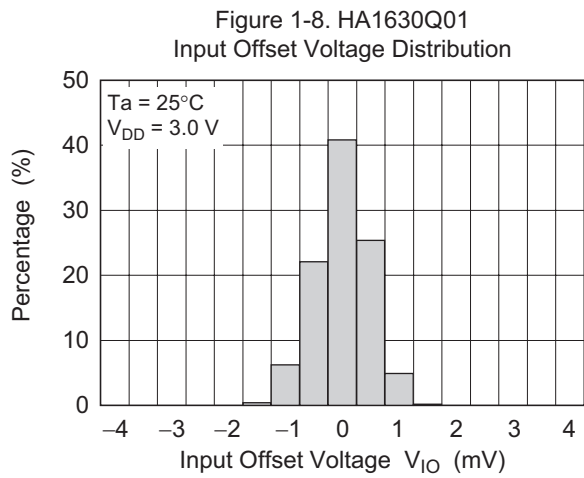
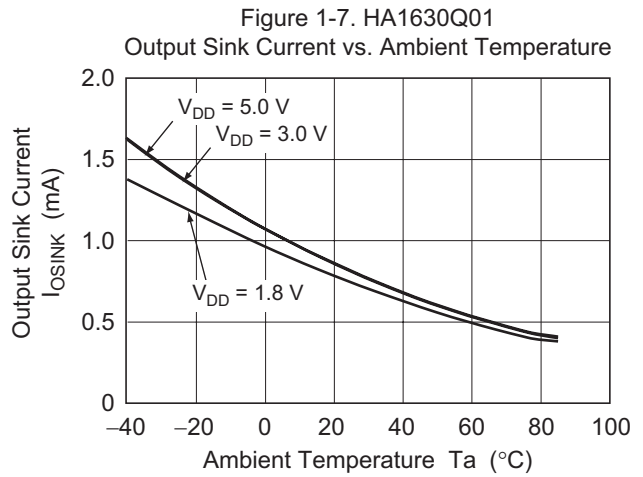
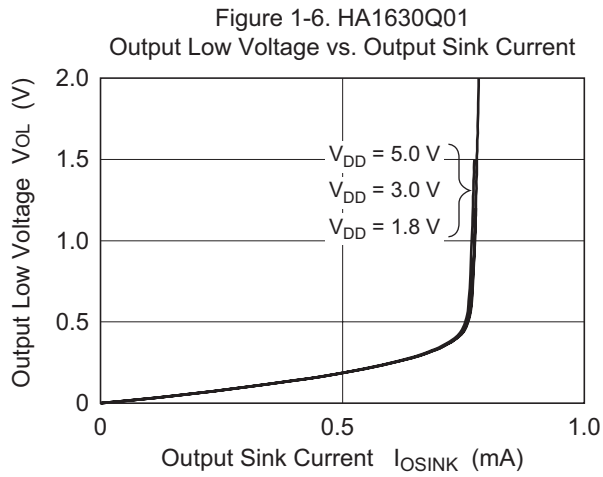


Figure 1-12. HA1630Q01  
Power Supply Rejection Ratio vs. Frequency

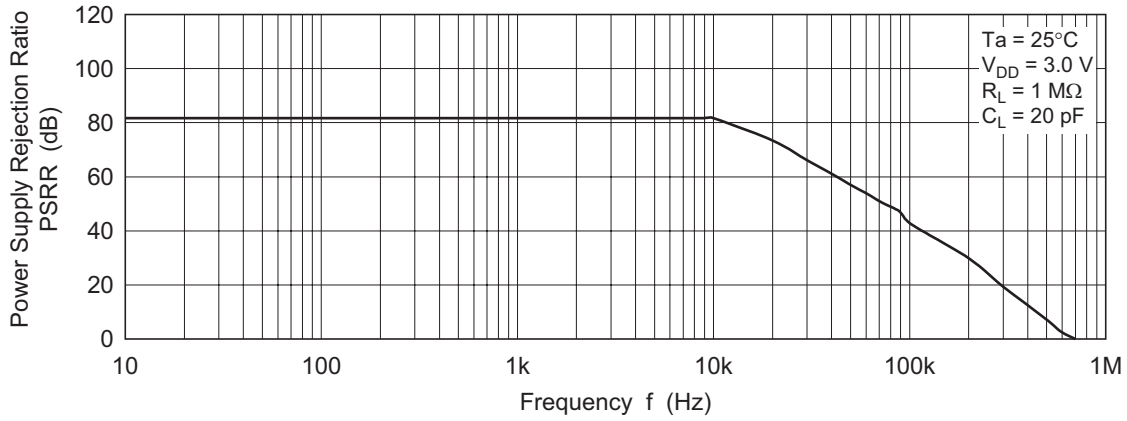


Figure 1-13. HA1630Q01  
Common Mode Rejection Ratio vs. Frequency

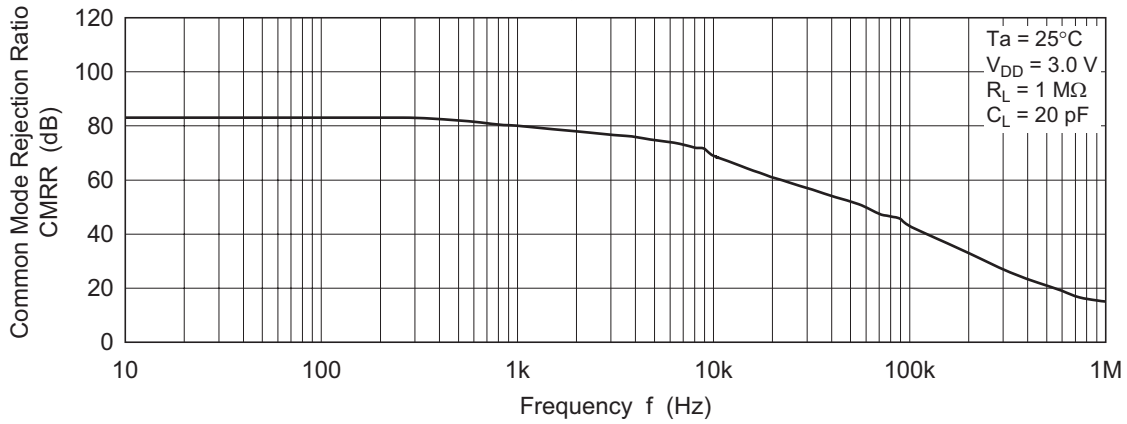
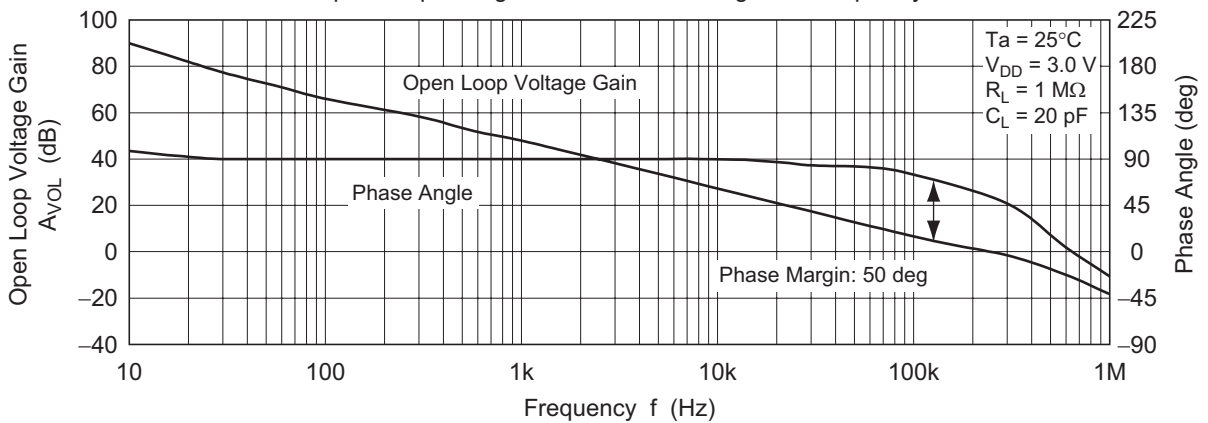


