HA1630S04/05/06 Series

Ultra-Small Low Voltage Operation CMOS Single Operational Amplifier

R03DS0082EJ0200
Rev.2.00
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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.

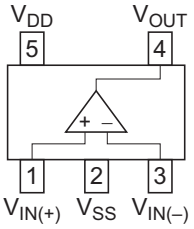
Features

- 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 µA Typ (HA1630S04)
  I_{DD} = 400 µA Typ (HA1630S05)
  I_{DD} = 800 µA Typ (HA1630S06)
- High slew rate — SR = 2 V/µs Typ (HA1630S04)
  SR = 4 V/µs Typ (HA1630S05)
  SR = 8 V/µs 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

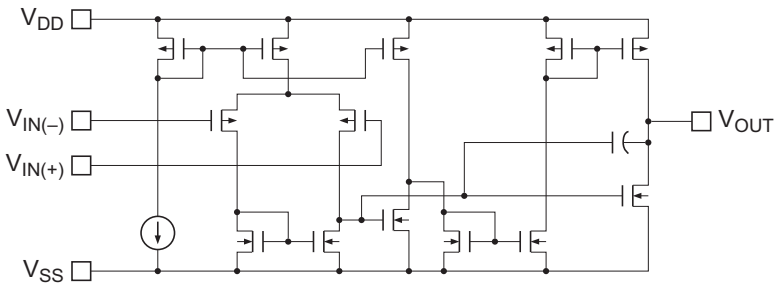
Ordering Information

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	Vin = 1.5 V
Input offset current	I_{IO}	—	(1.0)	—	pA	Vin = 1.5 V
Input bias current	I_{IB}	—	(1.0)	—	pA	Vin = 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 Voltage

