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April 1st, 2010
Renesas Electronics Corporation

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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.

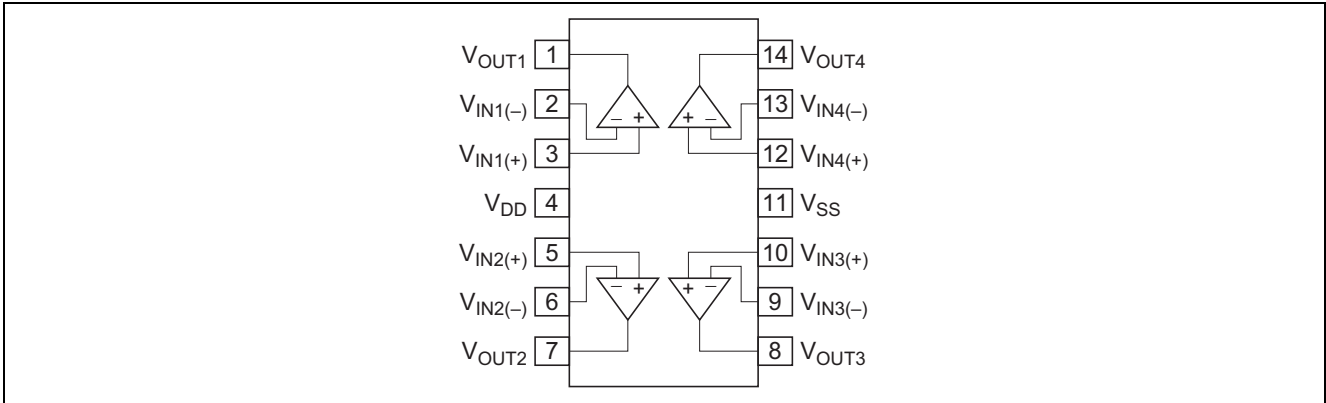
Features

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

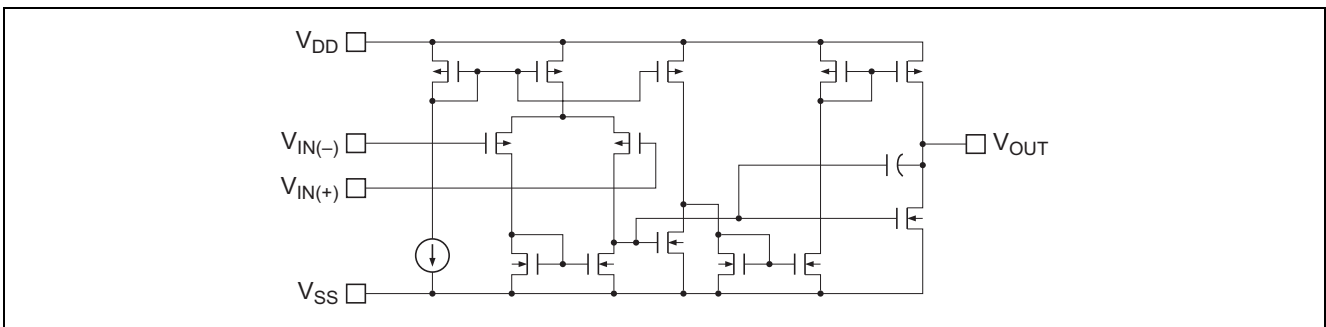
Ordering Information

| 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 _{DD} | 7 | V | |
| Differential input voltage | V _{IN(diff)} | -V _{DD} to +V _{DD} | V | |
| Input voltage | V _{IN} | -0.3 to +V _{DD} | V | 1 |
| Power dissipation | P _T | 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_{DD} or 7 V.

Electrical Characteristics

(V_{DD} = 3.0 V, Ta = 25°C)

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

Note: 1. () : Design specification

Table of Graphs

| Electrical Characteristics | | | HA1630Q01 Figure | HA1630Q02 Figure | HA1630Q03 Figure | Test Circuit |
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| 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 |
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| 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

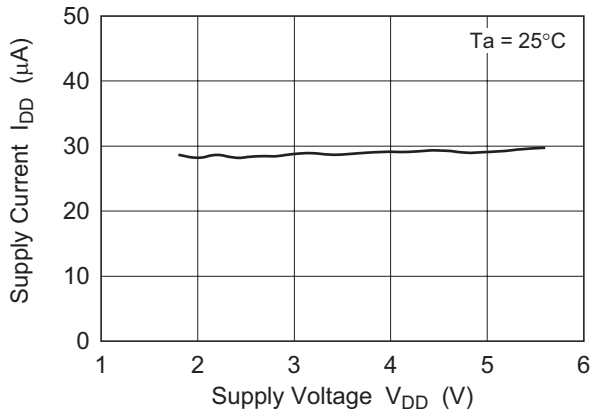


Figure 1-2. HA1630Q01
Supply Current vs. Ambient Temperature

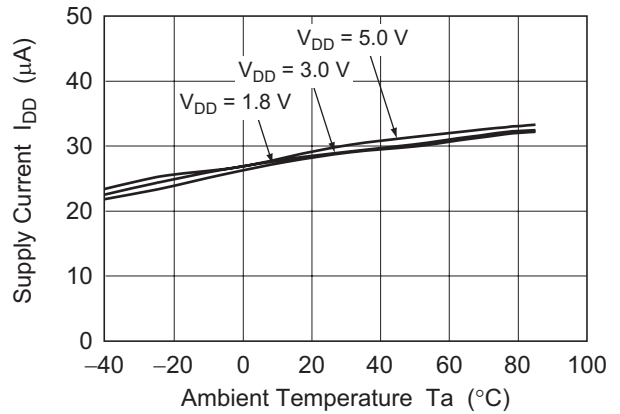


Figure 1-3. HA1630Q01
Output High Voltage vs. Output Source Current

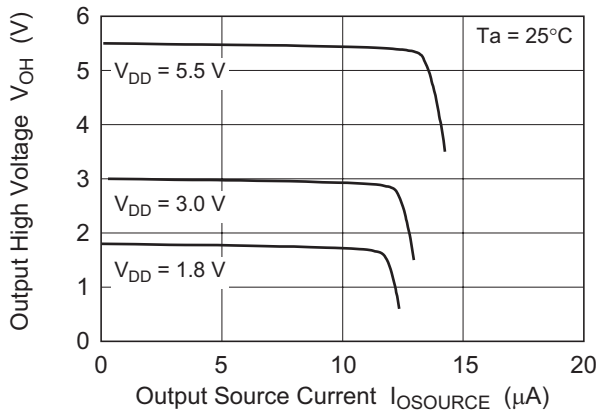


Figure 1-4. HA1630Q01
Output High Voltage vs. Supply Voltage

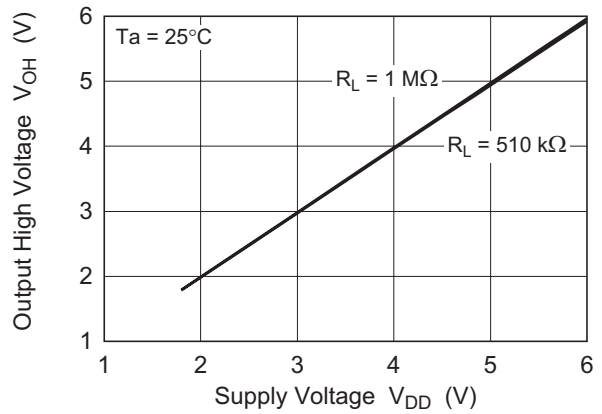
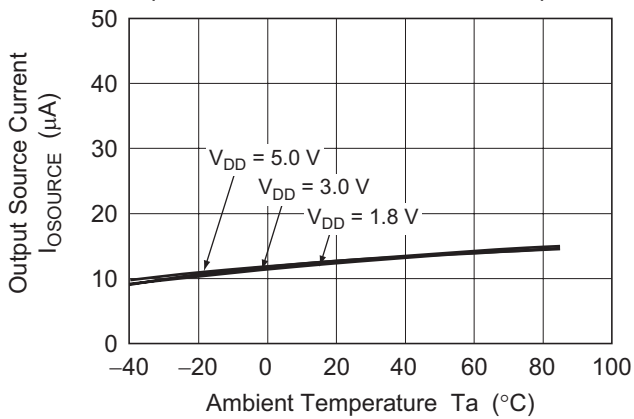


Figure 1-5. HA1630Q01
Output Source Current vs. Ambient Temperature



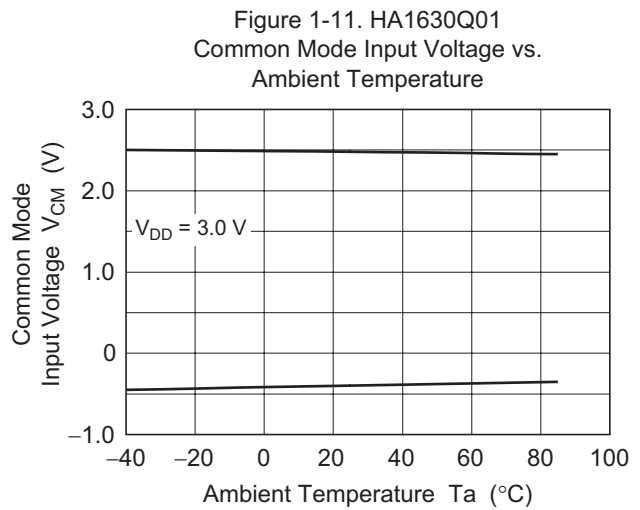
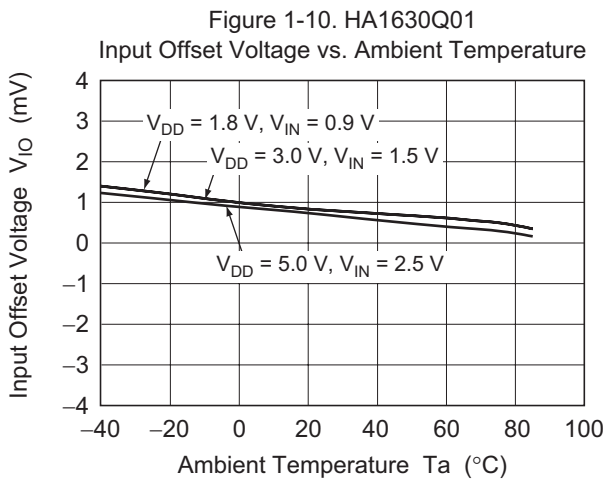
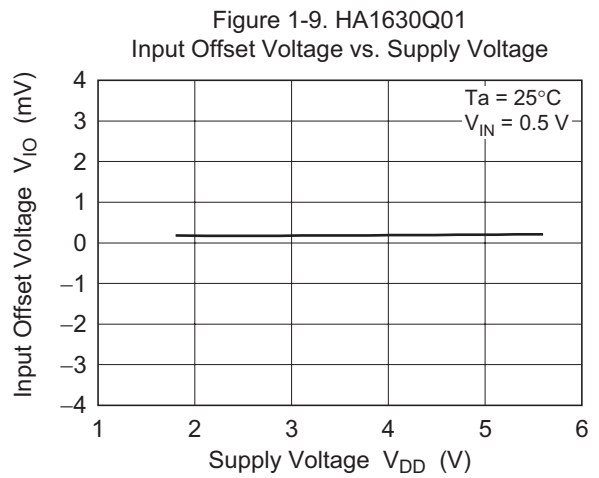
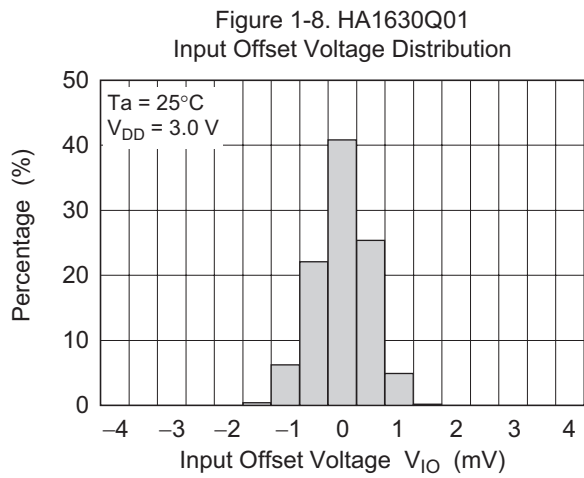
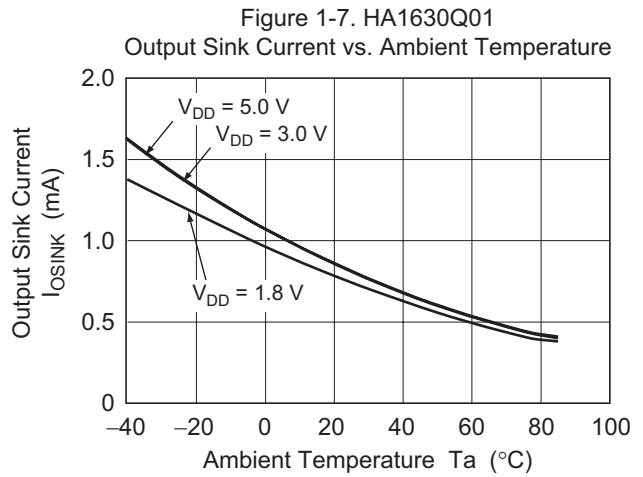
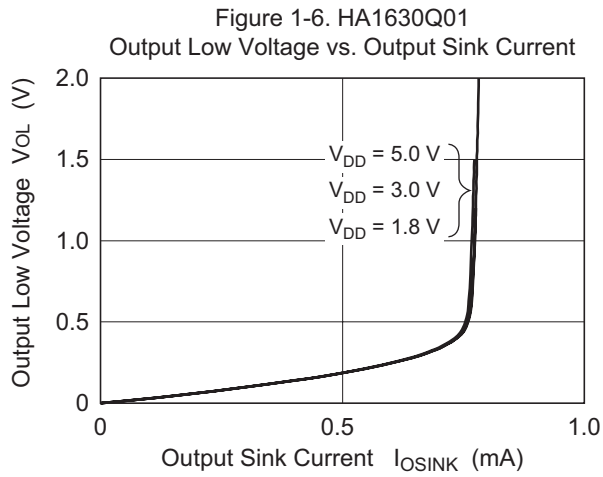