Figure 1-14. HA1630Q01  
Open Loop Voltage Gain and Phase Angle vs. Frequency



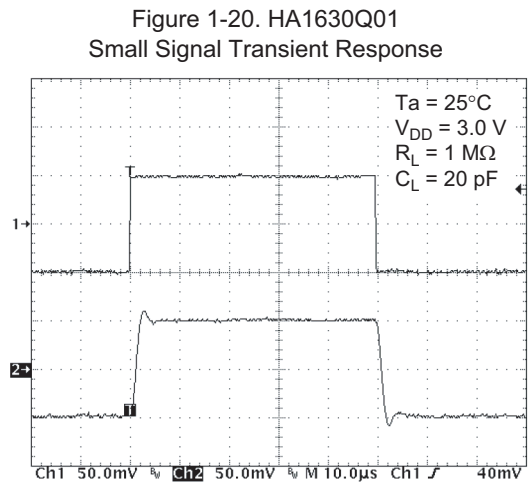
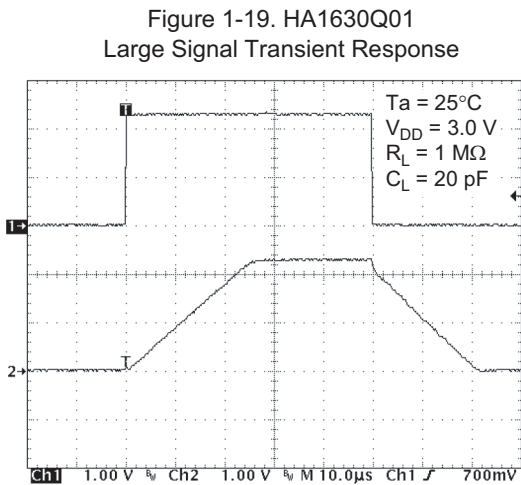
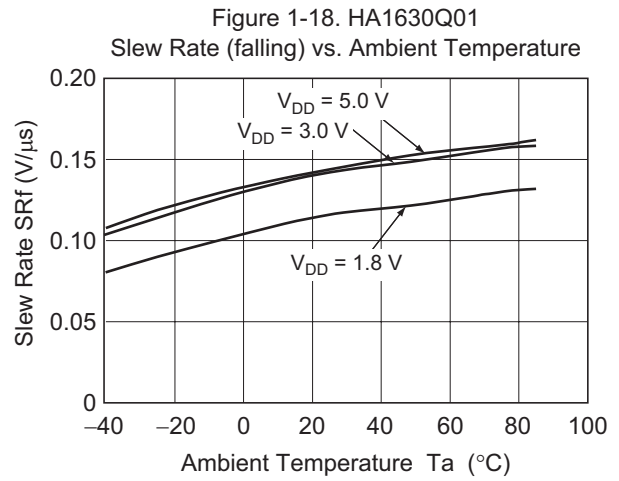
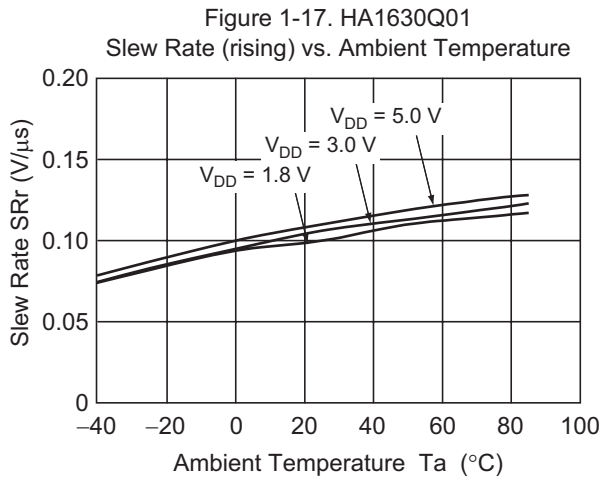
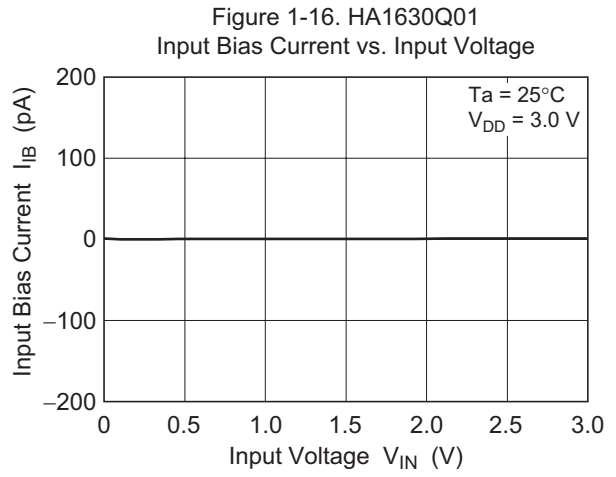
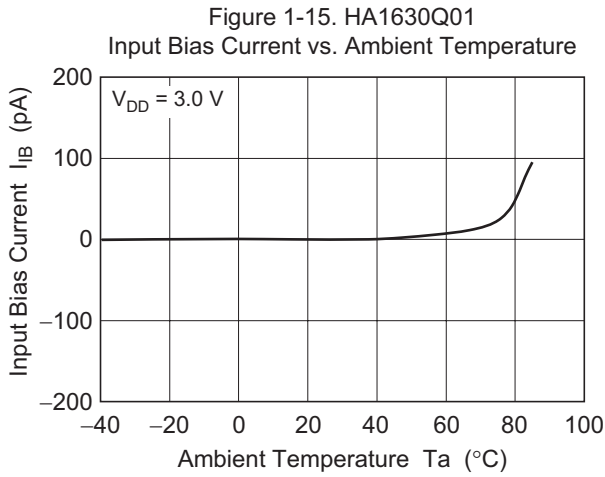




Figure 1-21. HA1630Q01  
Voltage Output p-p vs. Frequency

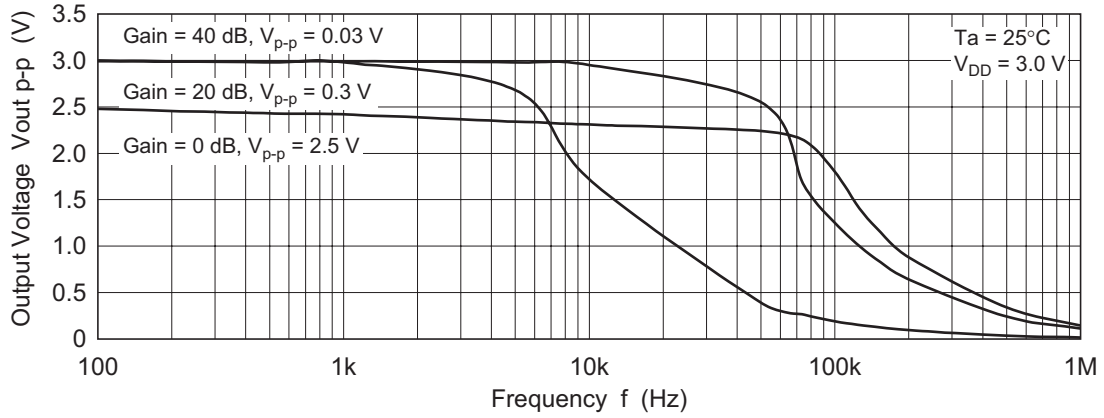
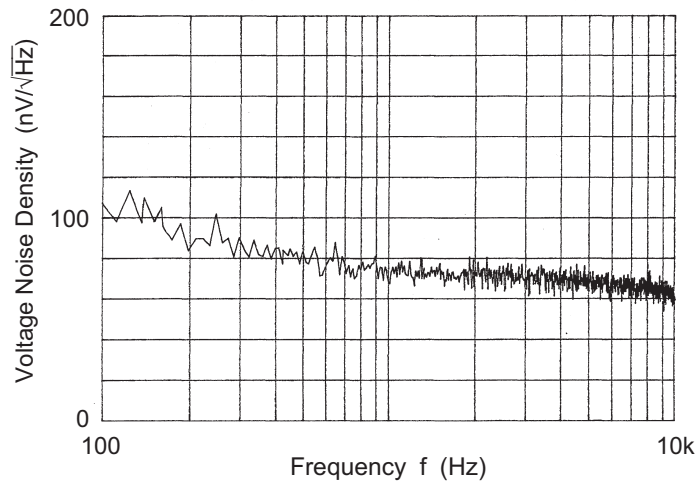


Figure 1-22. HA1630Q01  
Voltage Noise Density vs. Frequency



Main Characteristics (HA1630Q02)

Figure 2-1. HA1630Q02  
Supply Current vs. Supply Voltage

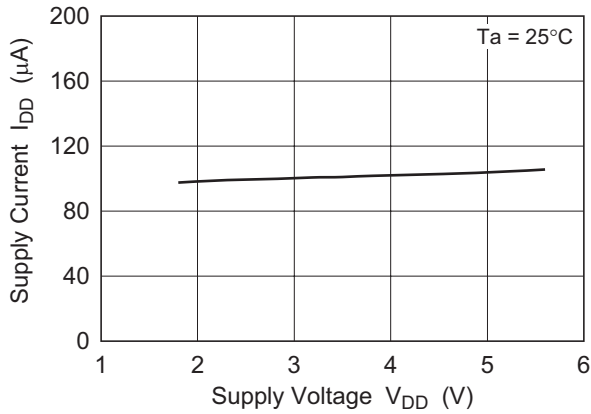


Figure 2-2. HA1630Q02  
Supply Current vs. Ambient Temperature

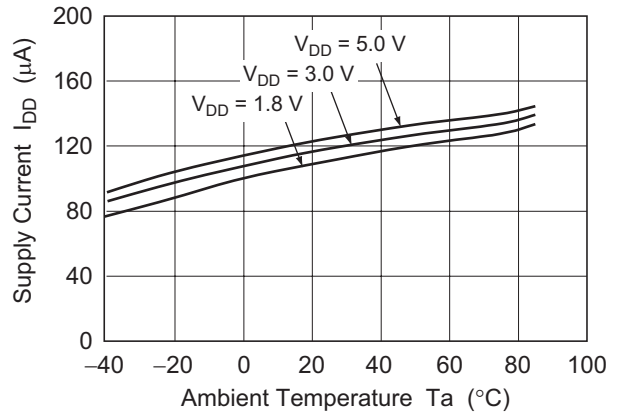


Figure 2-3. HA1630Q02  
Output High Voltage vs. Output Source Current

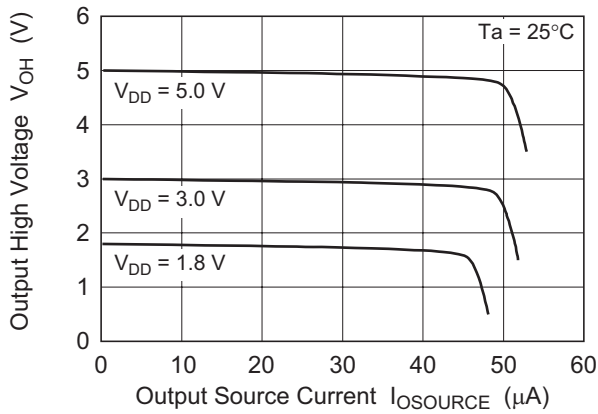


Figure 2-4. HA1630Q02  
Output High Voltage vs. Supply Voltage

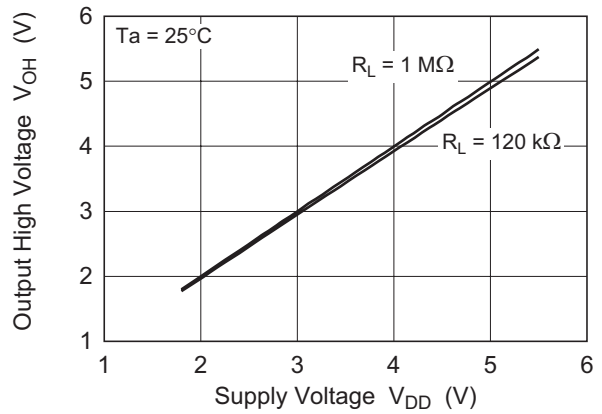
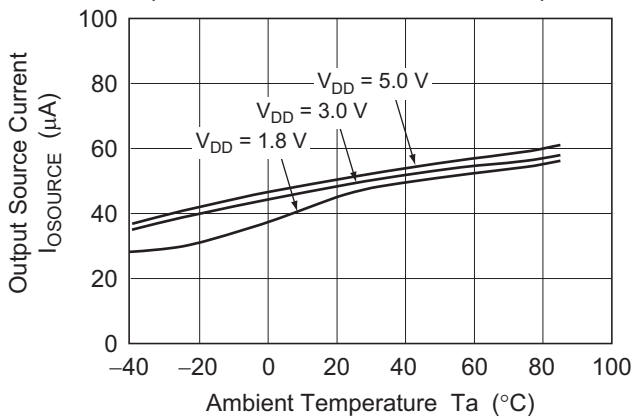