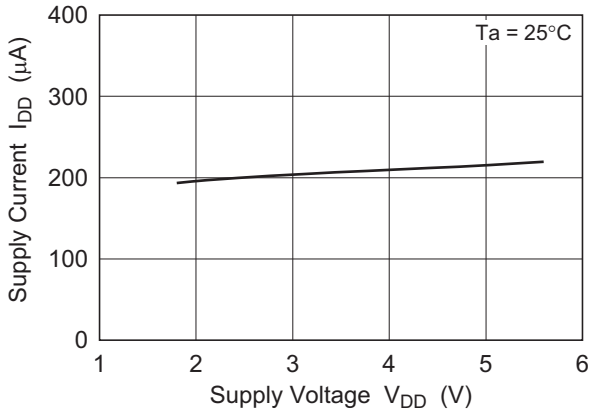


Figure 1-2. HA1630S04
Supply Current vs. Ambient Temperature

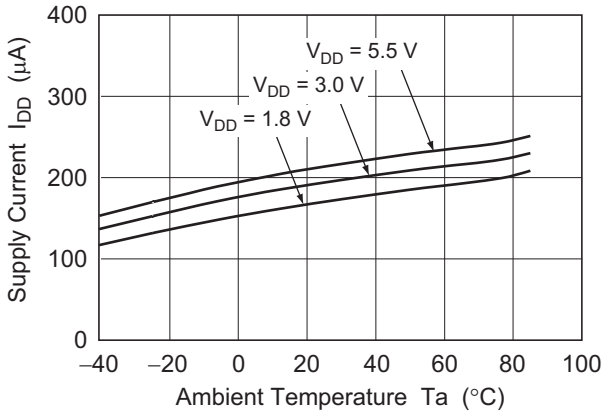


Figure 1-3. HA1630S04
Output High Voltage vs. Output Source Current

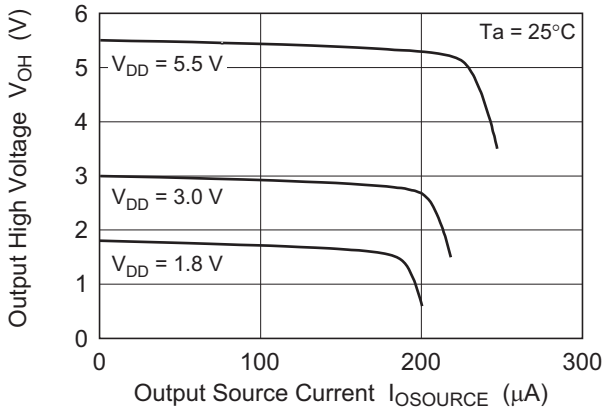


Figure 1-4. HA1630S04
Output High Voltage vs. Supply Voltage

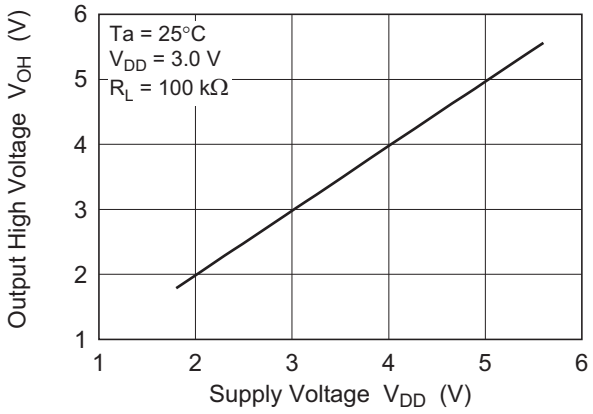


Figure 1-5. HA1630S04
Output Source Current vs. Ambient Temperature

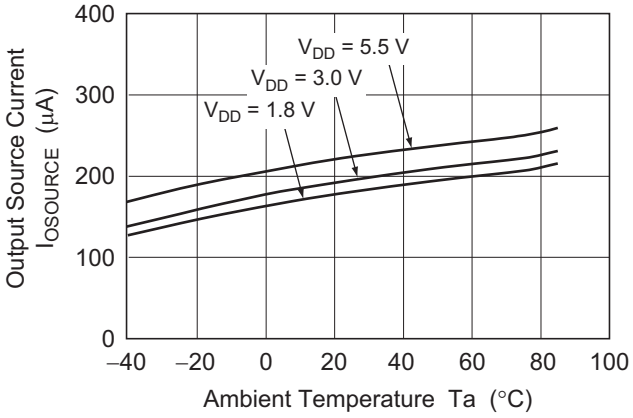


Figure 1-6. HA1630S04
Output Low Voltage vs. Output Sink Current

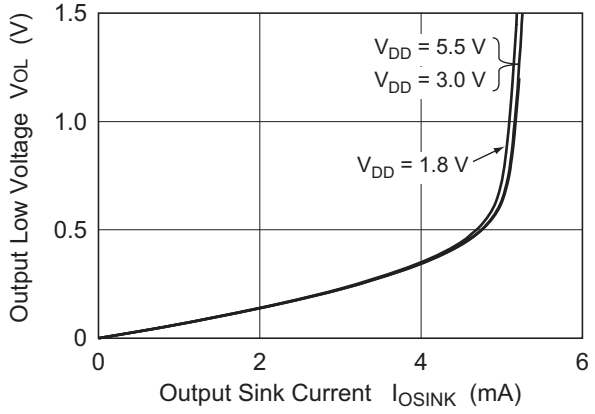


Figure 1-7. HA1630S04
Output Sink Current vs. Ambient Temperature

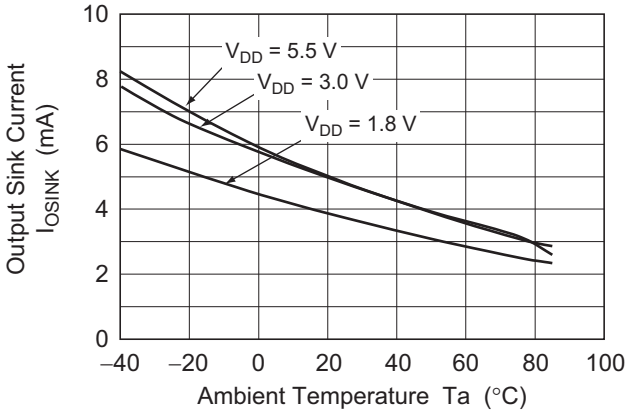


Figure 1-8. HA1630S04
Input Offset Voltage Distribution

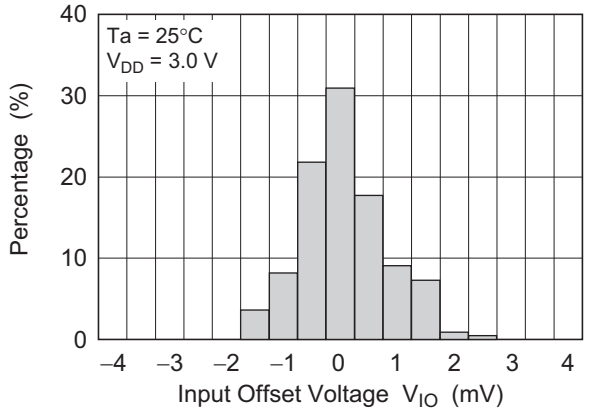


Figure 1-9. HA1630S04
Input Offset Voltage vs. Supply Voltage

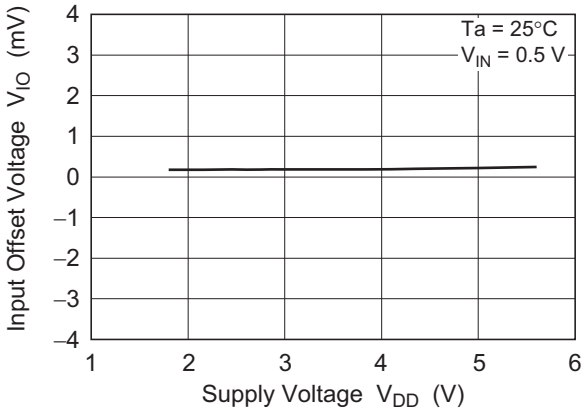


Figure 1-10. HA1630S04
Input Offset Voltage vs. Ambient Temperature

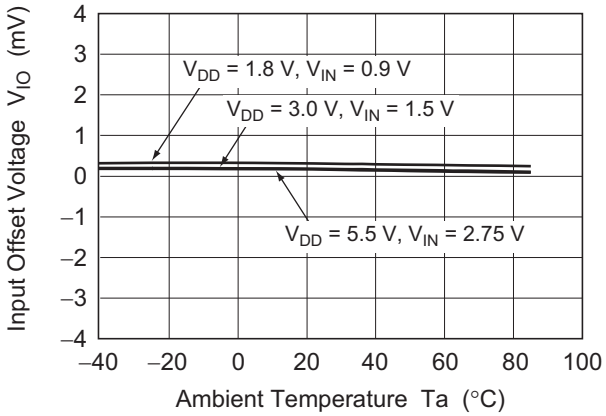


Figure 1-11. HA1630S04
Common Mode Input Voltage vs.
Ambient Temperature

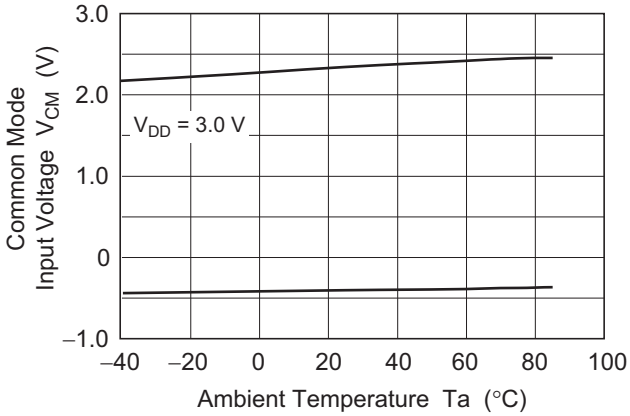


Figure 1-12. HA1630S04
Power Supply Rejection Ratio vs. Frequency

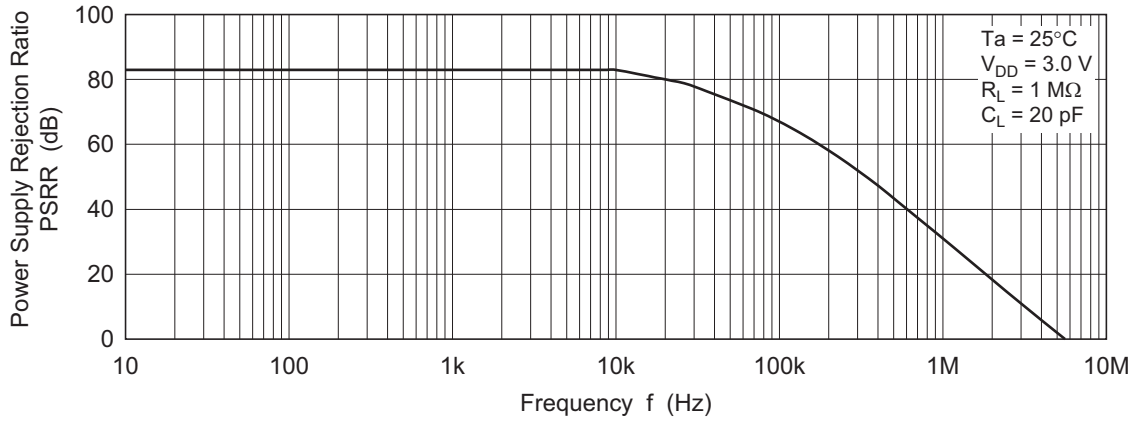


Figure 1-13. HA1630S04
Common Mode Rejection Ratio vs. Frequency