Figure 1-12. HA1630Q01
Power Supply Rejection Ratio vs. Frequency

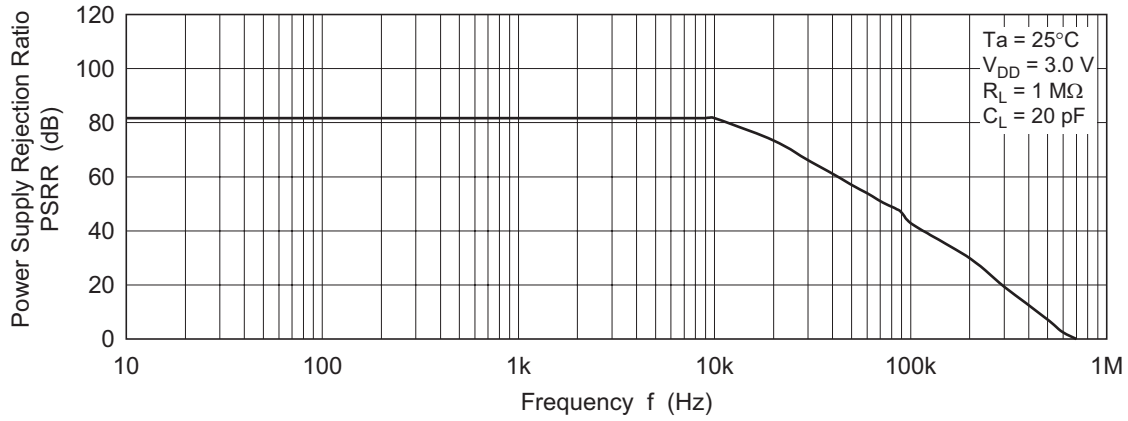


Figure 1-13. HA1630Q01
Common Mode Rejection Ratio vs. Frequency

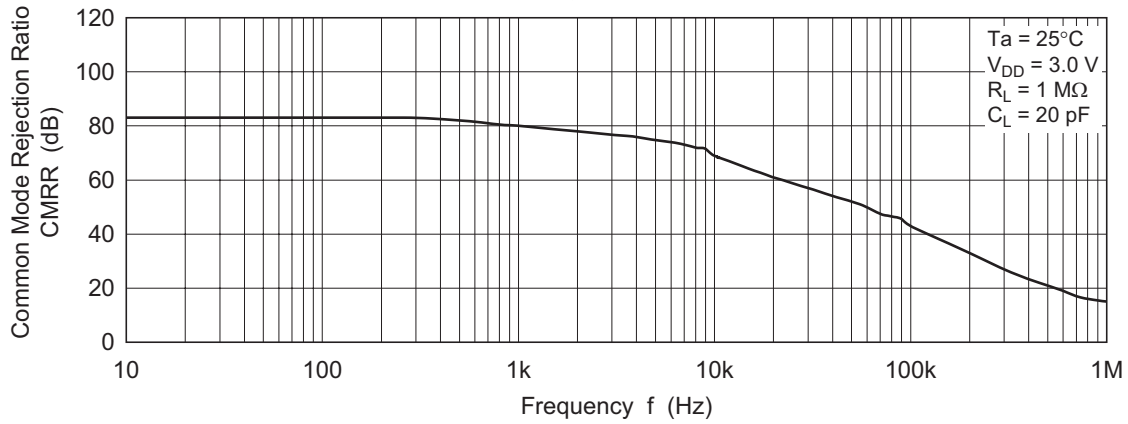
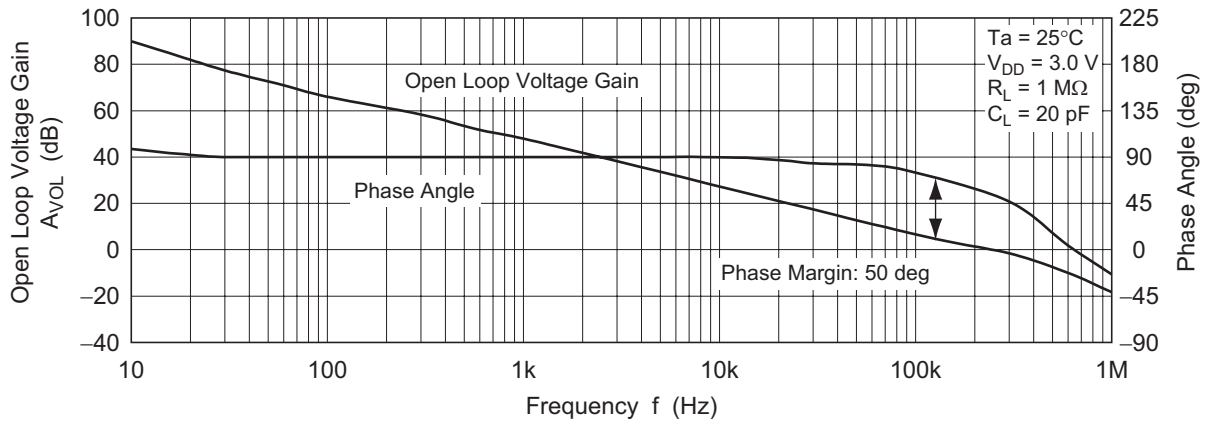


Figure 1-14. HA1630Q01
Open Loop Voltage Gain and Phase Angle vs. Frequency



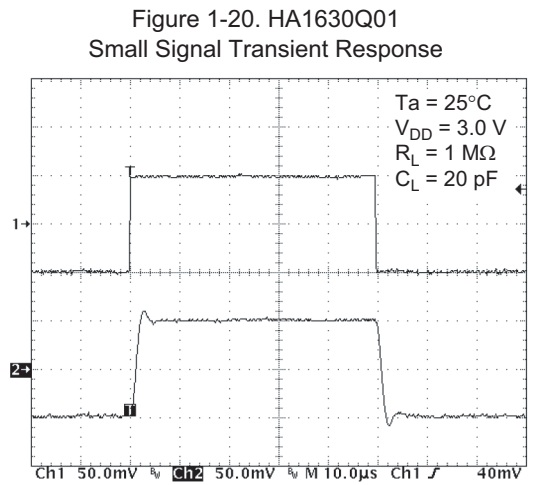
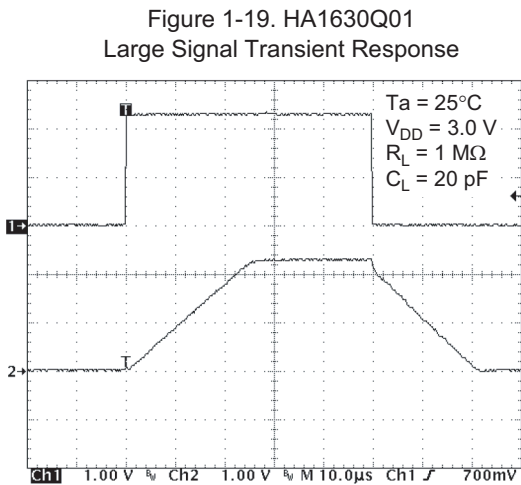
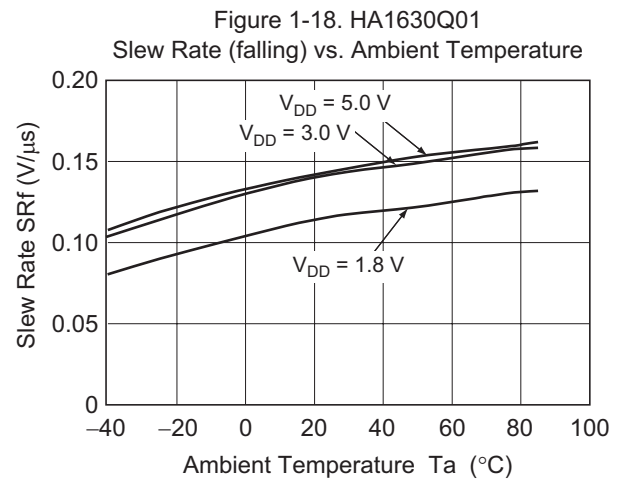
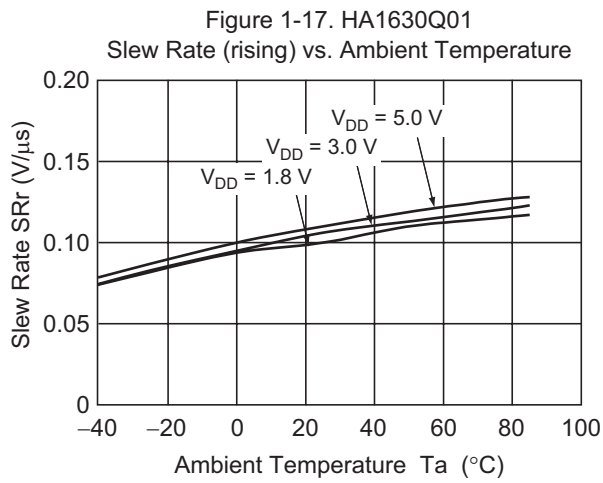
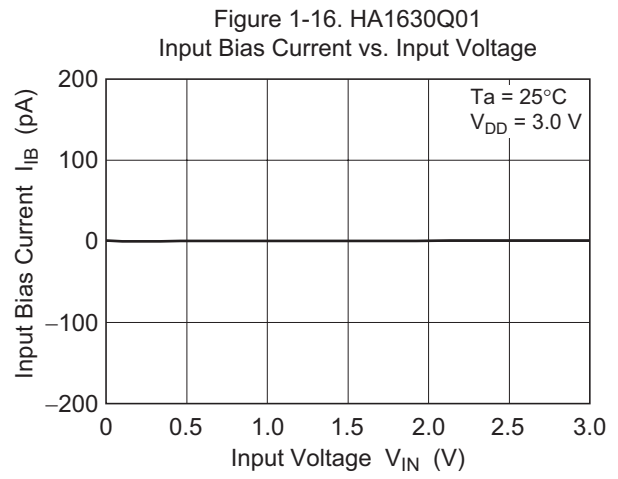
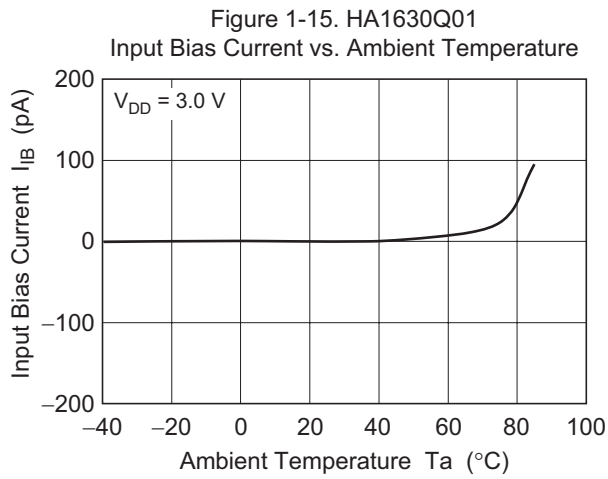