Figure 2-5. HA1630Q02  
Output Source Current vs. Ambient Temperature



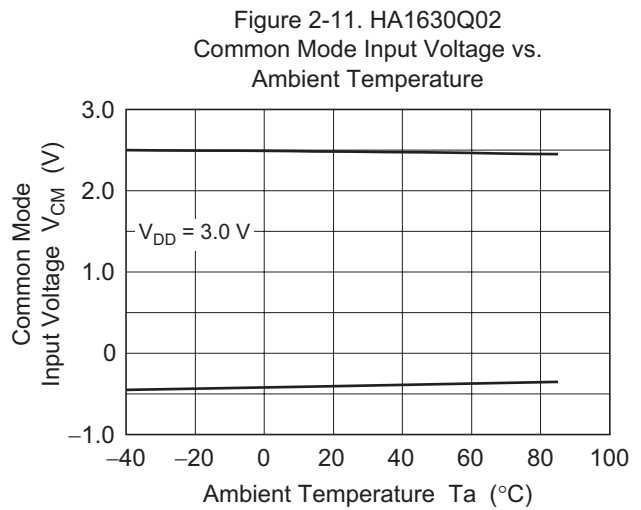
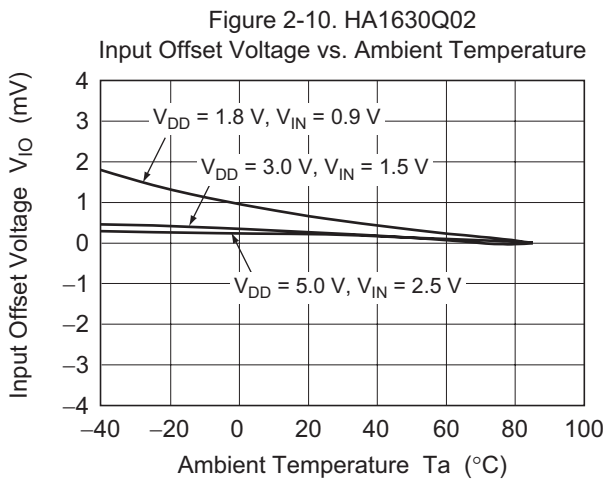
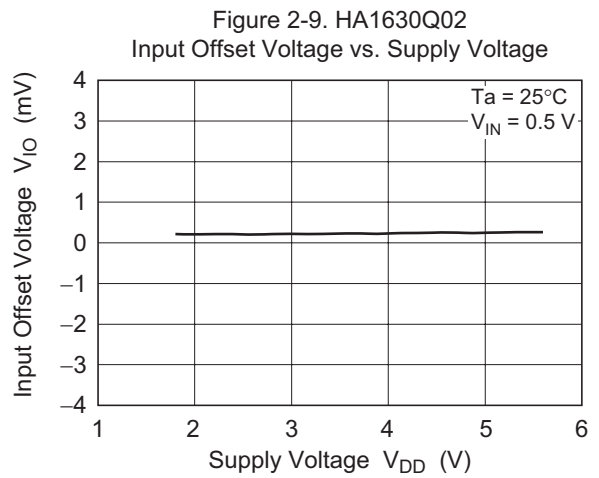
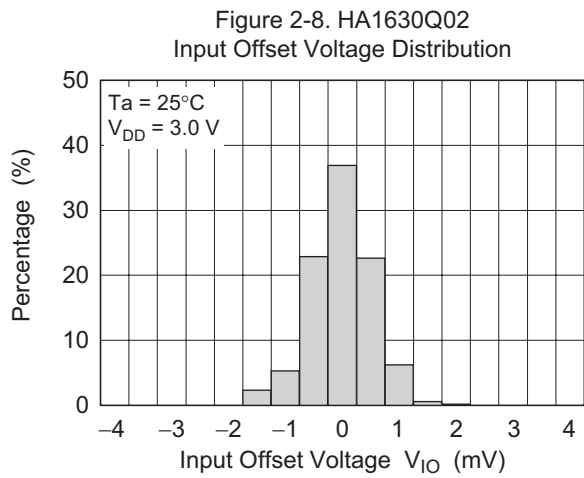
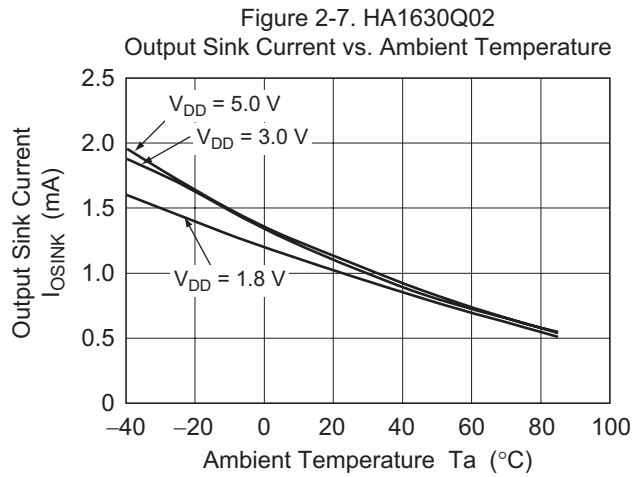
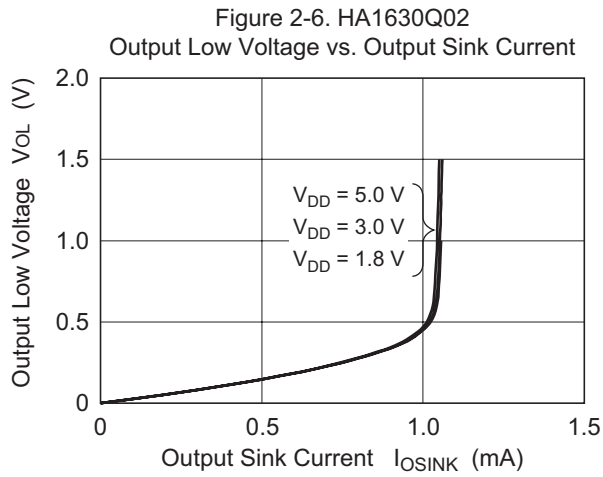


Figure 2-12. HA1630Q02  
Power Supply Rejection Ratio vs. Frequency

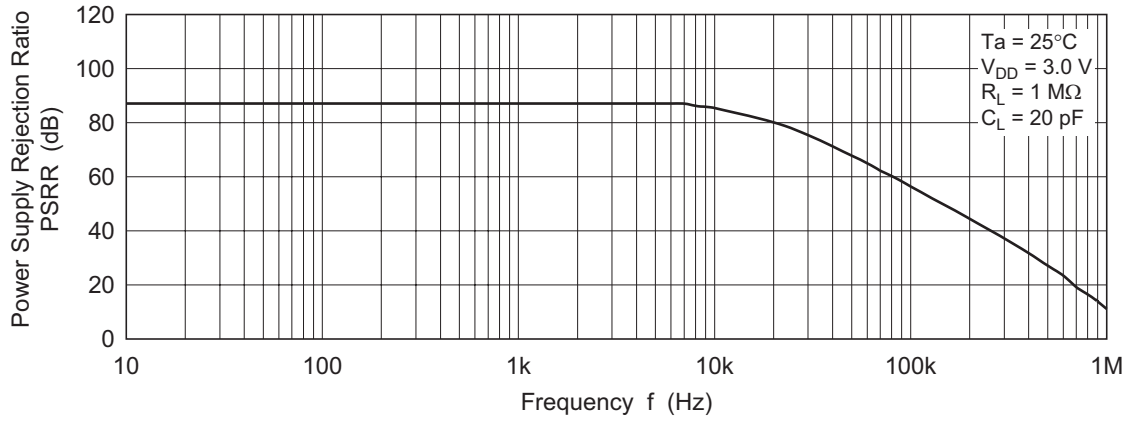


Figure 2-13. HA1630Q02  
Common Mode Rejection Ratio vs. Frequency

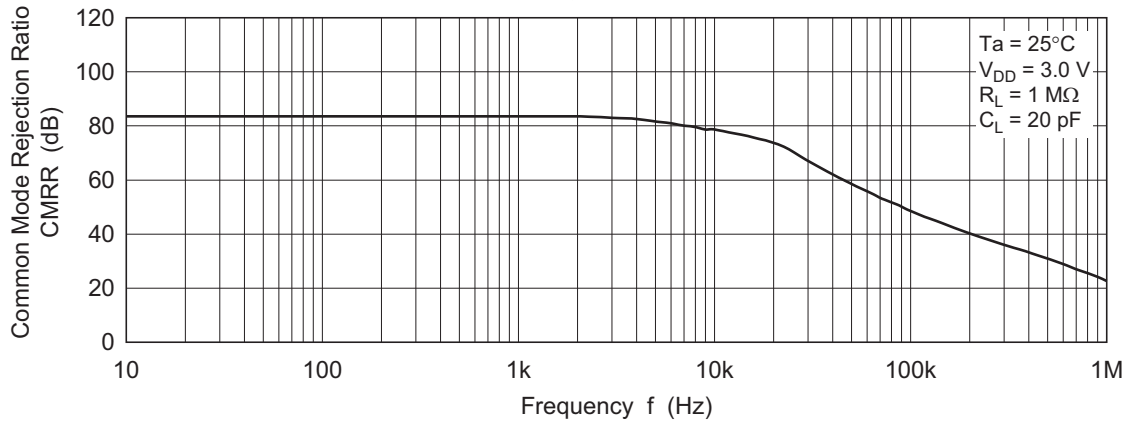
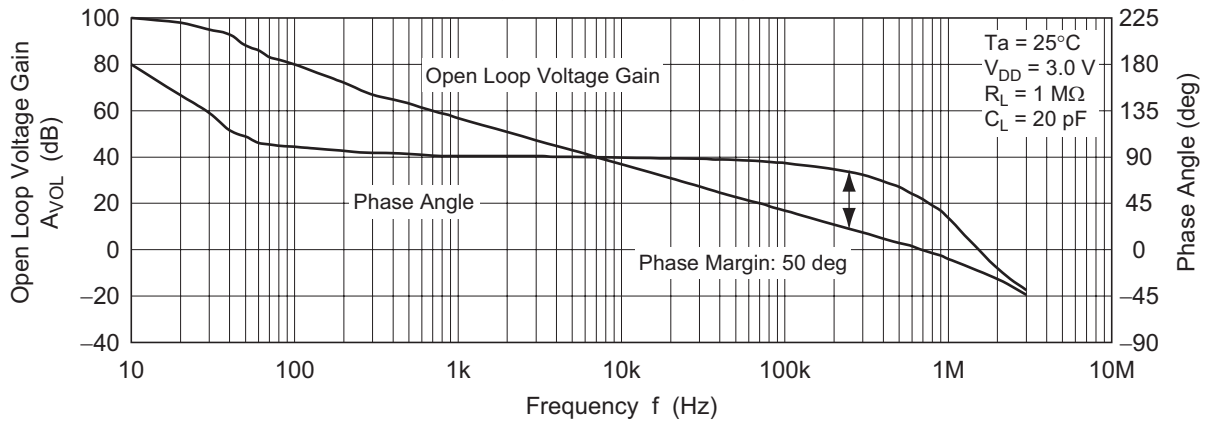


