

# HA1630S01/02/03 Series

## Ultra-Small Low Voltage Operation CMOS Single Operational Amplifier

R03DS0081EJ0200

Rev.2.00

Jan 10, 2014

### Description

The HA1630S01/02/03 are single 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 CMPAK-5 package that occupies only 1/8 the area of the SOP-8 package.

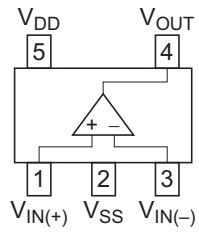
### Features

- 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  $I_{DD} = 15$   $\mu$ A Typ (HA1630S01)  
 $I_{DD} = 50$   $\mu$ A Typ (HA1630S02)  
 $I_{DD} = 100$   $\mu$ A Typ (HA1630S03)
- Maximum output voltage  $V_{OH} = 2.9$  V Min (at  $V_{DD} = 3.0$  V)
- Low input bias current  $I_{IB} = 1$  pA Typ

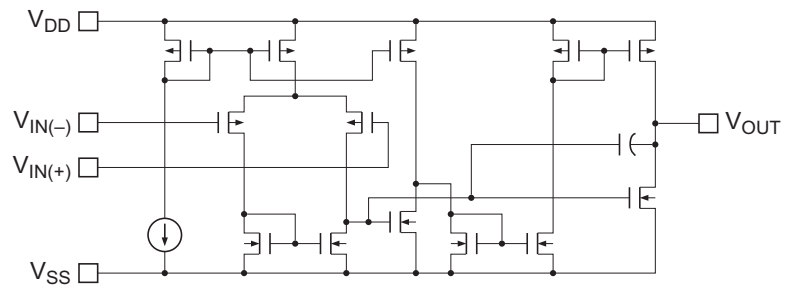
### Ordering Information

| Type No.    | Package Name | Package Code |
|-------------|--------------|--------------|
| HA1630S01CM | CMPAK-5      | PTSP0005ZC-A |
| HA1630S01LP | MPAK-5       | PLSP0005ZB-A |
| HA1630S02CM | CMPAK-5      | PTSP0005ZC-A |
| HA1630S02LP | MPAK-5       | PLSP0005ZB-A |
| HA1630S03CM | CMPAK-5      | PTSP0005ZC-A |
| HA1630S03LP | MPAK-5       | PLSP0005ZB-A |

## Pin Arrangement



## Equivalent Circuit



## 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>        | 200                                  | 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)

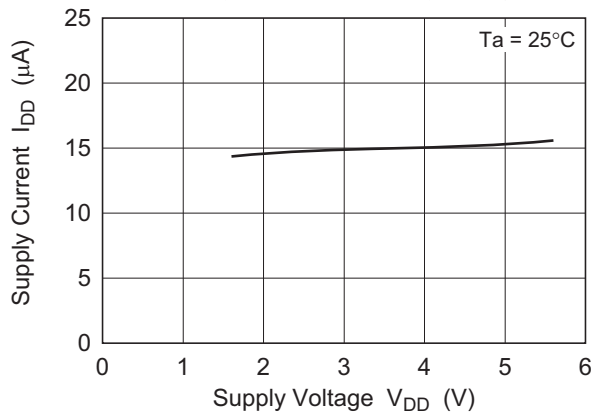
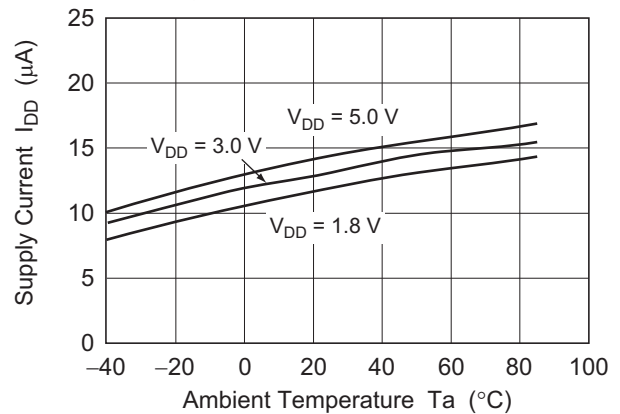
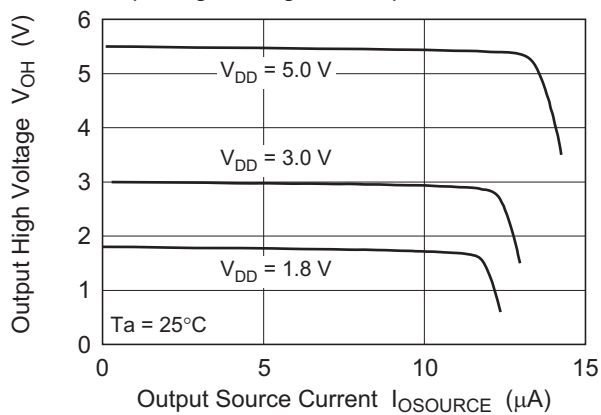
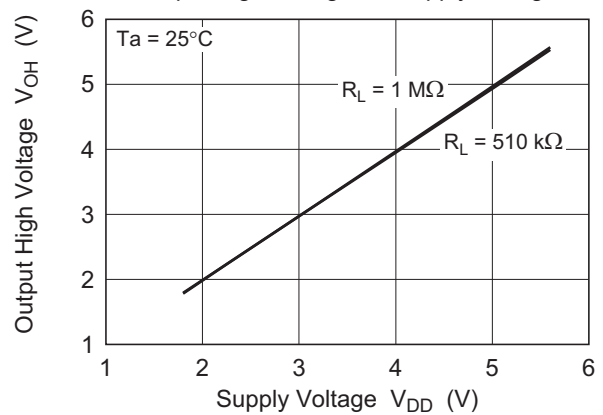
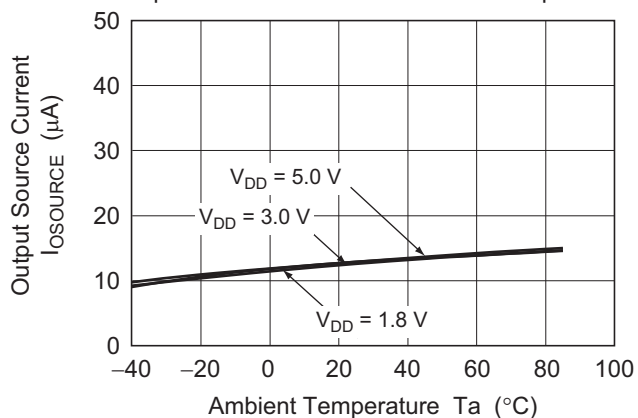
| Items                           | Symbol                | Min         | Typ     | Max | Unit | Test Condition                      |
|---------------------------------|-----------------------|-------------|---------|-----|------|-------------------------------------|
| Input offset voltage            | 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 (HA1630S01) |
|                                 |                       | 25          | 50      | —   |      | V <sub>OH</sub> = 2.5 V (HA1630S02) |
|                                 |                       | 50          | 100     | —   |      | V <sub>OH</sub> = 2.5 V (HA1630S03) |
| 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 (HA1630S01) |
|                                 |                       | —           | (1.0)   | —   |      | V <sub>OL</sub> = 0.5 V (HA1630S02) |
|                                 |                       | —           | (1.2)   | —   |      | V <sub>OL</sub> = 0.5 V (HA1630S03) |
| 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 (HA1630S01)  |
|                                 |                       | —           | (0.50)  | —   |      | C <sub>L</sub> = 20 pF (HA1630S02)  |
|                                 |                       | —           | (1.00)  | —   |      | C <sub>L</sub> = 20 pF (HA1630S03)  |
| Voltage gain                    | A <sub>V</sub>        | 60          | 100     | —   | dB   |                                     |
| Gain bandwidth product          | BW                    | —           | (200)   | —   | kHz  | C <sub>L</sub> = 20 pF (HA1630S01)  |
|                                 |                       | —           | (680)   | —   |      | C <sub>L</sub> = 20 pF (HA1630S02)  |
|                                 |                       | —           | (1200)  | —   |      | C <sub>L</sub> = 20 pF (HA1630S03)  |
| Power supply rejection ratio    | PSRR                  | 60          | 80      | —   | dB   |                                     |
| Common mode rejection ratio     | CMRR                  | 60          | 80      | —   | dB   |                                     |
| Supply current                  | I <sub>DD</sub>       | —           | 15      | 30  | μA   | R <sub>L</sub> = ∞ (HA1630S01)      |
|                                 |                       | —           | 50      | 100 |      | R <sub>L</sub> = ∞ (HA1630S02)      |
|                                 |                       | —           | 100     | 200 |      | R <sub>L</sub> = ∞ (HA1630S03)      |

Note: 1. ( ) : Design specification

Table of Graphs

| Electrical Characteristics        |                 |                                 | HA1630S01<br>Figure | HA1630S02<br>Figure | HA1630S03<br>Figure | Test<br>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 (HA1630S01)

Figure 1-1. HA1630S01  
Supply Current vs. Supply VoltageFigure 1-2. HA1630S01  
Supply Current vs. Ambient TemperatureFigure 1-3. HA1630S01  
Output High Voltage vs. Output Source CurrentFigure 1-4. HA1630S01  
Output High Voltage vs. Supply VoltageFigure 1-5. HA1630S01  
Output Source Current vs. Ambient Temperature

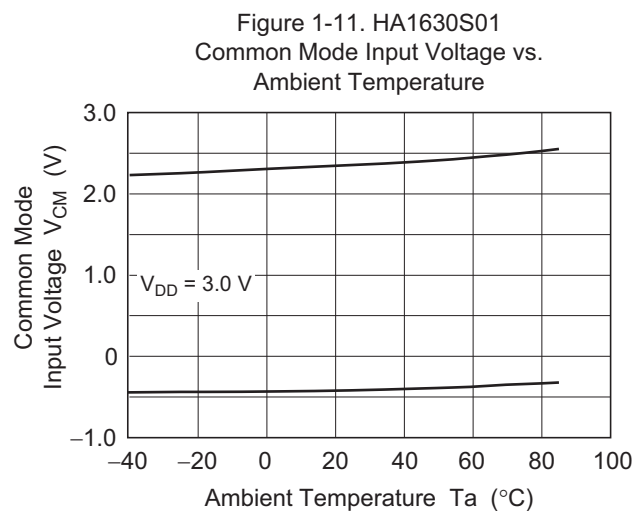
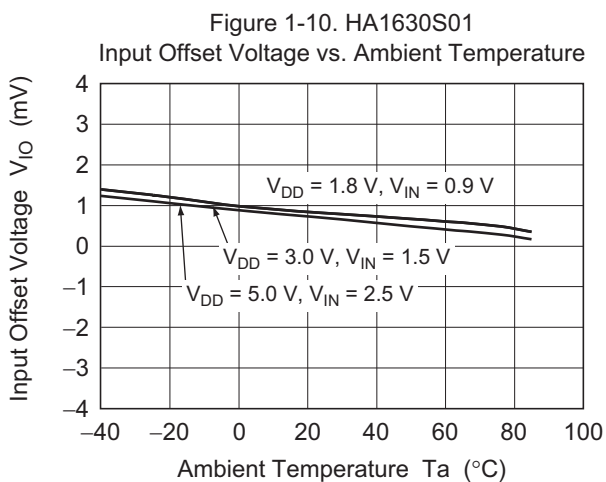
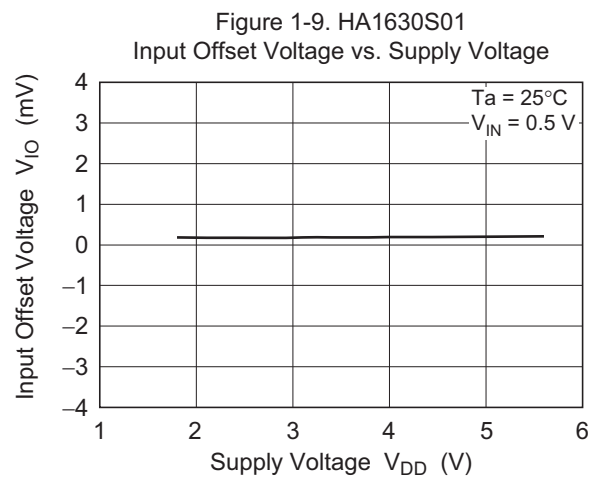
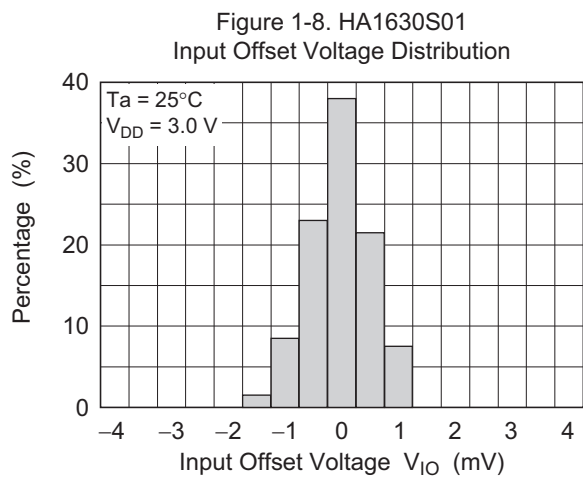
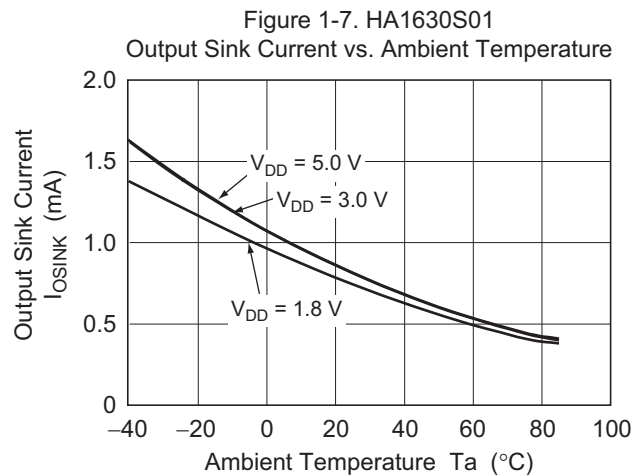
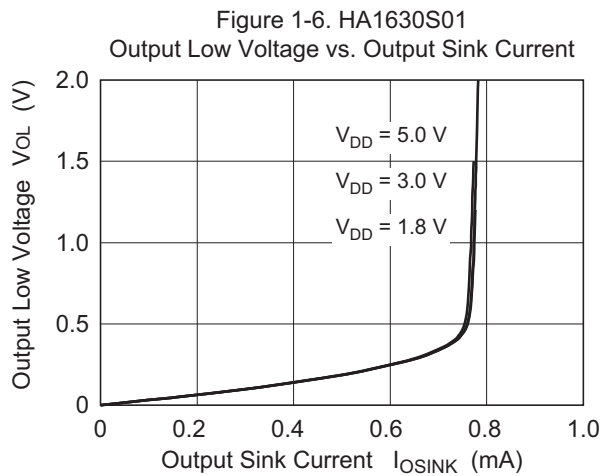