Figure 1-21. HA1630Q01
Voltage Output p-p vs. Frequency

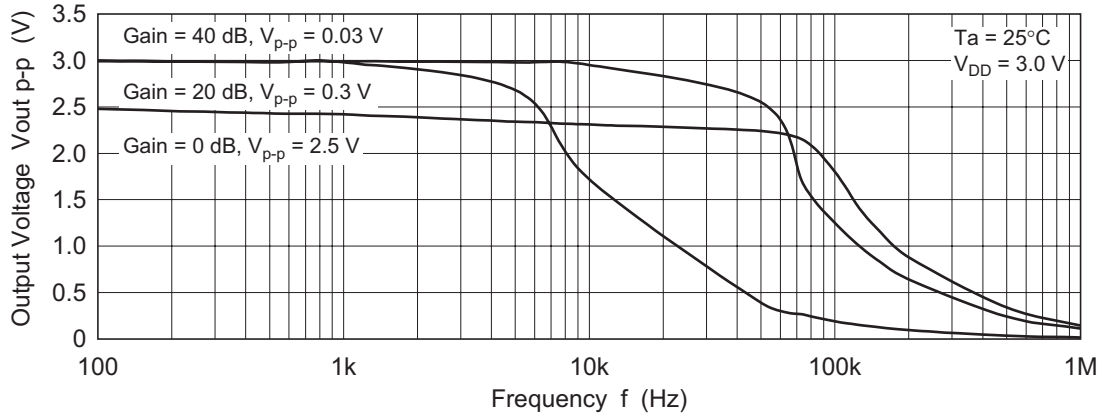
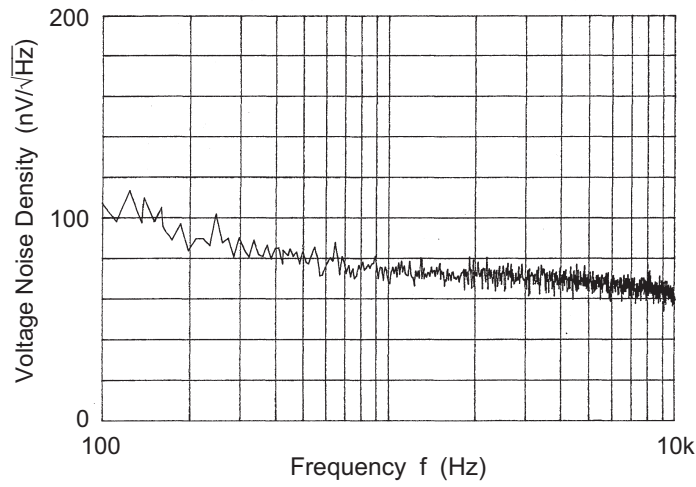


Figure 1-22. HA1630Q01
Voltage Noise Density vs. Frequency



Main Characteristics (HA1630Q02)

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

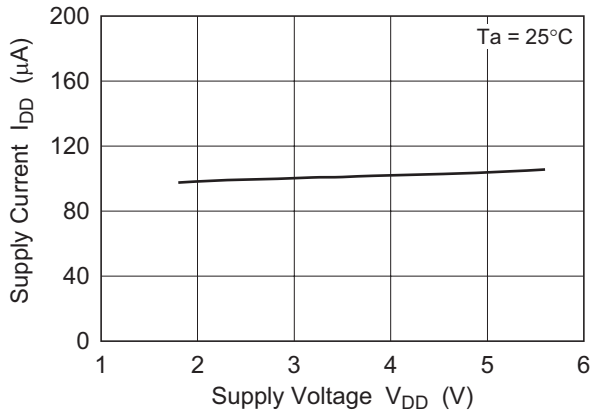


Figure 2-2. HA1630Q02
Supply Current vs. Ambient Temperature

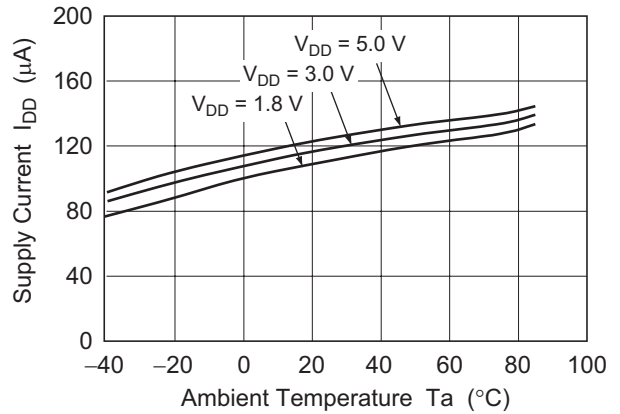


Figure 2-3. HA1630Q02
Output High Voltage vs. Output Source Current

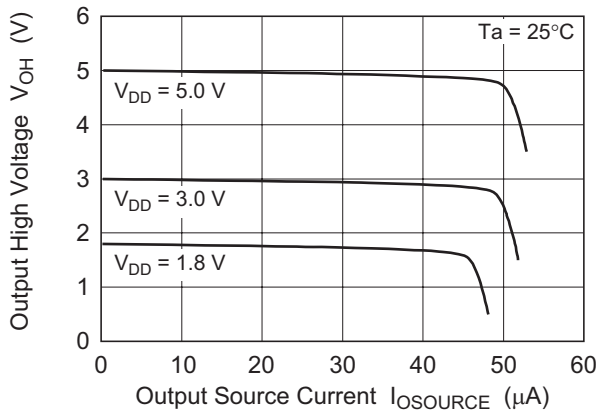


Figure 2-4. HA1630Q02
Output High Voltage vs. Supply Voltage

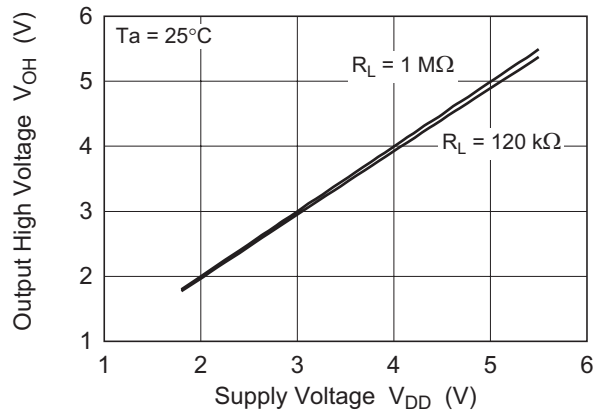
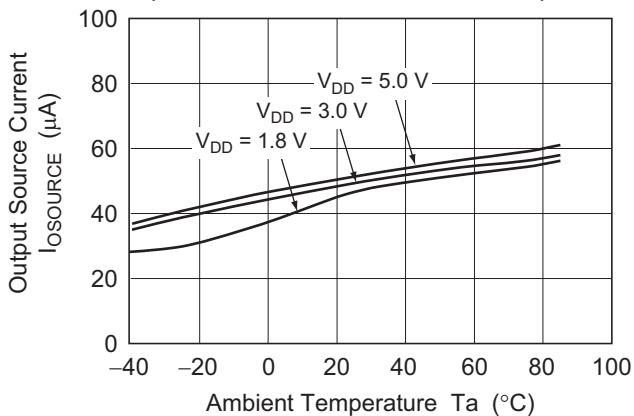