Figure 2-14. HA1630Q02  
Open Loop Voltage Gain and Phase Angle vs. Frequency



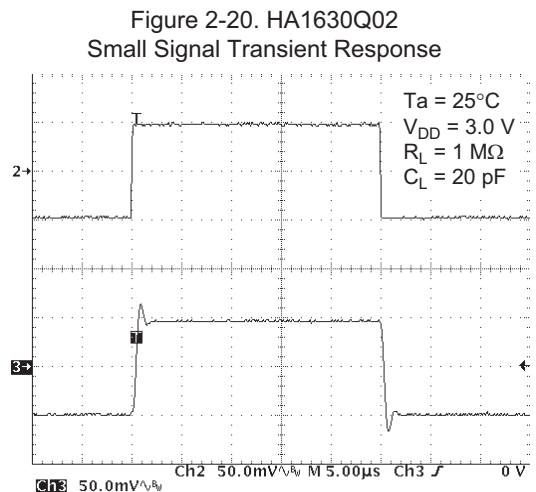
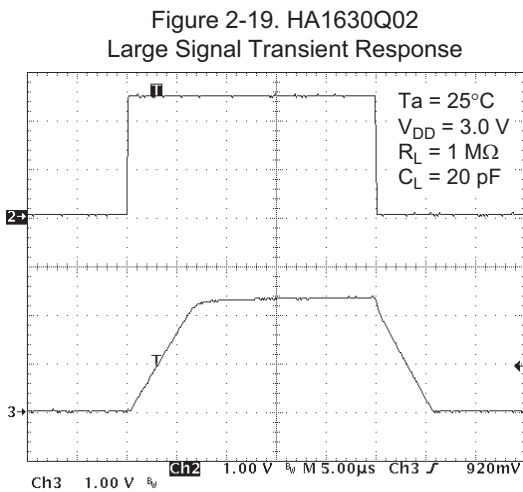
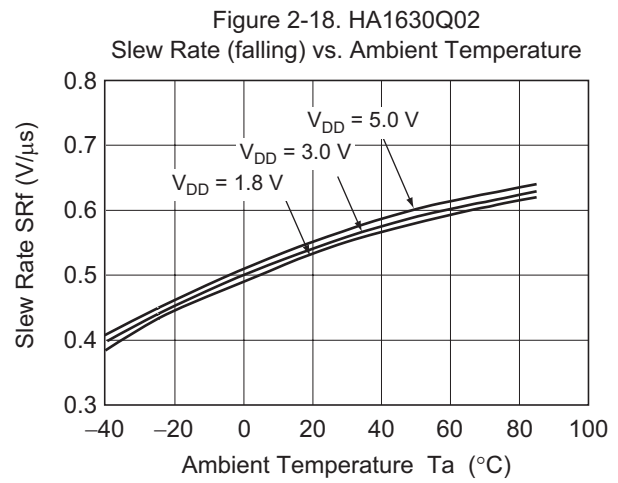
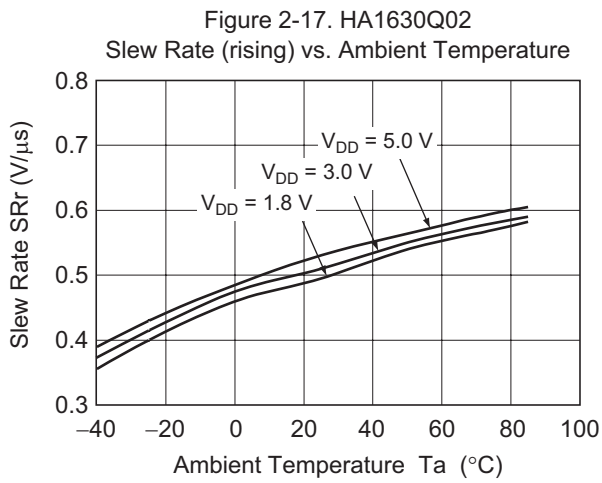
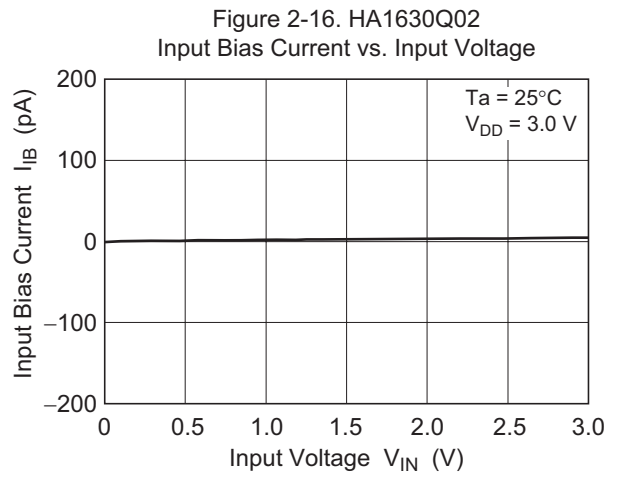
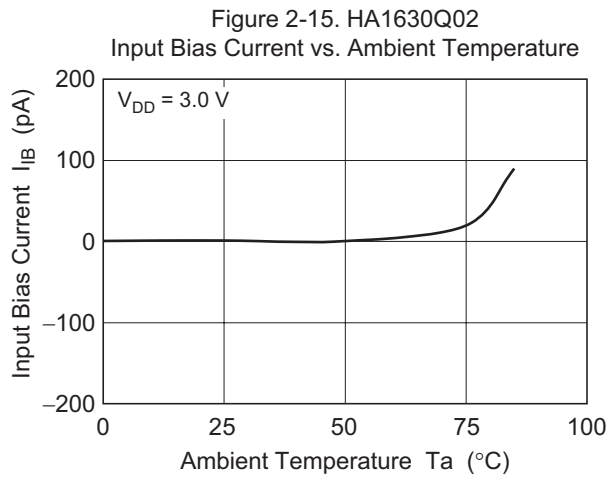


Figure 2-21. HA1630Q02  
Total Harmonic Distortion + Noise vs.  
Output Voltage p-p

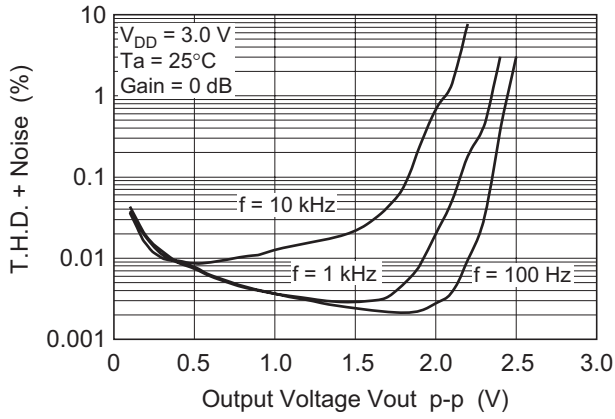


Figure 2-22. HA1630Q02  
Total Harmonic Distortion + Noise vs.  
Output Voltage p-p