Figure 1-12. HA1630S01  
Power Supply Rejection Ratio vs. Frequency

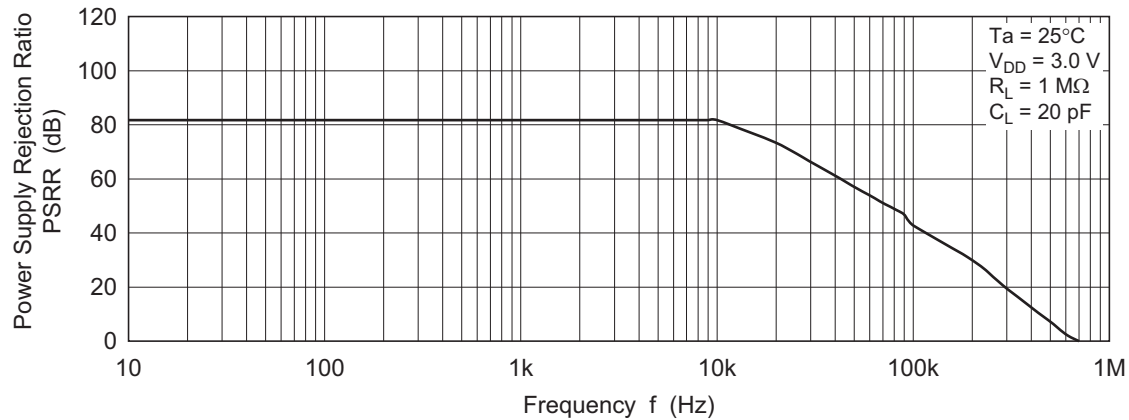


Figure 1-13. HA1630S01  
Common Mode Rejection Ratio vs. Frequency

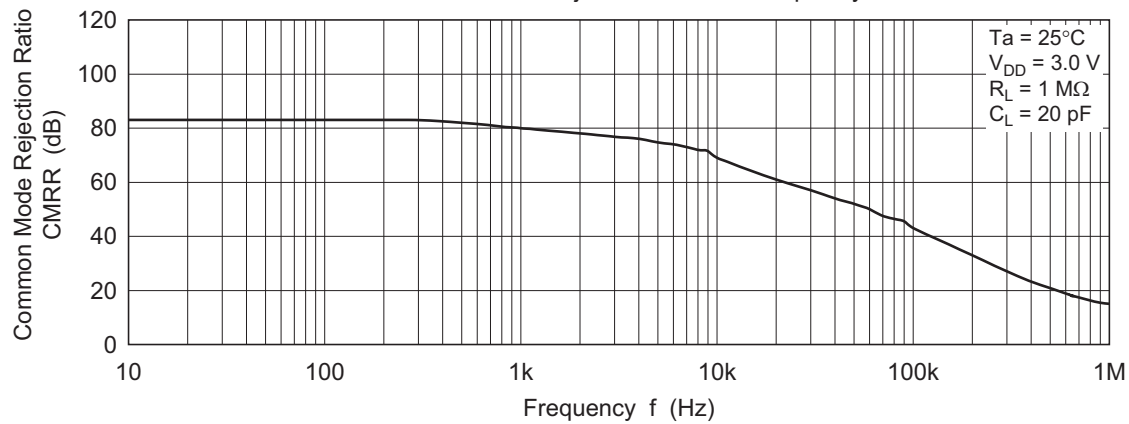


Figure 1-14. HA1630S01  
Open Loop Voltage Gain and Phase Angle vs. Frequency

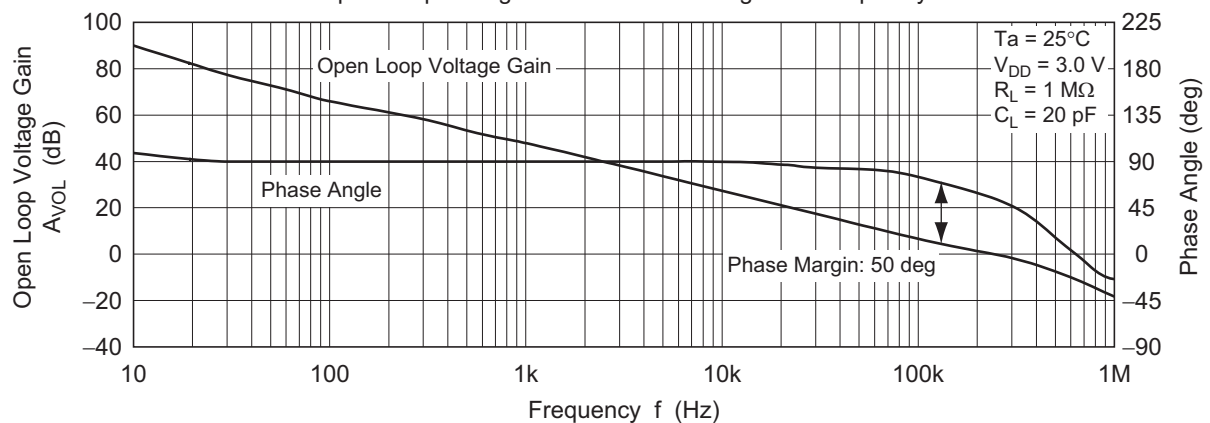


Figure 1-15. HA1630S01  
Input Bias Current vs. Ambient Temperature

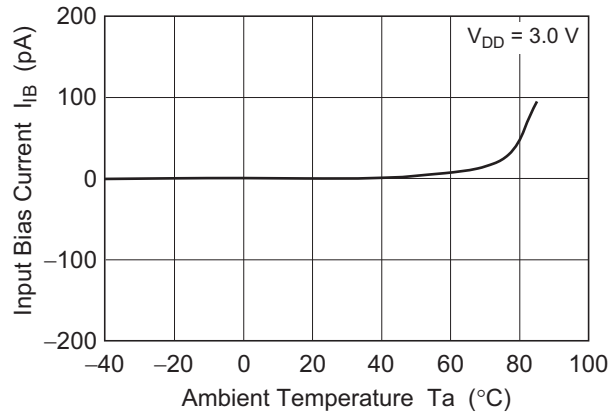


Figure 1-16. HA1630S01  
Input Bias Current vs. Input Voltage

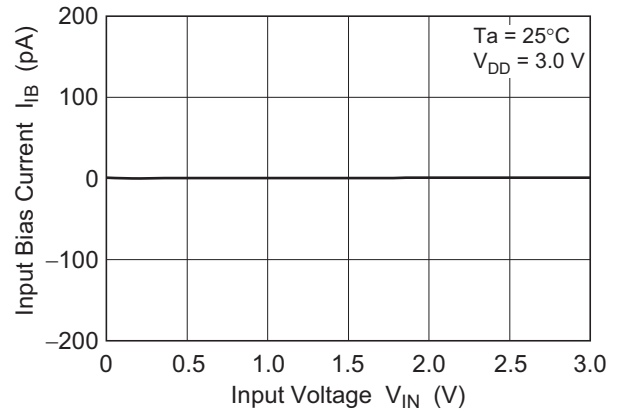


Figure 1-17. HA1630S01  
Slew Rate (rising) vs. Ambient Temperature

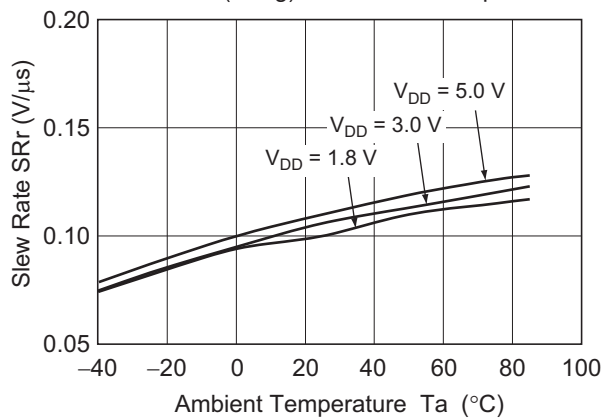


Figure 1-18. HA1630S01  
Slew Rate (falling) vs. Ambient Temperature

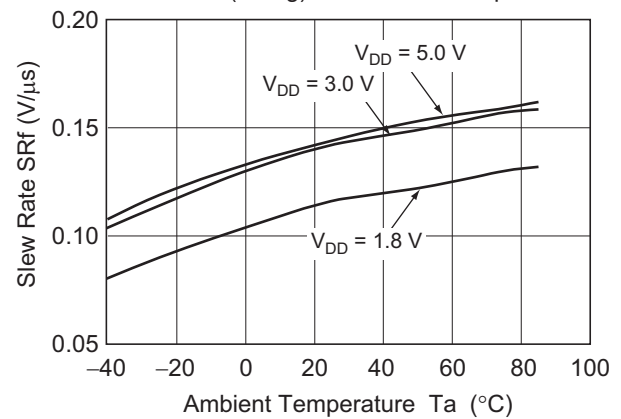


Figure 1-19. HA1630S01  
Large Signal Transient Response

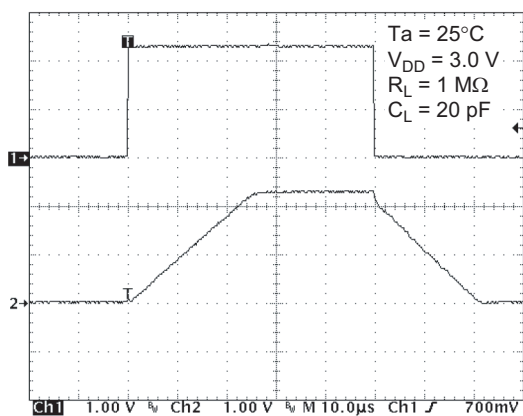


Figure 1-20. HA1630S01  
Small Signal Transient Response

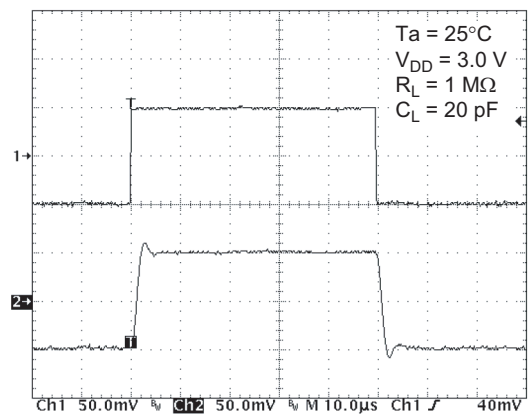




Figure 1-21. HA1630S01  