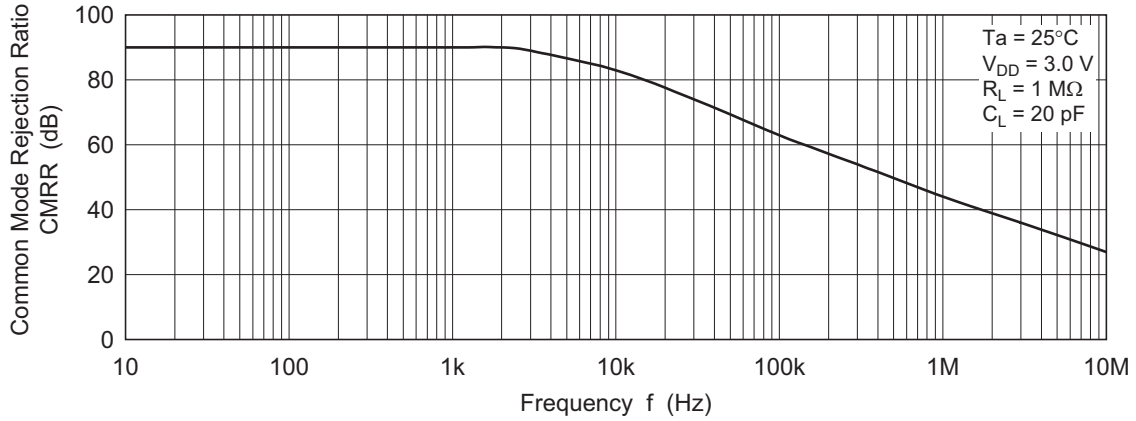


Figure 1-14. HA1630S04
Open Loop Voltage Gain and Phase Angle vs. Frequency

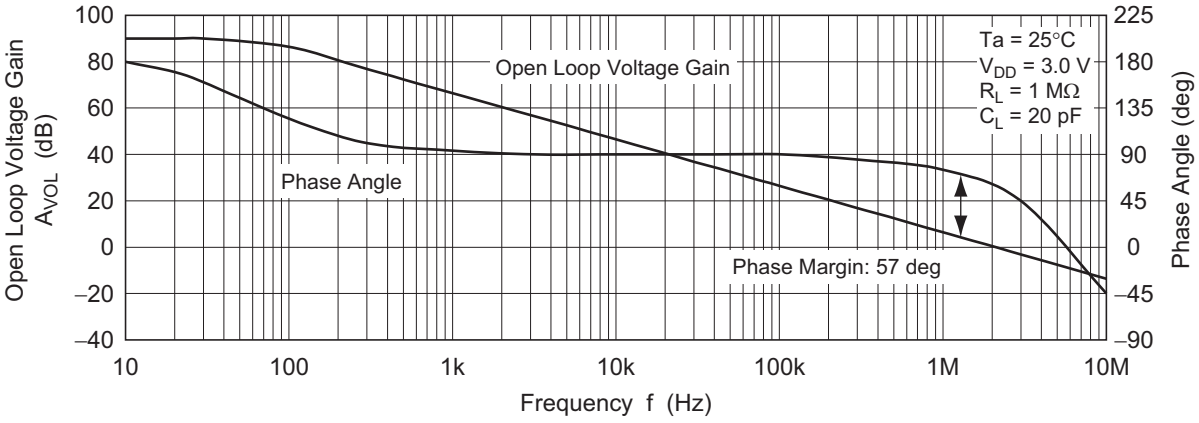


Figure 1-15. HA1630S04
Input Bias Current vs. Ambient Temperature

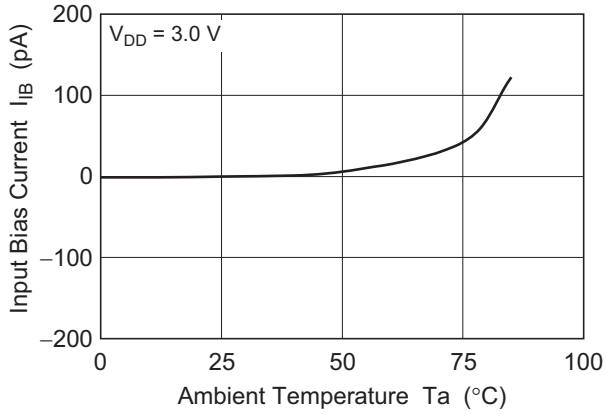


Figure 1-16. HA1630S04
Input Bias Current vs. Input Voltage

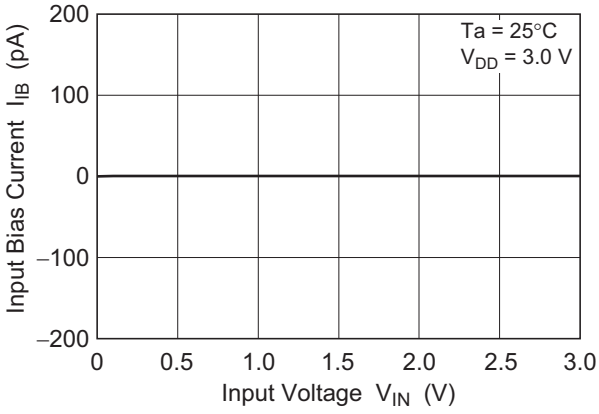


Figure 1-17. HA1630S04
Slew Rate (rising) vs. Ambient Temperature

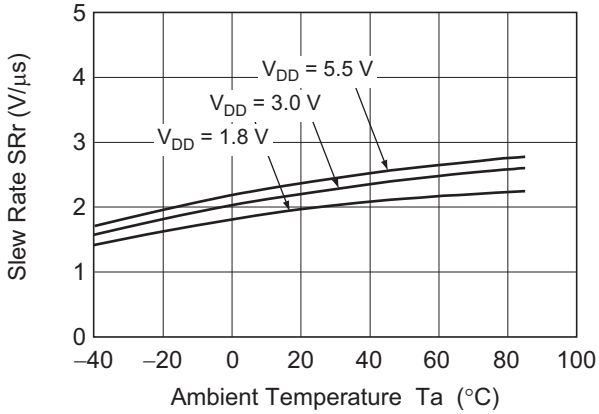


Figure 1-18. HA1630S04
Slew Rate (falling) vs. Ambient Temperature

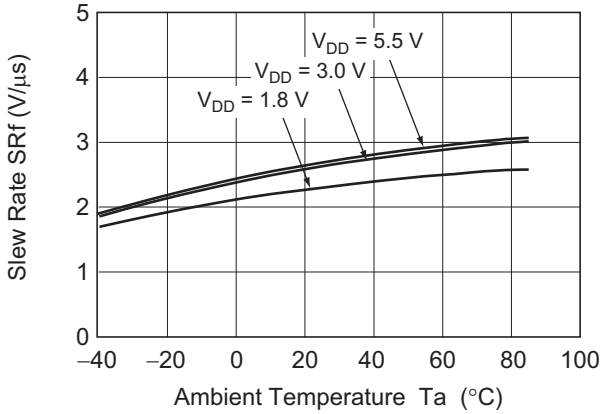


Figure 1-19. HA1630S04
Large Signal Transient Response

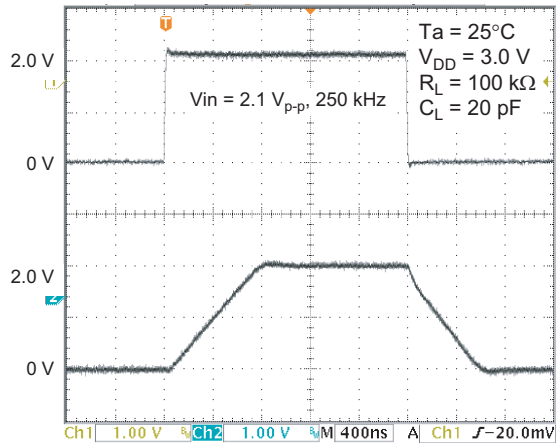


Figure 1-20. HA1630S04
Small Signal Transient Response

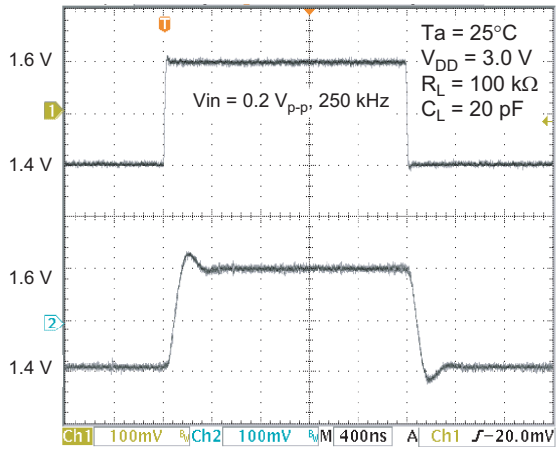


Figure 1-21. HA1630S04
Total Harmonic Distortion + Noise vs.
Output Voltage p-p

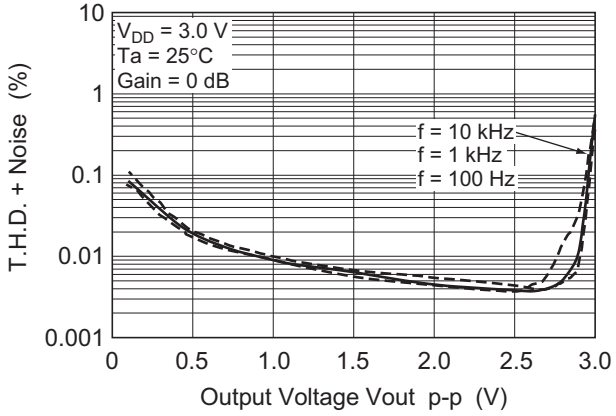


Figure 1-22. HA1630S04
Total Harmonic Distortion + Noise vs.
Output Voltage p-p

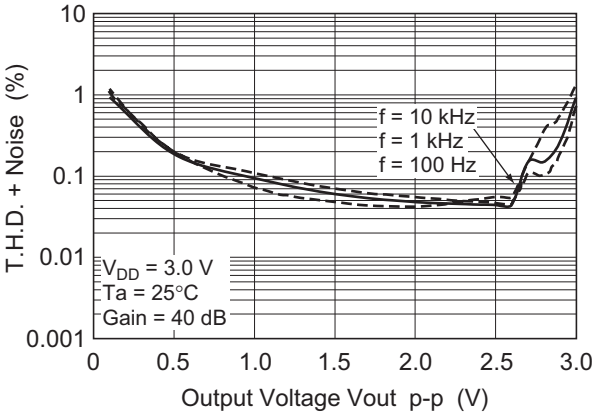


Figure 1-23. HA1630S04
Voltage Output p-p vs. Frequency

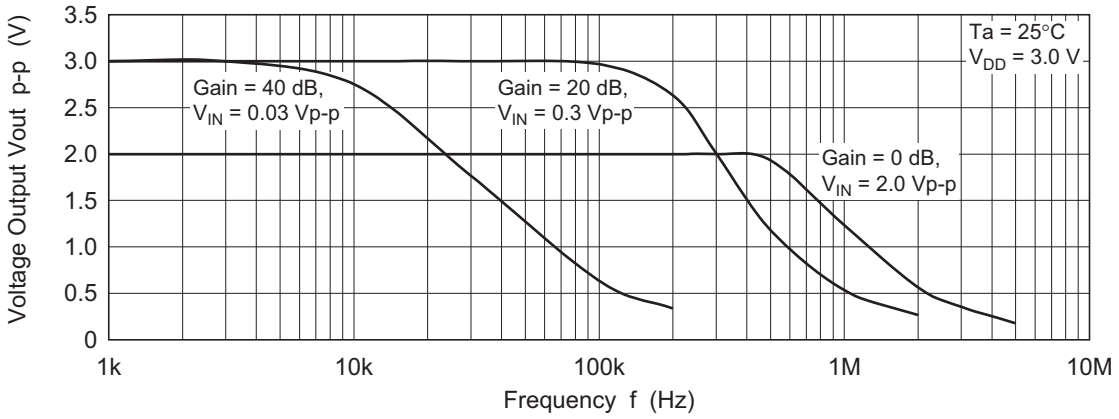
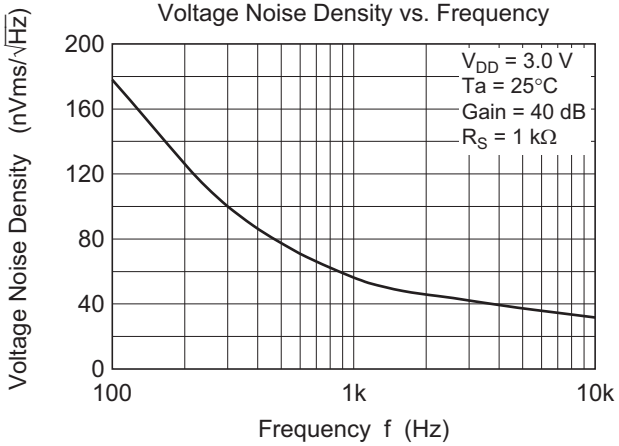


Figure 1-24. HA1630S04
Voltage Noise Density vs. Frequency



Main Characteristics (HA1630S05)