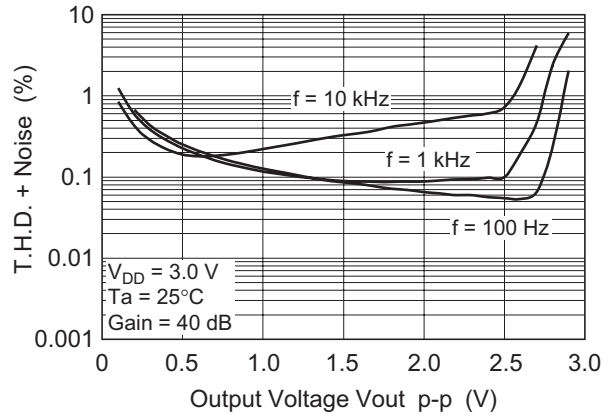


Figure 2-23. HA1630Q02  
Voltage Output p-p vs. Frequency

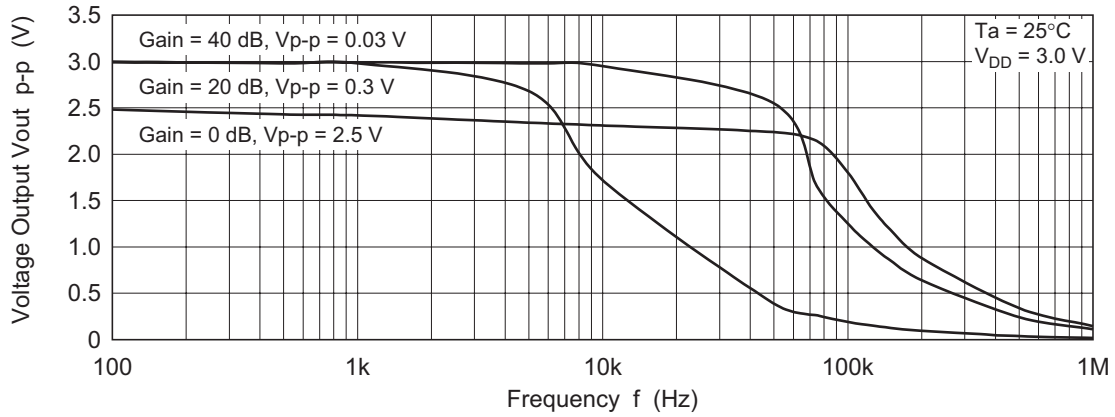
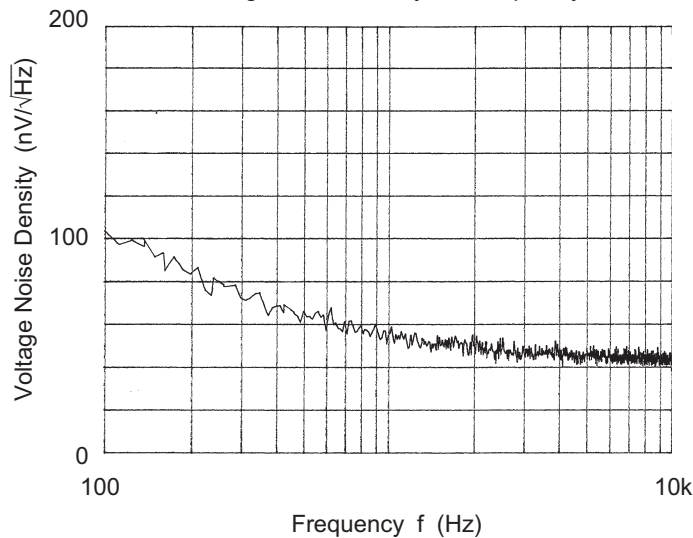
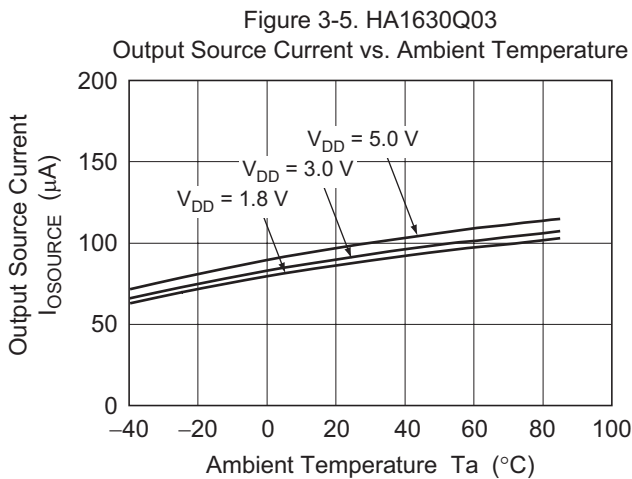
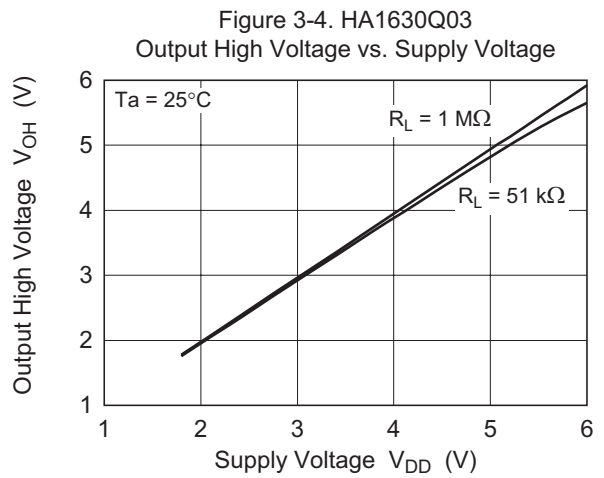
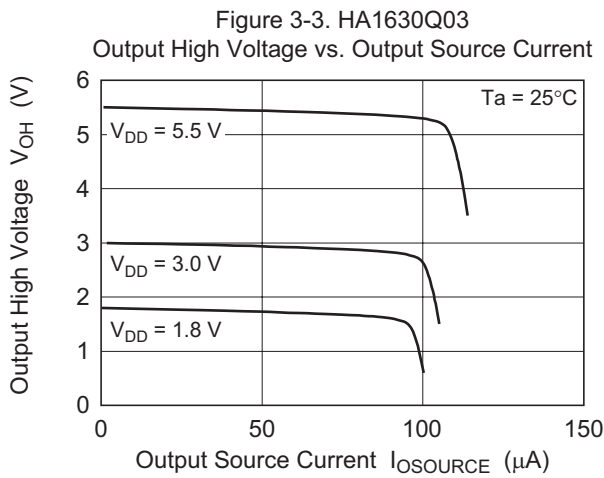
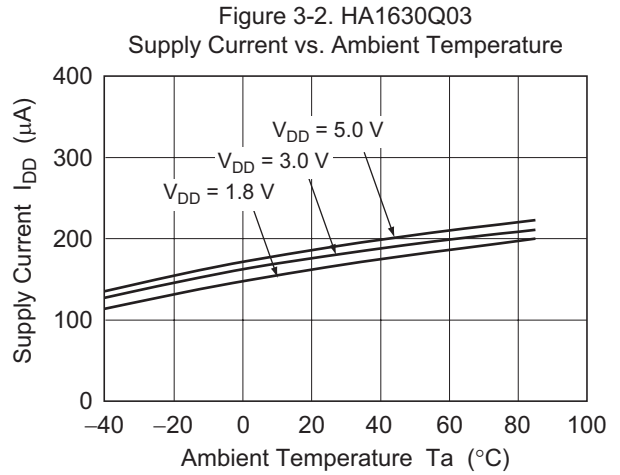
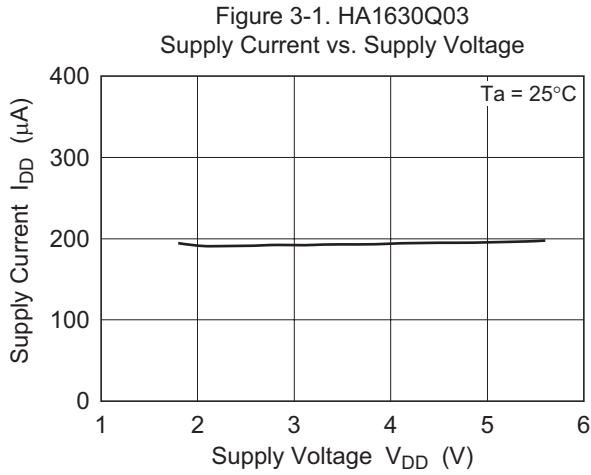


Figure 2-24. HA1630Q02  
Voltage Noise Density vs. Frequency



Main Characteristics (HA1630Q03)



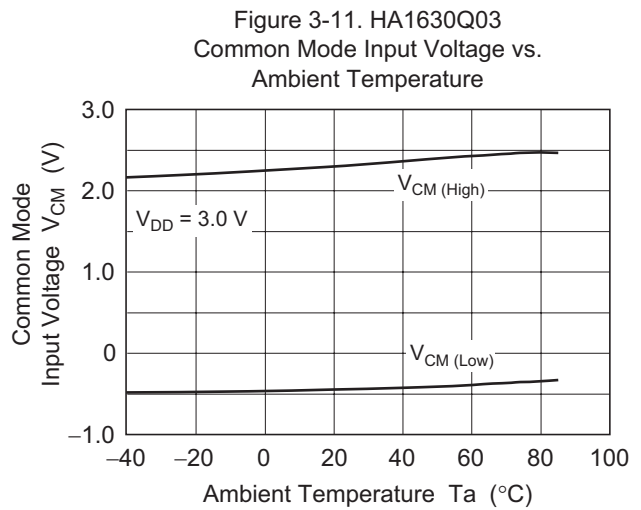
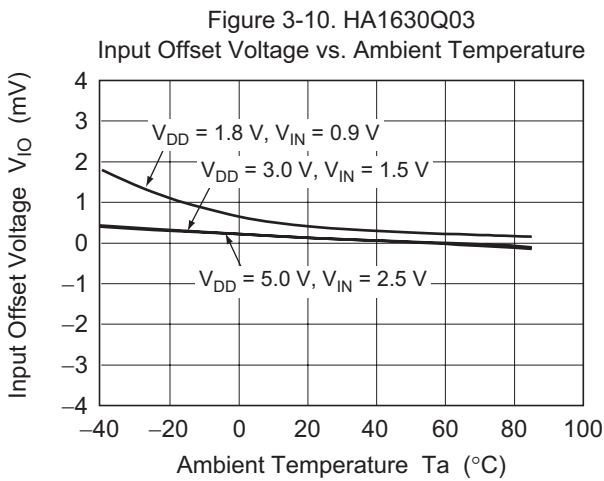
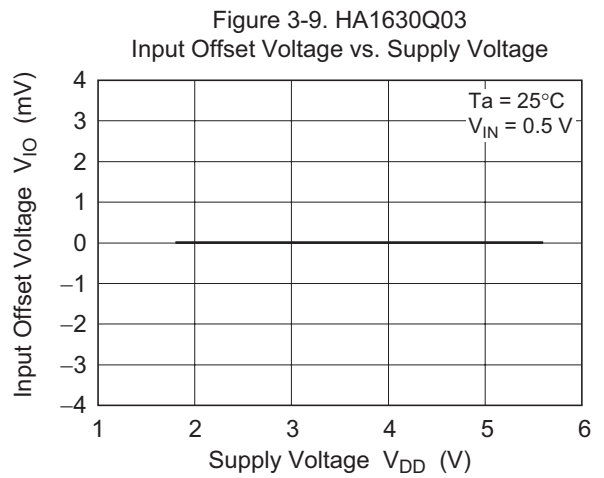
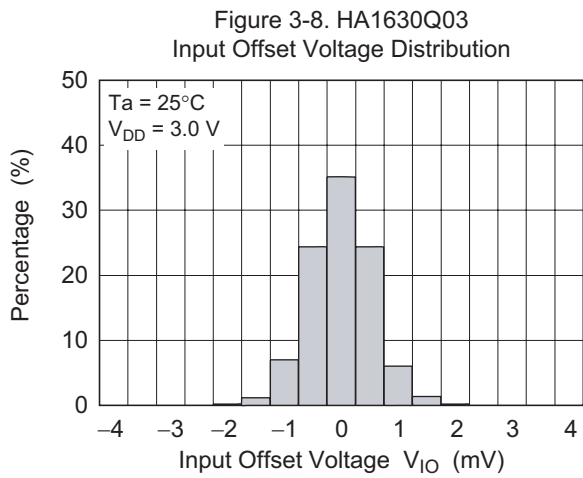
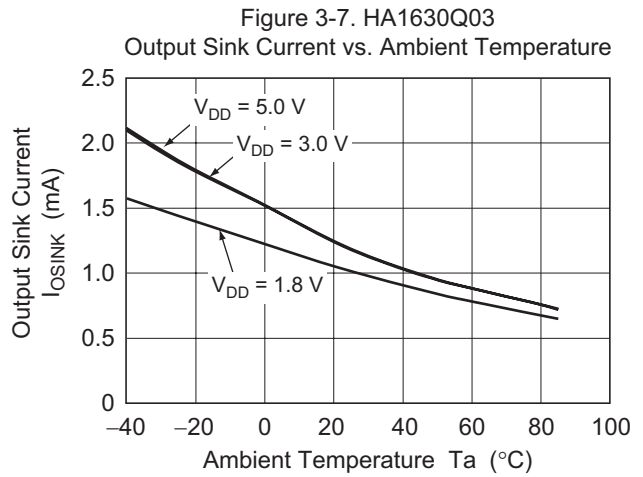
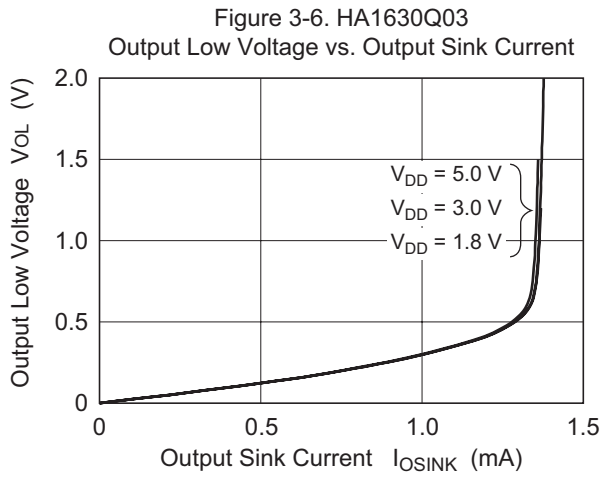