Voltage Output p-p vs. Frequency

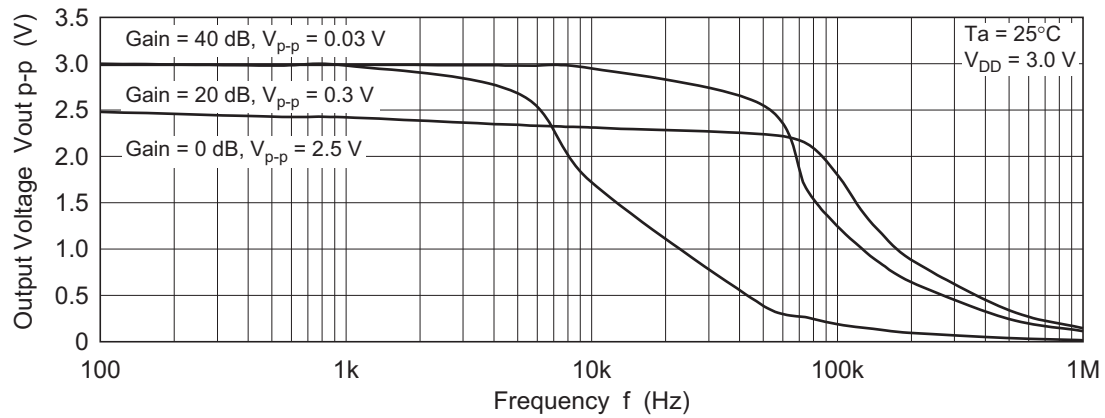
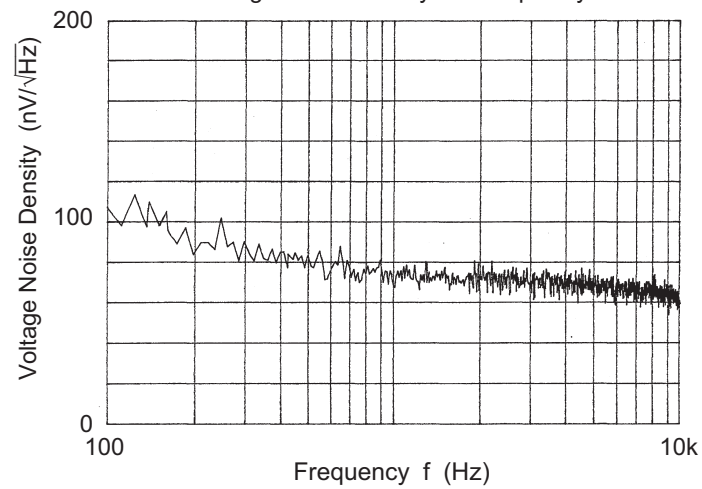
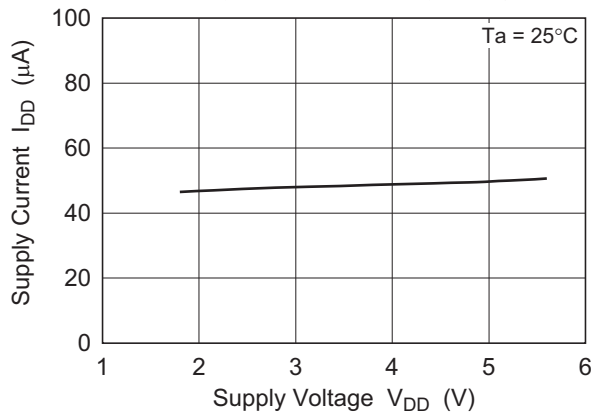
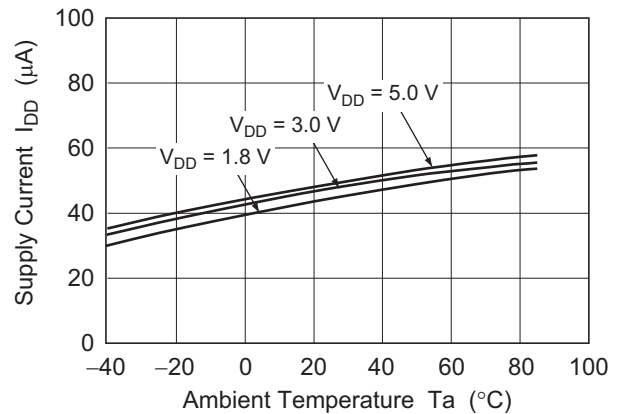
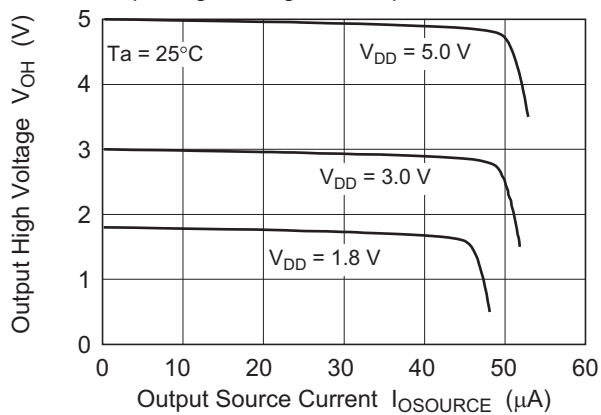
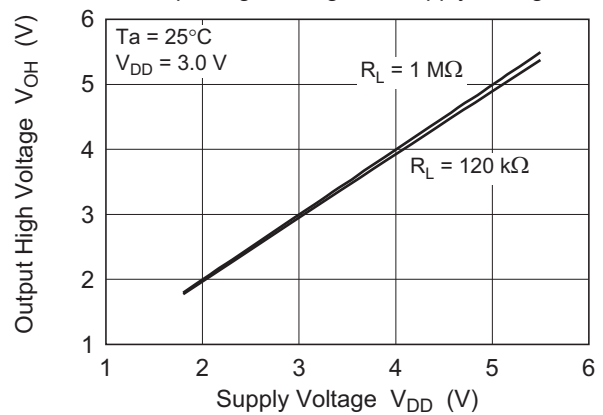
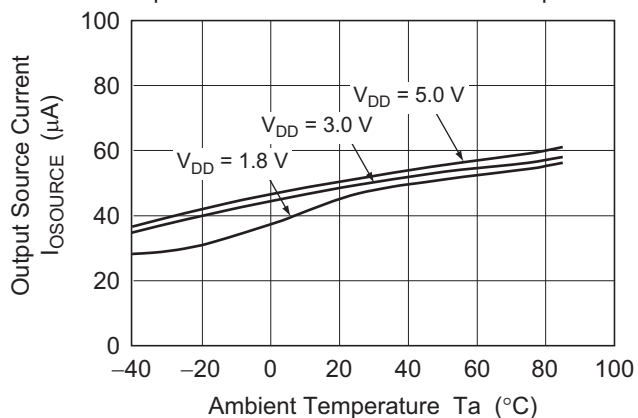


Figure 1-22. HA1630S01  
Voltage Noise Density vs. Frequency



## Main Characteristics (HA1630S02)

Figure 2-1. HA1630S02  
Supply Current vs. Supply VoltageFigure 2-2. HA1630S02  
Supply Current vs. Ambient TemperatureFigure 2-3. HA1630S02  
Output High Voltage vs. Output Source CurrentFigure 2-4. HA1630S02  
Output High Voltage vs. Supply VoltageFigure 2-5. HA1630S02  
Output Source Current vs. Ambient Temperature

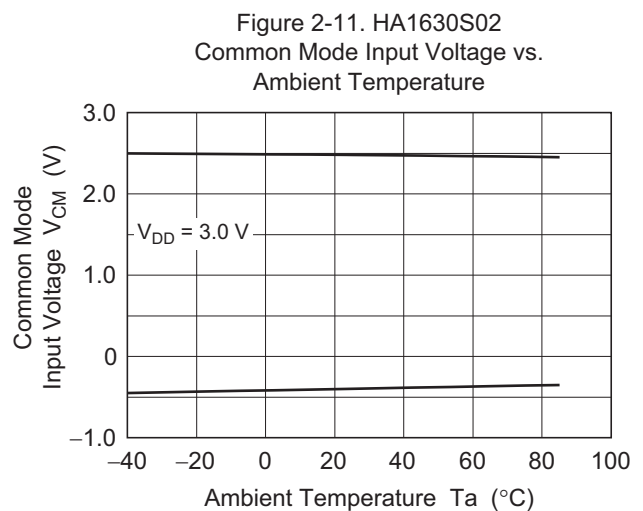
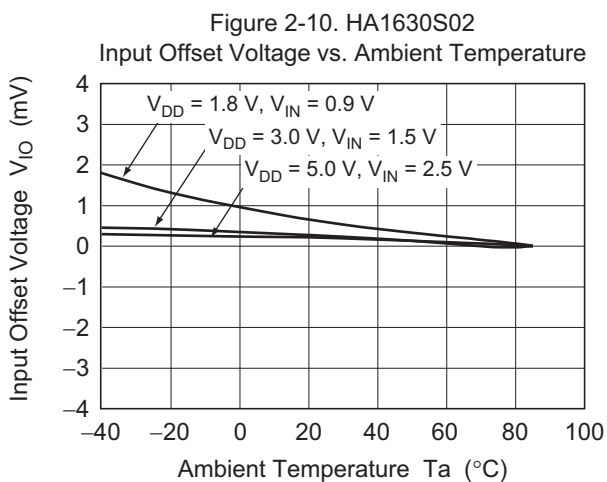
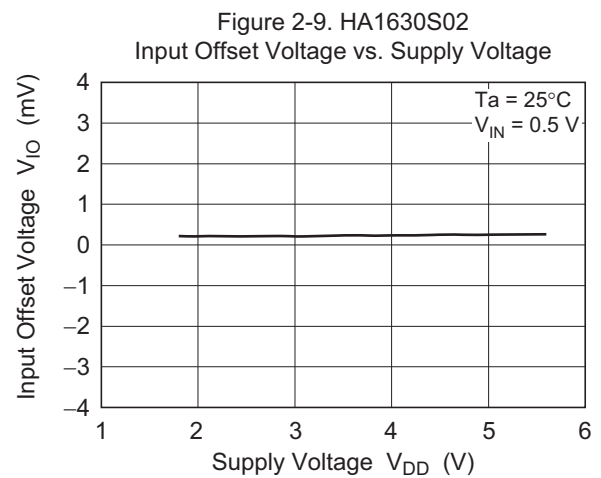
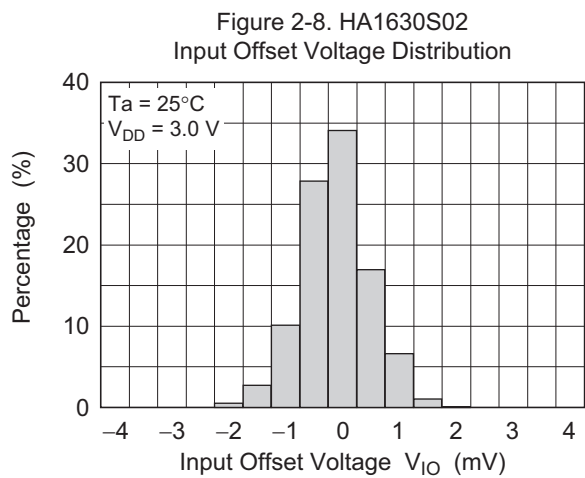
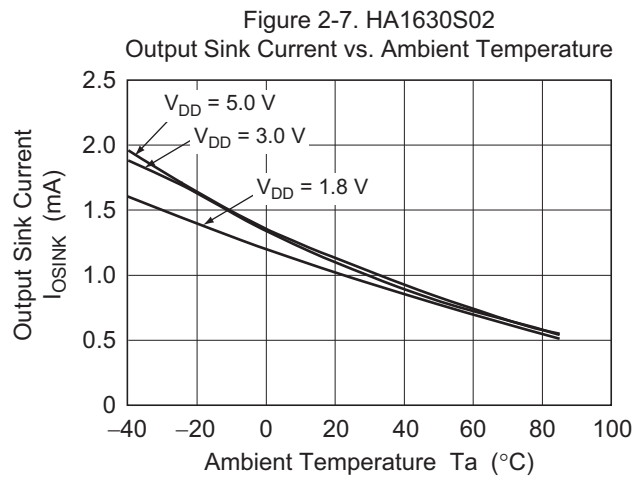
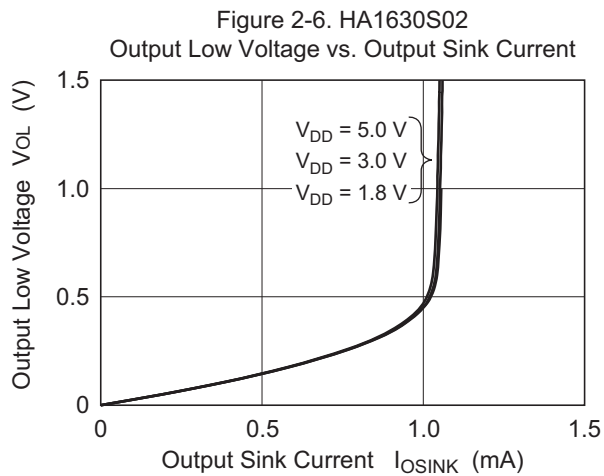