Figure 2-1. HA1630S05
Supply Current vs. Supply Voltage

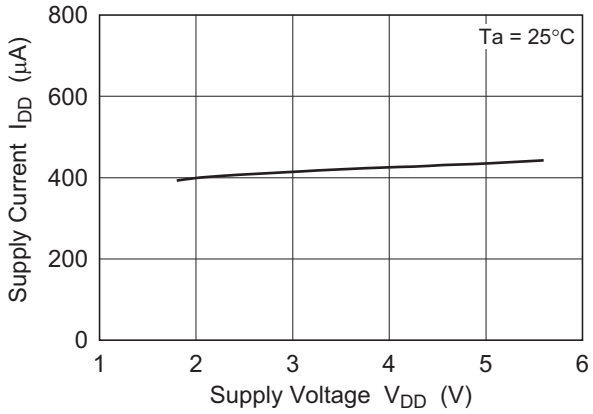


Figure 2-2. HA1630S05
Supply Current vs. Ambient Temperature

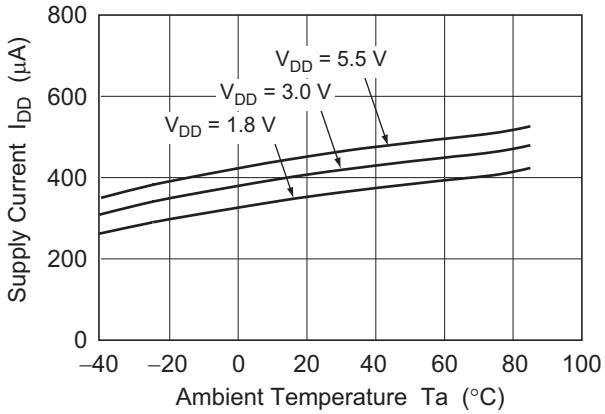


Figure 2-3. HA1630S05
Output High Voltage vs. Output Source Current

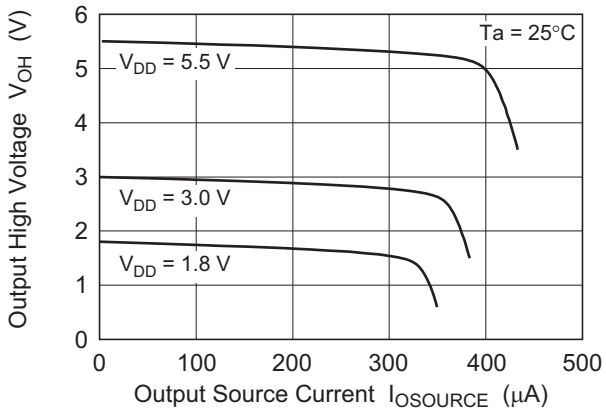


Figure 2-4. HA1630S05
Output High Voltage vs. Supply Voltage

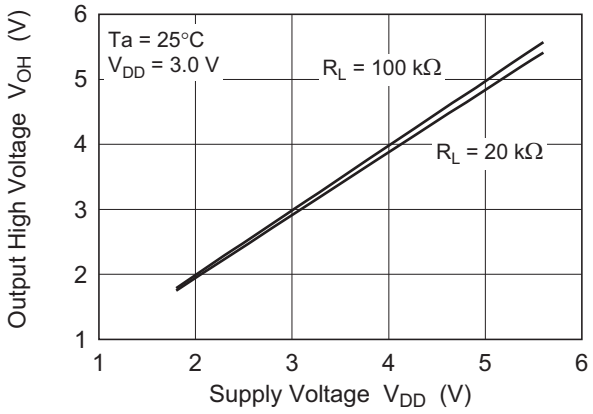


Figure 2-5. HA1630S05
Output Source Current vs. Ambient Temperature

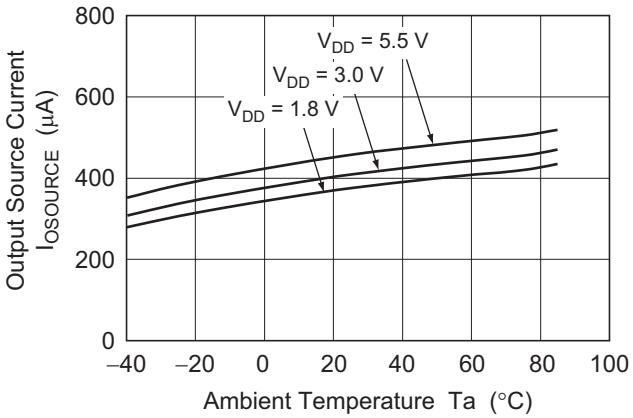


Figure 2-6. HA1630S05
Output Low Voltage vs. Output Sink Current

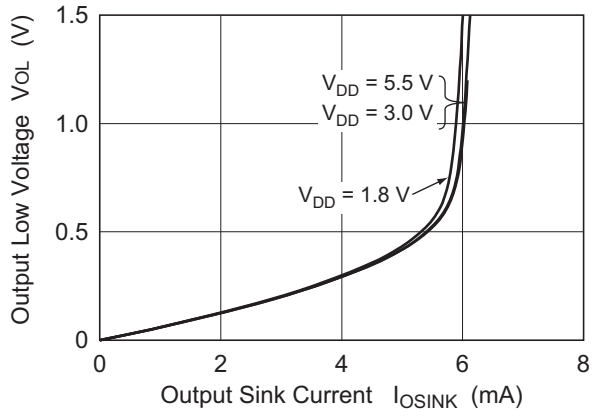


Figure 2-7. HA1630S05
Output Sink Current vs. Ambient Temperature

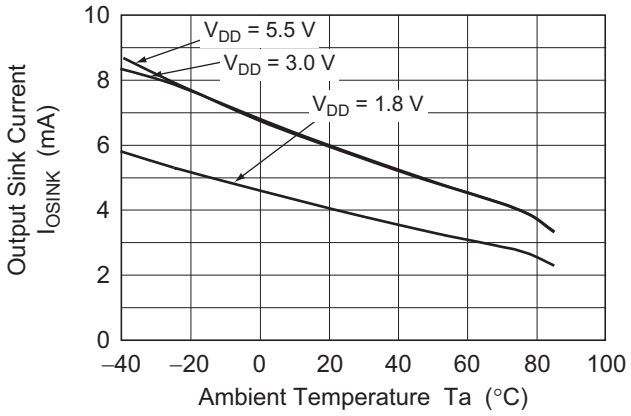


Figure 2-8. HA1630S05
Input Offset Voltage Distribution

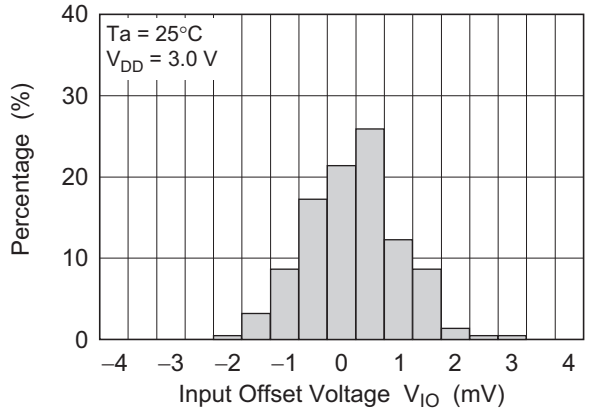


Figure 2-9. HA1630S05
Input Offset Voltage vs. Supply Voltage

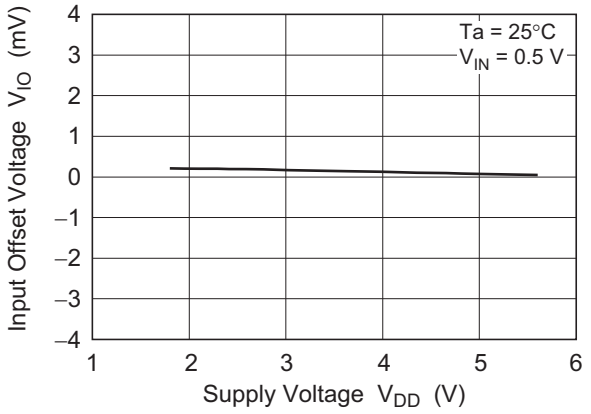


Figure 2-10. HA1630S05
Input Offset Voltage vs. Ambient Temperature

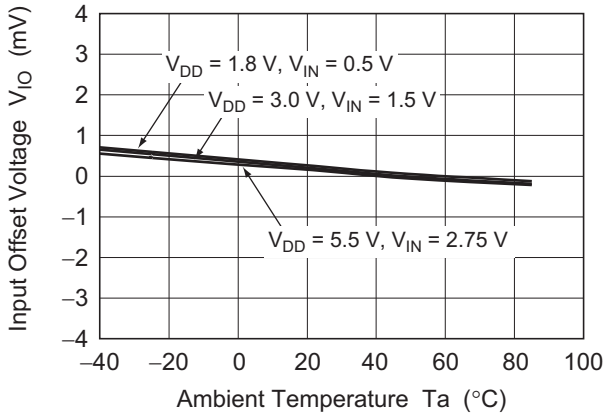


Figure 2-11. HA1630S05
Common Mode Input Voltage vs.
Ambient Temperature

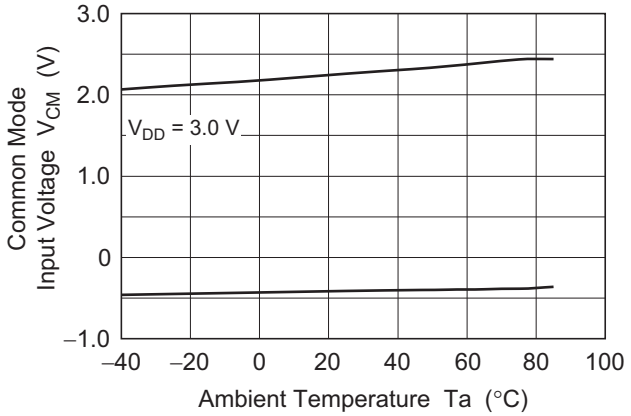


Figure 2-12. HA1630S05
Power Supply Rejection Ratio vs. Frequency

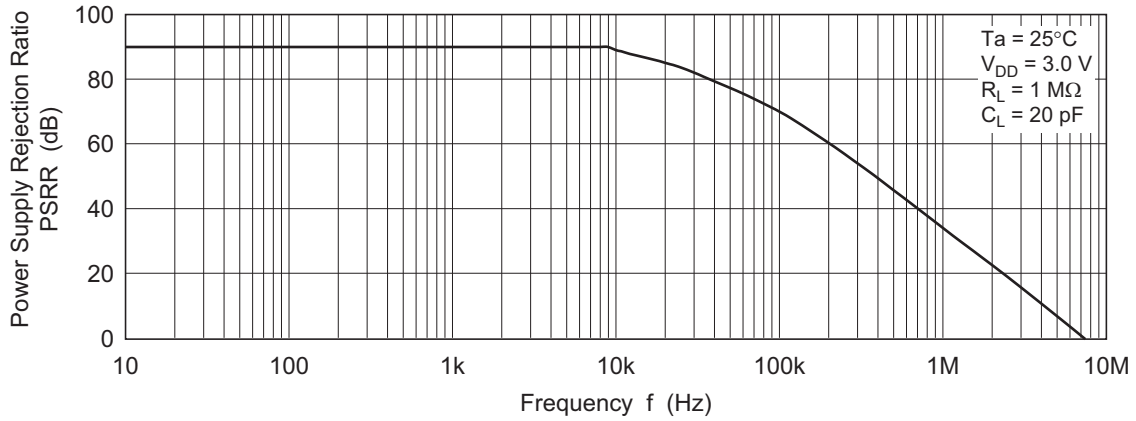


Figure 2-13. HA1630S05
