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April 1st, 2010
Renesas Electronics Corporation

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HA1630S04/05/06 Series

Ultra-Small Low Voltage Operation CMOS Single Operational Amplifier

REJ03D0799-0100

Rev.1.00

Mar 10, 2006

Description

The HA1630S04/05/06 are high slew rate 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.

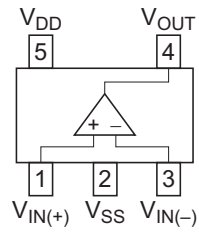
Features

- 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 $I_{DD} = 200$ μ A Typ (HA1630S04)
 $I_{DD} = 400$ μ A Typ (HA1630S05)
 $I_{DD} = 800$ μ A Typ (HA1630S06)
- High slew rate $SR = 2$ V/ μ s Typ (HA1630S04)
 $SR = 4$ V/ μ s Typ (HA1630S05)
 $SR = 8$ V/ μ s Typ (HA1630S06)
- Maximum output voltage $V_{OH} = 2.9$ V Min (at $V_{DD} = 3.0$ V)
- Low input bias current $I_{IB} = 1$ pA Typ

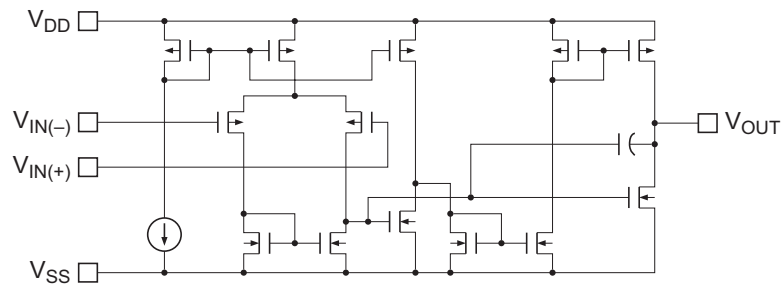
Ordering Information

Type No.	Package Name	Package Code
HA1630S04CM	CMPAK-5	PTSP0005ZC-A
HA1630S04LP	MPAK-5	PLSP0005ZB-A
HA1630S05CM	CMPAK-5	PTSP0005ZC-A
HA1630S05LP	MPAK-5	PLSP0005ZB-A
HA1630S06CM	CMPAK-5	PTSP0005ZC-A
HA1630S06LP	MPAK-5	PLSP0005ZB-A

Pin Arrangement



Equivalent Circuit



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	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_{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 = 100 kΩ
Output source current	I _{O SOURCE}	100	200	—	μA	V _{OH} = 2.5 V (HA1630S04)
		200	400	—		V _{OH} = 2.5 V (HA1630S05)
		400	800	—		V _{OH} = 2.5 V (HA1630S06)
Output low voltage	V _{OL}	—	—	0.1	V	R _L = 100 kΩ
Output sink current	I _{O SINK}	—	(5.0)	—	mA	V _{OL} = 0.5 V (HA1630S04)
		—	(6.0)	—		V _{OL} = 0.5 V (HA1630S05)
		—	(6.5)	—		V _{OL} = 0.5 V (HA1630S06)
Common mode input voltage range	V _{CM}	−0.05 to 2.1	—	—	V	(HA1630S04, HA1630S05)
		0 to 1.9	—	—		(HA1630S06)
Slew rate	SR	—	(2.0)	—	V/μs	C _L = 20 pF (HA1630S04)
		—	(4.0)	—		C _L = 20 pF (HA1630S05)
		—	(8.0)	—		C _L = 20 pF (HA1630S06)
Voltage gain	A _V	60	90	—	dB	
Gain bandwidth product	BW	—	(2.1)	—	MHz	C _L = 20 pF (HA1630S04)
		—	(3.3)	—		C _L = 20 pF (HA1630S05)
		—	(3.6)	—		C _L = 20 pF (HA1630S06)
Power supply rejection ratio	PSRR	50	70	—	dB	
Common mode rejection ratio	CMRR	50	70	—	dB	
Supply current	I _{DD}	—	200	400	μA	R _L = ∞ (HA1630S04)
		—	400	800		R _L = ∞ (HA1630S05)
		—	800	1700		R _L = ∞ (HA1630S06)

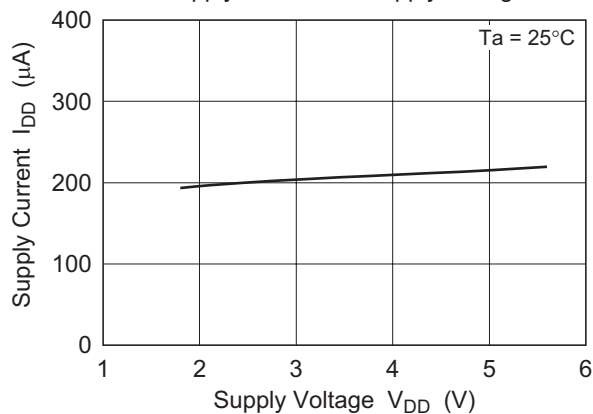
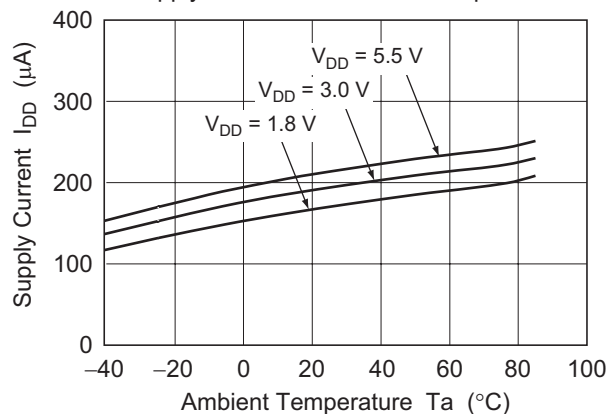
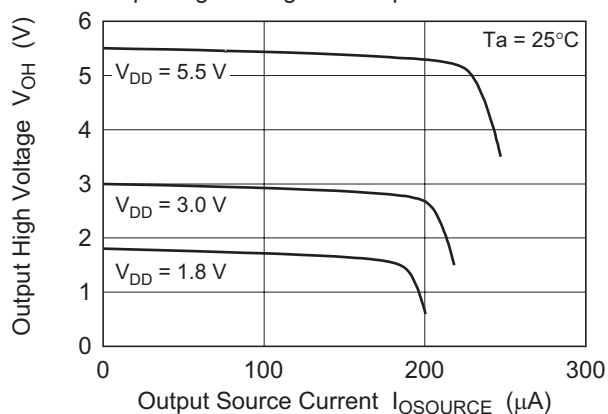
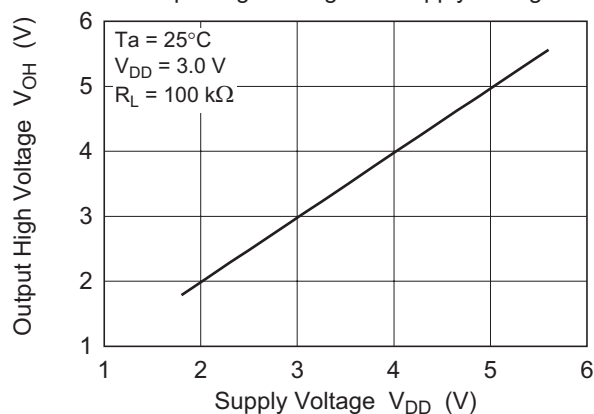
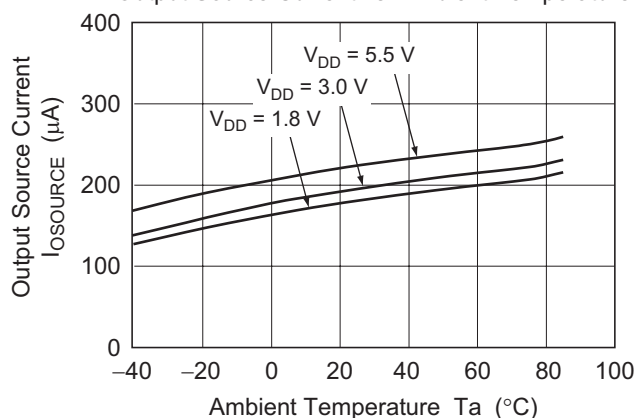
Notes: 1. In the case of continuous current flow, use a sink current of under 4 mA.

2. () : Design specification

Table of Graphs

Electrical Characteristics			HA1630S04 Figure	HA1630S05 Figure	HA1630S06 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	1-21	2-21	3-21	8
	(40 dB)	vs. Output voltage p-p	1-22	2-22	3-22	
Maximum p-p output voltage		vs Frequency	1-23	2-23	3-23	
Voltage noise density		vs Frequency	1-24	2-24	3-24	

Main Characteristics (HA1630S04)

Figure 1-1. HA1630S04
Supply Current vs. Supply VoltageFigure 1-2. HA1630S04
Supply Current vs. Ambient TemperatureFigure 1-3. HA1630S04
Output High Voltage vs. Output Source CurrentFigure 1-4. HA1630S04
Output High Voltage vs. Supply VoltageFigure 1-5. HA1630S04
Output Source Current vs. Ambient Temperature

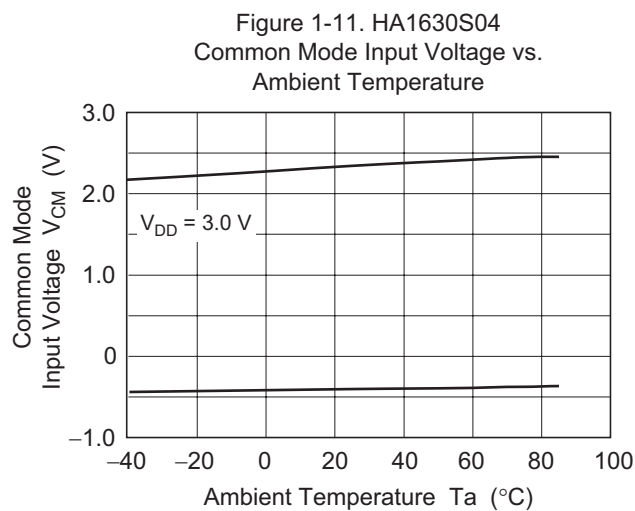
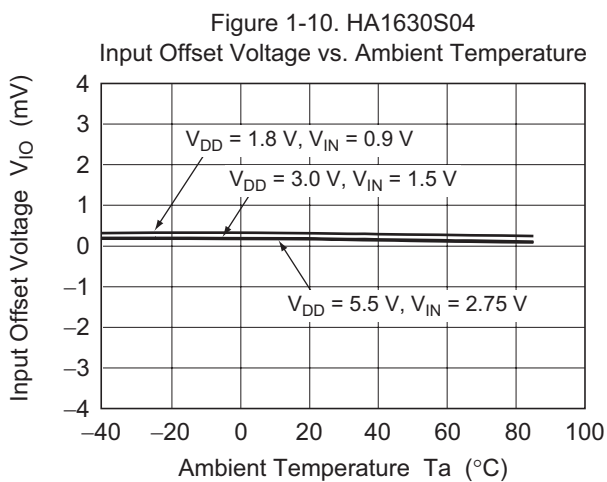
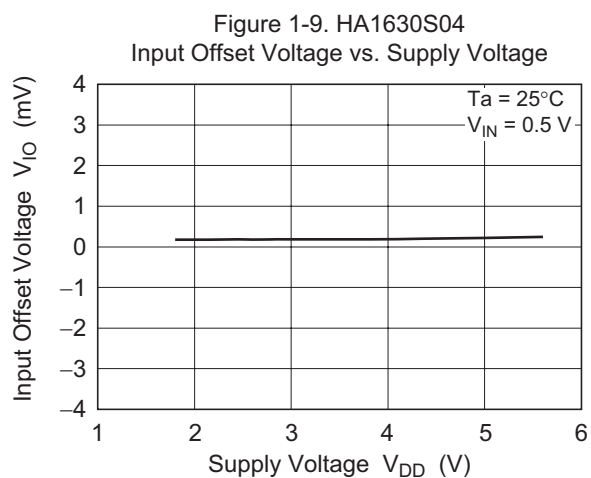
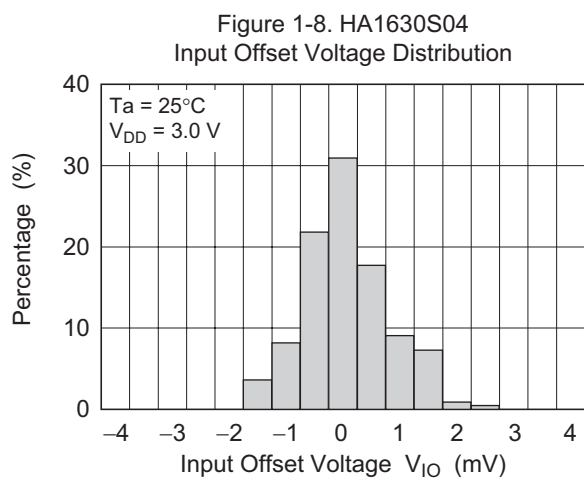
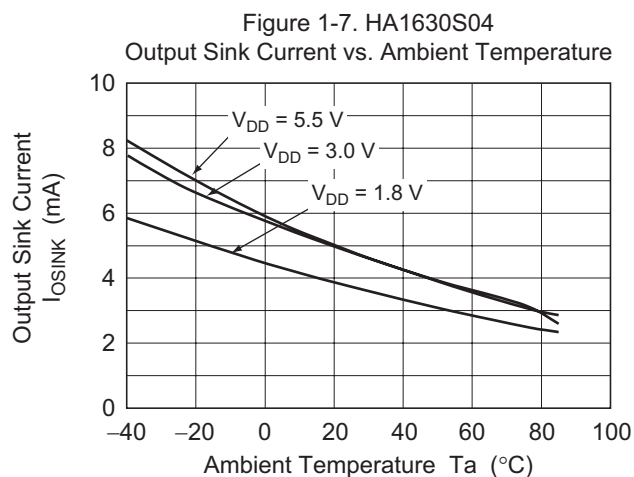
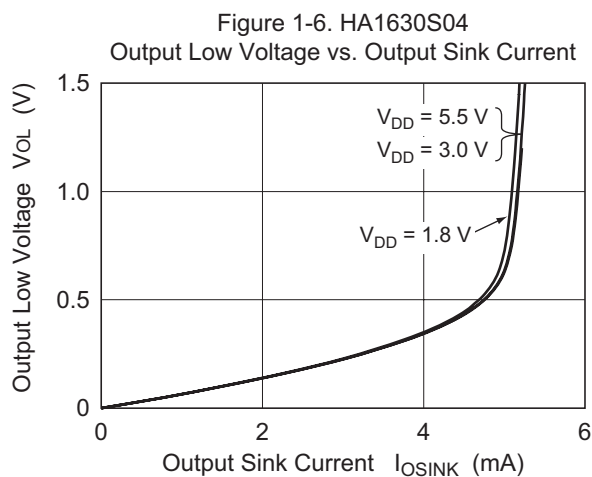