Figure 2-12. HA1630S02  
Power Supply Rejection Ratio vs. Frequency

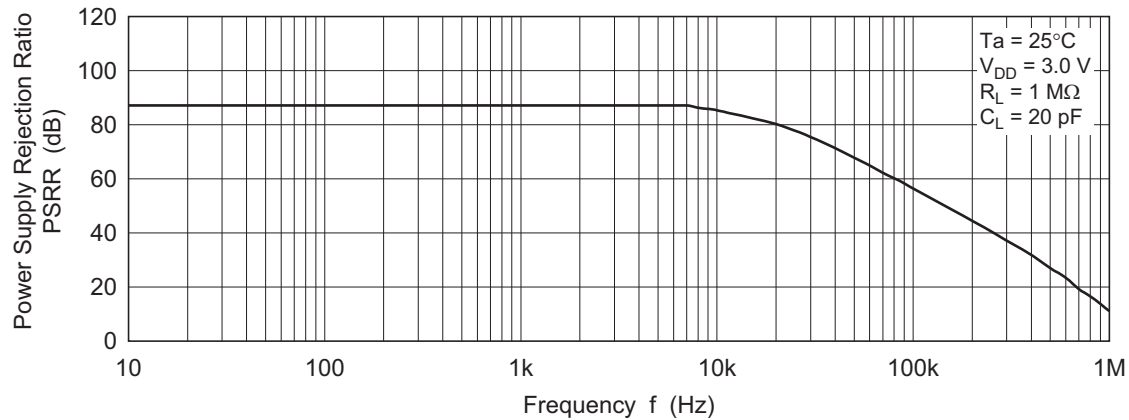


Figure 2-13. HA1630S02  
Common Mode Rejection Ratio vs. Frequency

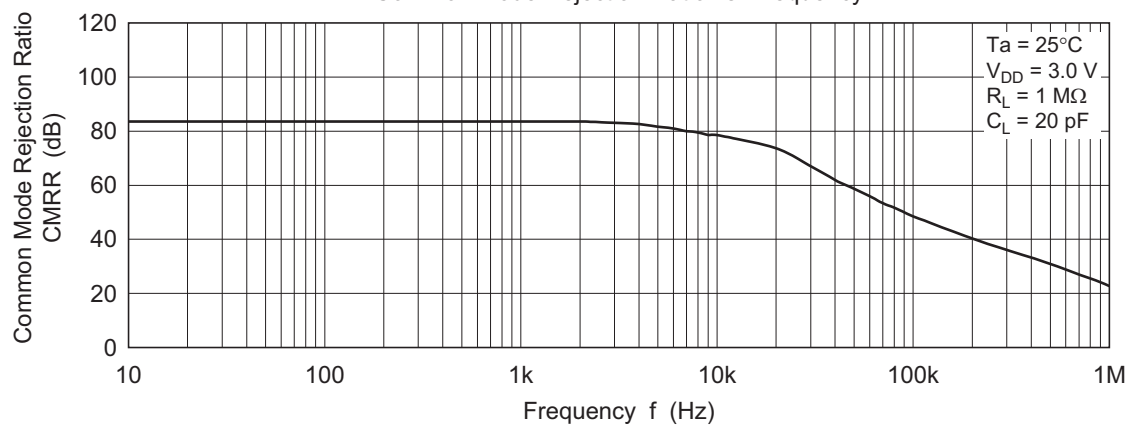


Figure 2-14. HA1630S02  
Open Loop Voltage Gain and Phase Angle vs. Frequency

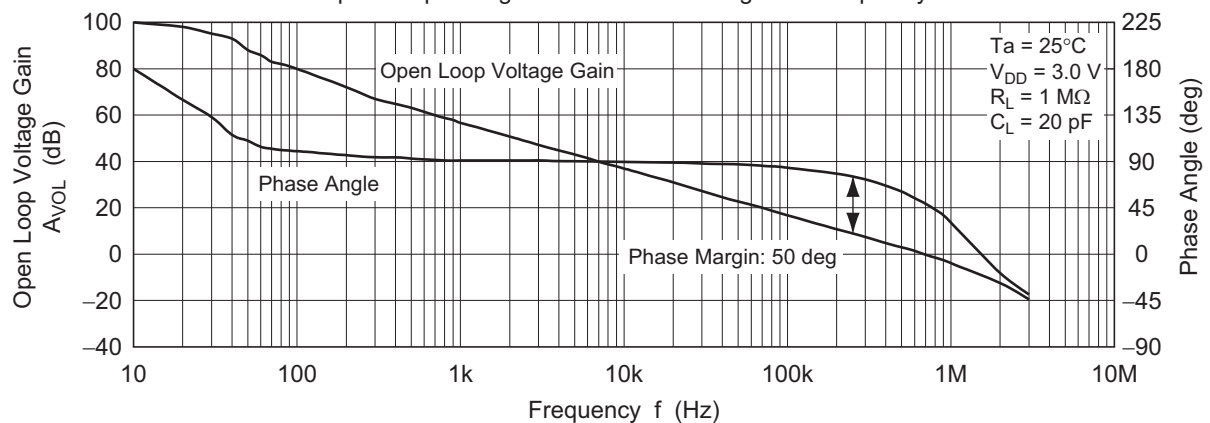


Figure 2-15. HA1630S02  
Input Bias Current vs. Ambient Temperature

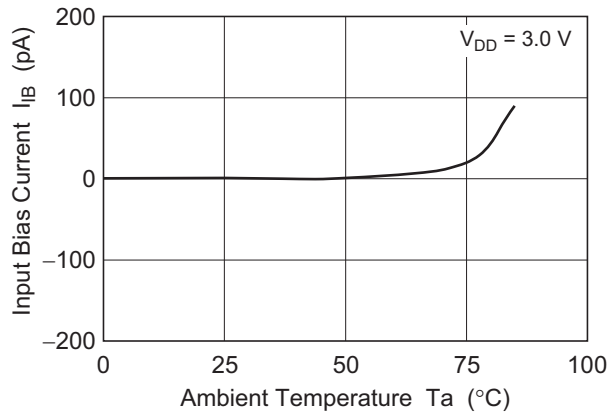


Figure 2-16. HA1630S02  
Input Bias Current vs. Input Voltage

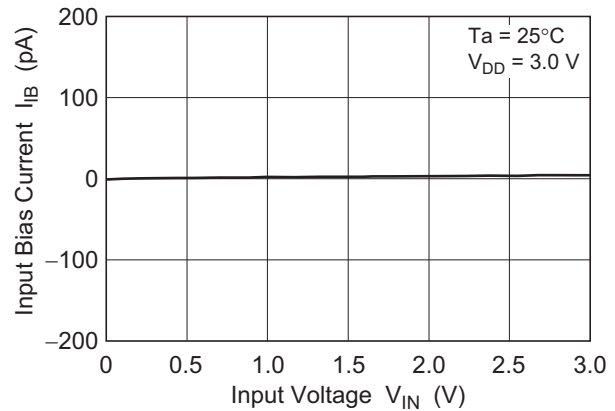


Figure 2-17. HA1630S02  
Slew Rate (rising) vs. Ambient Temperature

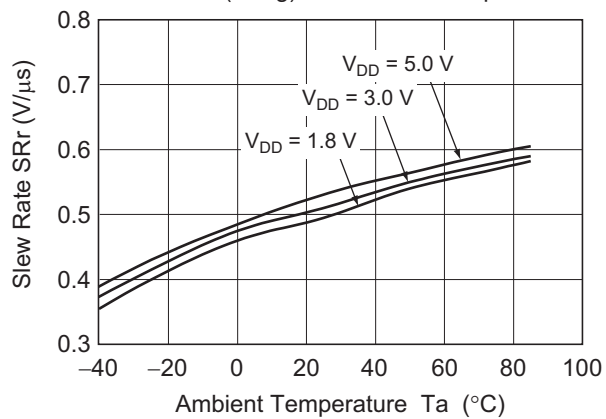


Figure 2-18. HA1630S02  
Slew Rate (falling) vs. Ambient Temperature

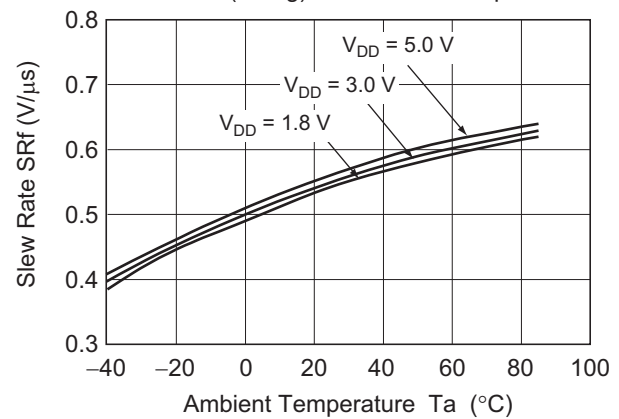


Figure 2-19. HA1630S02  
Large Signal Transient Response

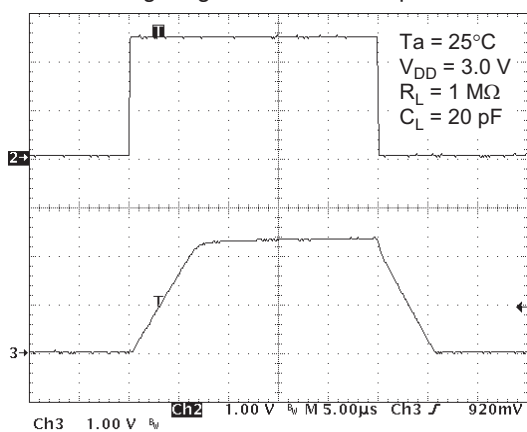


Figure 2-20. HA1630S02  
Small Signal Transient Response

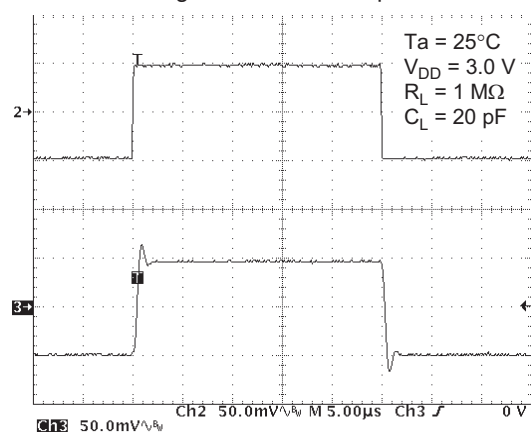


Figure 2-21. HA1630S02  
Total Harmonic Distortion + Noise vs.  
Output Voltage p-p