Common Mode Rejection Ratio vs. Frequency

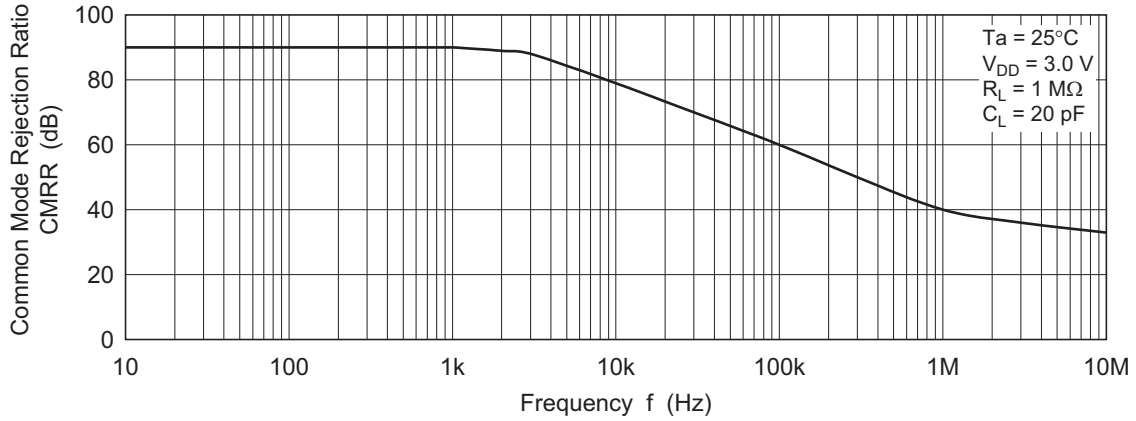


Figure 2-14. HA1630S05
Open Loop Voltage Gain and Phase Angle vs. Frequency

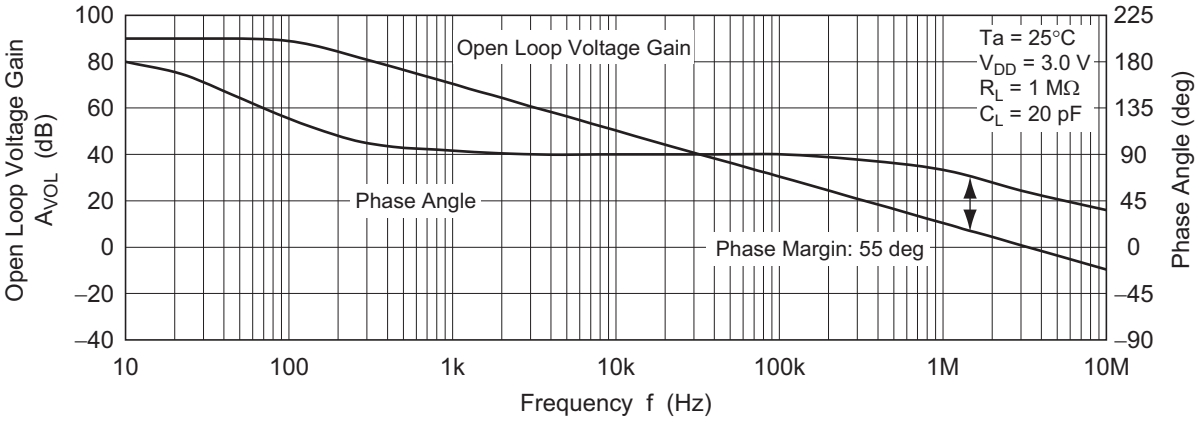


Figure 2-15. HA1630S05
Input Bias Current vs. Ambient Temperature

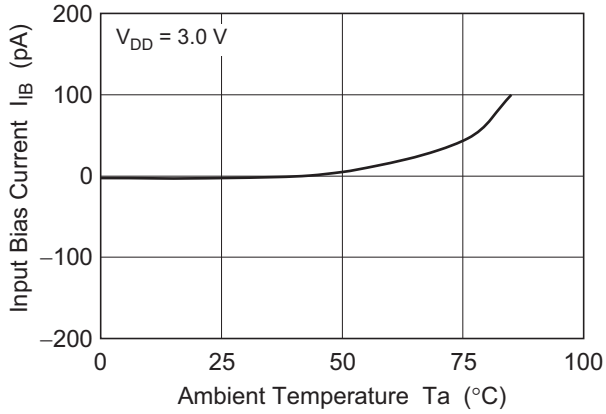


Figure 2-16. HA1630S05
Input Bias Current vs. Input Voltage

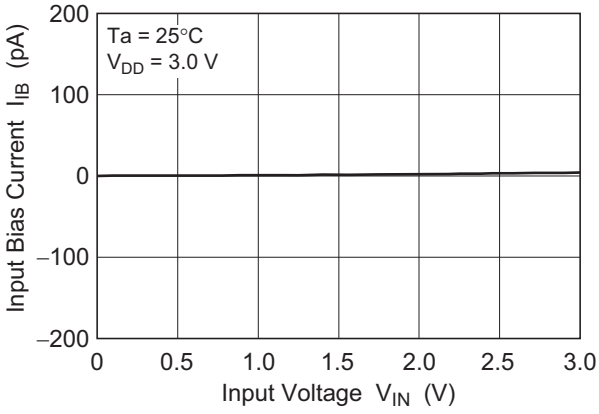


Figure 2-17. HA1630S05
Slew Rate (rising) vs. Ambient Temperature

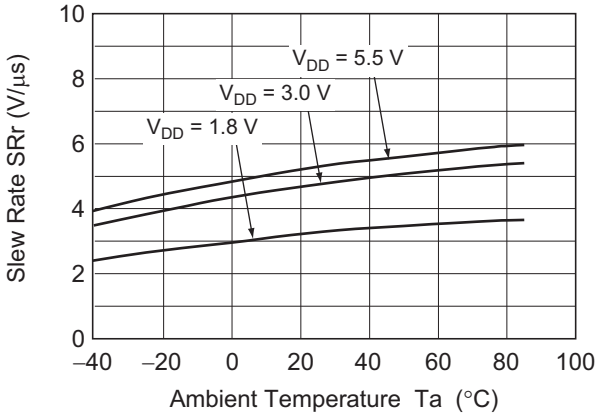


Figure 2-18. HA1630S05
Slew Rate (falling) vs. Ambient Temperature

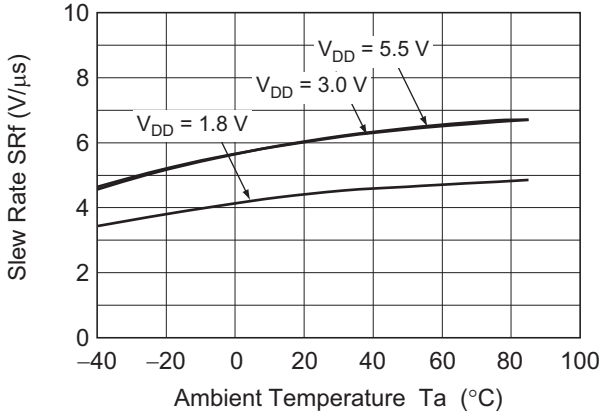


Figure 2-19. HA1630S05
Large Signal Transient Response

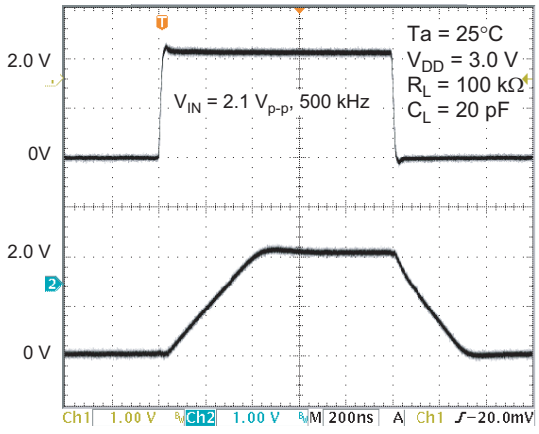


Figure 2-20. HA1630S05
Small Signal Transient Response

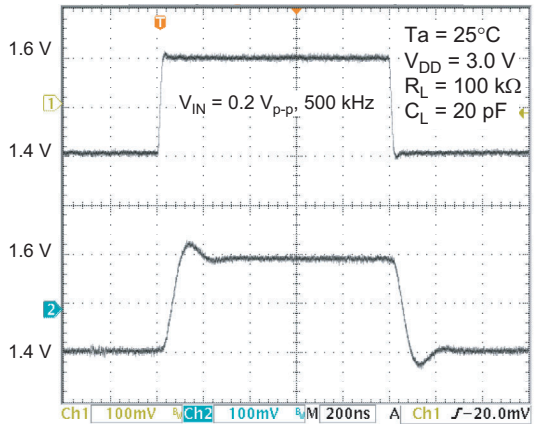


Figure 2-21. HA1630S05
Total Harmonic Distortion + Noise vs.
Output Voltage p-p

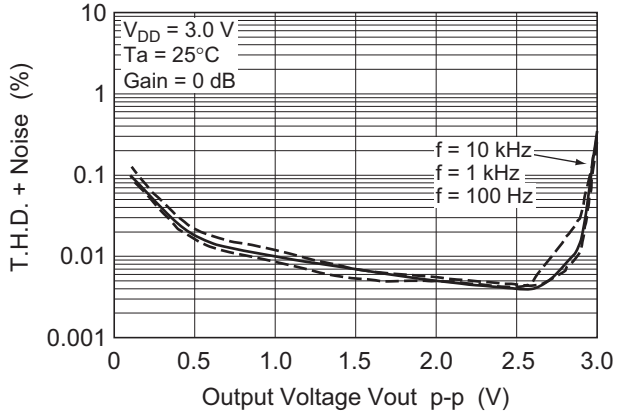


Figure 2-22. HA1630S05
Total Harmonic Distortion + Noise vs.
Output Voltage p-p

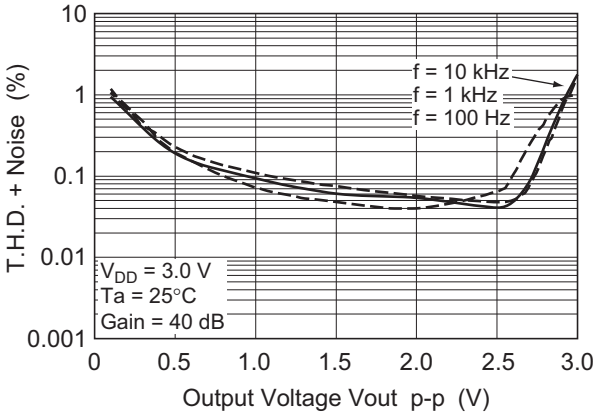


Figure 2-23. HA1630S05
Voltage Output p-p vs. Frequency

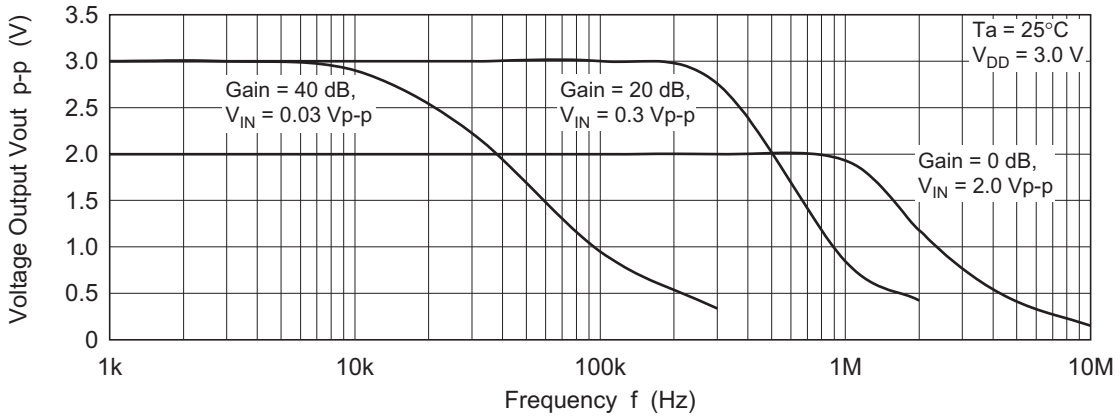
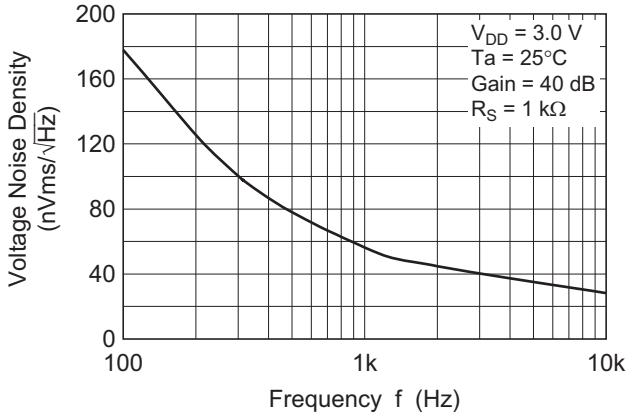


Figure 2-24. HA1630S05
Voltage Noise Density vs. Frequency



Main Characteristics (HA1630S06)