Figure 3-12. HA1630Q03  
Power Supply Rejection Ratio vs. Frequency

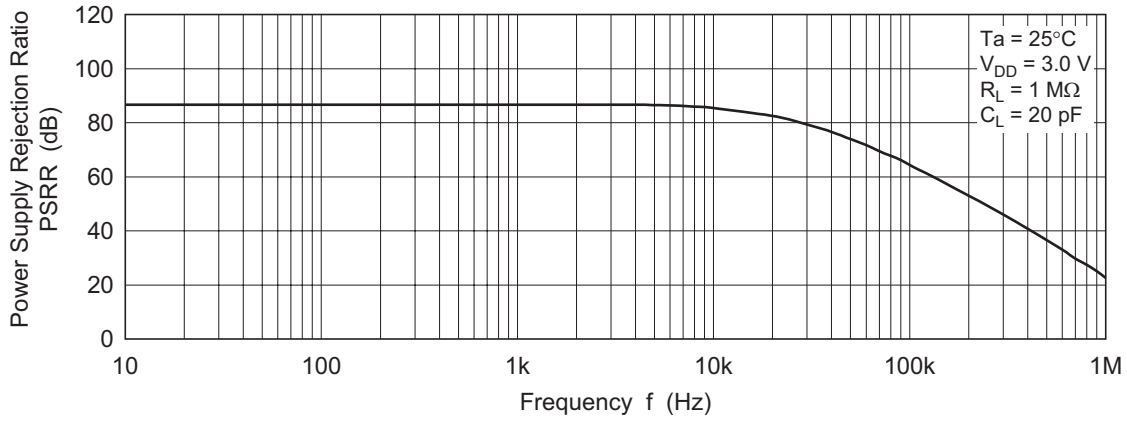


Figure 3-13. HA1630Q03  
Common Mode Rejection Ratio vs. Frequency

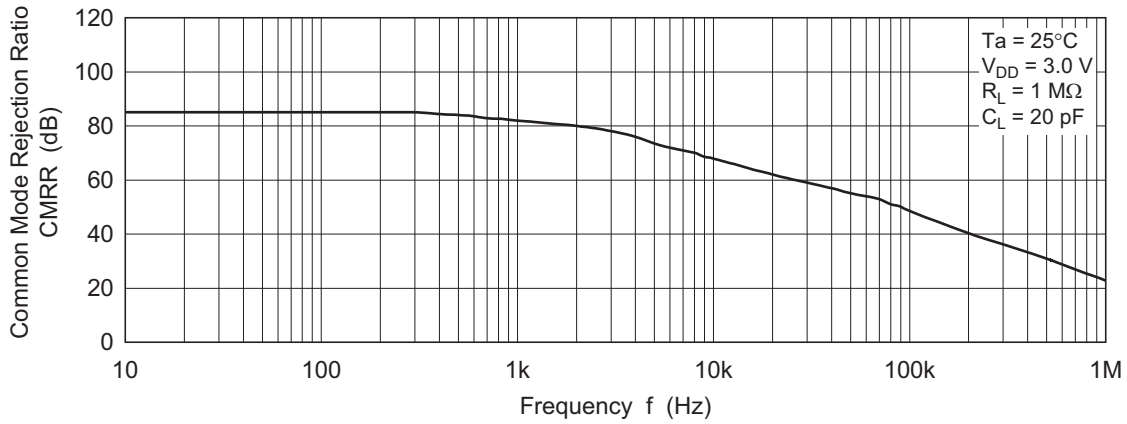
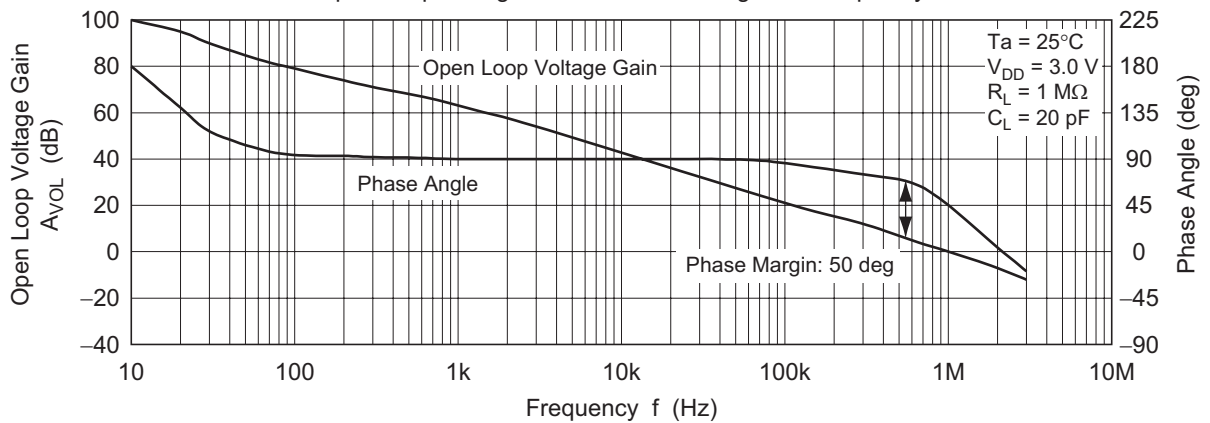


Figure 3-14. HA1630Q03  
Open Loop Voltage Gain and Phase Angle vs. Frequency



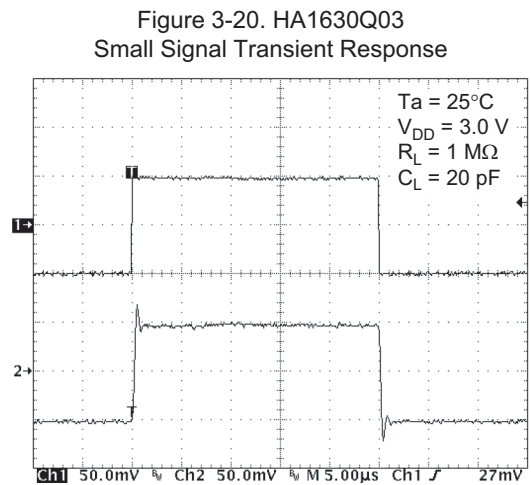
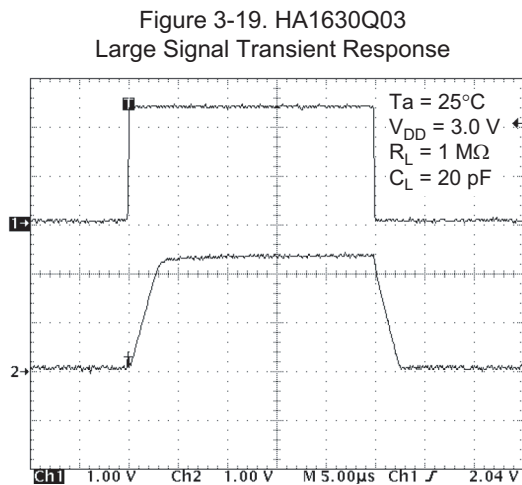
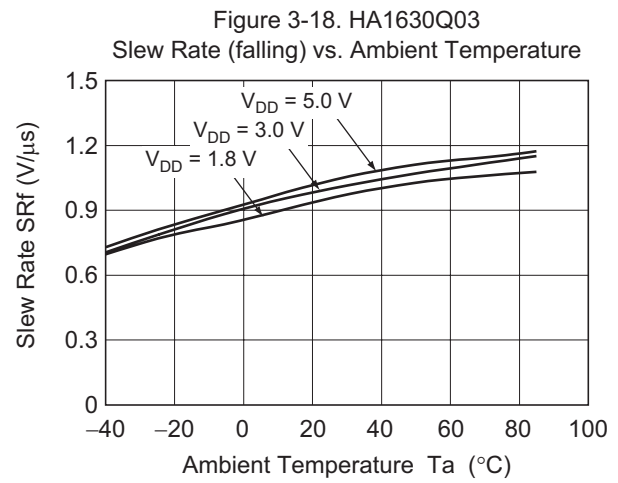
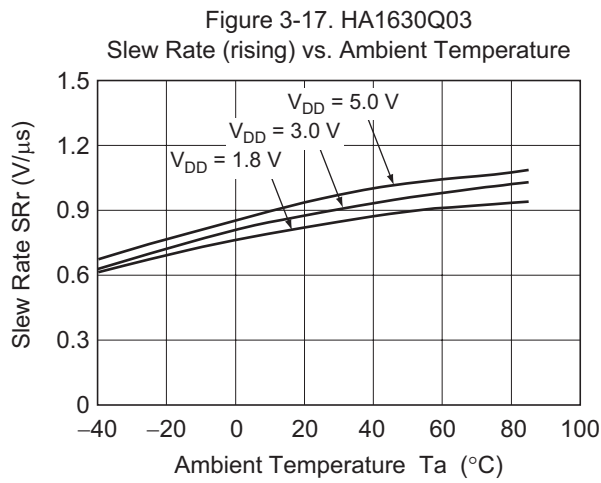
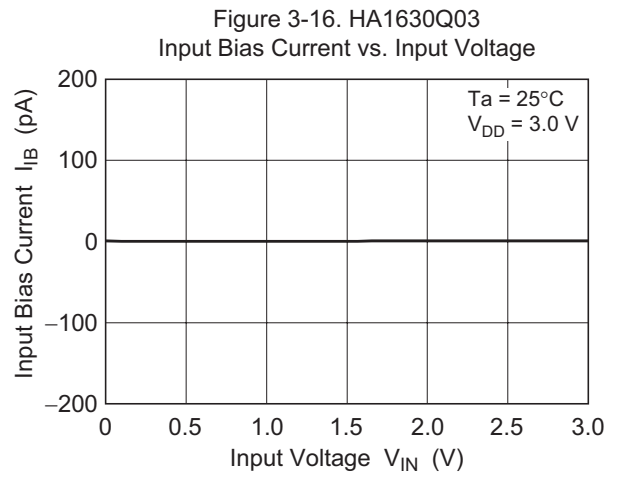
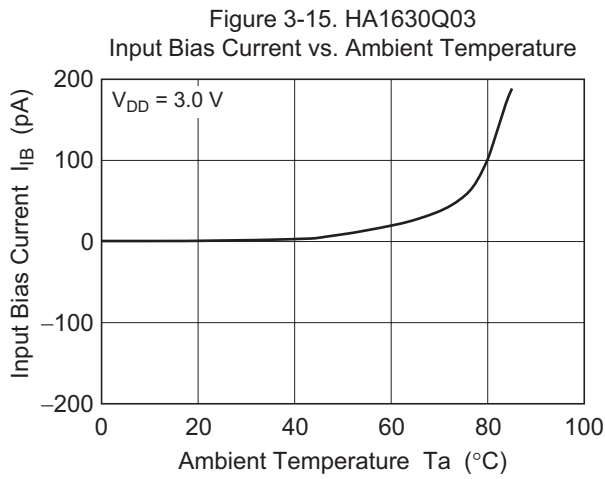