Figure 1-12. HA1630S04
Power Supply Rejection Ratio vs. Frequency

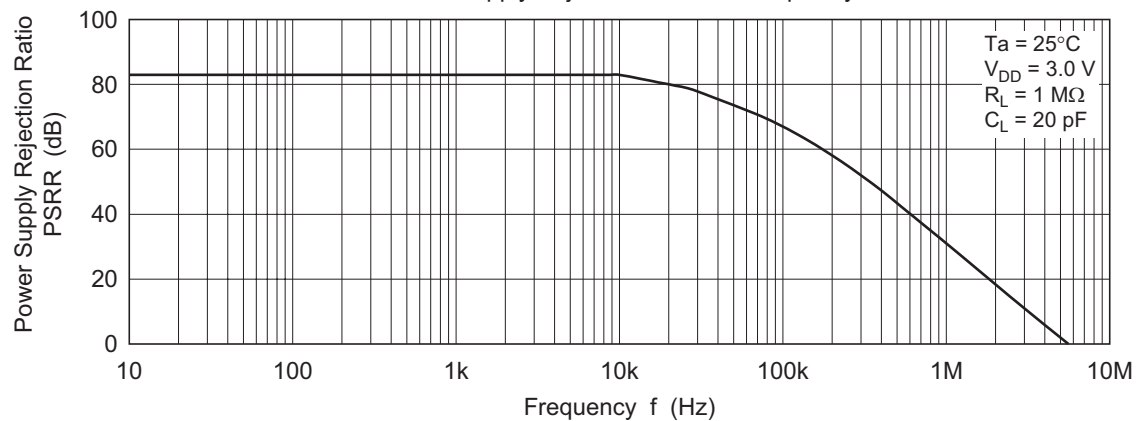


Figure 1-13. HA1630S04
Common Mode Rejection Ratio vs. Frequency

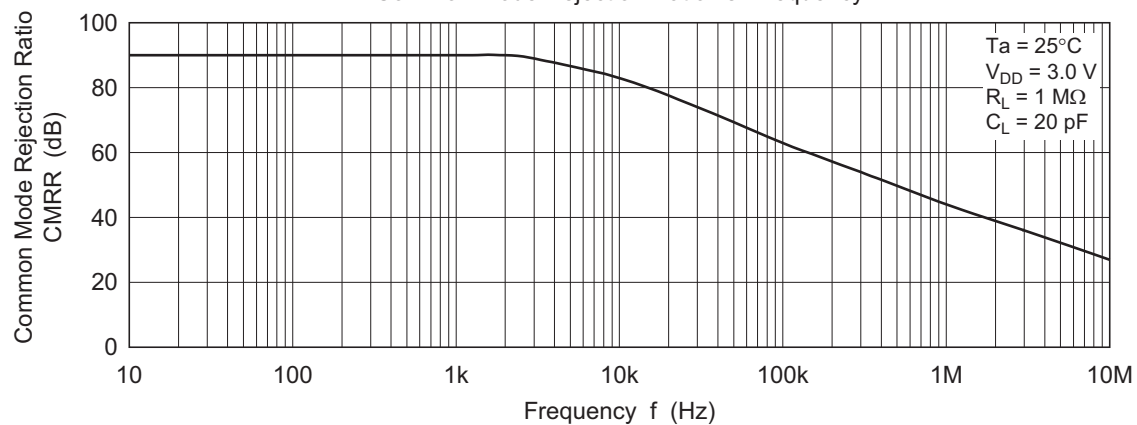
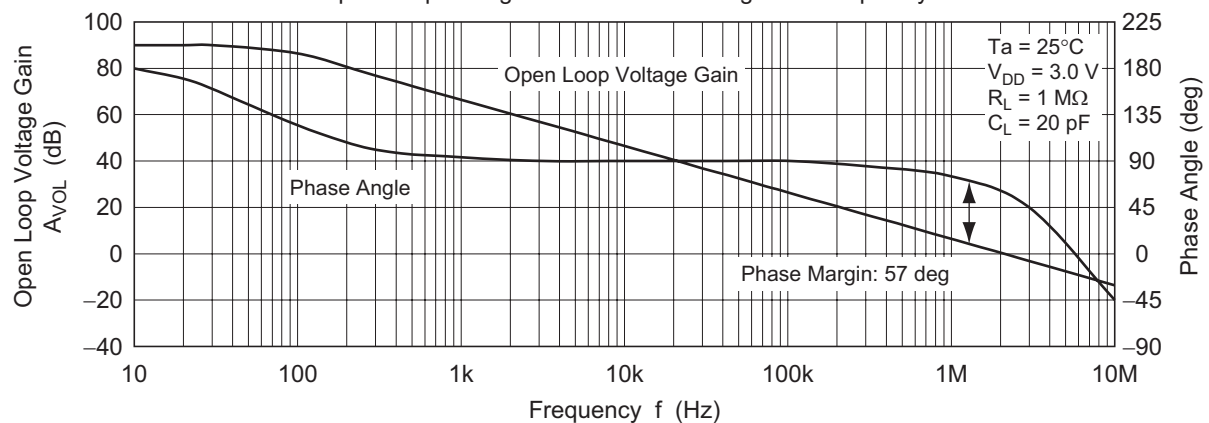


Figure 1-14. HA1630S04
Open Loop Voltage Gain and Phase Angle vs. Frequency



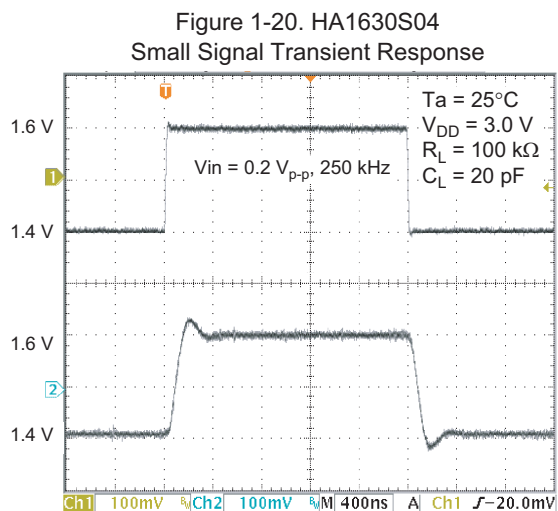
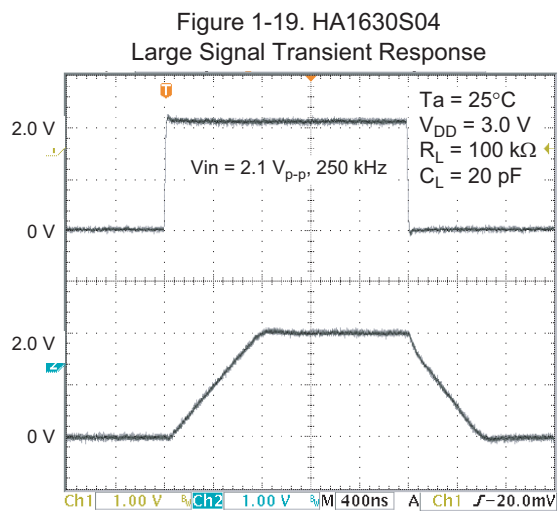
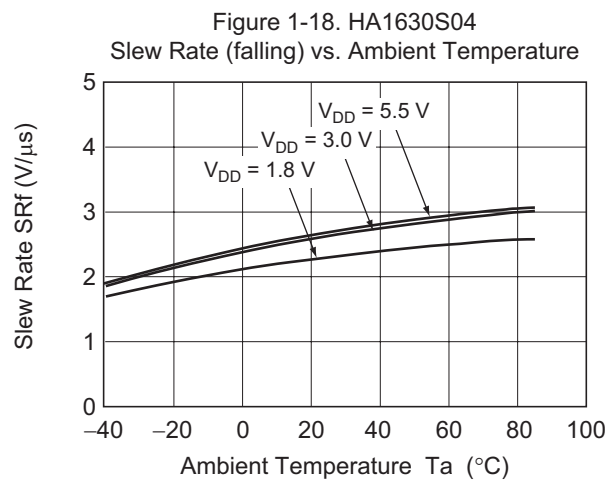
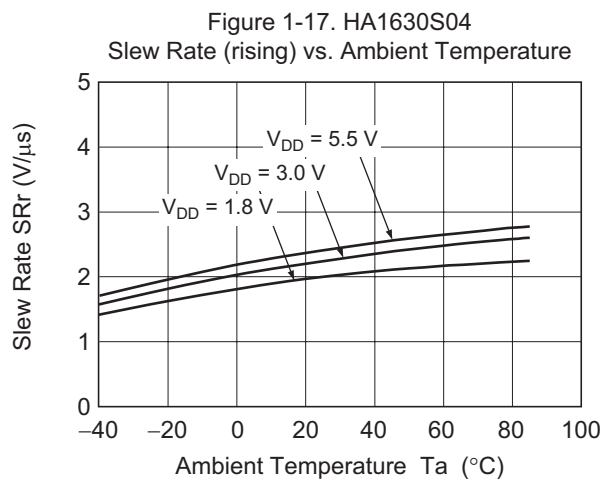
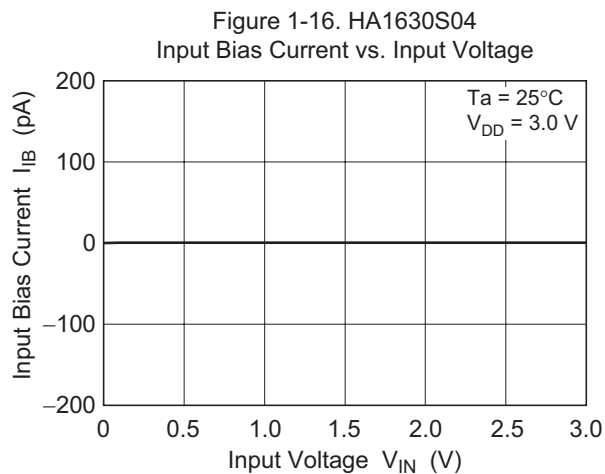
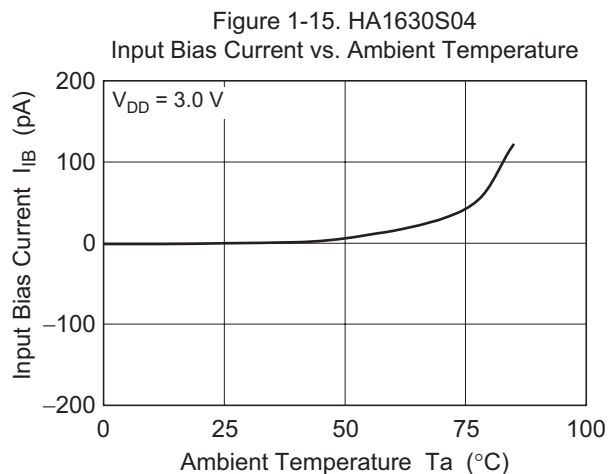