Figure 3-1. HA1630S06
Supply Current vs. Supply Voltage

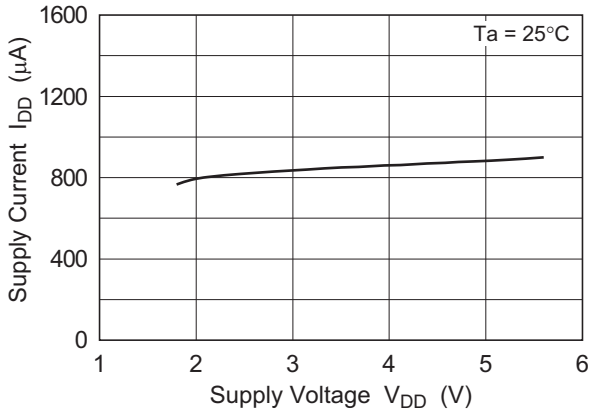


Figure 3-2. HA1630S06
Supply Current vs. Ambient Temperature

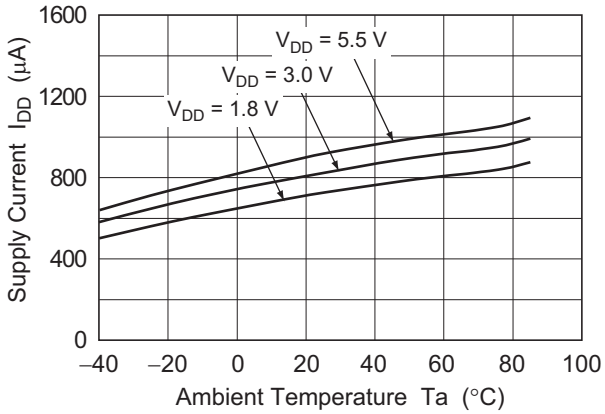


Figure 3-3. HA1630S06
Output High Voltage vs. Output Source Current

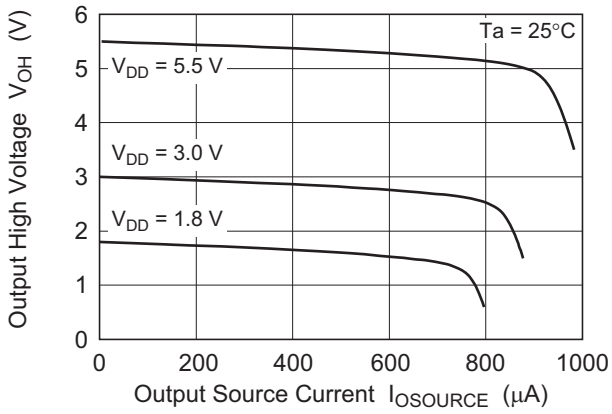


Figure 3-4. HA1630S06
Output High Voltage vs. Supply Voltage

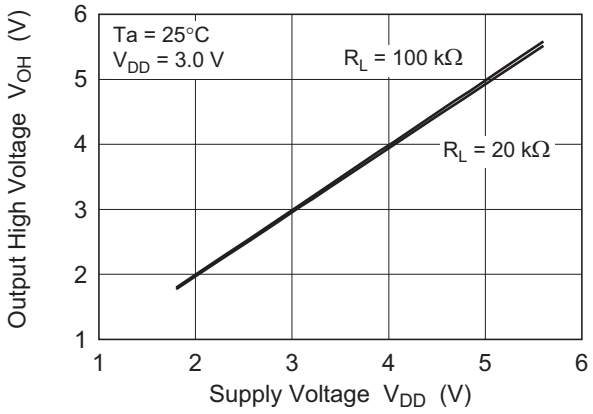


Figure 3-5. HA1630S06
Output Source Current vs. Ambient Temperature

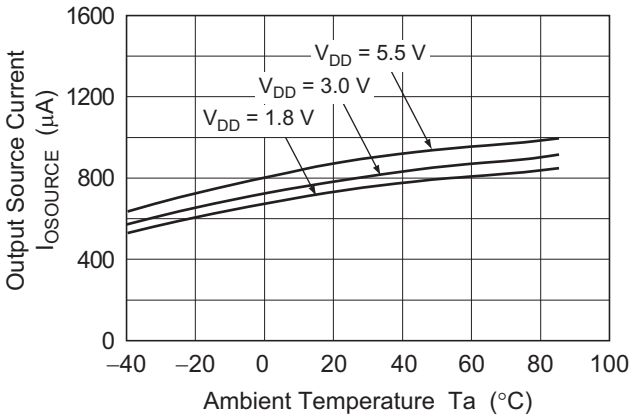


Figure 3-6. HA1630S06
Output Low Voltage vs. Output Sink Current

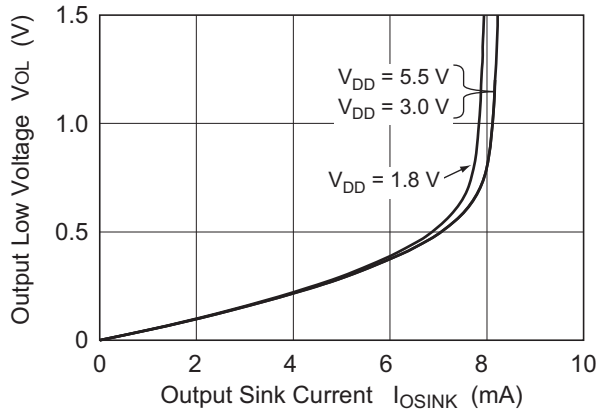


Figure 3-7. HA1630S06
Output Sink Current vs. Ambient Temperature

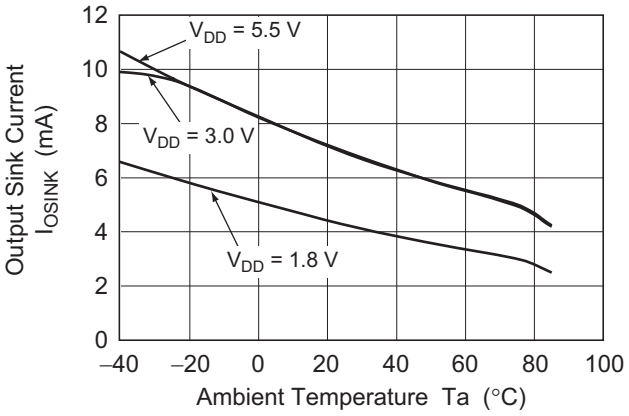


Figure 3-8. HA1630S06
Input Offset Voltage Distribution

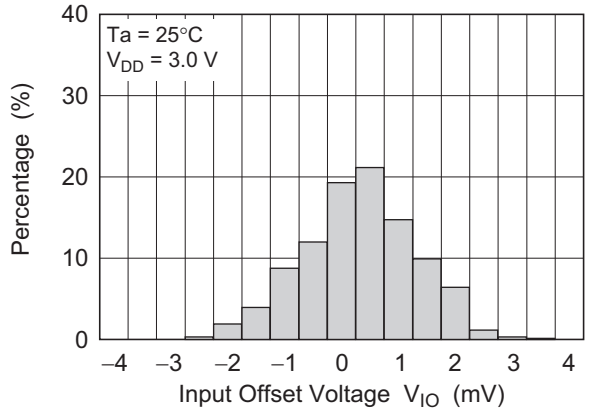


Figure 3-9. HA1630S06
Input Offset Voltage vs. Supply Voltage

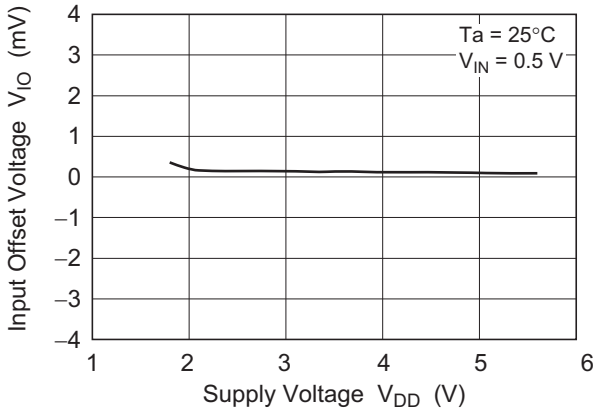


Figure 3-10. HA1630S06
Input Offset Voltage vs. Ambient Temperature

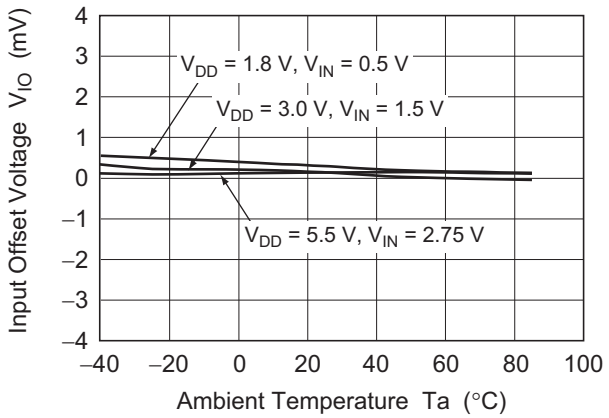


Figure 3-11. HA1630S06
Common Mode Input Voltage vs.
Ambient Temperature

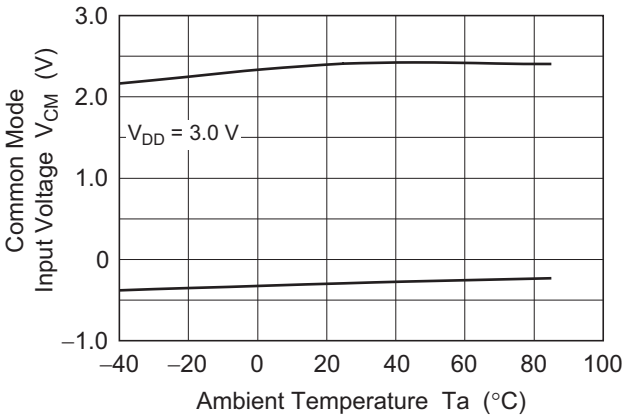


Figure 3-12. HA1630S06
Power Supply Rejection Ratio vs. Frequency

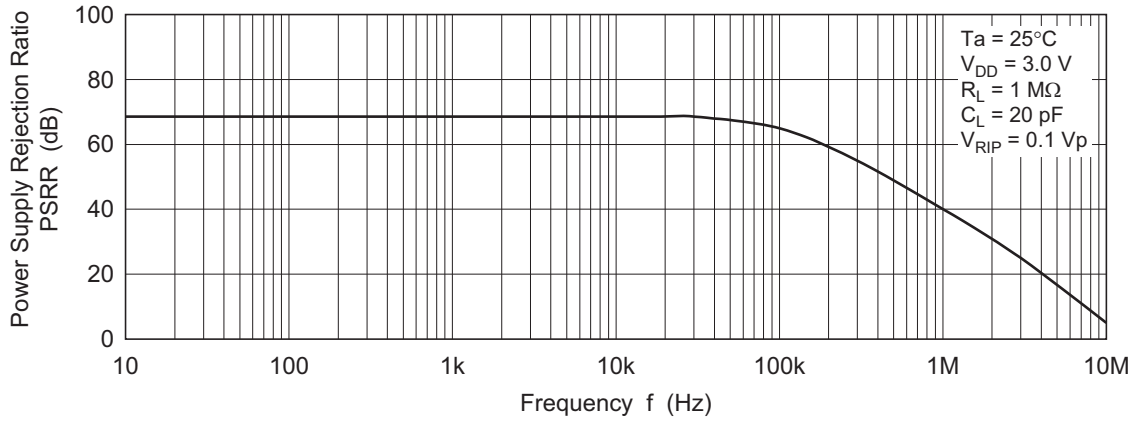


Figure 3-13. HA1630S06
Common Mode Rejection Ratio vs. Frequency

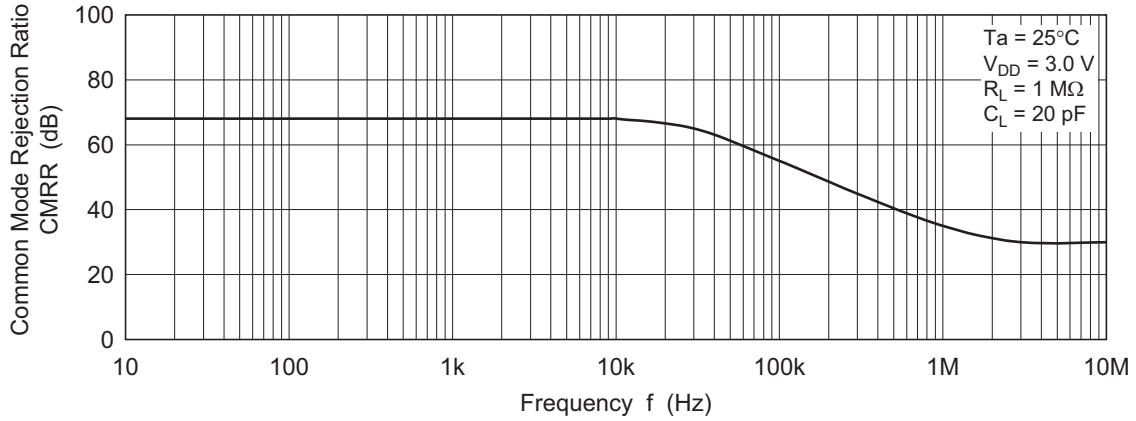


Figure 3-14. HA1630S06
Open Loop Voltage Gain and Phase Angle vs. Frequency

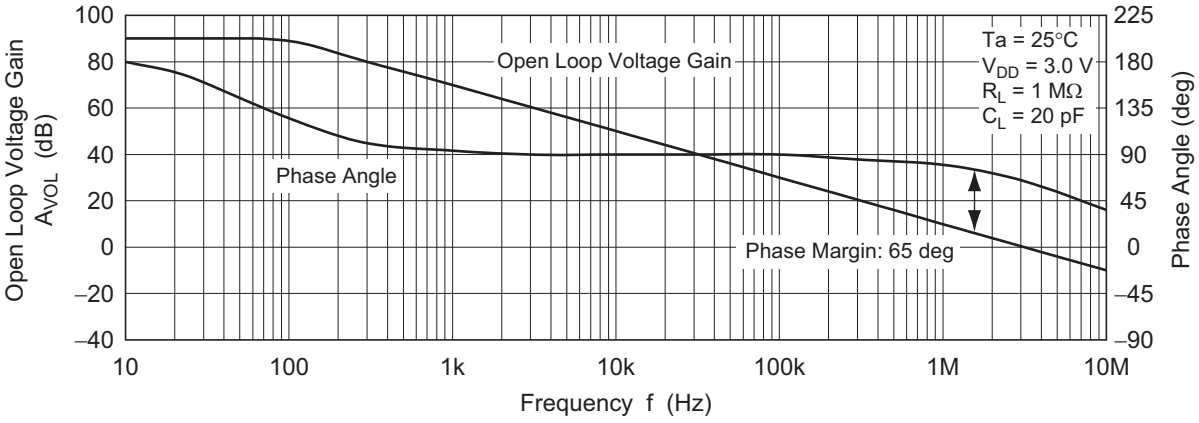