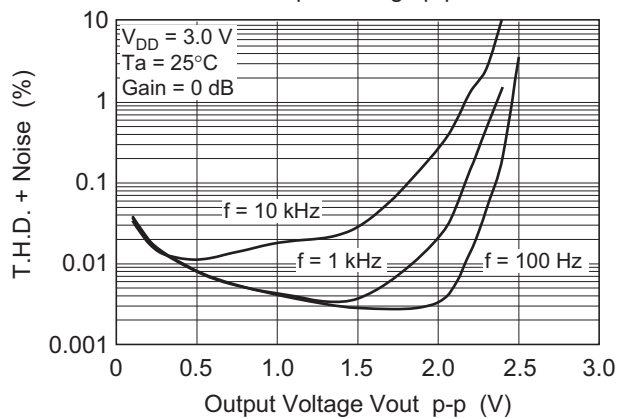


Figure 2-22. HA1630S02  
Total Harmonic Distortion + Noise vs.  
Output Voltage p-p

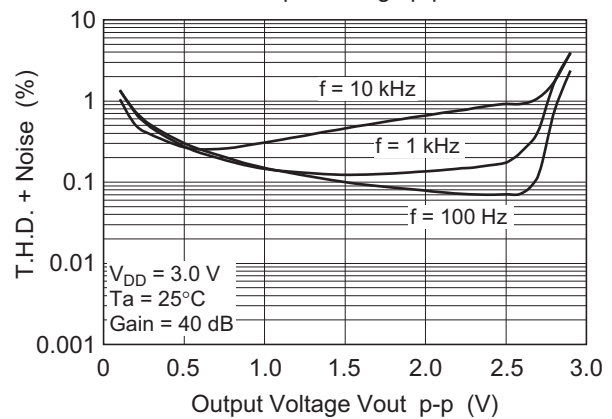


Figure 2-23. HA1630S02  
Voltage Output p-p vs. Frequency

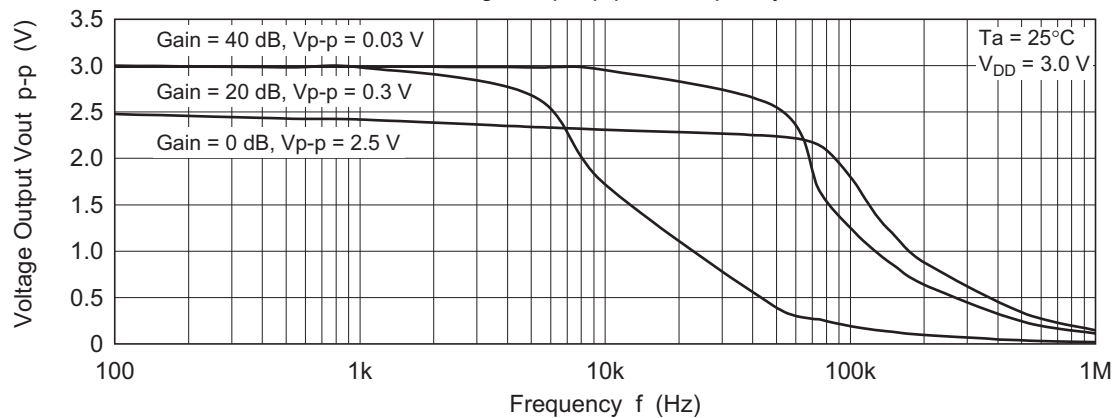
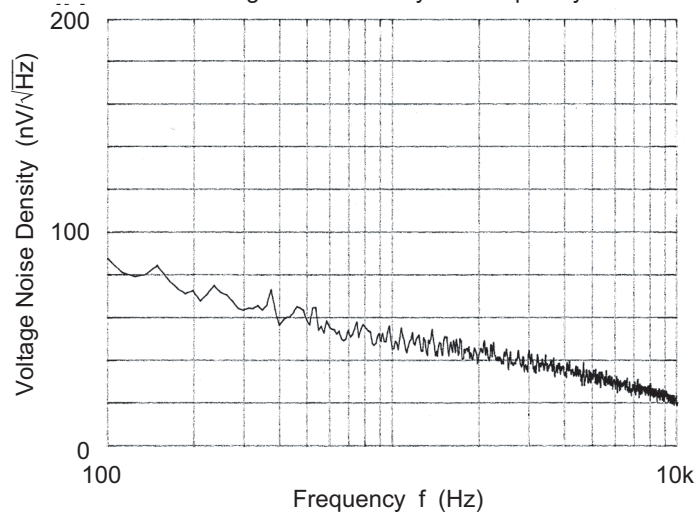
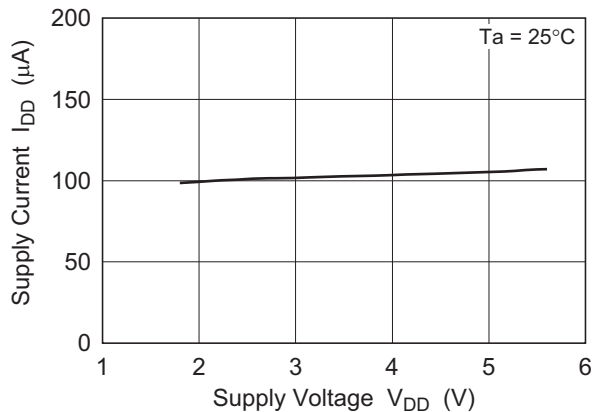
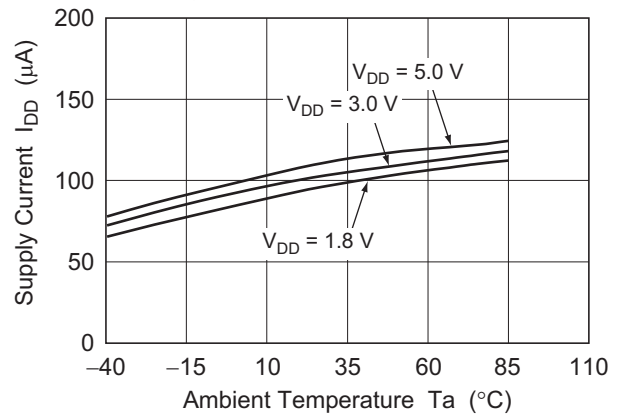
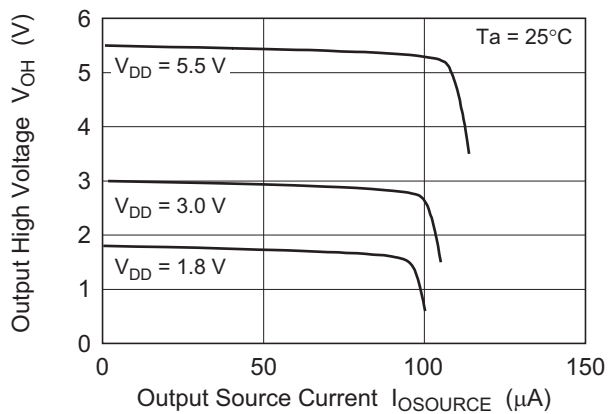
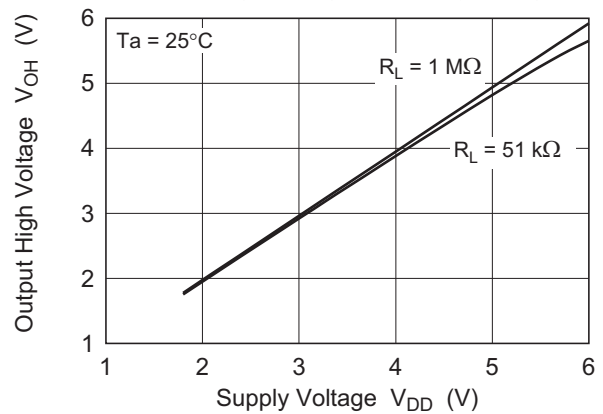
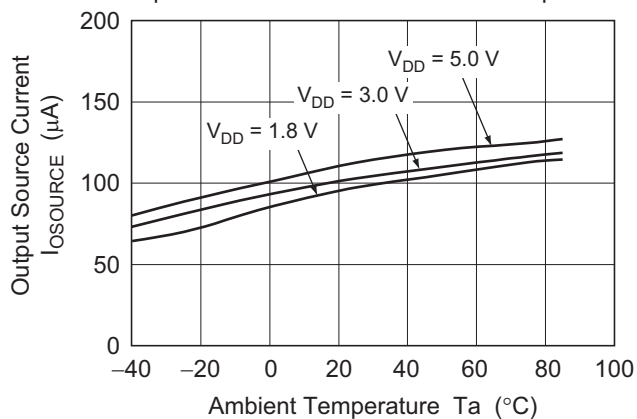


Figure 2-24. HA1630S02  
Voltage Noise Density vs. Frequency



## Main Characteristics (HA1630S03)

Figure 3-1. HA1630S03  
Supply Current vs. Supply VoltageFigure 3-2. HA1630S03  
Supply Current vs. Ambient TemperatureFigure 3-3. HA1630S03  
Output High Voltage vs. Output Source CurrentFigure 3-4. HA1630S03  
Output High Voltage vs. Supply VoltageFigure 3-5. HA1630S03  
Output Source Current vs. Ambient Temperature