Figure 3-21. HA1630Q03  
Total Harmonic Distortion + Noise vs.  
Output Voltage p-p

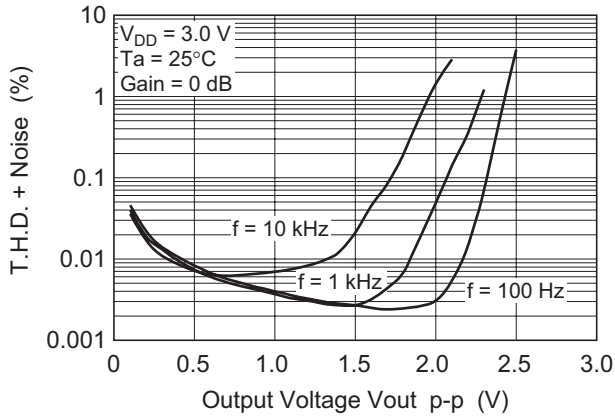


Figure 3-22. HA1630Q03  
Total Harmonic Distortion + Noise vs.  
Output Voltage p-p

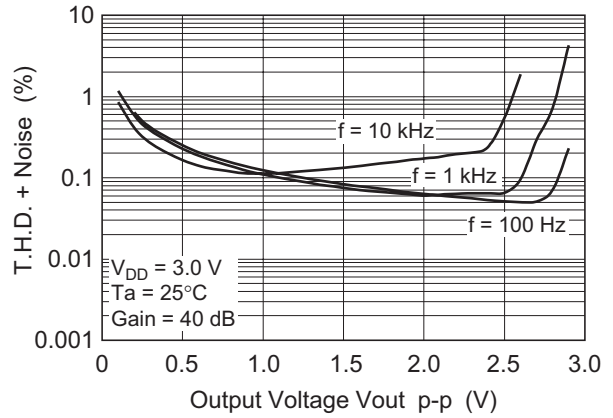


Figure 3-23. HA1630Q03  
Voltage Output p-p vs. Frequency

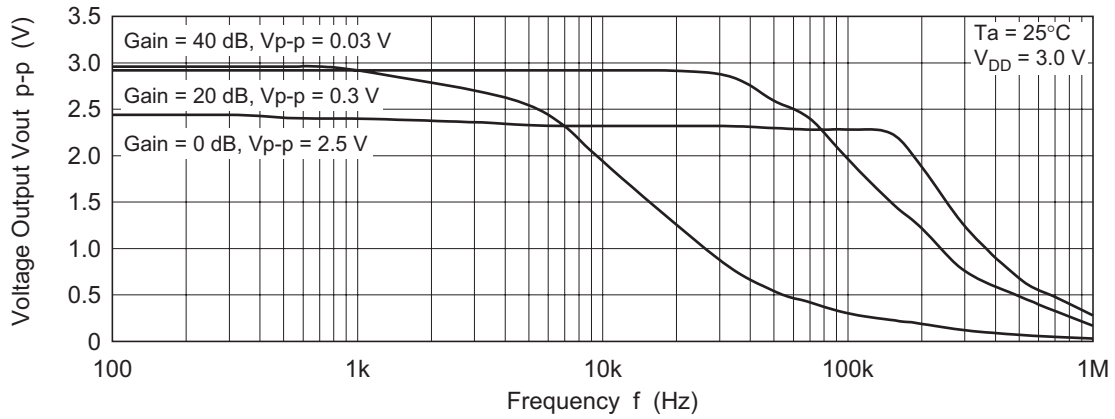
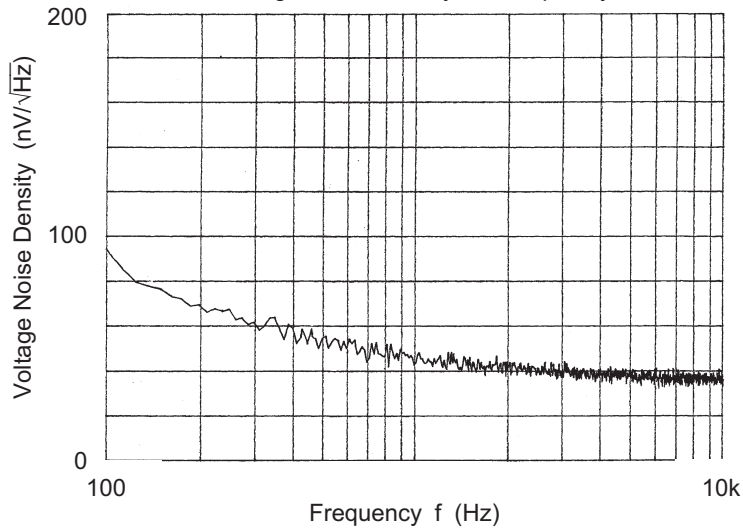
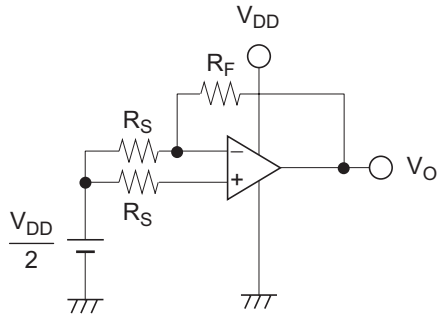


Figure 3-24. HA1630Q03  
Voltage Noise Density vs. Frequency



Test Circuits

1. Power Supply Rejection Ratio, PSRR & Voltage Offset,  $V_{IO}$



$$\frac{V_{IO}}$$

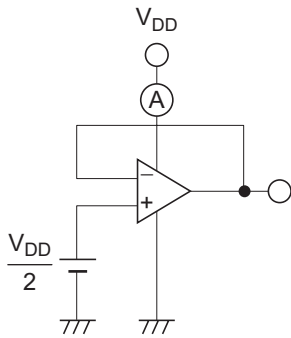
$$V_{IO} = \left( V_O - \frac{V_{DD}}{2} \right) \times \frac{R_S}{R_S + R_F}$$

$$\text{PSRR}$$

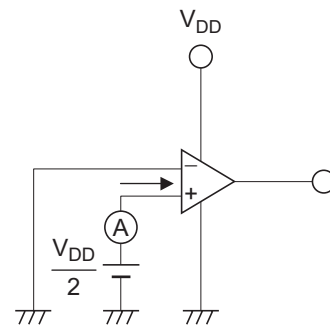
$$\text{PSRR} = -20 \log \left( \left| \frac{V_{O1} - V_{O2}}{V_{DD1} - V_{DD2}} \right| \times \frac{R_S}{R_S + R_F} \right)$$

Measure  $V_O$  corresponding to  $V_{DD1} = 1.8 \text{ V}$  and  $V_{DD2} = 5.5 \text{ V}$