Figure 2-5. HA1630Q02
Output Source Current vs. Ambient Temperature



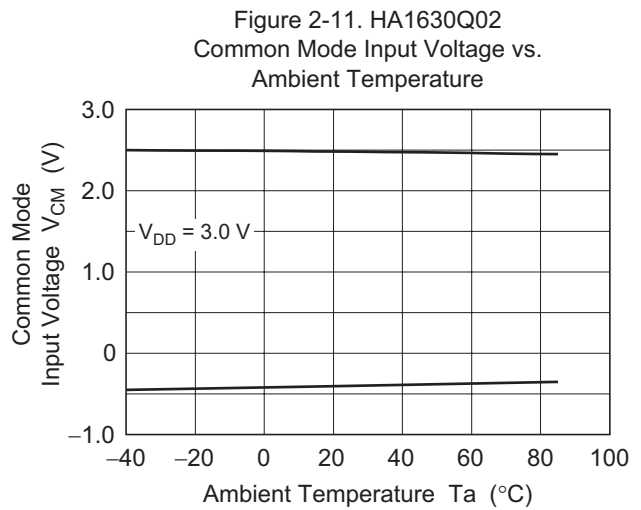
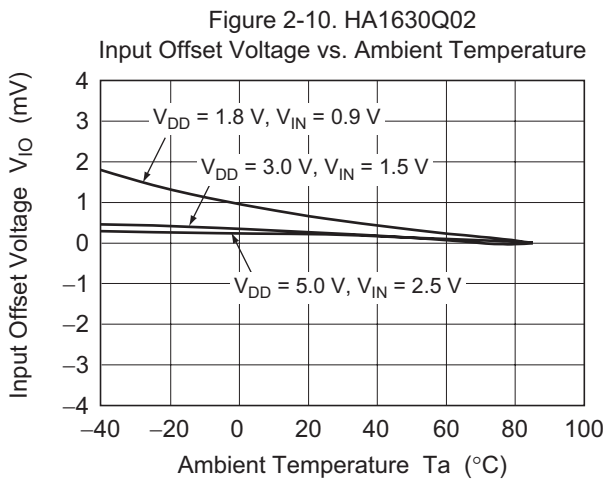
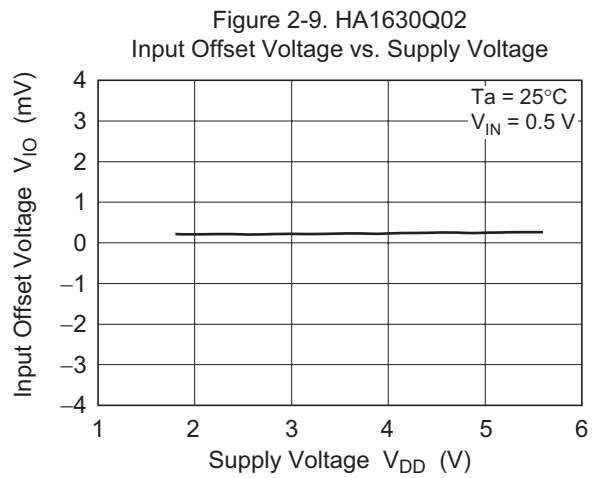
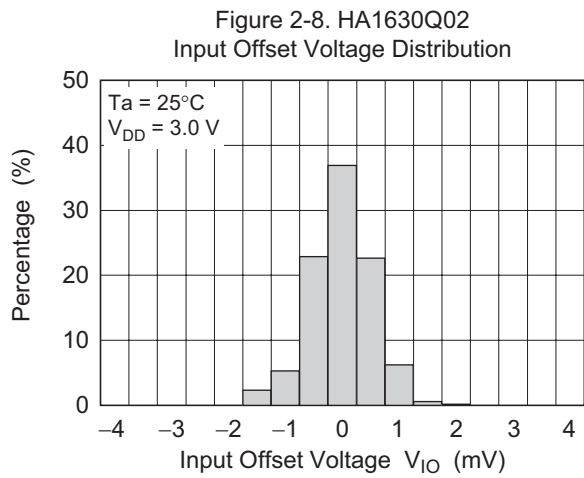
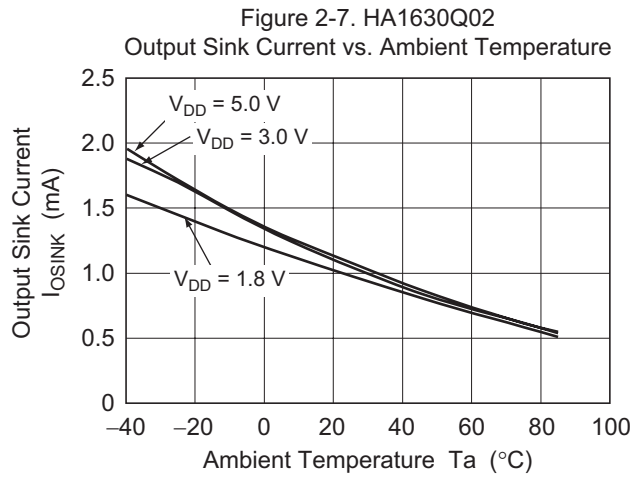
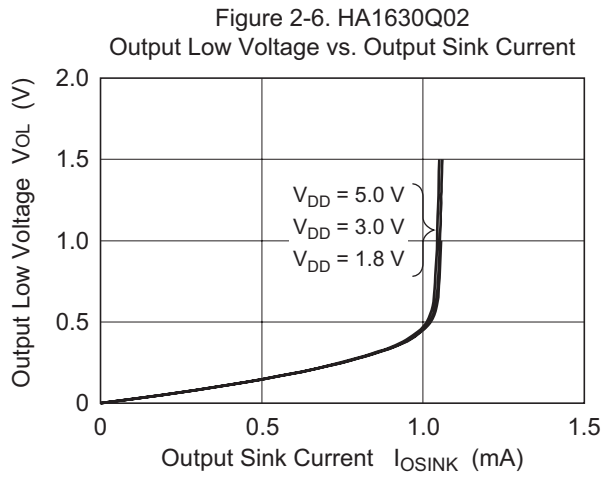


Figure 2-12. HA1630Q02
Power Supply Rejection Ratio vs. Frequency

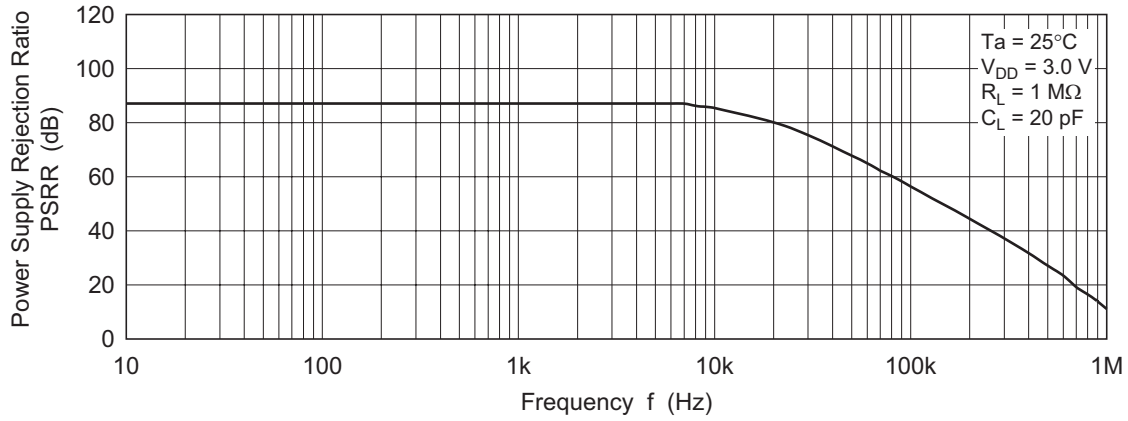


Figure 2-13. HA1630Q02
Common Mode Rejection Ratio vs. Frequency

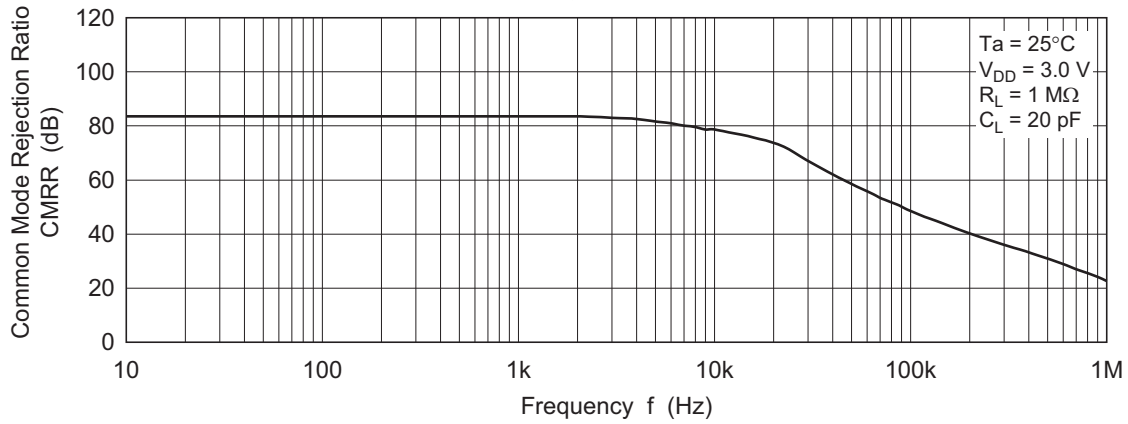
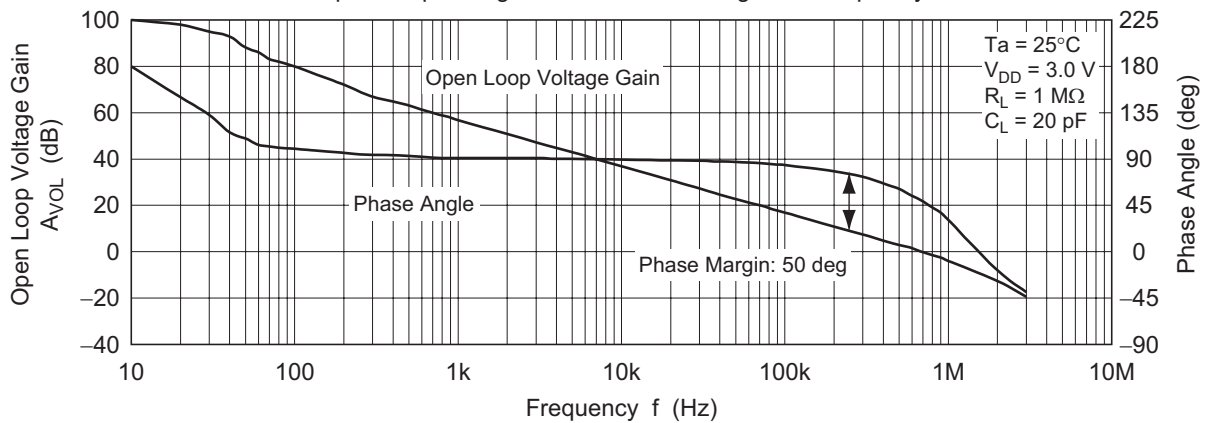