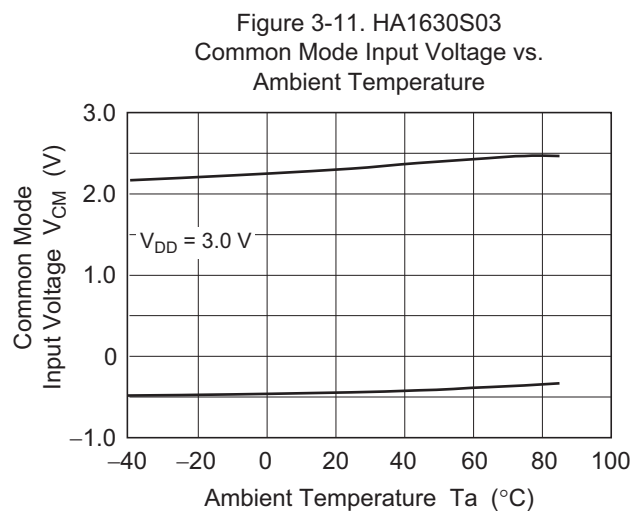
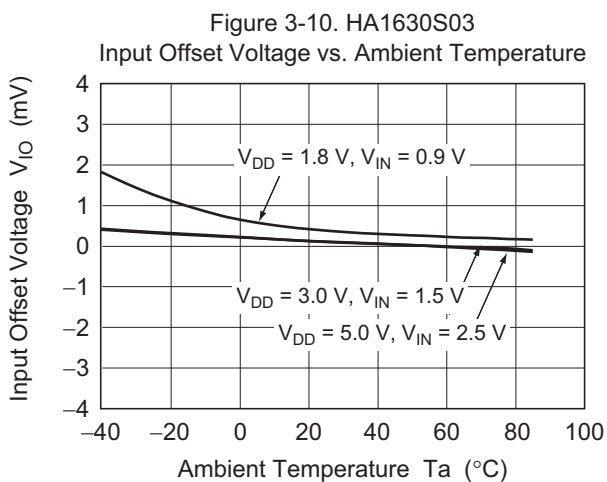
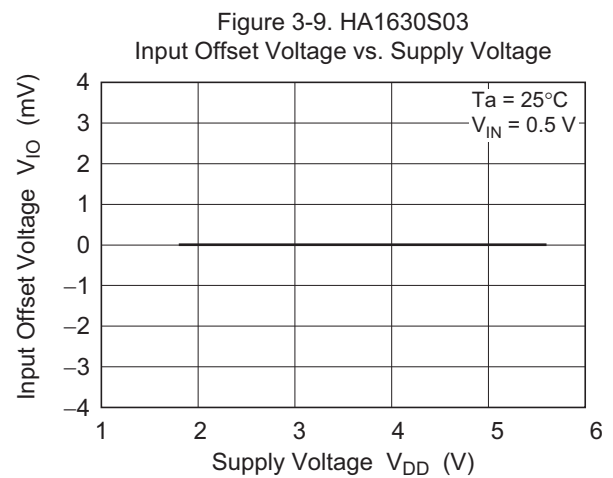
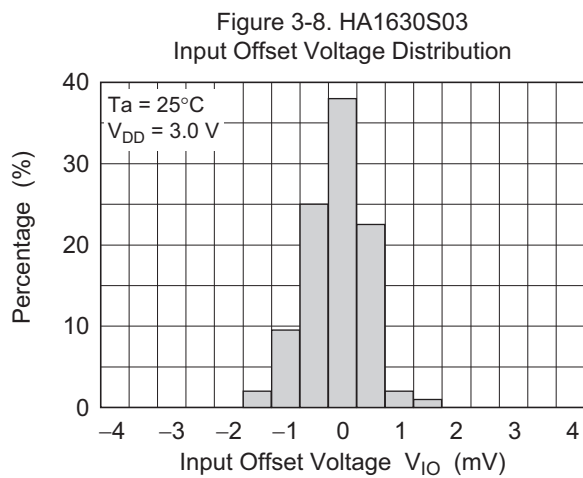
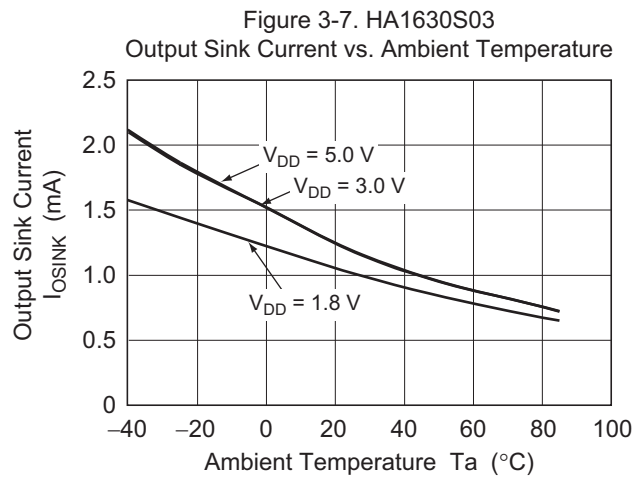
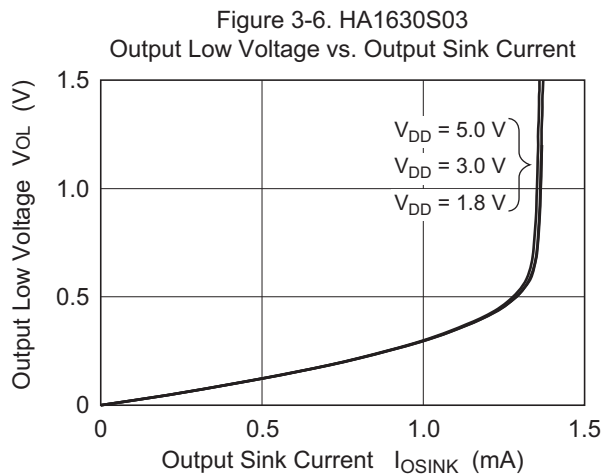




Figure 3-12. HA1630S03  
Power Supply Rejection Ratio vs. Frequency

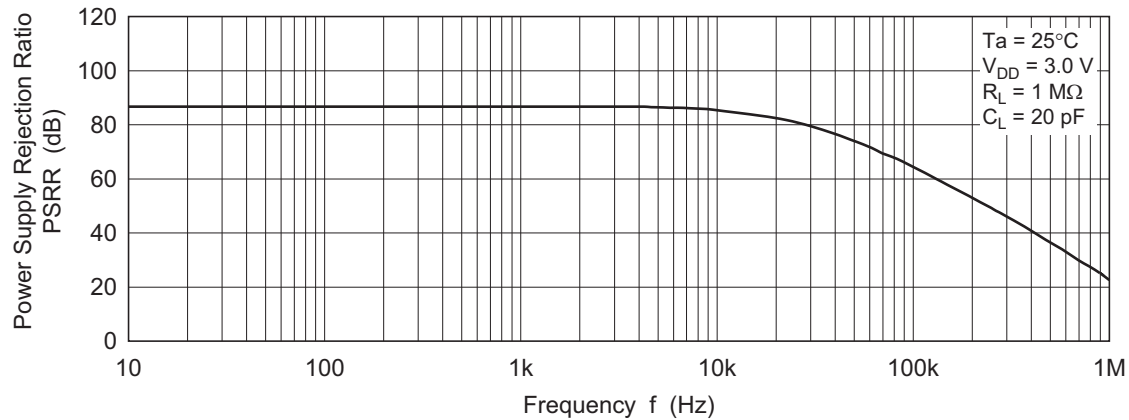


Figure 3-13. HA1630S03  
Common Mode Rejection Ratio vs. Frequency

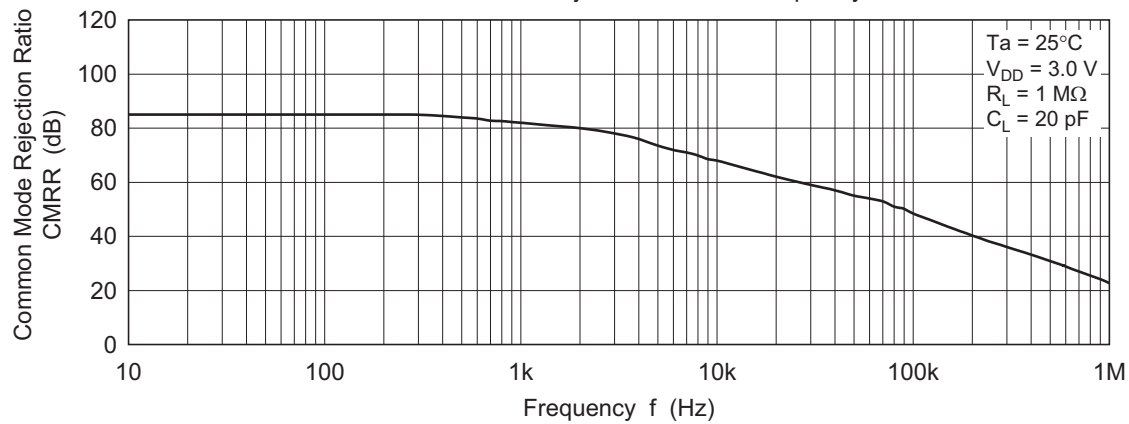
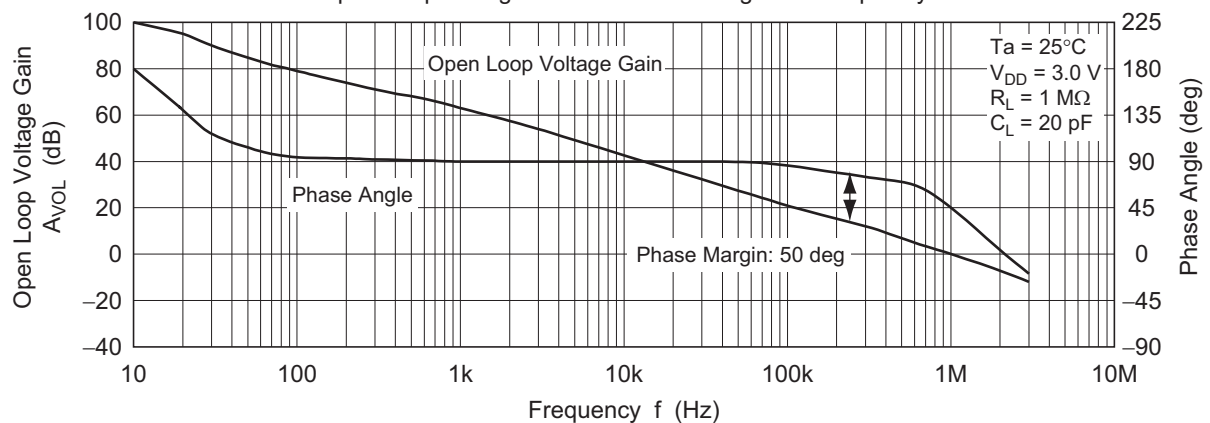


Figure 3-14. HA1630S03  
Open Loop Voltage Gain and Phase Angle vs. Frequency



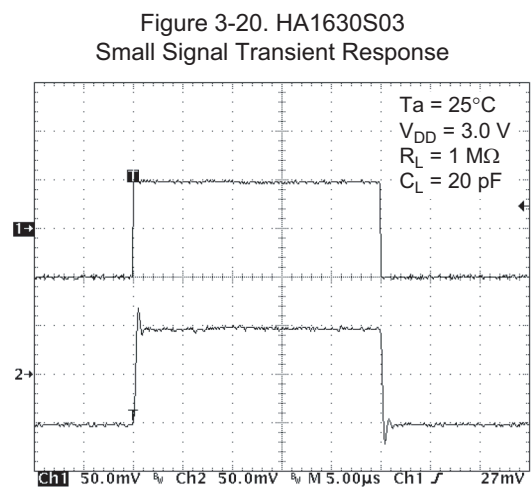
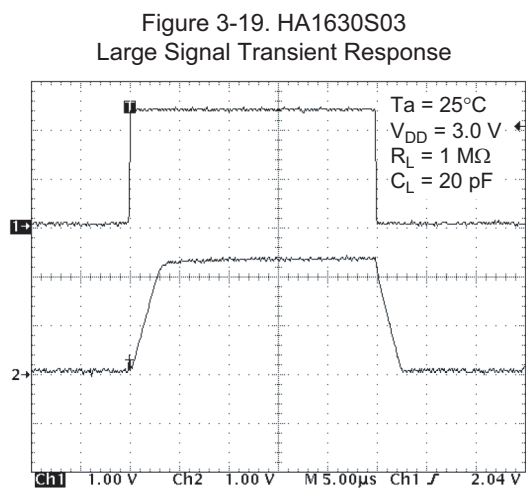
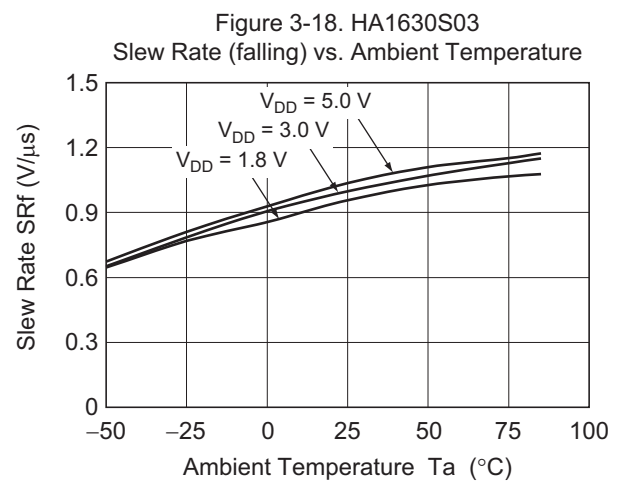
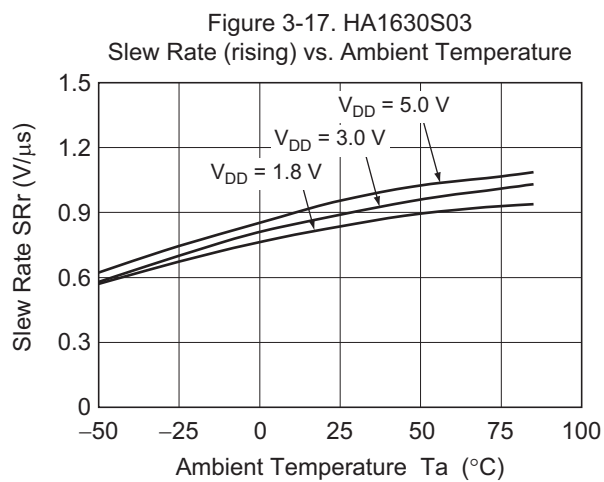
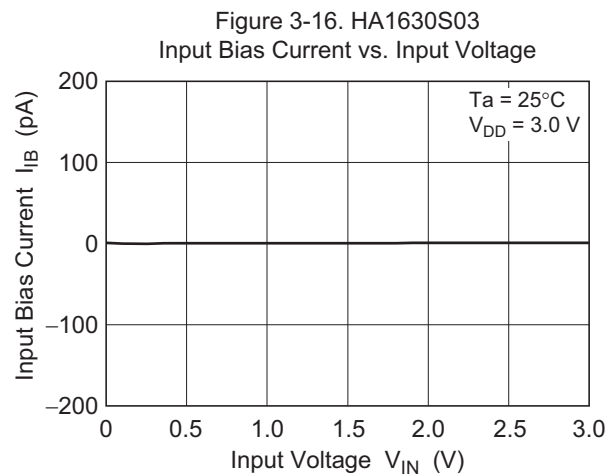
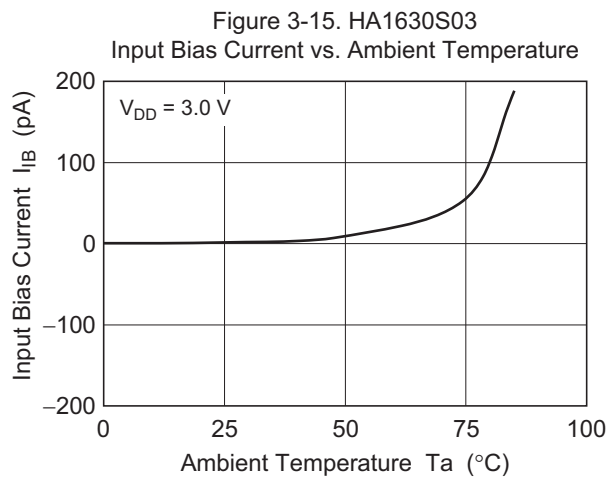