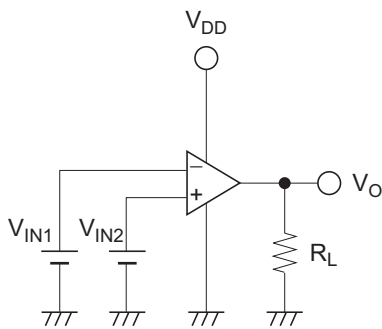
2. Supply Current,  $I_{DD}$



3. Input Bias Current,  $I_B$



4. Output High Voltage,  $V_{OH}$



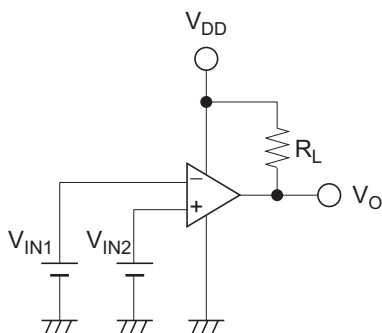
$$\frac{V_{OH}}$$

$$R_L = 1 \text{ M}\Omega$$

$$V_{IN1} = V_{DD} / 2 - 0.05 \text{ V}$$

$$V_{IN2} = V_{DD} / 2 + 0.05 \text{ V}$$

5. Output Low Voltage,  $V_{OL}$



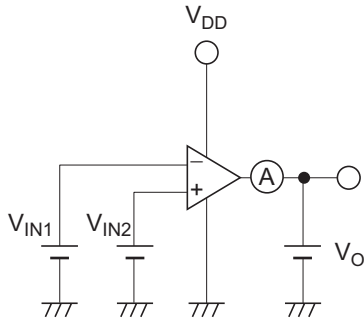
$$\frac{V_{OL}}$$

$$R_L = 1 \text{ M}\Omega$$

$$V_{IN1} = V_{DD} / 2 + 0.05 \text{ V}$$

$$V_{IN2} = V_{DD} / 2 - 0.05 \text{ V}$$

6. Output Source Current,  $I_{OSOURCE}$  & Output Sink Current,  $I_{OSINK}$



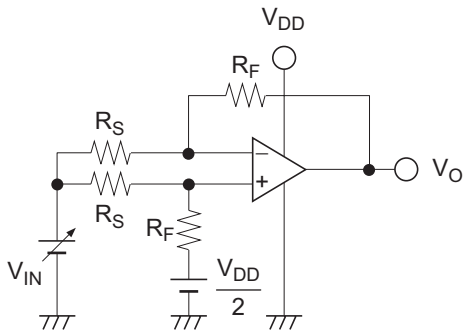
$I_{OSOURCE}$

$$\begin{aligned} V_O &= V_{DD} - 0.5 \text{ V} \\ V_{IN1} &= V_{DD} / 2 - 0.05 \text{ V} \\ V_{IN2} &= V_{DD} / 2 + 0.05 \text{ V} \end{aligned}$$

$I_{OSINK}$

$$\begin{aligned} V_O &= +0.5 \text{ V} \\ V_{IN1} &= V_{DD} / 2 + 0.05 \text{ V} \\ V_{IN2} &= V_{DD} / 2 - 0.05 \text{ V} \end{aligned}$$

7. Common Mode Input Voltage,  $V_{CM}$  & Common Mode Rejection Ratio, CMRR

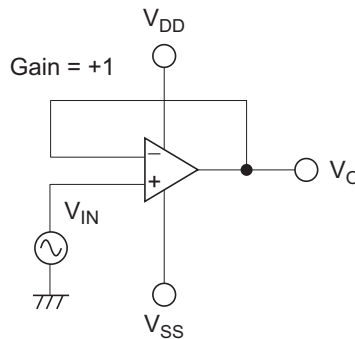
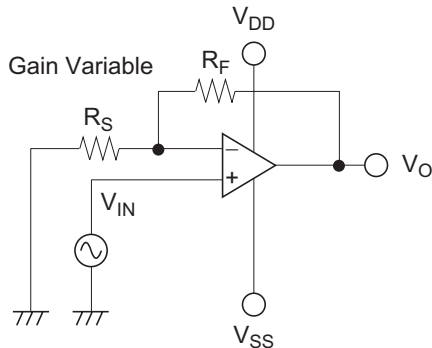


CMRR

$$CMRR = -20 \log \left( \left| \frac{V_{O1} - V_{O2}}{V_{IN1} - V_{IN2}} \right| \times \frac{R_S}{R_S + R_F} \right)$$

Measure  $V_O$  corresponding to  $V_{IN1} = 0 \text{ V}$  and  $V_{IN2} = 2.1 \text{ V}$

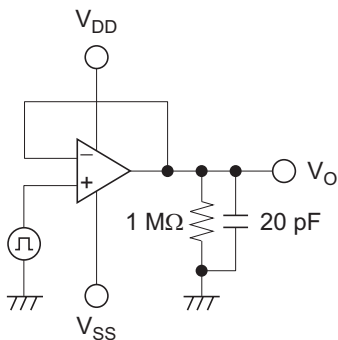
8. Total Harmonic Distortion, THD



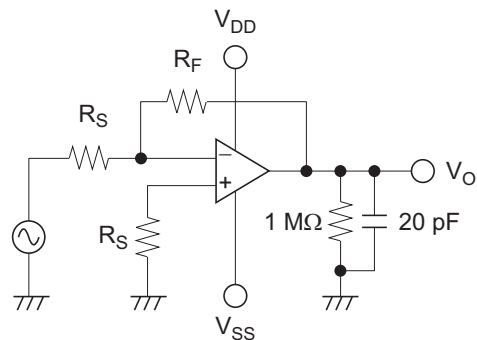
THD

Gain Variable  
 $1 + R_F / R_S = 100$   
 freq = 100 Hz, 1 kHz, 10 kHz

9. Slew Rate, SR

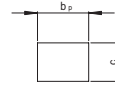
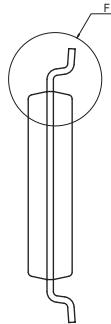
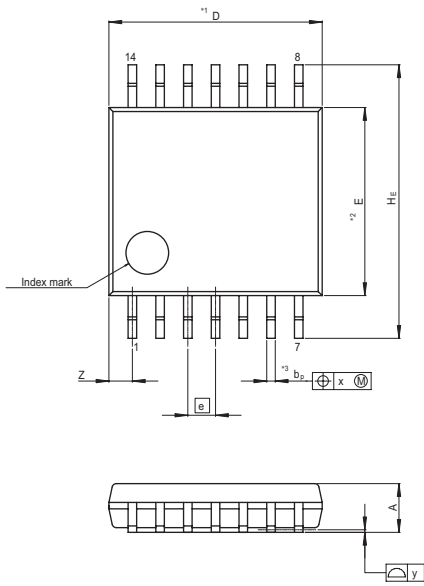


10. Gain,  $A_V$  & Phase, GBW

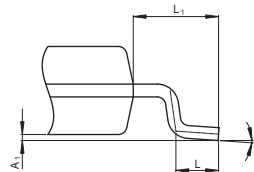


### Package Dimensions

JEITA Package Code	RENESAS Code	Previous Code	MASS[Typ.]
P-TSSOP14-4.4x5-0.65	PTSP0014JA-B	TTP-14DV	0.05g



Terminal cross section  
( Ni/Pd/Au plating )



Detail F

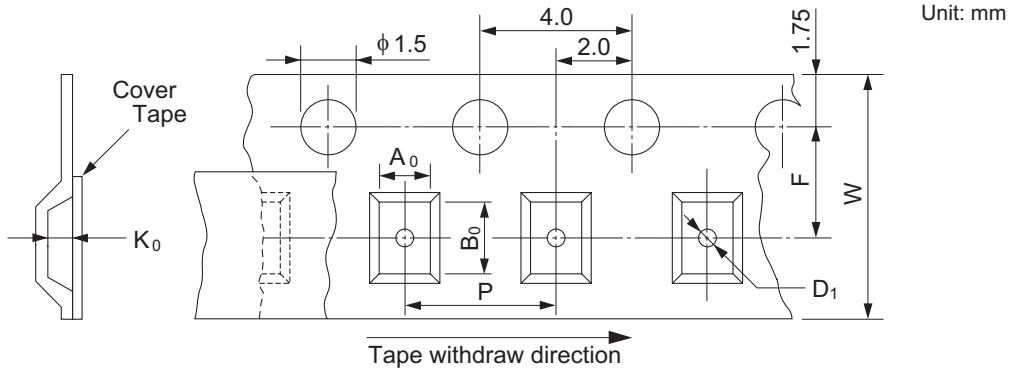
NOTE)  
1. DIMENSIONS\*\*1 (Nom)\*\*AND\*\*2"  
DO NOT INCLUDE MOLD FLASH.  
2. DIMENSION\*\*3"DOES NOT  
INCLUDE TRIM OFFSET.

Reference Symbol	Dimension in Millimeters		
	Min	Nom	Max
D	—	5.00	5.30
E	—	4.40	—
A <sub>2</sub>	—	—	—
A <sub>1</sub>	0.03	0.07	0.10
A	—	—	1.10
b <sub>p</sub>	0.15	0.20	0.25
b <sub>1</sub>	—	—	—
c	0.10	0.15	0.20
c <sub>1</sub>	—	—	—
θ	0°	—	8°
H <sub>E</sub>	6.20	6.40	6.60
e	—	0.65	—
x	—	—	0.13
y	—	—	0.10
Z	—	—	0.83
L	0.4	0.5	0.6
L <sub>1</sub>	—	1.0	—

### Taping & Reel Specification

[Taping]

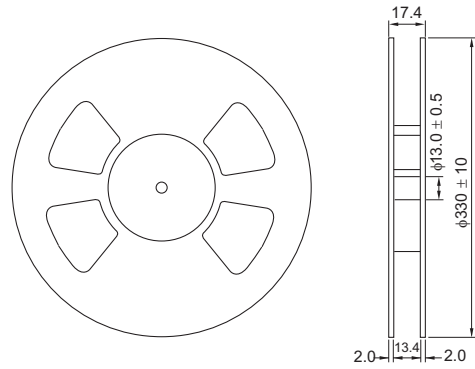
Package Code	W	P	Ao	Bo	Ko	E	F	D1	Maximum Storage No.
TSSOP-14	12	8	6.5	5.1	1.5	—	5.5	1.6	2,000 pcs/reel



Unit: mm

[Reel]

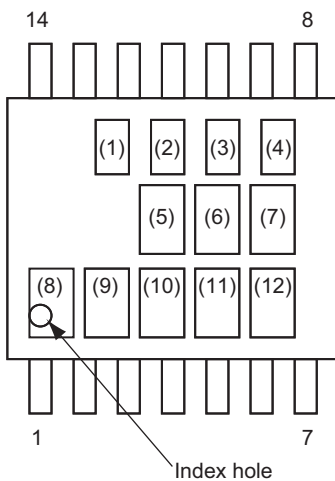
Package	Tape width	W1	W2
TSSOP-14	12	17.4	13.4



[Ordering Information]

Ordering Unit
2,000 pcs

### Mark Indication



(1) to (4)	Week code		
(5),(8) to (10)	Space		
(6), (7) (11), (12)	Product Name	0Q01	HA1630Q01
		0Q02	HA1630Q02
		0Q03	HA1630Q03

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