Figure 2-14. HA1630Q02
Open Loop Voltage Gain and Phase Angle vs. Frequency



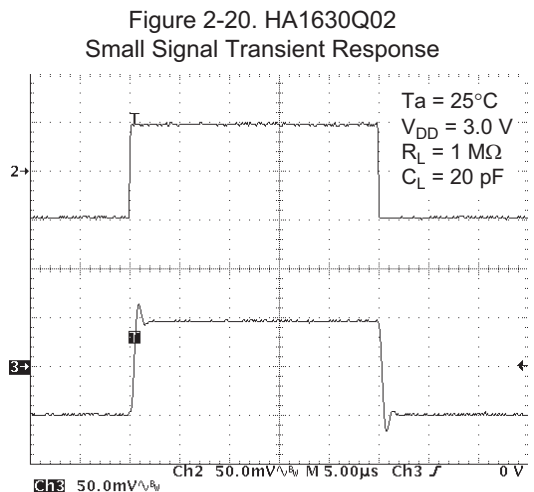
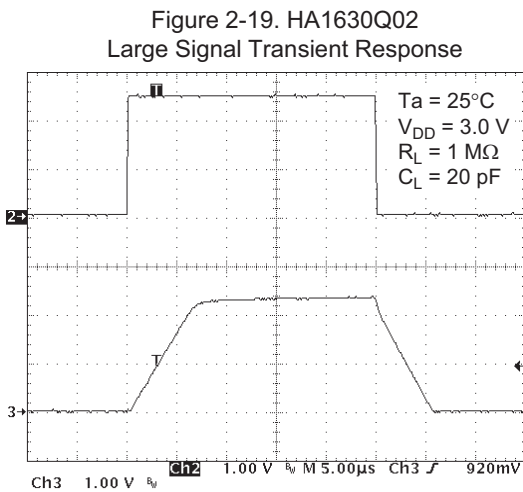
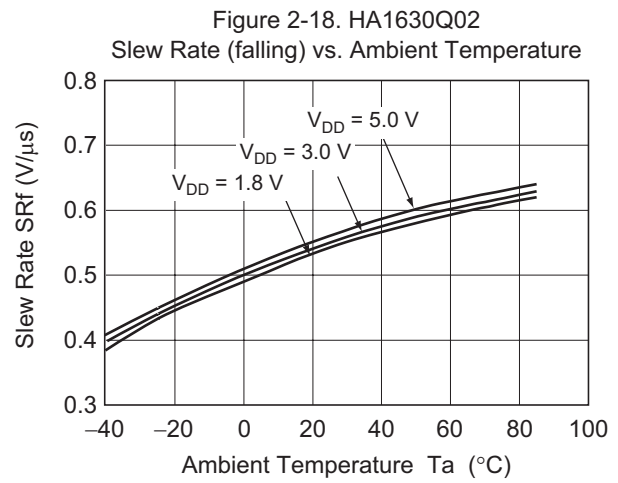
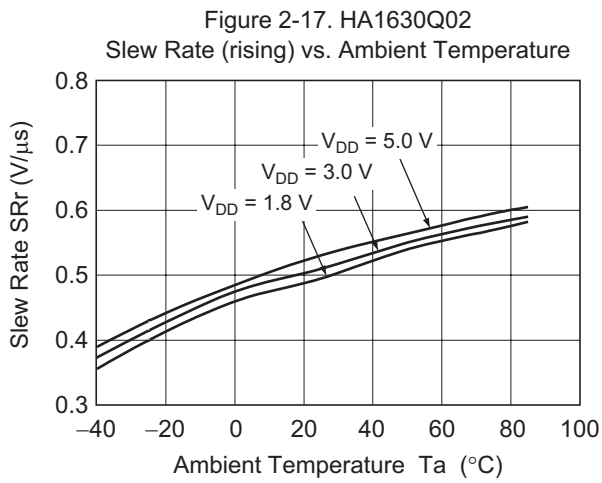
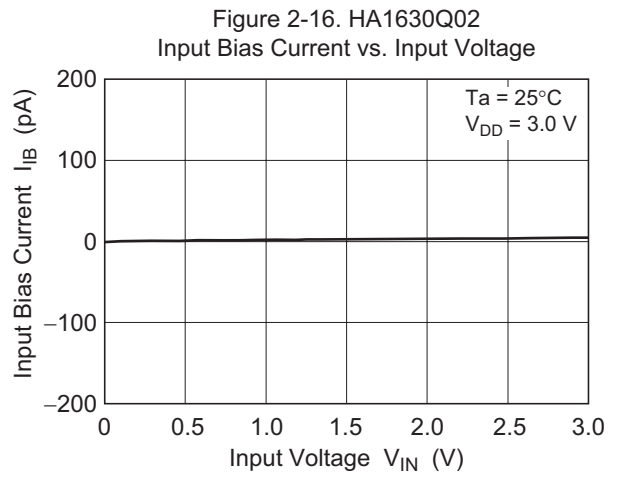
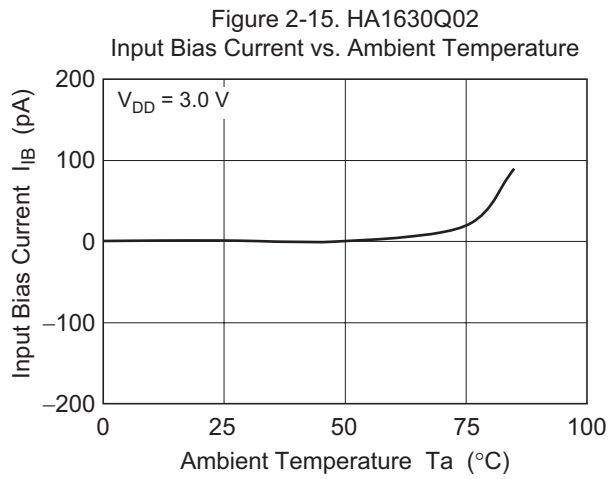


Figure 2-21. HA1630Q02
Total Harmonic Distortion + Noise vs.
Output Voltage p-p

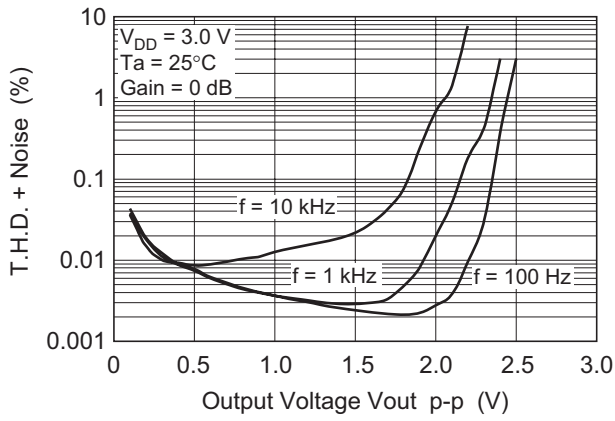


Figure 2-22. HA1630Q02
Total Harmonic Distortion + Noise vs.
Output Voltage p-p

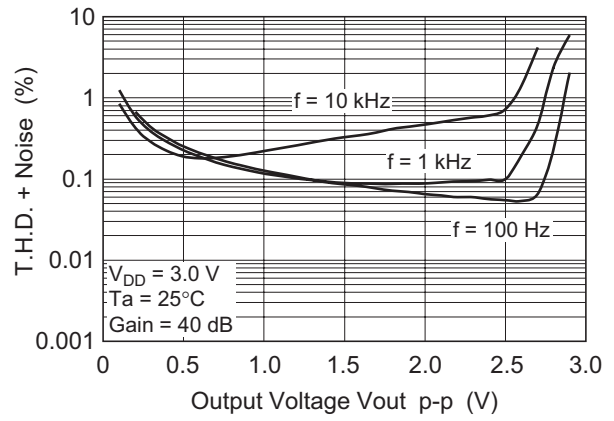


Figure 2-23. HA1630Q02
Voltage Output p-p vs. Frequency

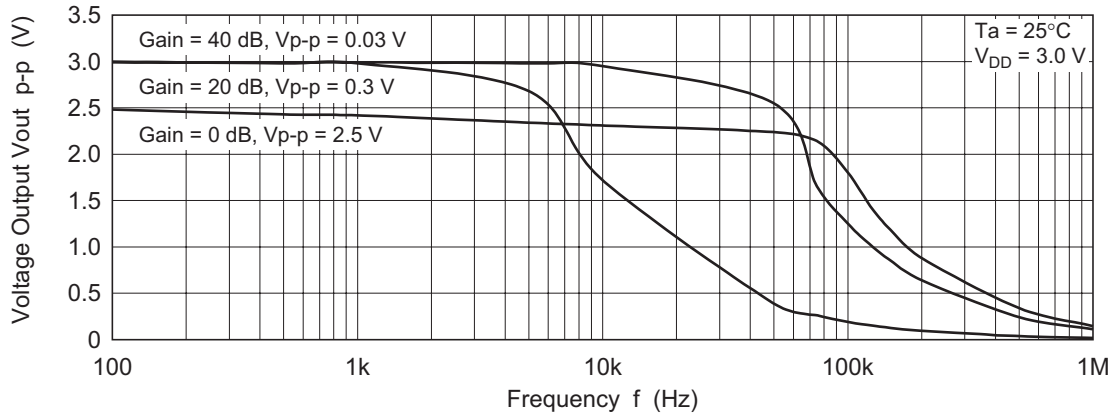
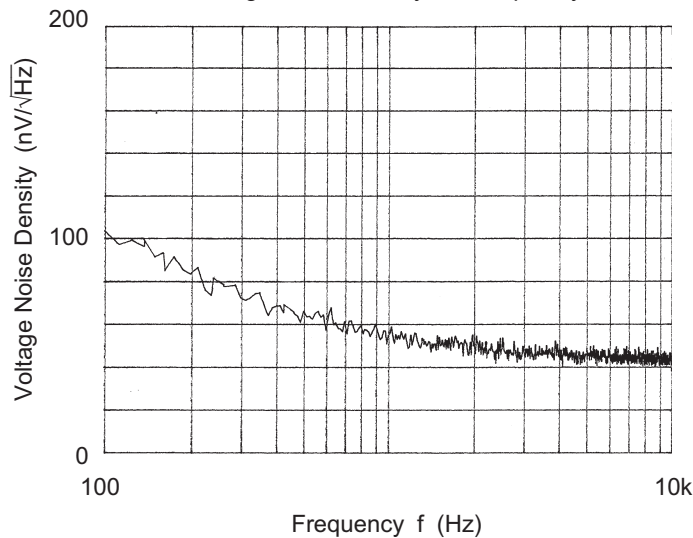
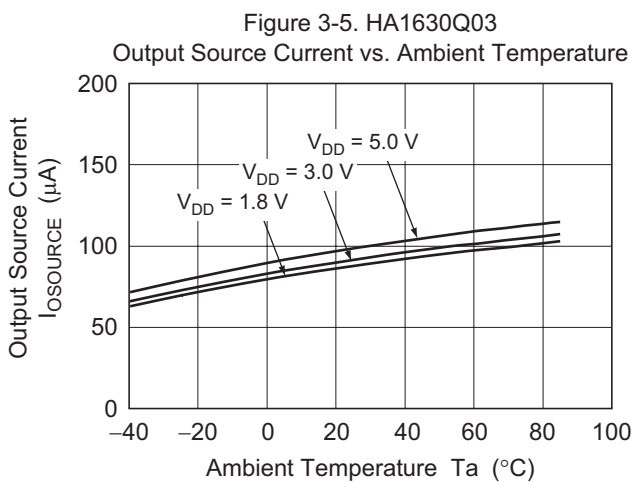
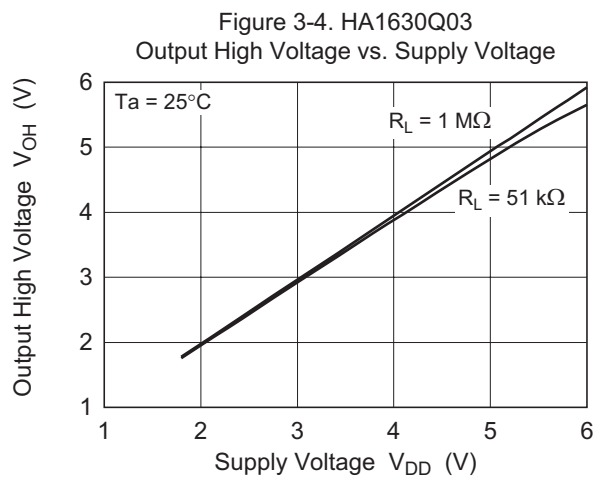
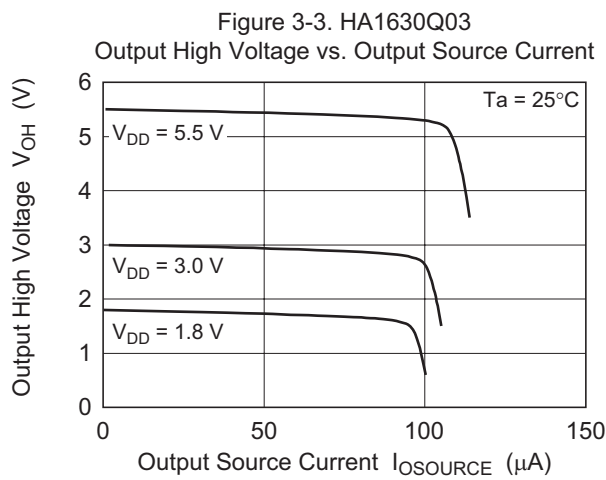
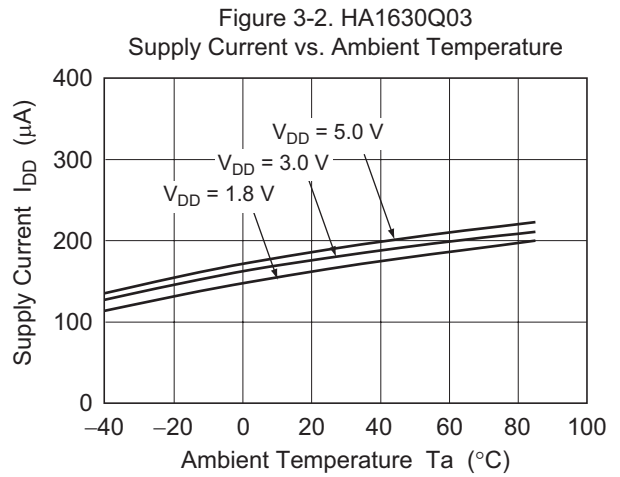
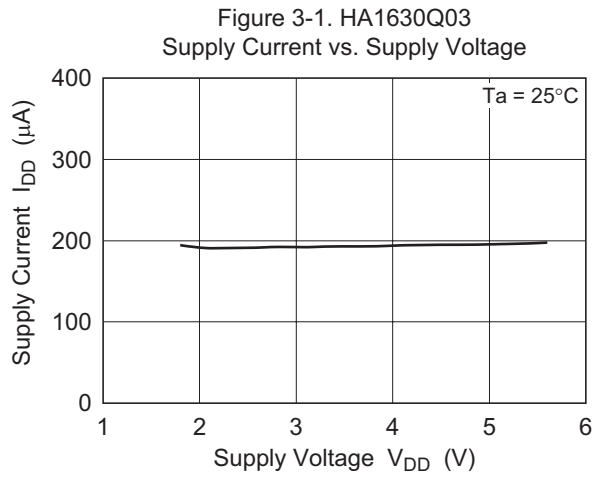