Figure 1-21. HA1630S04
Total Harmonic Distortion + Noise vs.
Output Voltage p-p

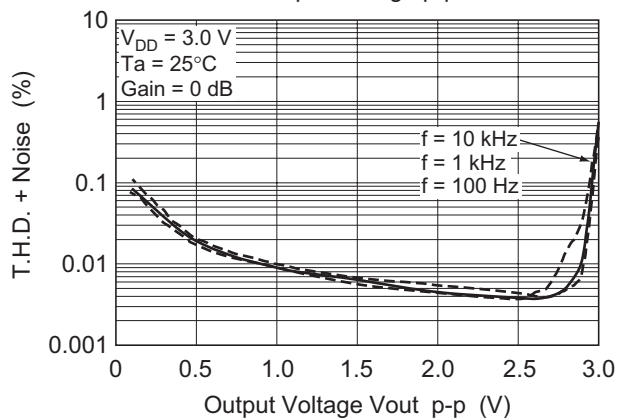


Figure 1-22. HA1630S04
Total Harmonic Distortion + Noise vs.
Output Voltage p-p

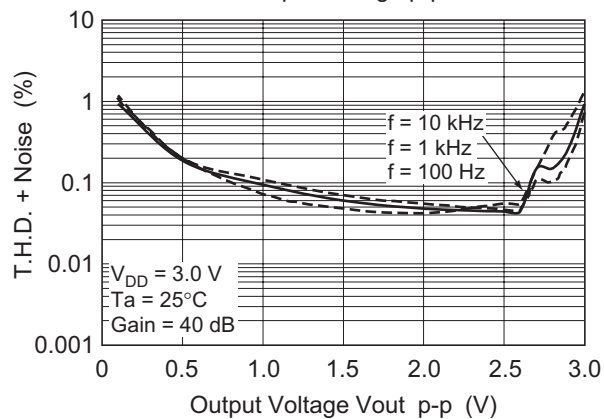


Figure 1-23. HA1630S04
Voltage Output p-p vs. Frequency

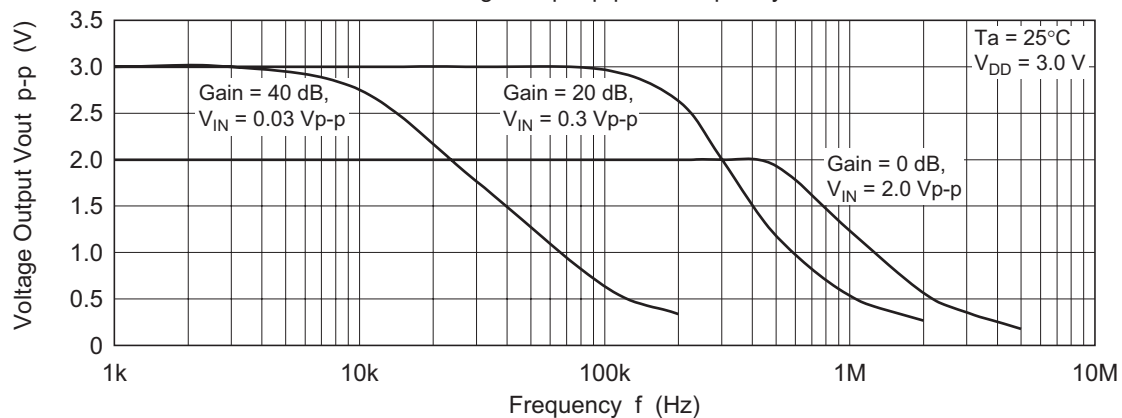
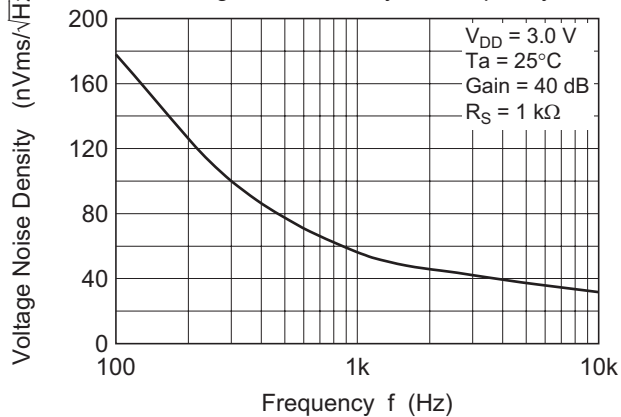
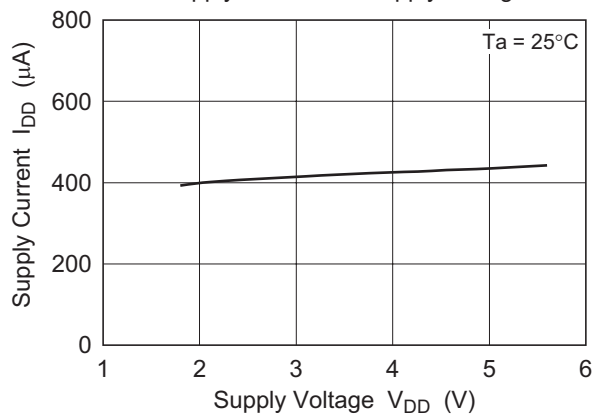
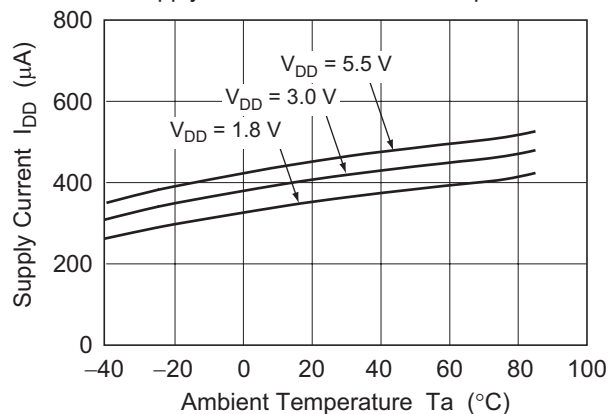
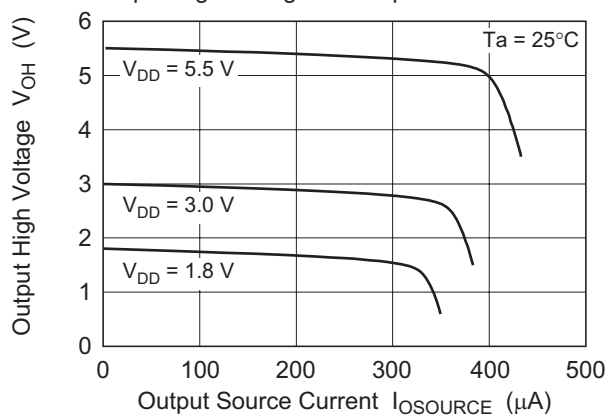
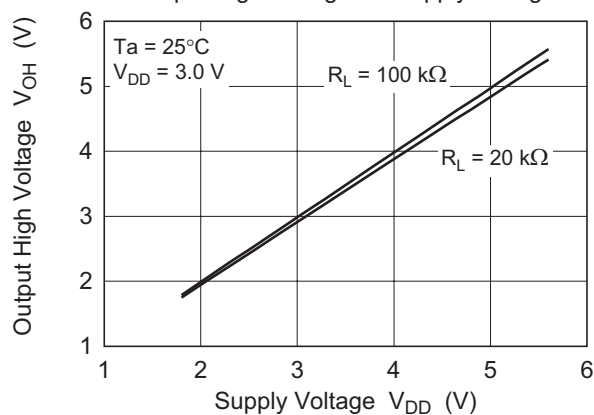
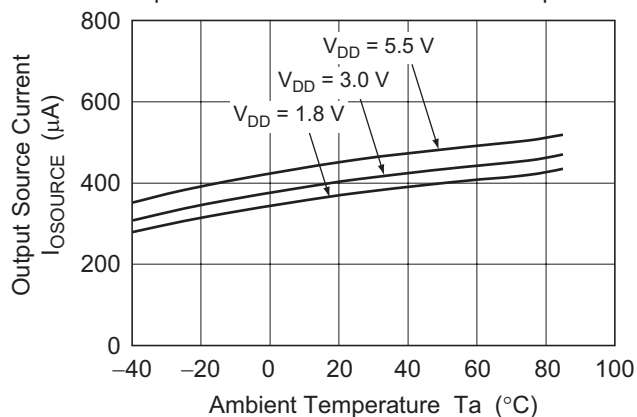


Figure 1-24. HA1630S04
Voltage Noise Density vs. Frequency



Main Characteristics (HA1630S05)

Figure 2-1. HA1630S05
Supply Current vs. Supply VoltageFigure 2-2. HA1630S05
Supply Current vs. Ambient TemperatureFigure 2-3. HA1630S05
Output High Voltage vs. Output Source CurrentFigure 2-4. HA1630S05
Output High Voltage vs. Supply VoltageFigure 2-5. HA1630S05
Output Source Current vs. Ambient Temperature