Figure 3-21. HA1630S03  
Total Harmonic Distortion + Noise vs.  
Output Voltage p-p

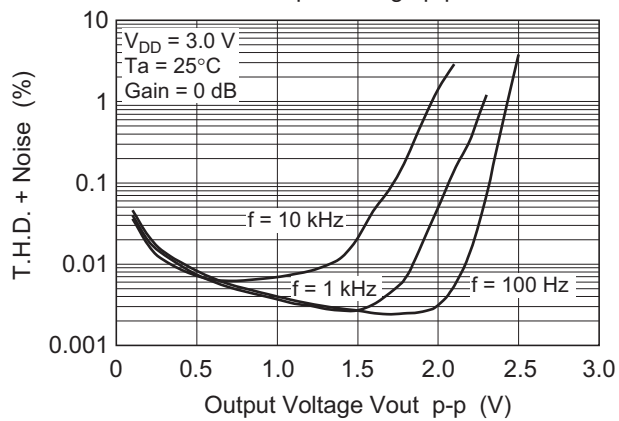


Figure 3-22. HA1630S03  
Total Harmonic Distortion + Noise vs.  
Output Voltage p-p

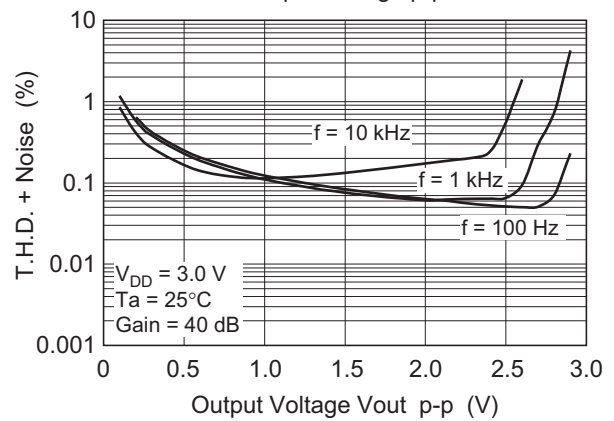


Figure 3-23. HA1630S03  
Voltage Output p-p vs. Frequency

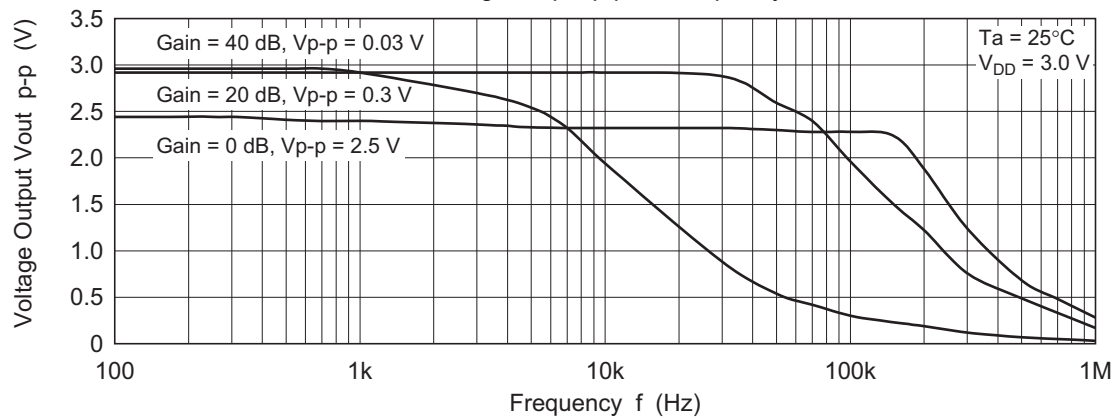
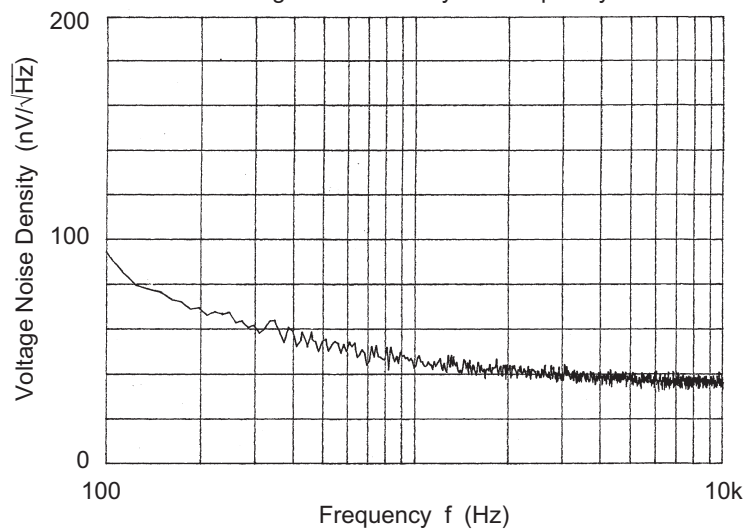
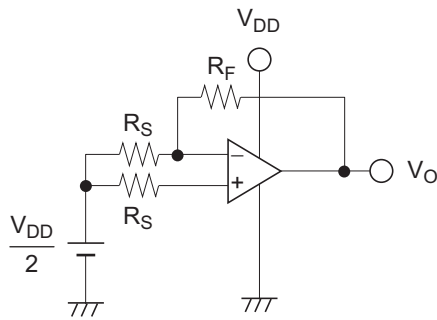


Figure 3-24. HA1630S03  
Voltage Noise Density vs. Frequency



## Test Circuits

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



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

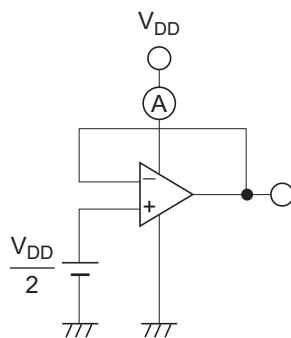
$$V_{IO} = \left( V_O - \frac{V_{DD}}{2} \right) \times \frac{R_S}{R_S + R_F}$$

$$\frac{PSRR}{V_{DD}}$$

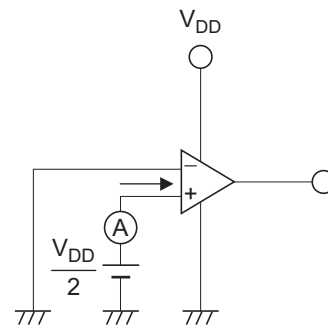
$$PSRR = -20 \log \left( \left| \frac{V_{O1} - V_{O2}}{V_{DD1} - V_{DD2}} \right| \times \frac{R_S}{R_S + R_F} \right)$$

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

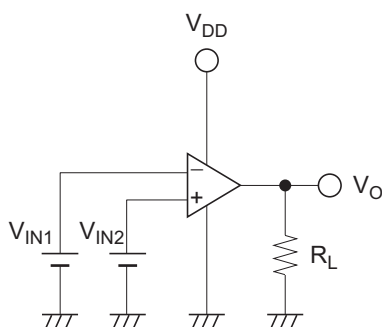
### 2. Supply Current, $I_{DD}$



### 3. Input Bias Current, $I_{IB}$



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



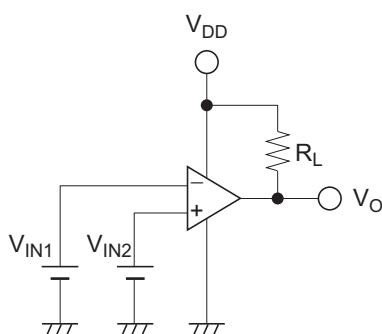
$$\frac{V_{OH}}{V_{DD}}$$

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

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

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

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

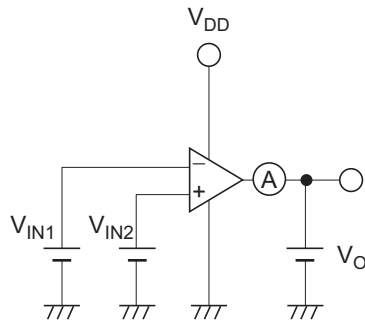


$$\frac{V_{OL}}{V_{DD}}$$

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

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

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

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

$$V_O = V_{DD} - 0.5 \text{ V}$$

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

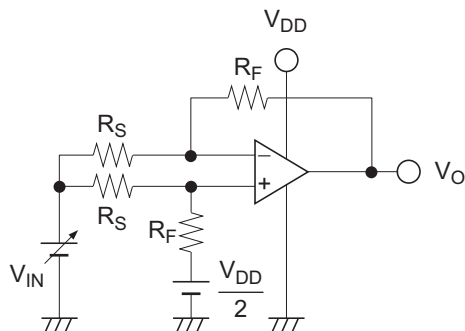
$$V_{IN2} = V_{DD} / 2 + 0.05 \text{ V}$$

 $I_{OSINK}$ 

$$V_O = +0.5 \text{ V}$$

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

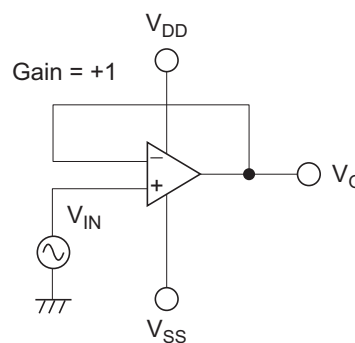
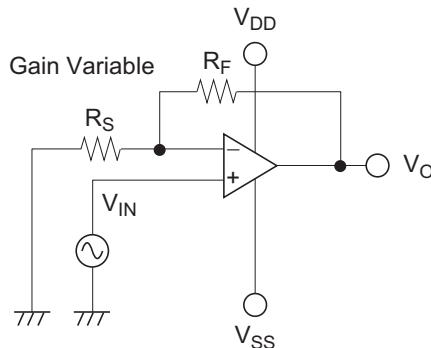
$$V_{IN2} = V_{DD} / 2 - 0.05 \text{ V}$$