Figure 2-24. HA1630Q02
Voltage Noise Density vs. Frequency



Main Characteristics (HA1630Q03)



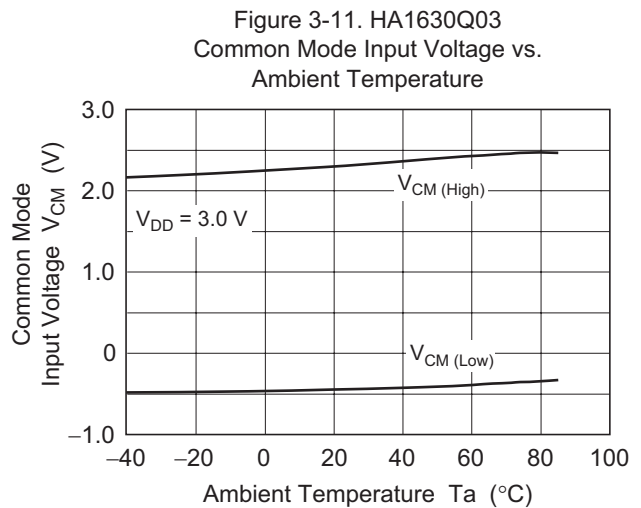
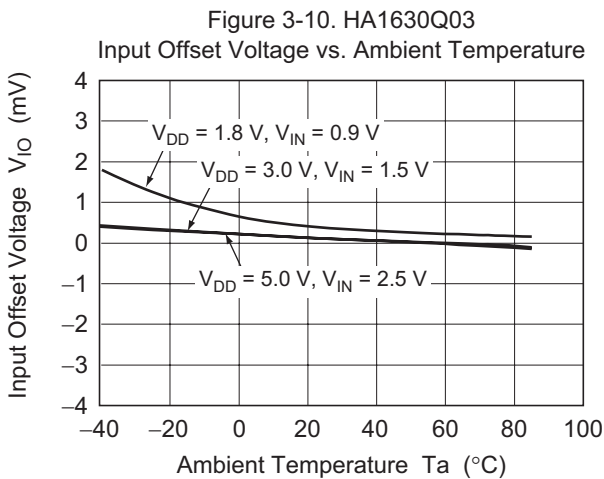
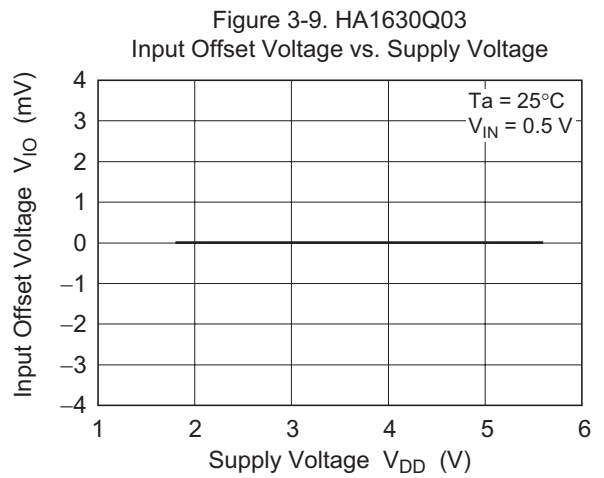
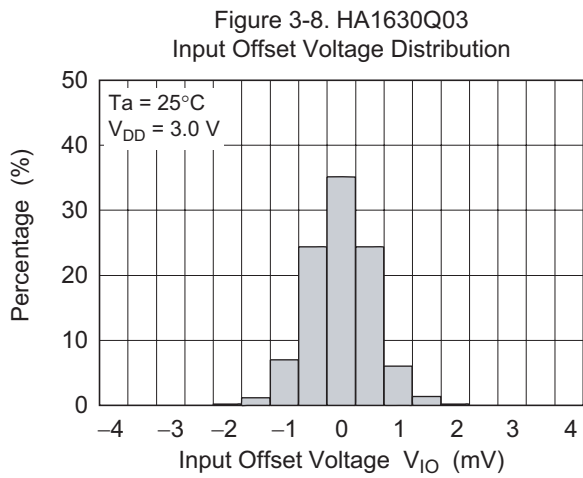
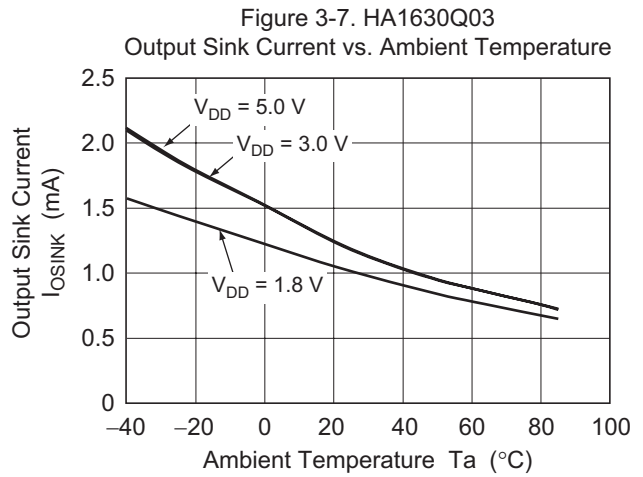
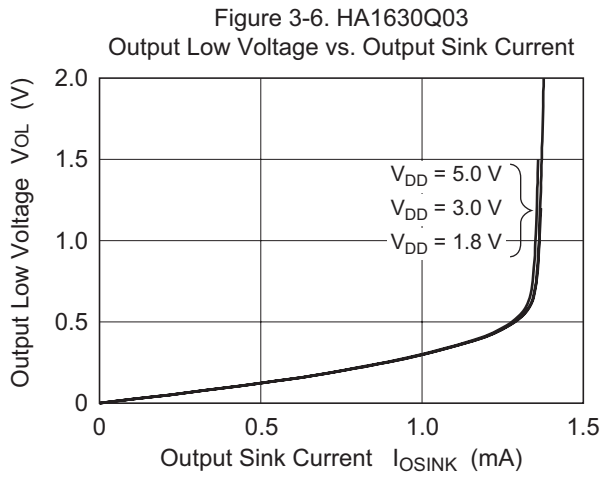


Figure 3-12. HA1630Q03
Power Supply Rejection Ratio vs. Frequency

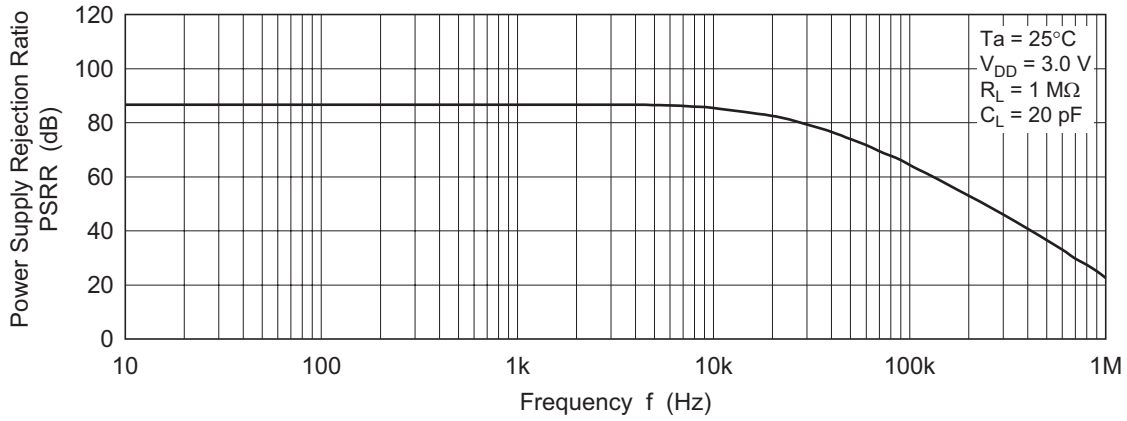


Figure 3-13. HA1630Q03
Common Mode Rejection Ratio vs. Frequency

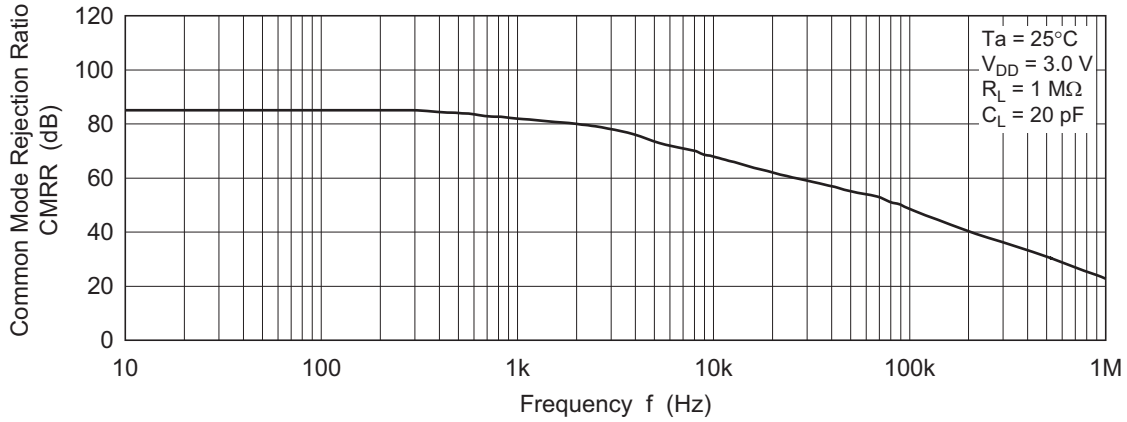
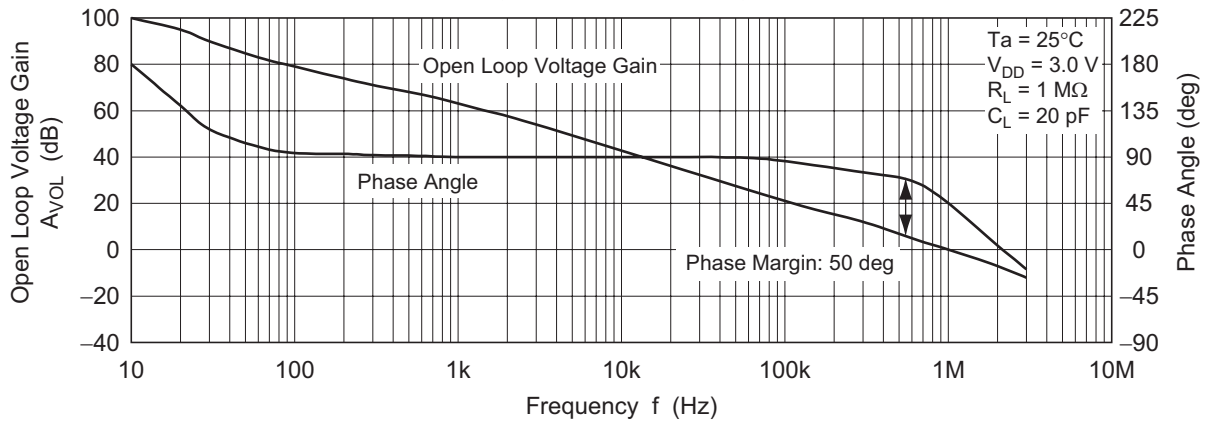