Figure 3-15. HA1630S06
Input Bias Current vs. Ambient Temperature

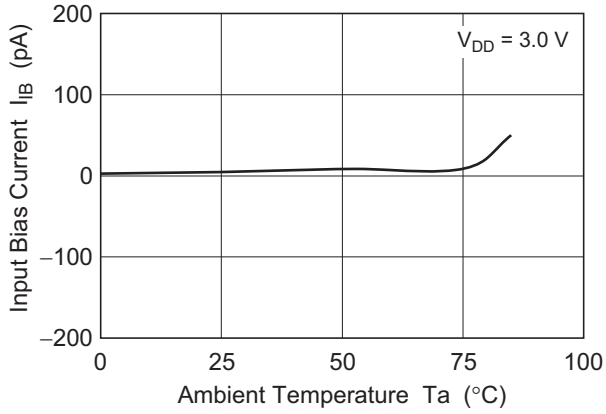


Figure 3-16. HA1630S06
Input Bias Current vs. Input Voltage

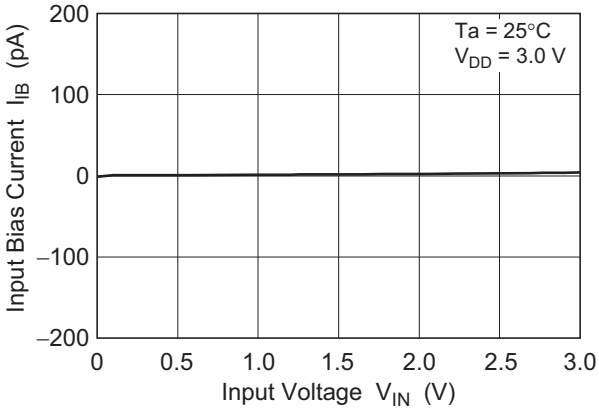


Figure 3-17. HA1630S06
Slew Rate (rising) vs. Ambient Temperature

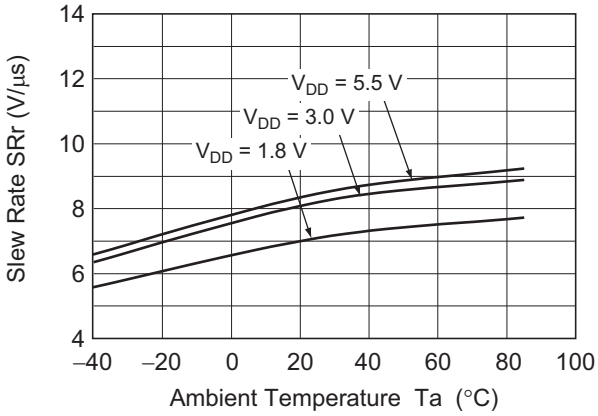


Figure 3-18. HA1630S06
Slew Rate (falling) vs. Ambient Temperature

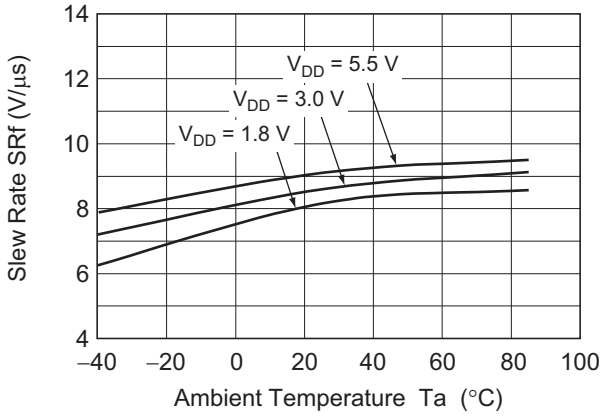


Figure 3-19. HA1630S06
Large Signal Transient Response

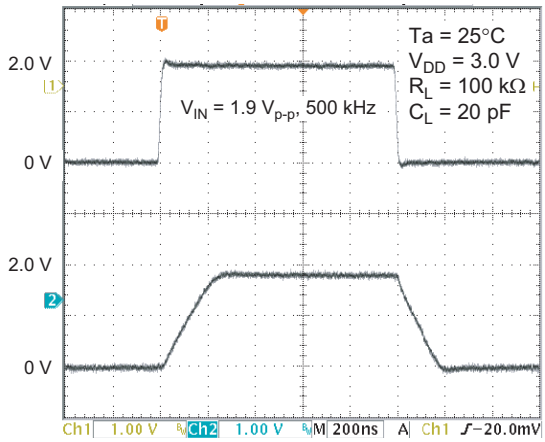


Figure 3-20. HA1630S06
Small Signal Transient Response

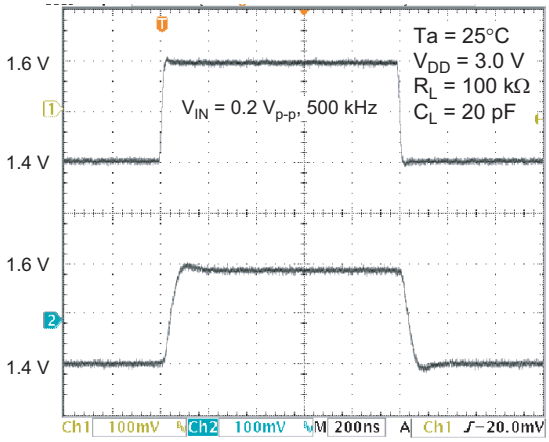


Figure 3-21. HA1630S06
Total Harmonic Distortion + Noise vs.
Output Voltage p-p

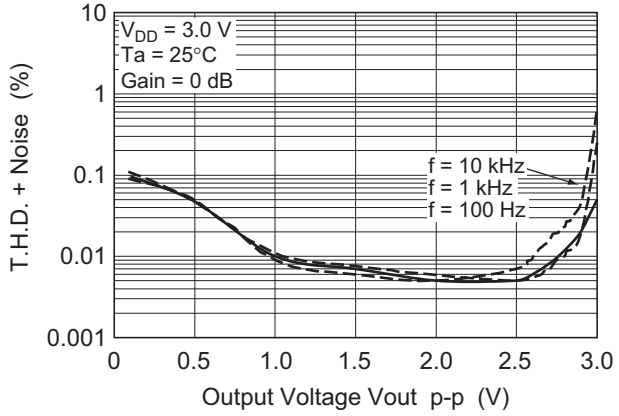


Figure 3-22. HA1630S06
Total Harmonic Distortion + Noise vs.
Output Voltage p-p

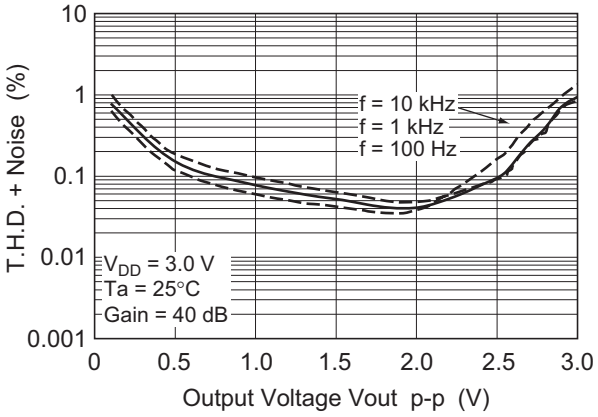


Figure 3-23. HA1630S06
Voltage Output p-p vs. Frequency

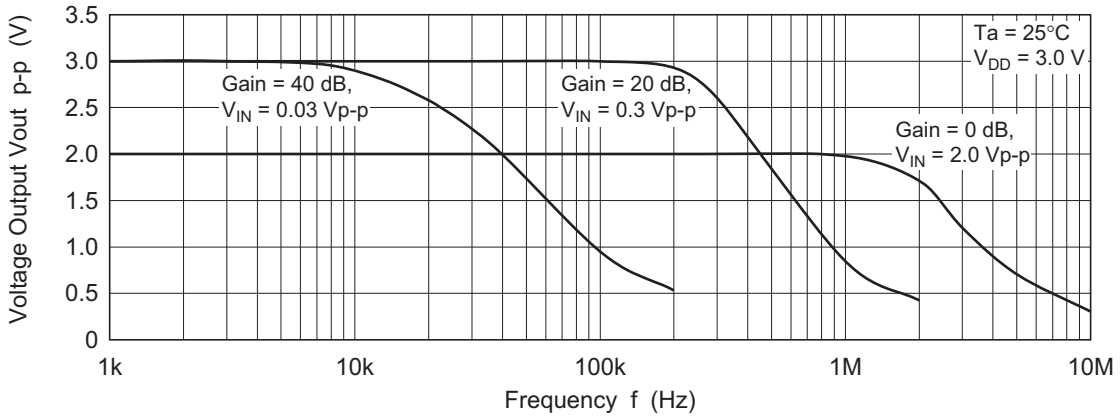
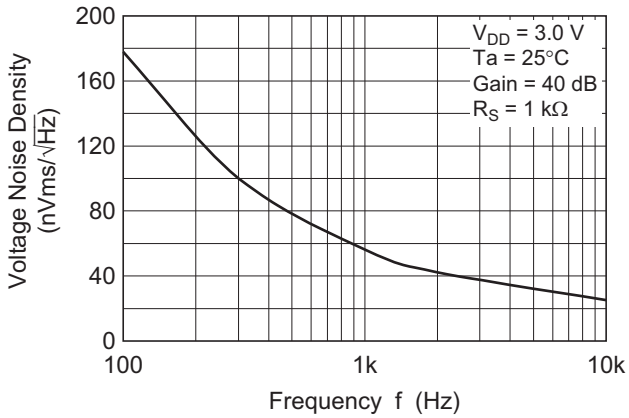
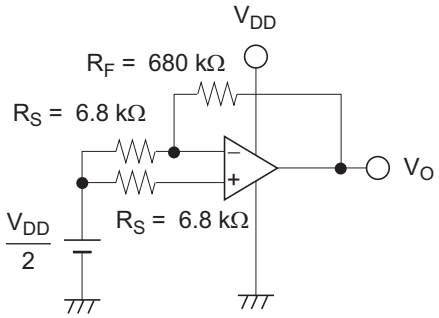


Figure 3-24. HA1630S06
Voltage Noise Density vs. Frequency



Test Circuits

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



V_{IO}

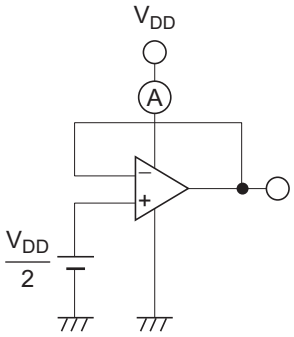
$$V_{IO} = \left(V_O - \frac{V_{DD}}{2}\right) \times \frac{R_S}{R_S + R_F}$$

PSRR

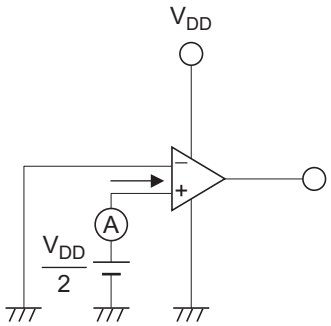
$$PSRR = -20\log\left(\left|\frac{V_{DD1} - V_{DD2}}{V_{O1} - V_{O2}}\right| \times \frac{R_S}{R_S + R_F}\right)$$