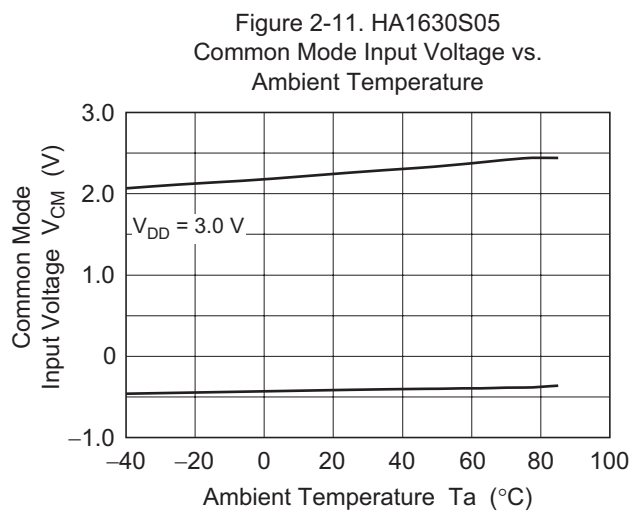
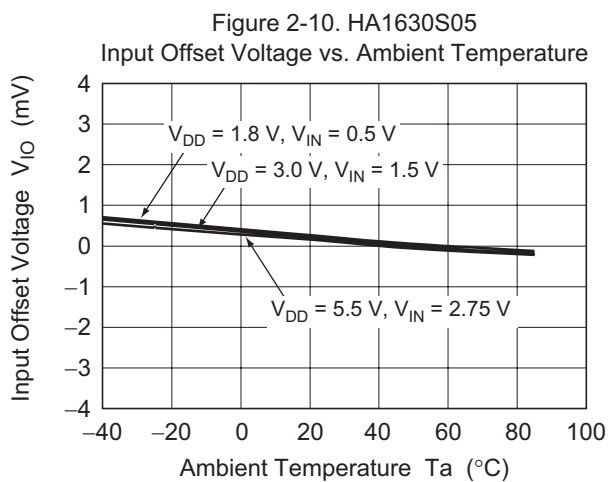
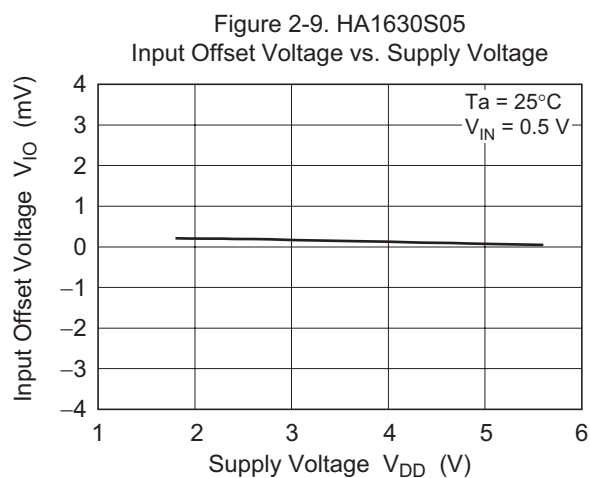
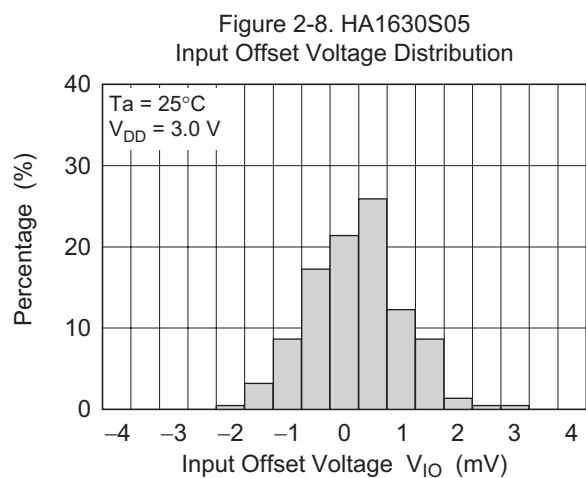
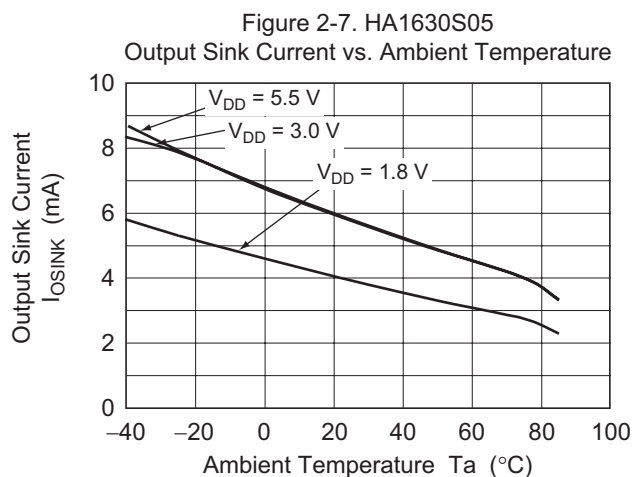
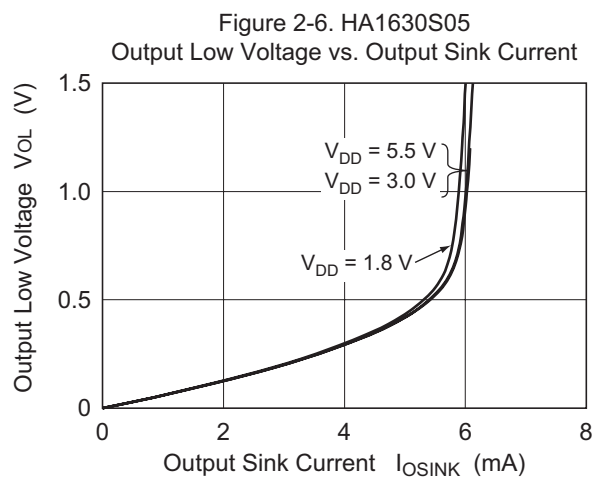


Figure 2-12. HA1630S05
Power Supply Rejection Ratio vs. Frequency

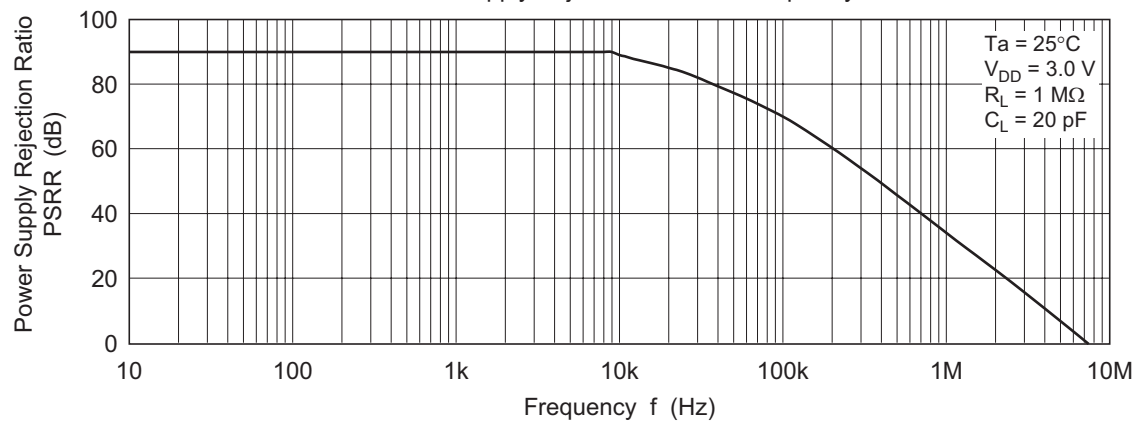


Figure 2-13. HA1630S05
Common Mode Rejection Ratio vs. Frequency

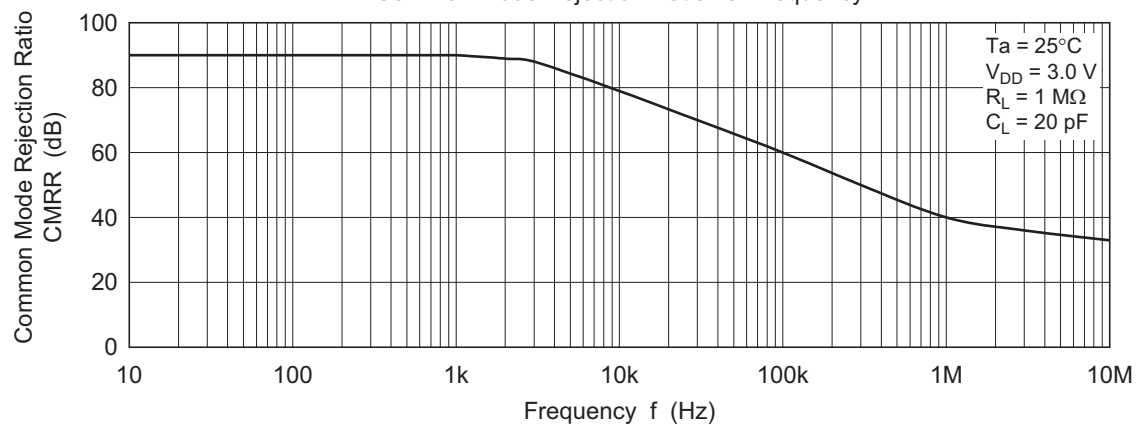
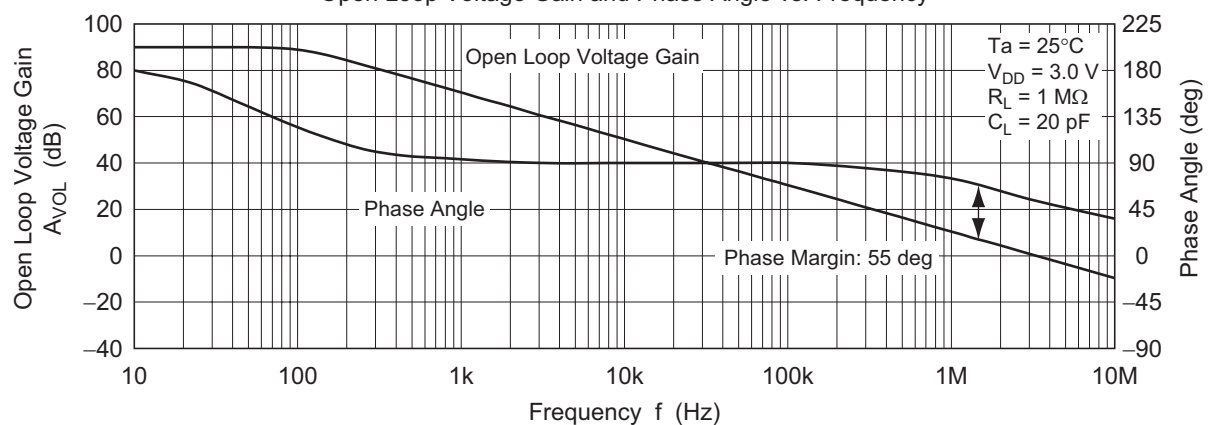