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

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

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

## 8. Total Harmonic Distortion, THD

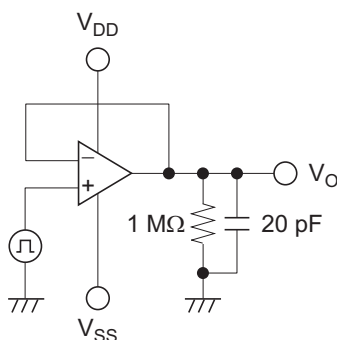
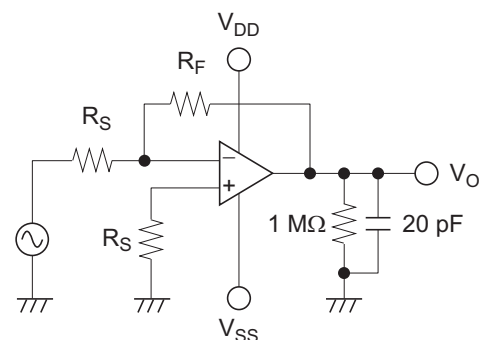
THD

Gain Variable

$$1 + R_F / R_S = 100$$

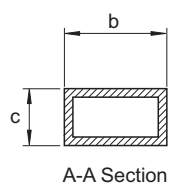
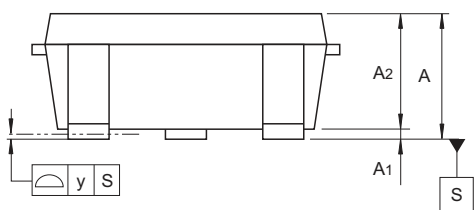
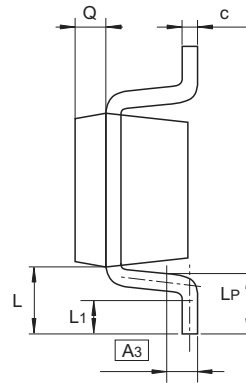
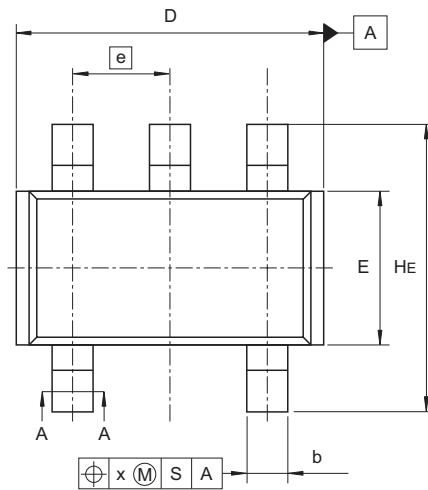
freq = 100 Hz, 1 kHz, 10 kHz

## 9. Slew Rate, SR

10. Gain,  $A_V$  & Phase, GBW

Package Dimensions

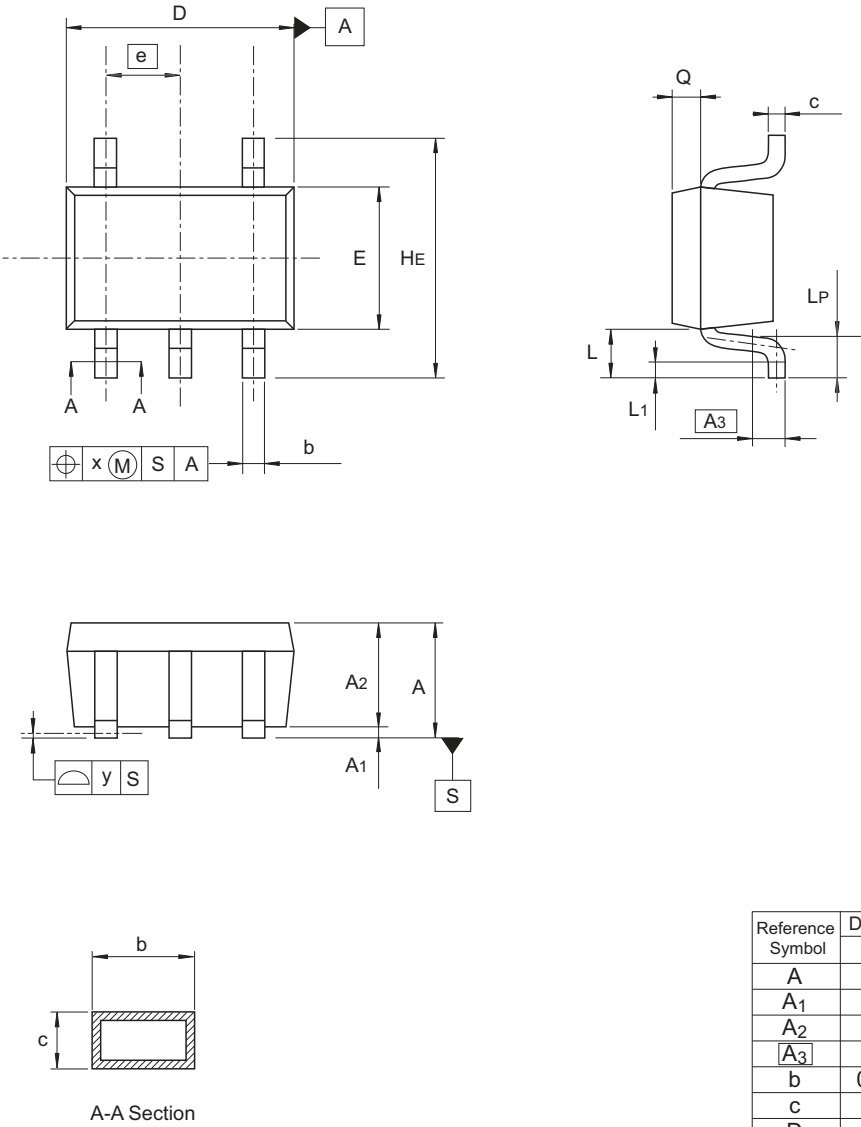
| JEITA Package Code | RENESAS Code | Previous Code    | MASS (Typ) [g] |
|--------------------|--------------|------------------|----------------|
| SC-74A             | PLSP0005ZB-A | MPAK-5 / MPAK-5V | 0.015          |



| Reference<br>Symbol | Dimensions in millimeters |      |      |
|---------------------|---------------------------|------|------|
|                     | Min                       | Nom  | Max  |
| A                   | 1.0                       | —    | 1.4  |
| A <sub>1</sub>      | 0                         | —    | 0.1  |
| A <sub>2</sub>      | 1.0                       | 1.1  | 1.3  |
| A <sub>3</sub>      | —                         | 0.25 | —    |
| b                   | 0.35                      | 0.4  | 0.5  |
| c                   | 0.11                      | 0.16 | 0.26 |
| D                   | 2.8                       | 2.95 | 3.1  |
| E                   | 1.5                       | 1.6  | 1.8  |
| e                   | —                         | 0.95 | —    |
| H <sub>E</sub>      | 2.5                       | 2.8  | 3.0  |
| L                   | 0.3                       | —    | 0.7  |
| L <sub>1</sub>      | 0.1                       | —    | 0.5  |
| L <sub>P</sub>      | 0.2                       | —    | 0.6  |
| x                   | —                         | —    | 0.05 |
| y                   | —                         | —    | 0.05 |
| Q                   | —                         | 0.3  | —    |

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| JEITA Package Code | RENESAS Code | Previous Code      | MASS (Typ) [g] |
|--------------------|--------------|--------------------|----------------|
| SC-88A             | PTSP0005ZC-A | CMPAK-5 / CMPAK-5V | 0.006          |



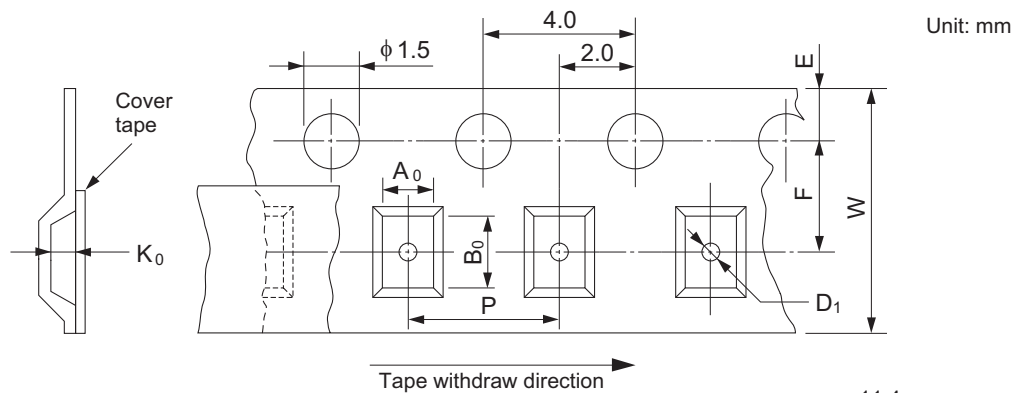
| Reference<br>Symbol | Dimensions in millimeters |      |      |
|---------------------|---------------------------|------|------|
|                     | Min                       | Nom  | Max  |
| A                   | 0.8                       | —    | 1.1  |
| A <sub>1</sub>      | 0                         | —    | 0.1  |
| A <sub>2</sub>      | 0.8                       | 0.9  | 1.0  |
| A <sub>3</sub>      | —                         | 0.25 | —    |
| b                   | 0.15                      | 0.22 | 0.3  |
| c                   | 0.1                       | 0.13 | 0.15 |
| D                   | 1.8                       | 2.0  | 2.2  |
| E                   | 1.15                      | 1.25 | 1.35 |
| e                   | —                         | 0.65 | —    |
| H <sub>E</sub>      | 1.8                       | 2.1  | 2.4  |
| L                   | 0.3                       | —    | 0.7  |
| L <sub>1</sub>      | 0.1                       | —    | 0.5  |
| L <sub>P</sub>      | 0.2                       | —    | 0.6  |
| x                   | —                         | —    | 0.05 |
| y                   | —                         | —    | 0.05 |
| Q                   | —                         | 0.25 | —    |

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## Taping & Reel Specification

### [Taping]

| Package Code | W | P | Ao   | Bo   | Ko  | E    | F   | D1   | Maximum Storage No. |
|--------------|---|---|------|------|-----|------|-----|------|---------------------|
| MPAK-5       | 8 | 4 | 3.3  | 3.3  | 1.5 | 1.75 | 3.5 | 1.05 | 3,000 pcs/reel      |
| CMPAK-5      | 8 | 4 | 2.25 | 2.45 | 1.1 | 1.75 | 3.5 | 1.05 | 3,000 pcs/reel      |

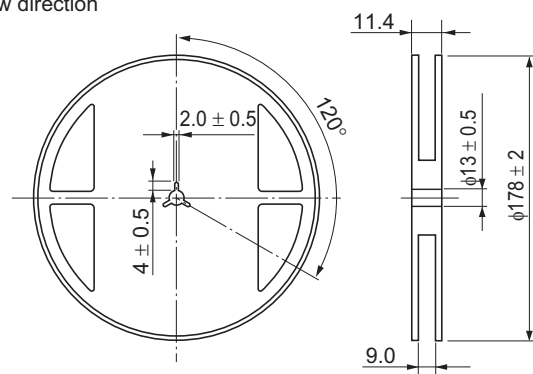


### [Reel]

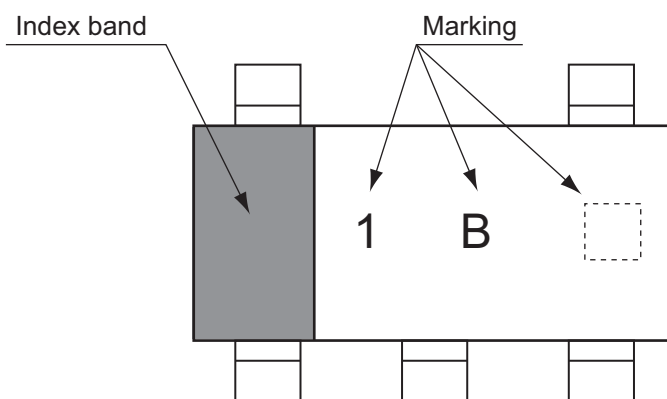
| Package | Tape width | W1   | W2 |
|---------|------------|------|----|
| MPAK-5  | 8          | 11.4 | 9  |
| CMPAK-5 | 8          | 11.4 | 9  |

### [Ordering Information]

| Ordering Unit |
|---------------|
| 3,000 pcs     |



## Mark Indication



1 A □ : HA1630S01

1 B □ : HA1630S02

1 C □ : HA1630S03

□ = Control code  
(— or blank)



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