Figure 3-14. HA1630Q03
Open Loop Voltage Gain and Phase Angle vs. Frequency



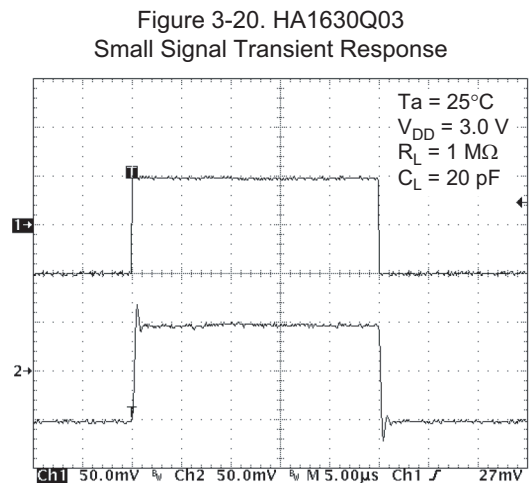
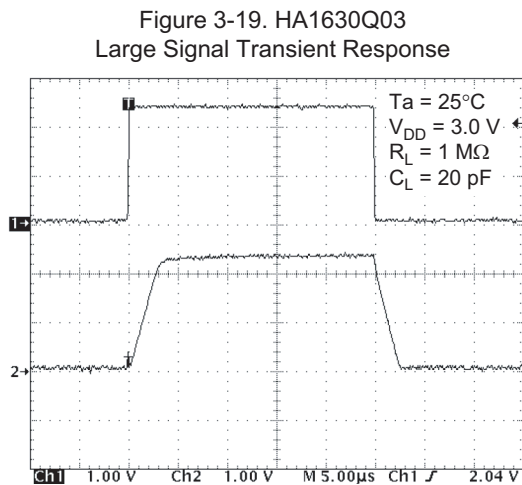
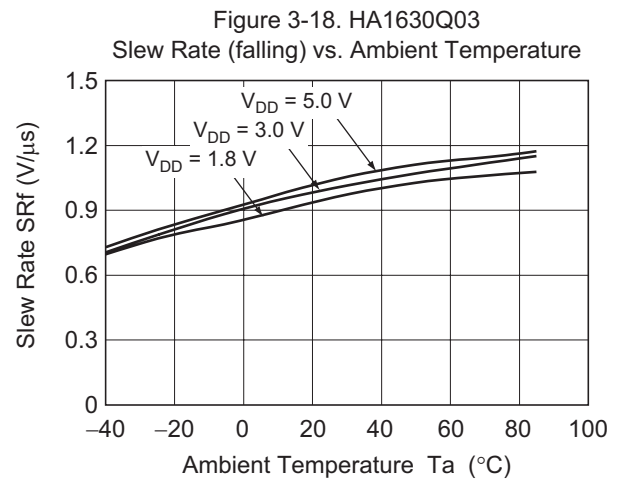
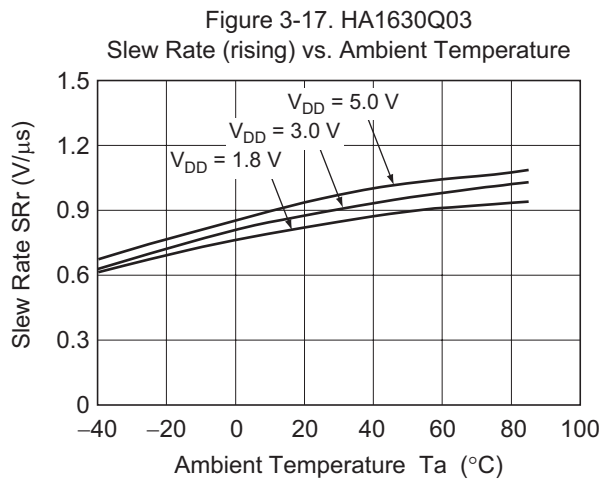
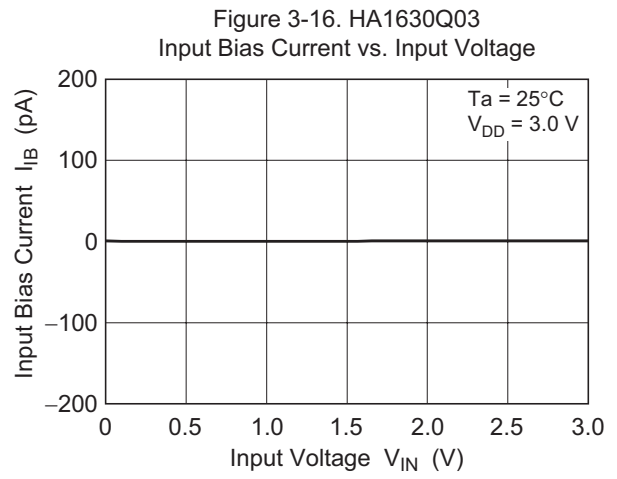
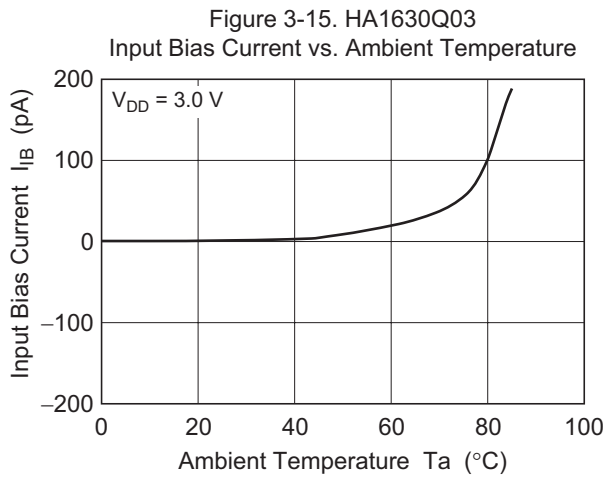


Figure 3-21. HA1630Q03
Total Harmonic Distortion + Noise vs.
Output Voltage p-p

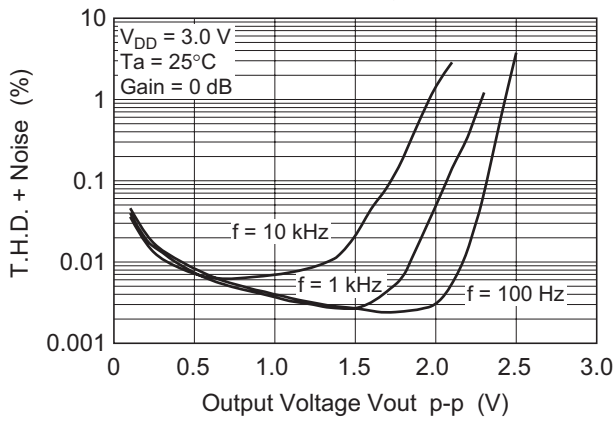


Figure 3-22. HA1630Q03
Total Harmonic Distortion + Noise vs.
Output Voltage p-p

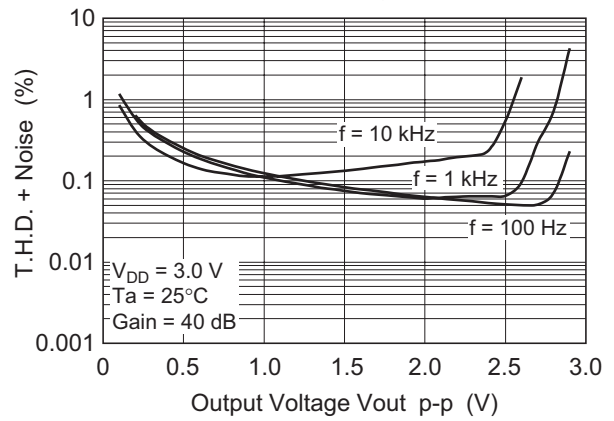


Figure 3-23. HA1630Q03
Voltage Output p-p vs. Frequency

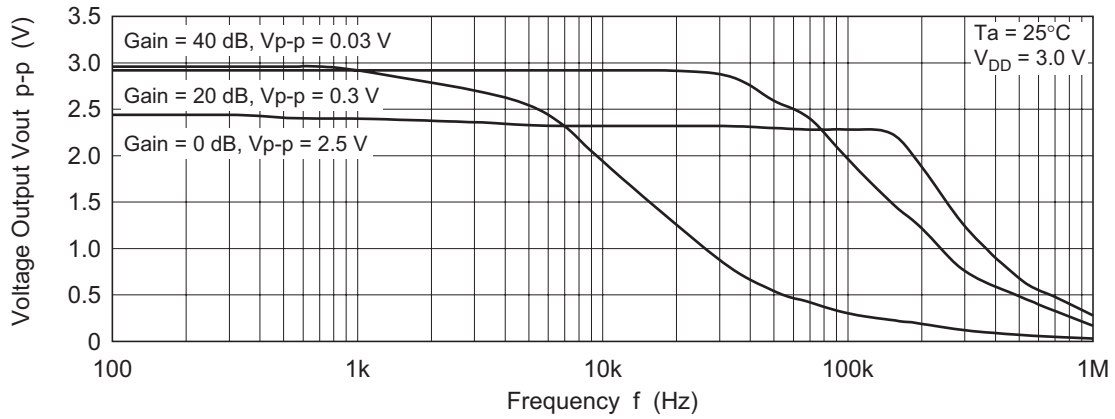
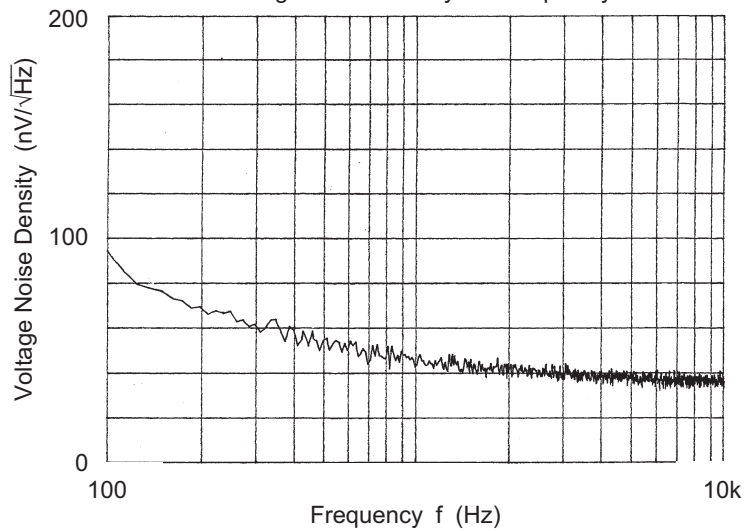
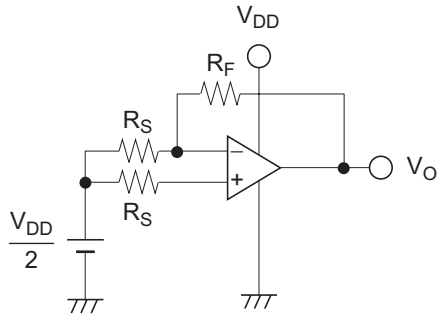