Figure 2-14. HA1630S05
Open Loop Voltage Gain and Phase Angle vs. Frequency



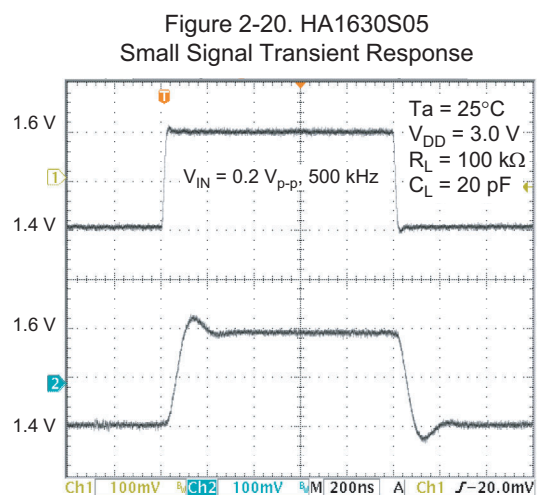
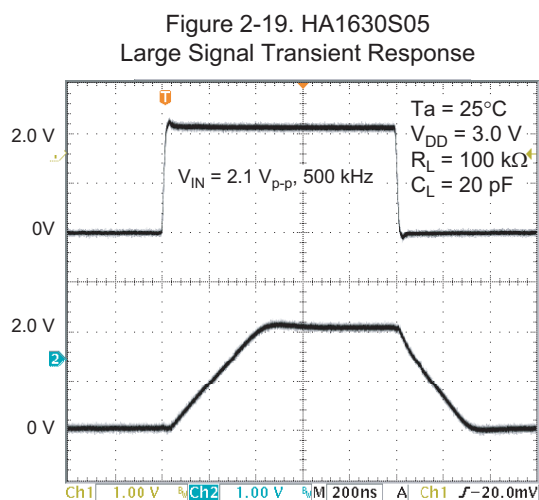
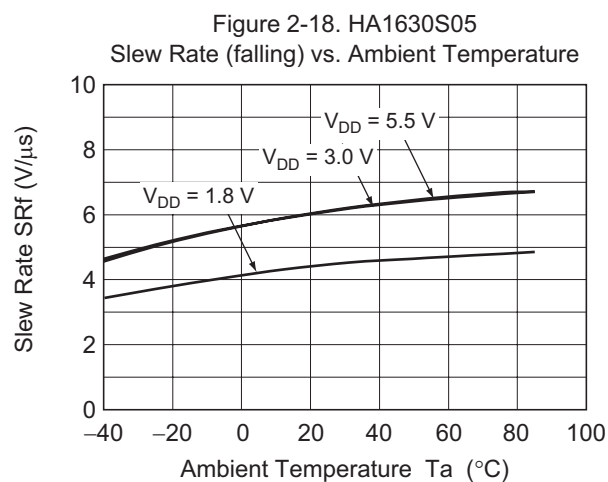
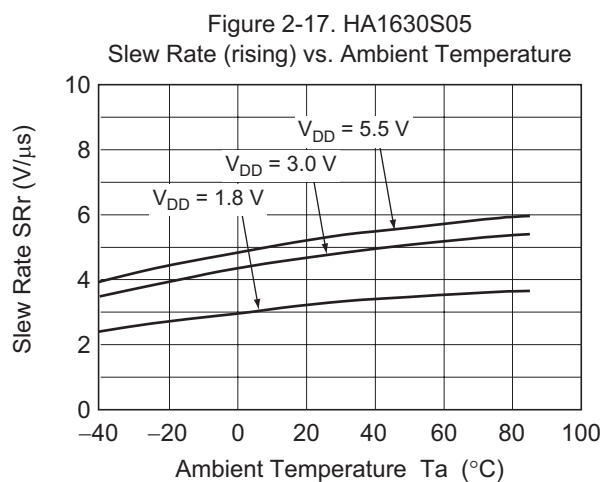
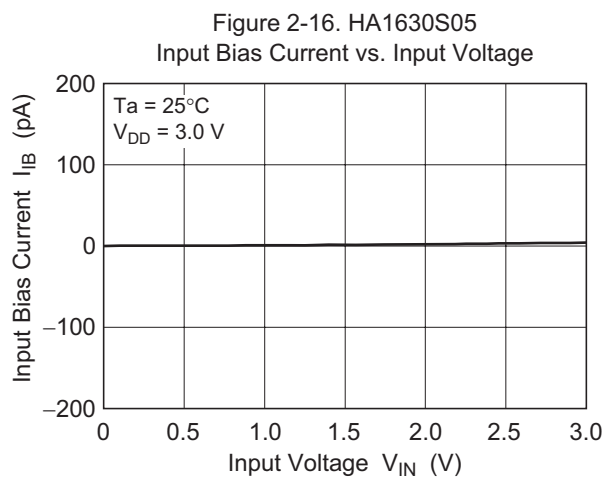
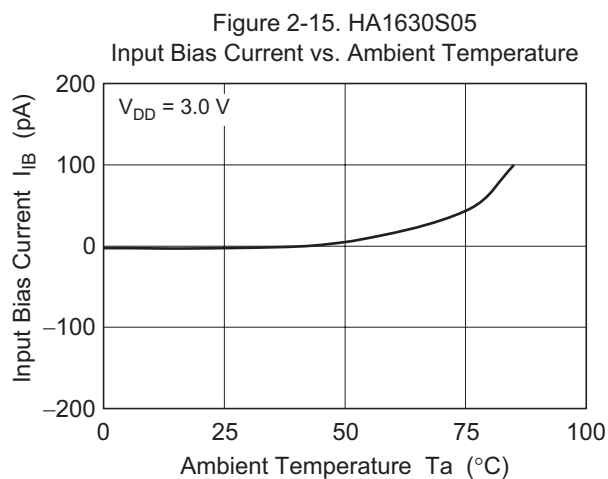


Figure 2-21. HA1630S05
Total Harmonic Distortion + Noise vs.
Output Voltage p-p

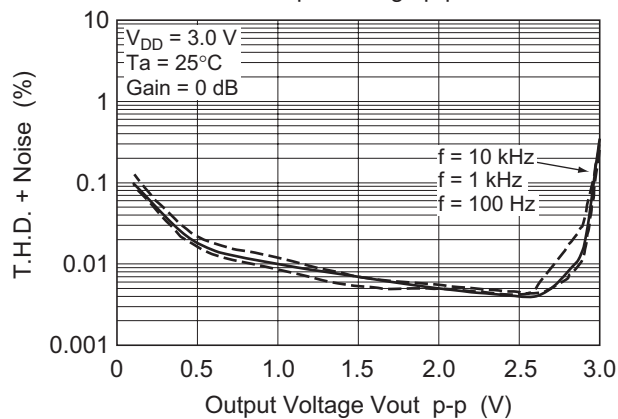


Figure 2-22. HA1630S05
Total Harmonic Distortion + Noise vs.
Output Voltage p-p

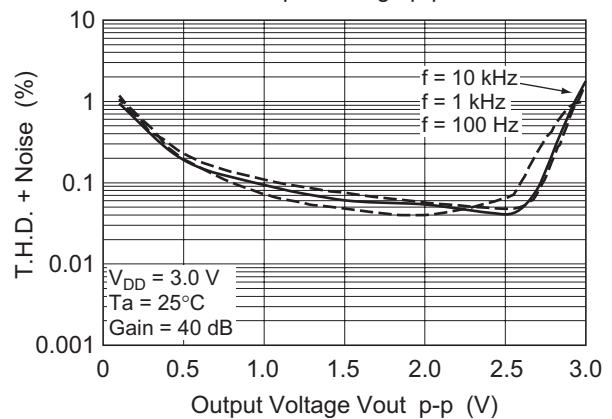


Figure 2-23. HA1630S05
Voltage Output p-p vs. Frequency

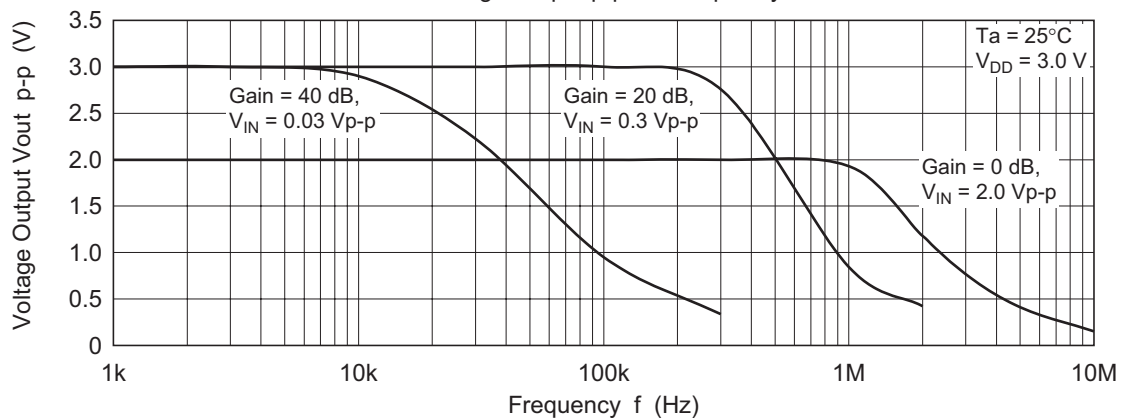
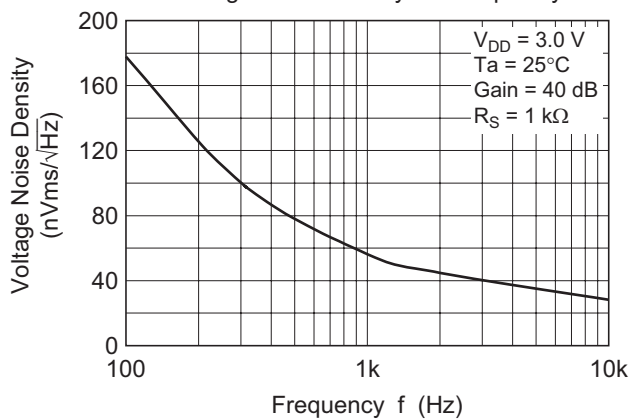
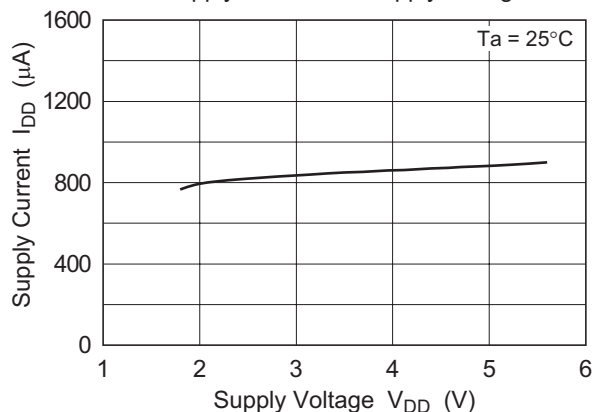
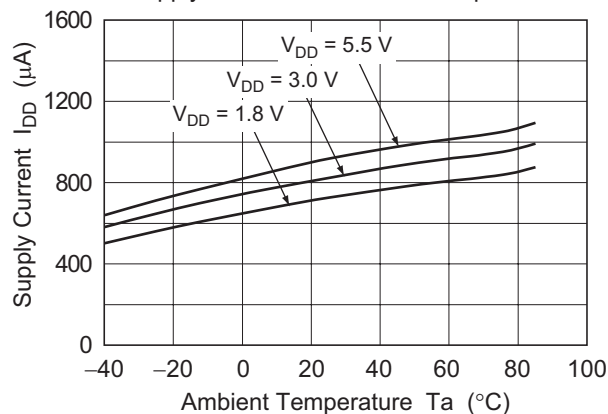
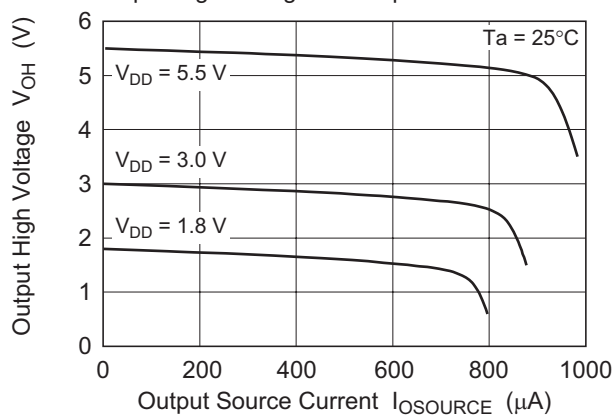
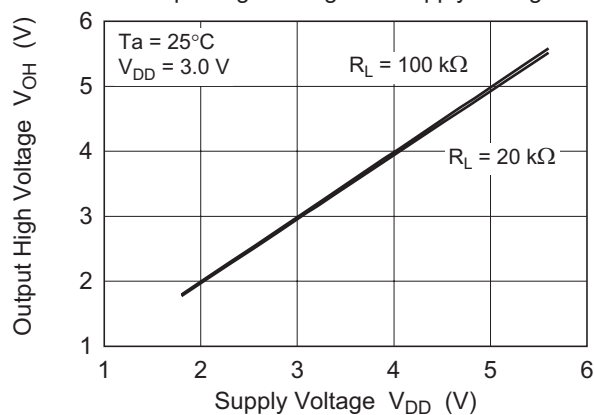
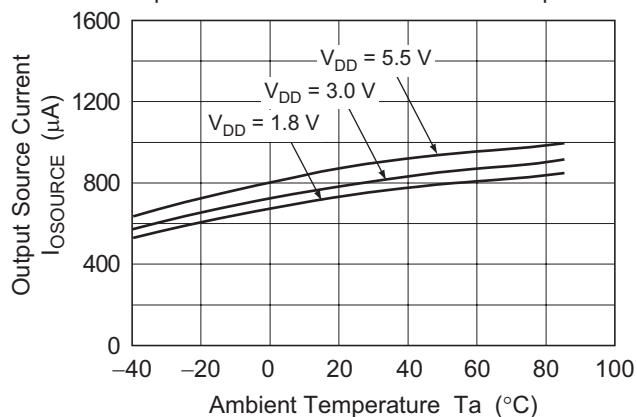


Figure 2-24. HA1630S05
Voltage Noise Density vs. Frequency



Main Characteristics (HA1630S06)

Figure 3-1. HA1630S06
Supply Current vs. Supply VoltageFigure 3-2. HA1630S06
Supply Current vs. Ambient TemperatureFigure 3-3. HA1630S06
Output High Voltage vs. Output Source CurrentFigure 3-4. HA1630S06
Output High Voltage vs. Supply VoltageFigure 3-5. HA1630S06
Output Source Current vs. Ambient Temperature

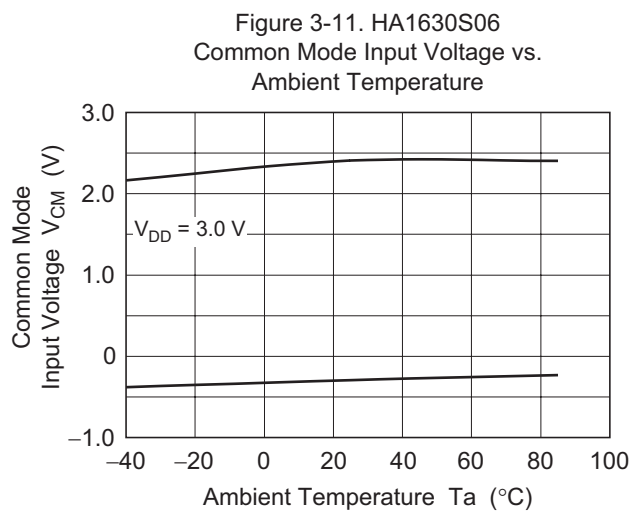
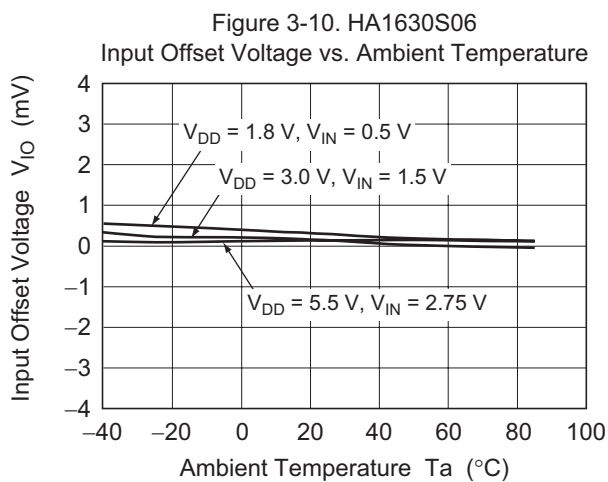
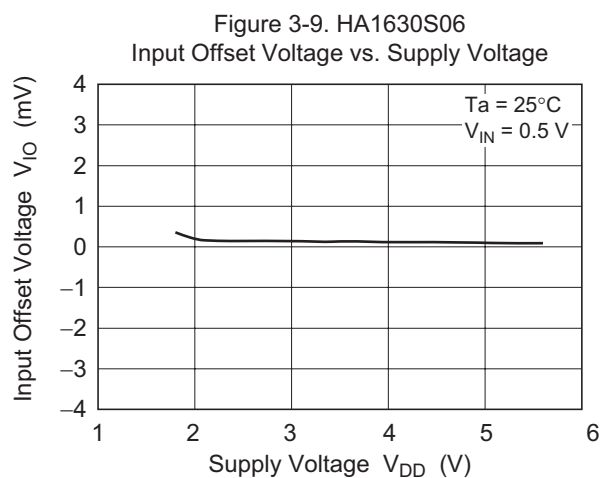
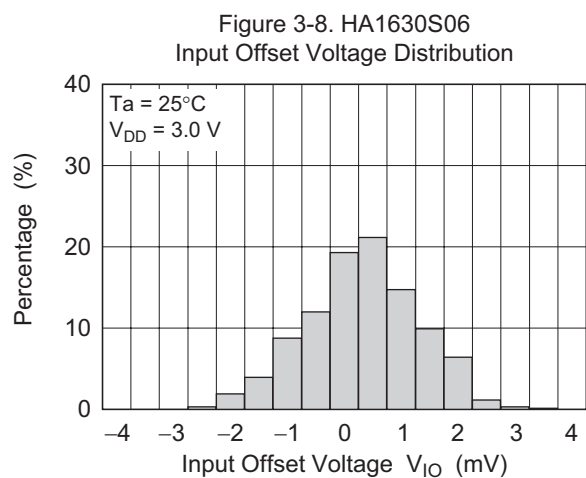
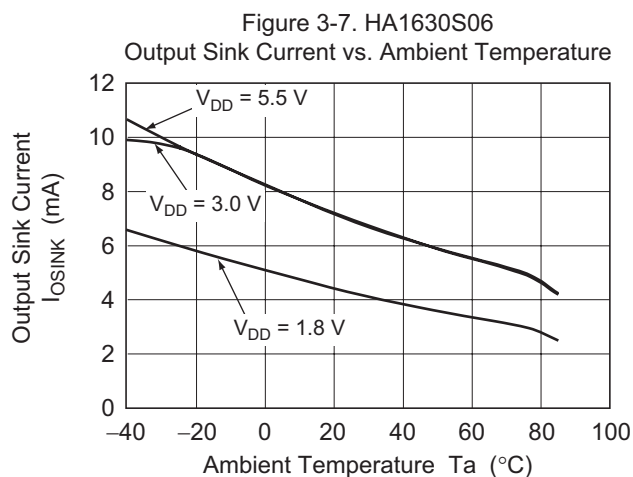
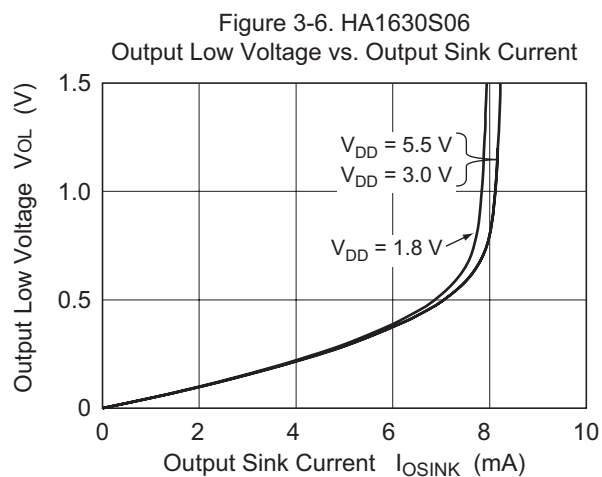


Figure 3-12. HA1630S06
Power Supply Rejection Ratio vs. Frequency

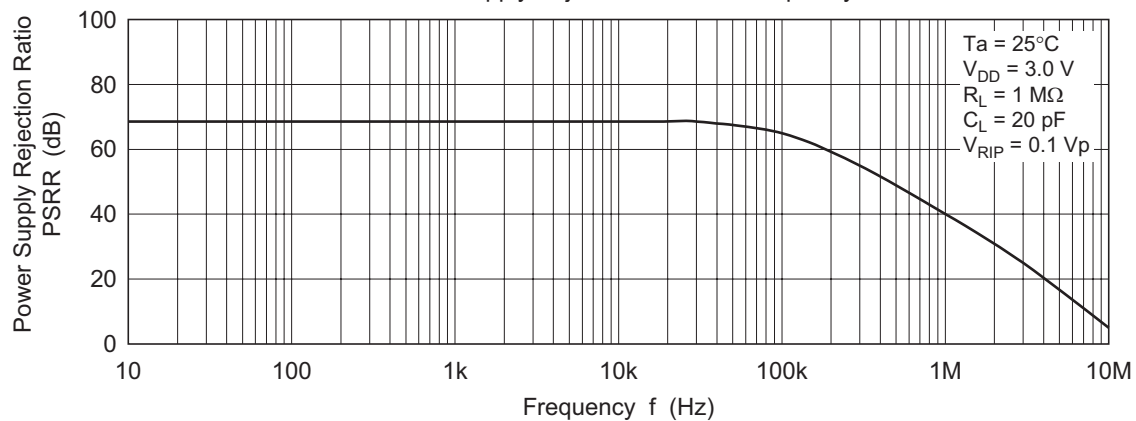


Figure 3-13. HA1630S06
Common Mode Rejection Ratio vs. Frequency

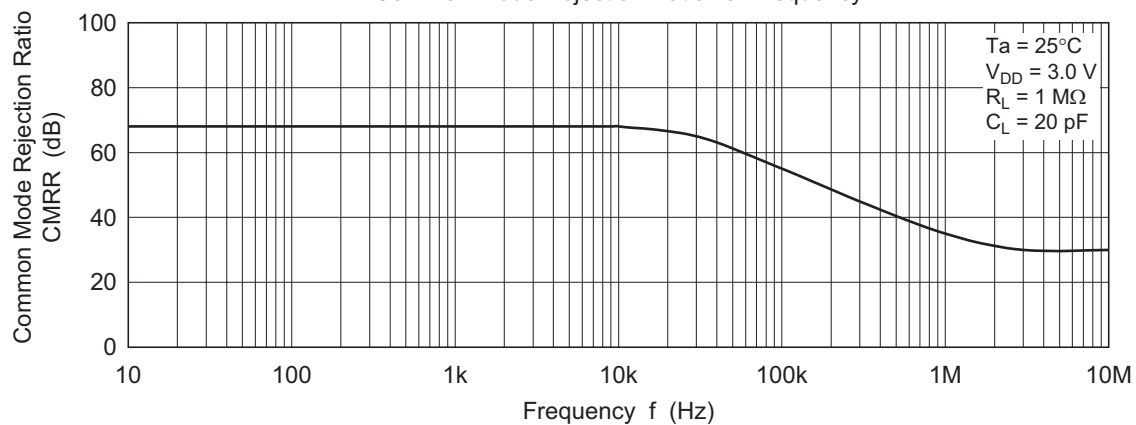
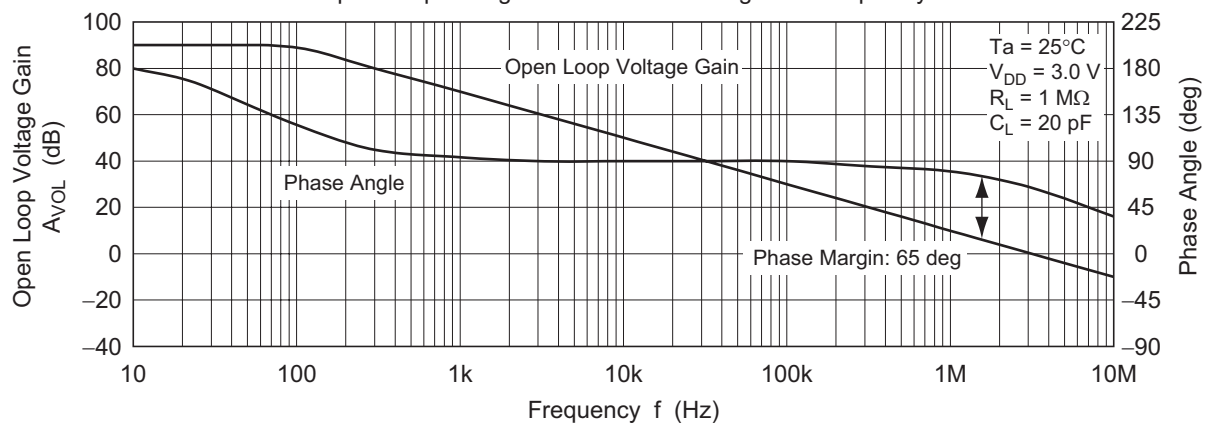