Figure 3-24. HA1630Q03
Voltage Noise Density vs. Frequency



Test Circuits

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



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

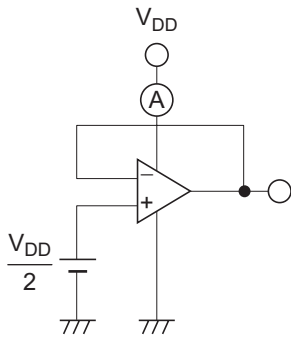
$$V_{IO} = \left(V_O - \frac{V_{DD}}{2} \right) \times \frac{R_S}{R_S + R_F}$$

$$\text{PSRR}$$

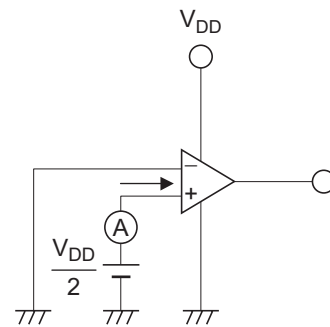
$$\text{PSRR} = -20 \log \left(\left| \frac{V_{O1} - V_{O2}}{V_{DD1} - V_{DD2}} \right| \times \frac{R_S}{R_S + R_F} \right)$$

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

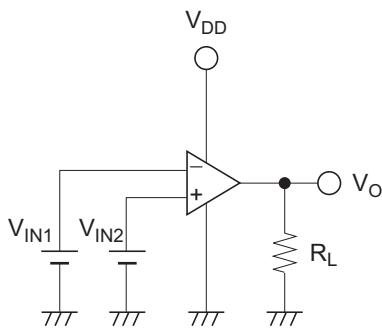
2. Supply Current, I_{DD}



3. Input Bias Current, I_B



4. Output High Voltage, V_{OH}



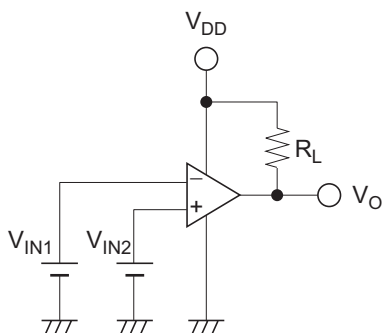
$$\frac{V_{OH}}$$

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

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

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

5. Output Low Voltage, V_{OL}



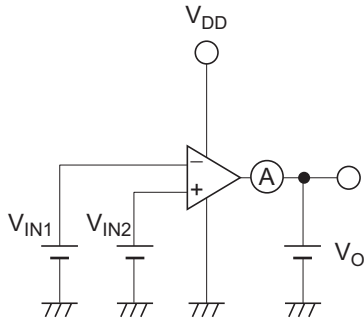
$$\frac{V_{OL}}$$

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

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

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

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



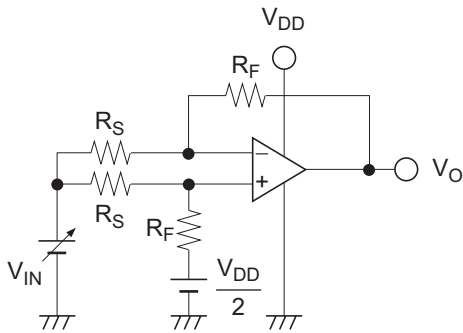
$I_{OSOURCE}$

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

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

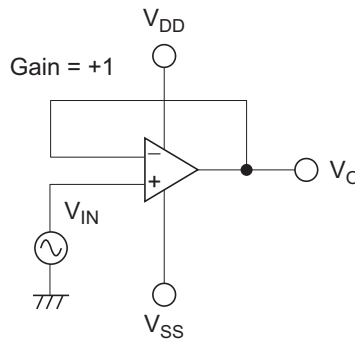
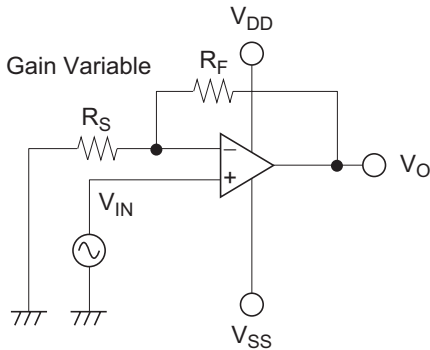


CMRR

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

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

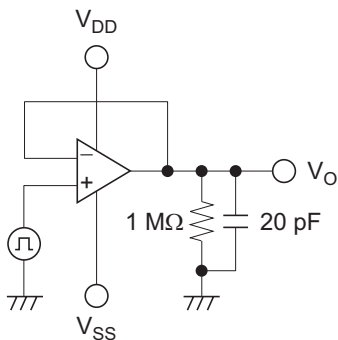
8. Total Harmonic Distortion, THD



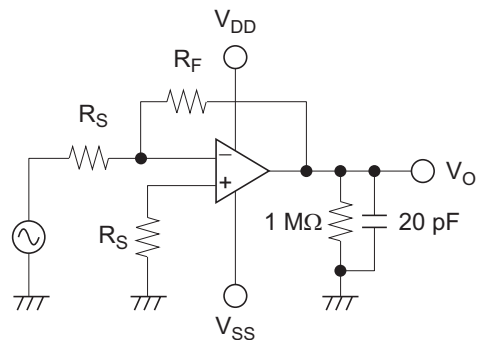
THD

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

9. Slew Rate, SR

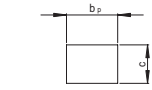
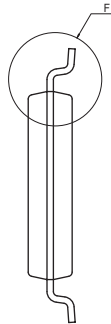
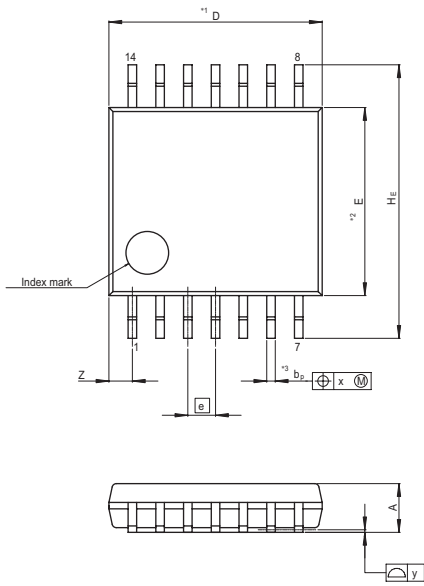


10. Gain, A_V & Phase, GBW

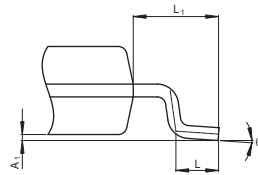


Package Dimensions

| | | | |
|----------------------|--------------|---------------|------------|
| 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)



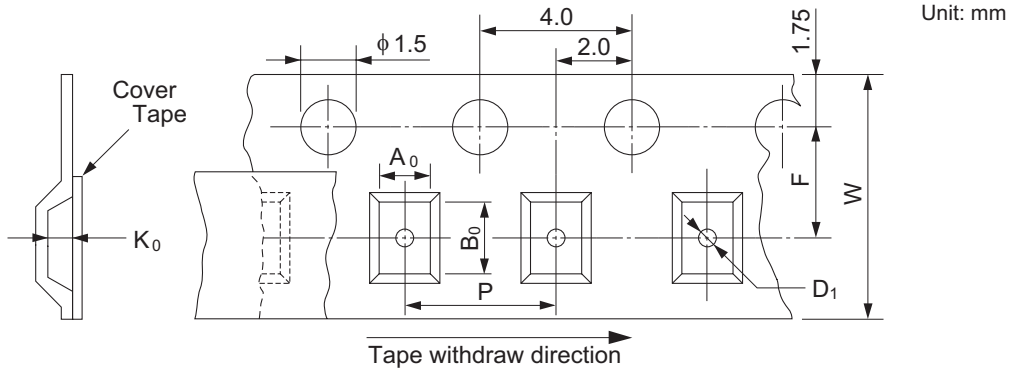
NOTE)
1. DIMENSIONS**1 (Nom)**AND**2*
DO NOT INCLUDE MOLD FLASH.
2. DIMENSION**3*DOES NOT
INCLUDE TRIM OFFSET.

| Reference Symbol | Dimension in Millimeters | | |
|------------------|--------------------------|------|------|
| | Min | Nom | Max |
| D | — | 5.00 | 5.30 |
| E | — | 4.40 | — |
| A ₂ | — | — | — |
| A ₁ | 0.03 | 0.07 | 0.10 |
| A | — | — | 1.10 |
| b _p | 0.15 | 0.20 | 0.25 |
| b ₁ | — | — | — |
| c | 0.10 | 0.15 | 0.20 |
| c ₁ | — | — | — |
| θ | 0° | — | 8° |
| H _E | 6.20 | 6.40 | 6.60 |
| \varnothing | — | 0.65 | — |
| x | — | — | 0.13 |
| y | — | — | 0.10 |
| Z | — | — | 0.83 |
| L | 0.4 | 0.5 | 0.6 |
| L ₁ | — | 1.0 | — |

Taping & Reel Specification

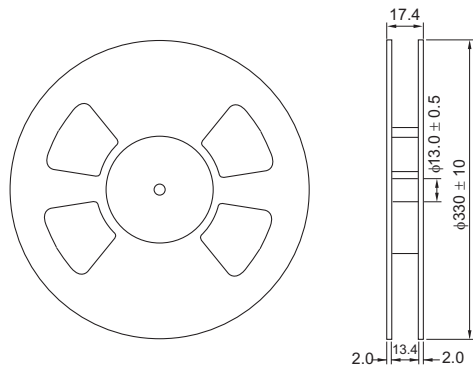
[Taping]

| 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 |



[Reel]

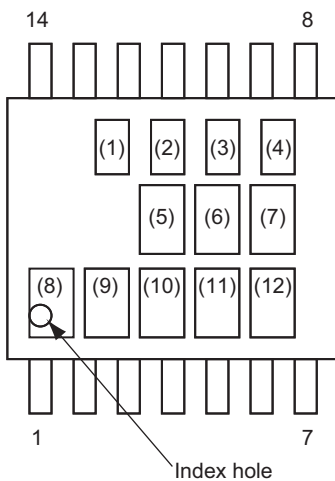
| Package | Tape width | W1 | W2 |
|----------|------------|------|------|
| TSSOP-14 | 12 | 17.4 | 13.4 |



[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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