Figure 3-14. HA1630S06
Open Loop Voltage Gain and Phase Angle vs. Frequency



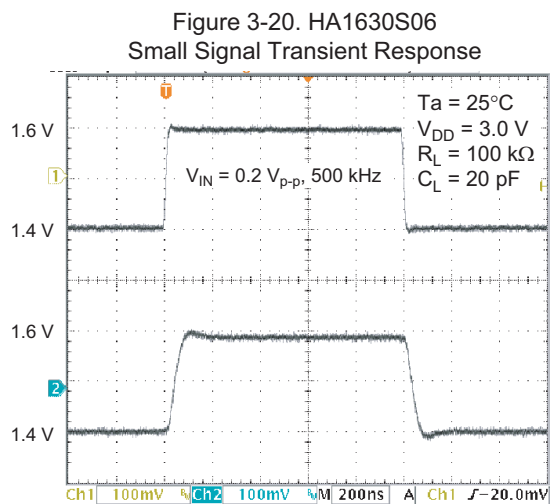
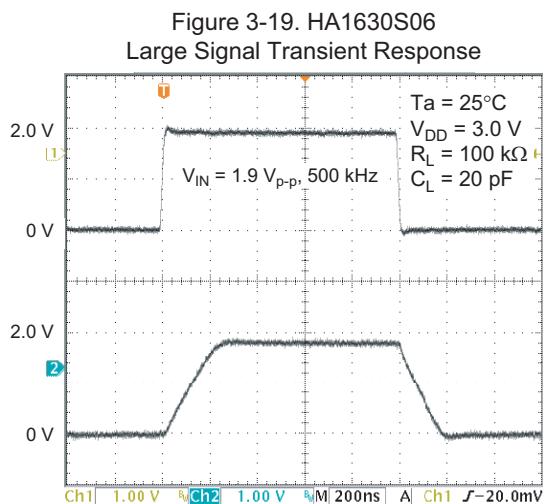
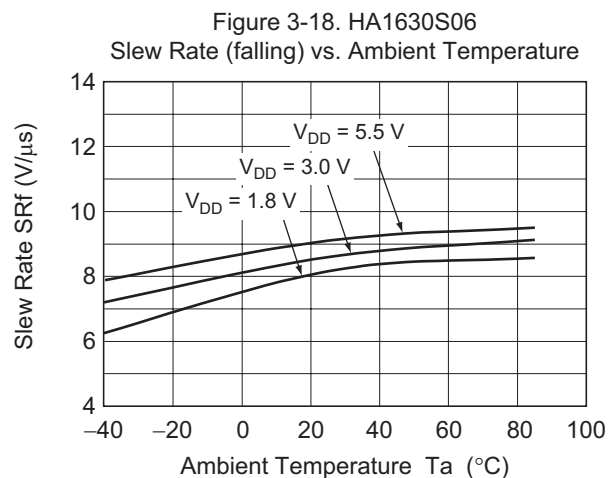
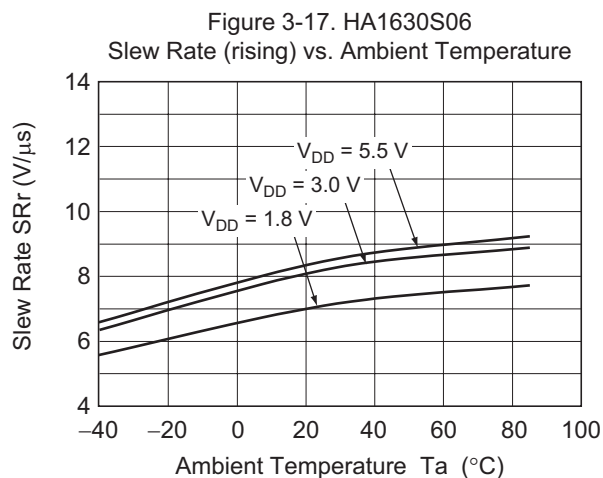
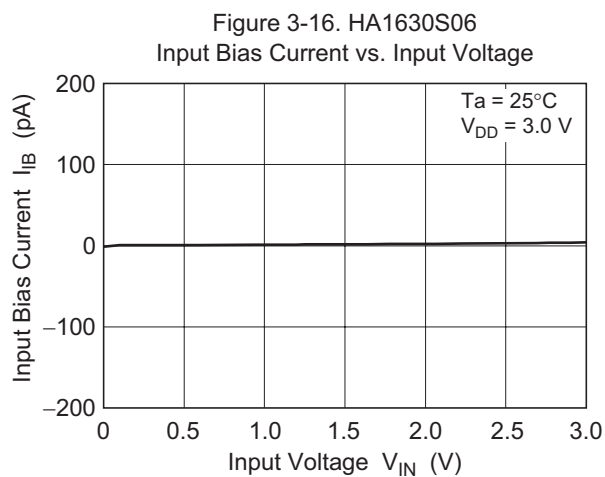
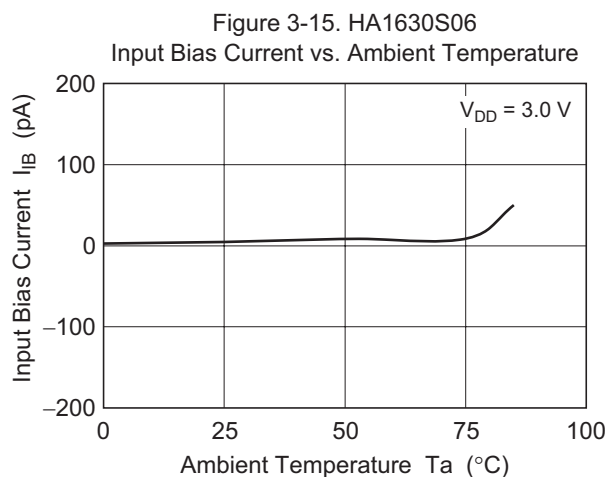


Figure 3-21. HA1630S06
Total Harmonic Distortion + Noise vs.
Output Voltage p-p

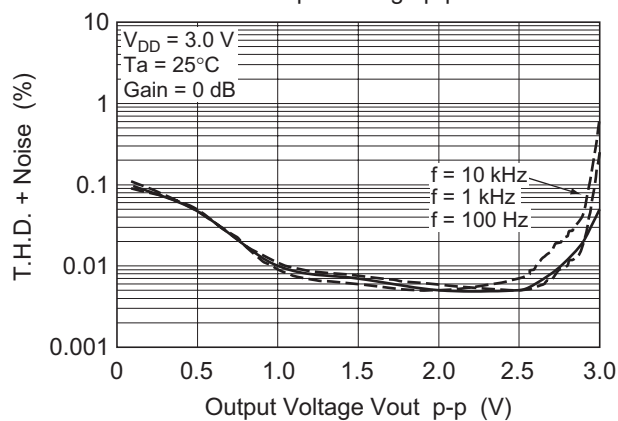


Figure 3-22. HA1630S06
Total Harmonic Distortion + Noise vs.
Output Voltage p-p

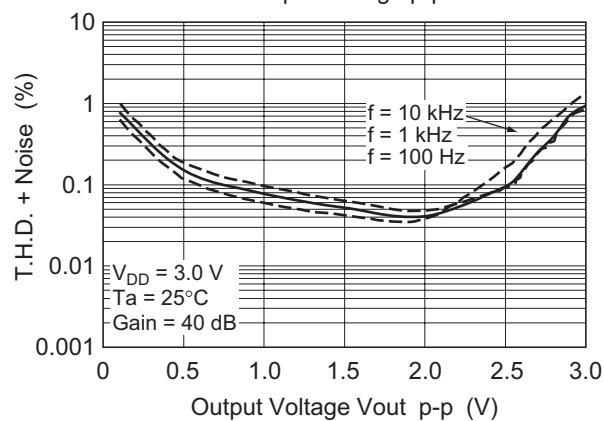


Figure 3-23. HA1630S06
Voltage Output p-p vs. Frequency

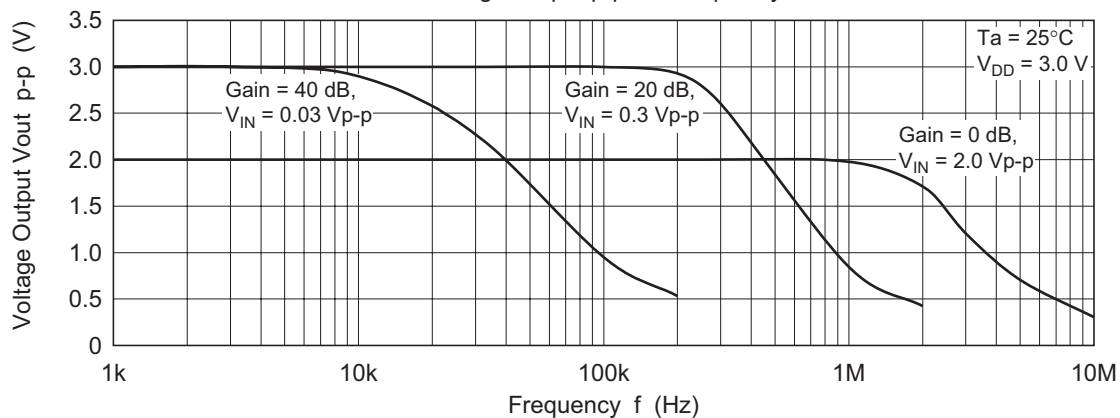
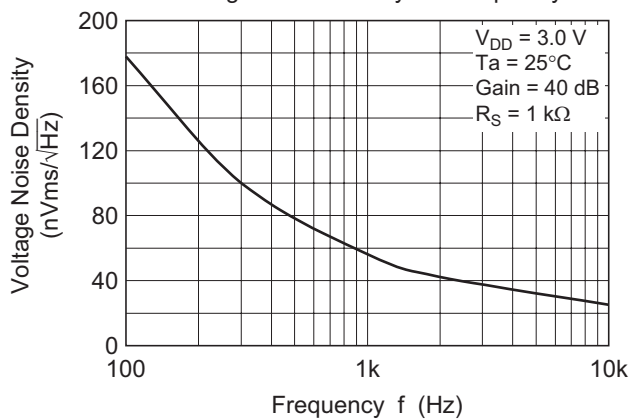
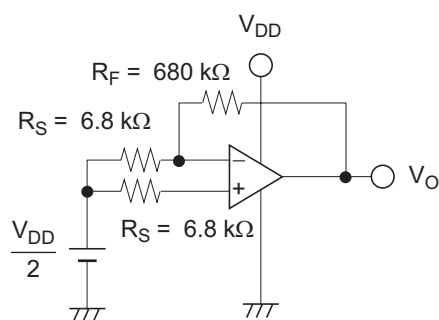


Figure 3-24. HA1630S06
Voltage Noise Density vs. Frequency



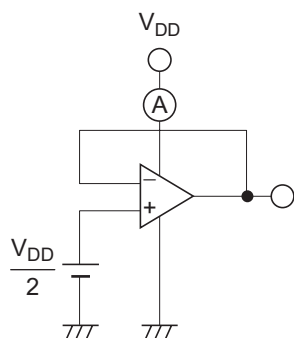
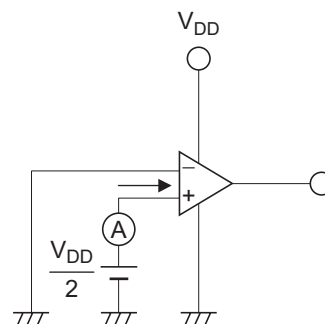
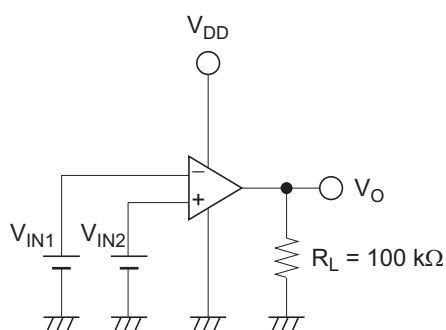
Test Circuits

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

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

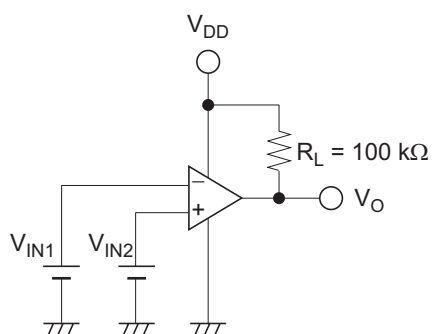
$$\text{PSRR} = -20 \log \left(\left| \frac{V_{DD1} - V_{DD2}}{V_{O1} - V_{O2}} \right| \times \frac{R_S}{R_S + R_F} \right)$$

Measure V_O corresponding to $V_{DD1} = 2.95 \text{ V}$ and $V_{DD2} = 3.05 \text{ V}$

2. Supply Current, I_{DD} 3. Input Bias Current, I_{IB} 4. Output High Voltage, V_{OH} 

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

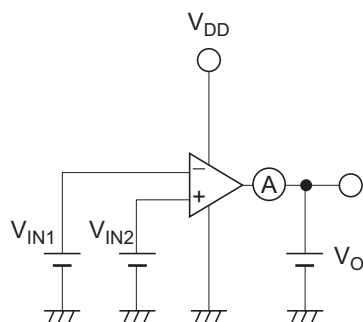
$$V_{IN2} = V_{DD} / 2 + 0.05 \text{ V}$$

5. Output Low Voltage, V_{OL} 

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

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

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



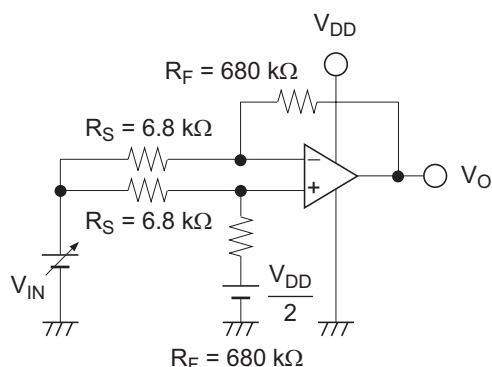
$I_{OSOURCE}$

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

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

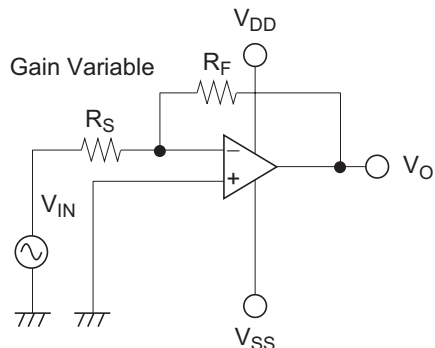


CMRR

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

Measure V_O corresponding to $V_{IN1} = 1.45 \text{ V}$ and $V_{IN2} = 1.55 \text{ V}$

8. Total Harmonic Distortion, THD

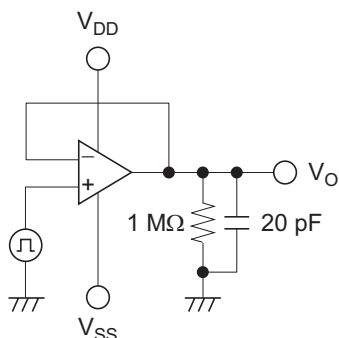


THD

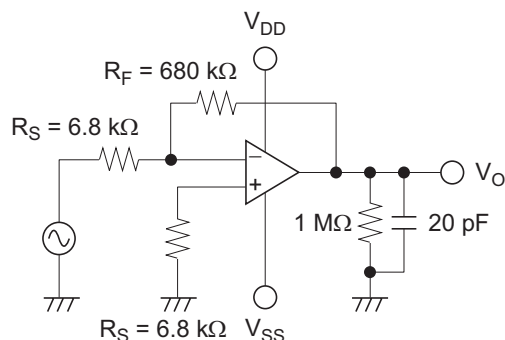
Gain Variable

$$\begin{aligned} R_F / R_S &= 20 \log (100 \text{ k}\Omega / 1 \text{ k}\Omega) = 40 \text{ dB} \\ R_F / R_S &= 20 \log (100 \text{ k}\Omega / 100 \text{ k}\Omega) = 0 \text{ dB} \\ \text{freq} &= 100 \text{ Hz, } 1 \text{ kHz, } 10 \text{ kHz} \\ 30 \text{ kHz LPF ON} \end{aligned}$$

9. Slew Rate, SR

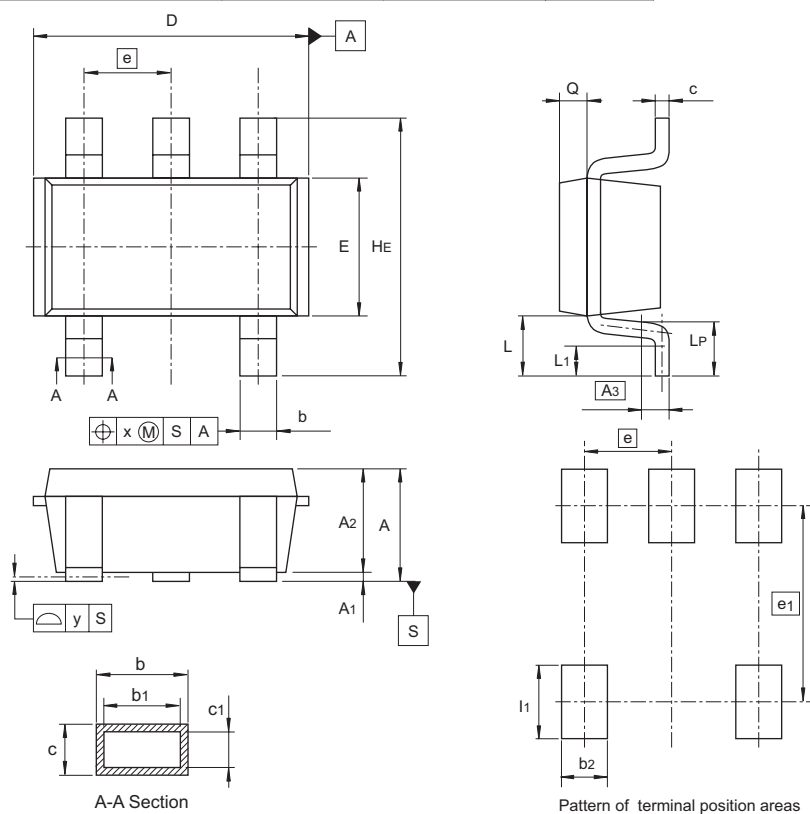


10. Gain, A_V & Phase, GBW



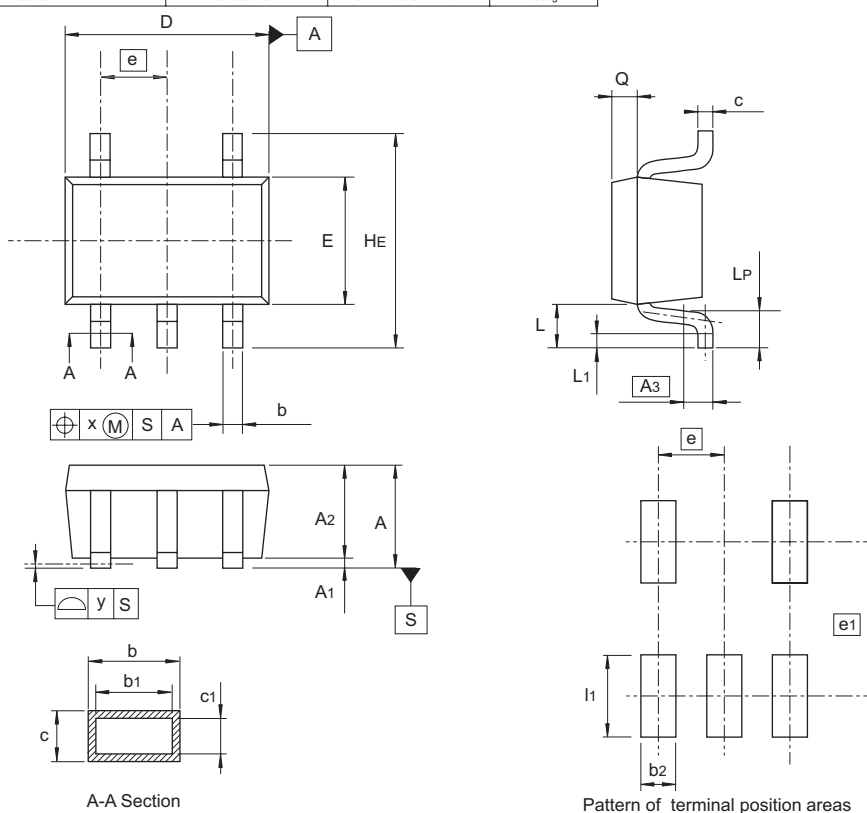
Package Dimensions

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



Reference Symbol	Dimension in Millimeters		
	Min	Nom	Max
A	1.0	—	1.3
A ₁	0	—	0.1
A ₂	1.0	1.1	1.2
A ₃	—	0.25	—
b	0.35	0.42	0.5
b ₁	—	0.4	—
c	0.1	0.13	0.15
c ₁	—	0.11	—
D	2.8	2.95	3.1
E	1.5	1.6	1.8
e	—	0.95	—
HE	2.5	2.8	3.0
L	0.3	—	0.7
L ₁	0.1	—	0.5
L _P	0.2	—	0.6
x	—	—	0.05
y	—	—	0.05
b ₂	—	—	0.55
e ₁	—	2.15	—
l ₁	—	—	0.85
Q	—	0.3	—

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

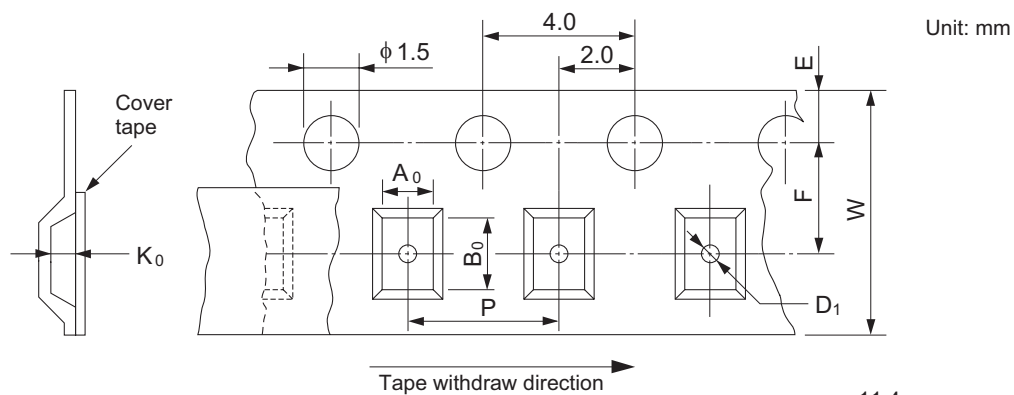


Reference Symbol	Dimension in Millimeters		
	Min	Nom	Max
A	0.8	—	1.1
A ₁	0	—	0.1
A ₂	0.8	0.9	1.0
A ₃	—	0.25	—
b	0.15	0.22	0.3
b ₁	—	0.2	—
c	0.1	0.13	0.15
c ₁	—	0.11	—
D	1.8	2.0	2.2
E	1.15	1.25	1.35
e	—	0.65	—
HE	1.8	2.1	2.4
L	0.3	—	0.7
L ₁	0.1	—	0.5
L _P	0.2	—	0.6
x	—	—	0.05
y	—	—	0.05
b ₂	—	—	0.35
e ₁	—	1.5	—
l ₁	—	—	0.9
Q	—	0.25	—

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

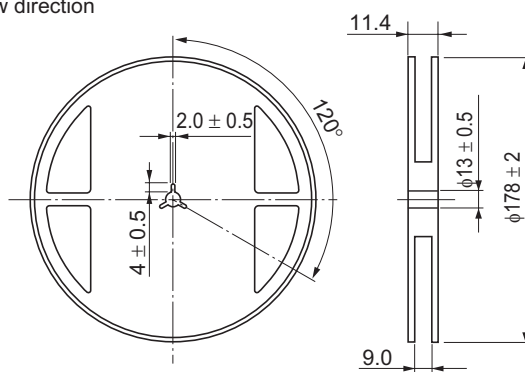


[Reel]

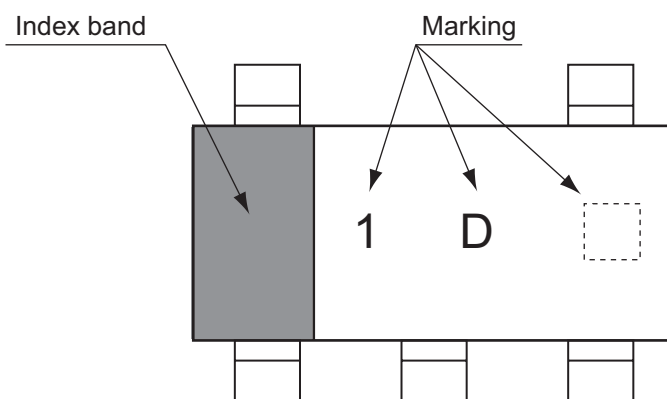
Package	Tape width	W1	W2
MPAK-5	8	11.4	9
CMPAK-5	8	11.4	9

[Ordering Information]

Ordering Unit
3,000 pcs



Mark Indication



1 D □ : HA1630S04

1 E □ : HA1630S05

1 F □ : HA1630S06

□ = Control code
(— or blank)

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