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

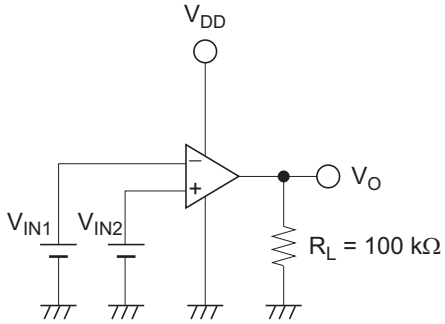
2. Supply Current, I_{DD}



3. Input Bias Current, I_{IB}



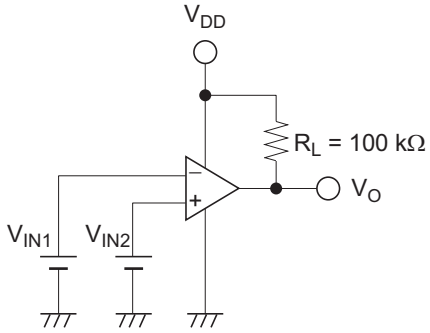
4. Output High Voltage, V_{OH}



V_{OH}

$V_{IN1} = V_{DD} / 2 - 0.05$ V
$V_{IN2} = V_{DD} / 2 + 0.05$ V

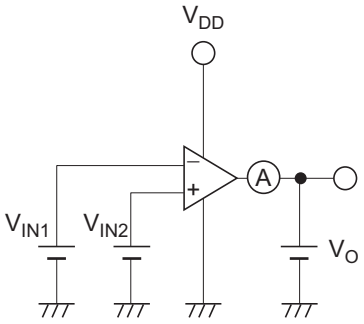
5. Output Low Voltage, V_{OL}



V_{OL}

$V_{IN1} = V_{DD} / 2 + 0.05$ V
$V_{IN2} = V_{DD} / 2 - 0.05$ V

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



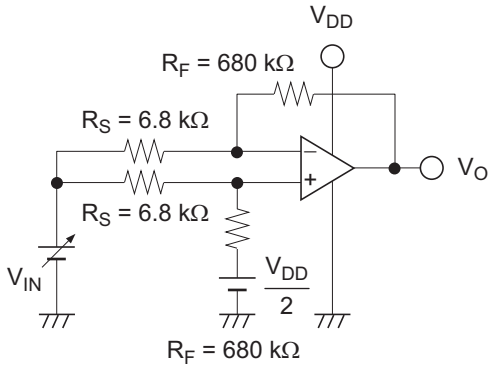
$I_{OSOURCE}$

$V_O = V_{DD} - 0.5$ V
$V_{IN1} = V_{DD} / 2 - 0.05$ V
$V_{IN2} = V_{DD} / 2 + 0.05$ V

I_{OSINK}

$V_O = + 0.5$ V
$V_{IN1} = V_{DD} / 2 + 0.05$ V
$V_{IN2} = V_{DD} / 2 - 0.05$ V

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

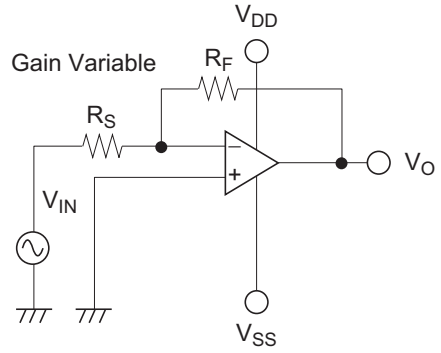


CMRR

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

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

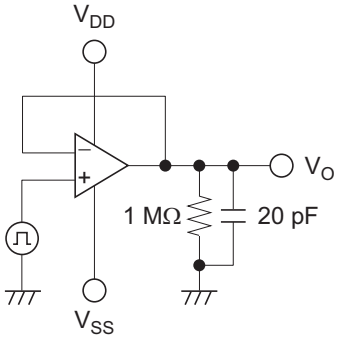
8. Total Harmonic Distortion, THD



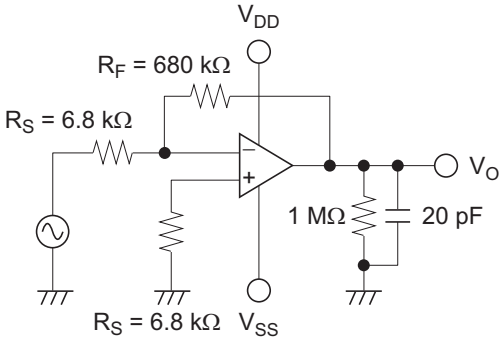
THD

Gain Variable
R_F / R_S = 20log (100 kΩ / 1 kΩ) = 40 dB
R_F / R_S = 20log (100 kΩ / 100 kΩ) = 0 dB
freq = 100 Hz, 1 kHz, 10 kHz
30 kHz LPF ON

9. Slew Rate, SR

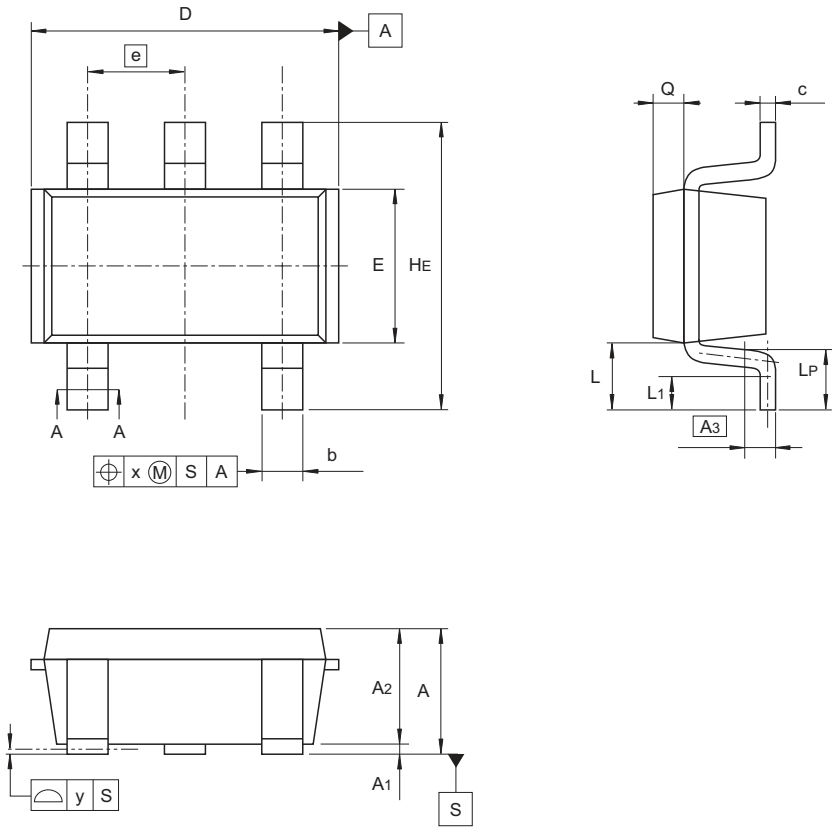


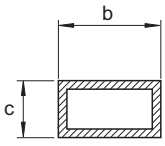
10. Gain, A_V & Phase, GBW



Package Dimensions

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

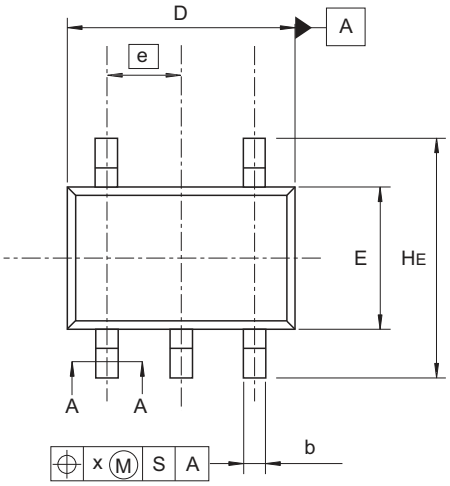


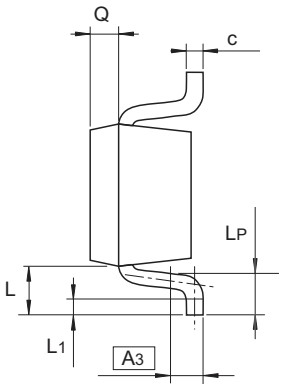


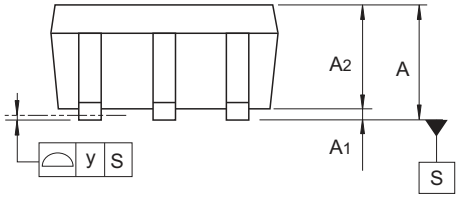
A-A Section

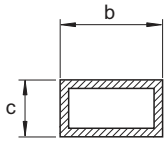
Reference Symbol	Dimensions in millimeters		
	Min	Nom	Max
A	1.0	—	1.4
A_1	0	—	0.1
A_2	1.0	1.1	1.3
$\boxed{A_3}$	—	0.25	—
b	0.35	0.4	0.5
c	0.11	0.16	0.26
D	2.8	2.95	3.1
E	1.5	1.6	1.8
$\boxed{e}$	—	0.95	—
H_E	2.5	2.8	3.0
L	0.3	—	0.7
L_1	0.1	—	0.5
L_P	0.2	—	0.6
x	—	—	0.05
y	—	—	0.05
Q	—	0.3	—

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









A-A Section

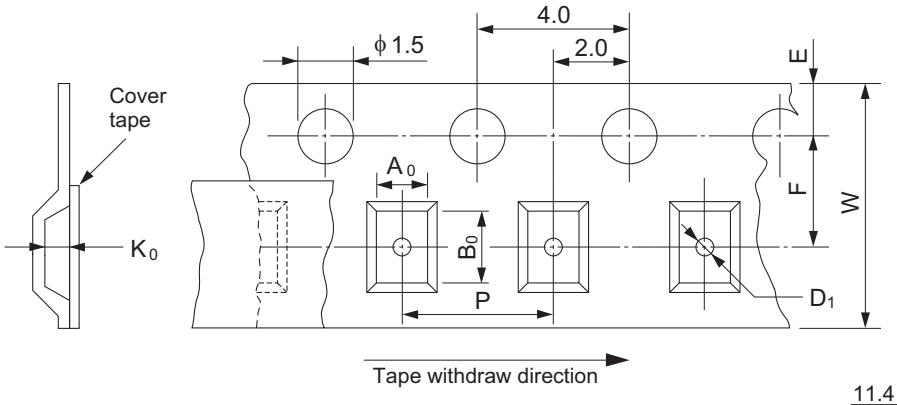
Reference Symbol	Dimensions in millimeters		
	Min	Nom	Max
A	0.8	—	1.1
A_1	0	—	0.1
A_2	0.8	0.9	1.0
$\boxed{A_3}$	—	0.25	—
b	0.15	0.22	0.3
c	0.1	0.13	0.15
D	1.8	2.0	2.2
E	1.15	1.25	1.35
$\boxed{e}$	—	0.65	—
H_E	1.8	2.1	2.4
L	0.3	—	0.7
L_1	0.1	—	0.5
L_P	0.2	—	0.6
x	—	—	0.05
y	—	—	0.05
Q	—	0.25	—

Taping & Reel Specification

[Taping]

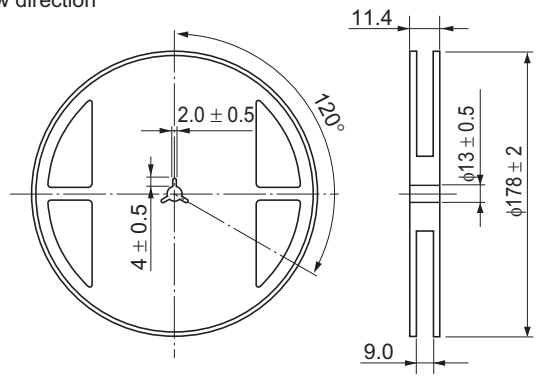
Package Code	W	P	Ao	Bo	Ko	E	F	D1	Maximum Storage No.
MPAK-5	8	4	3.3	3.3	1.5	1.75	3.5	1.05	3,000 pcs/reel
CMPAK-5	8	4	2.25	2.45	1.1	1.75	3.5	1.05	3,000 pcs/reel

Unit: mm



[Reel]

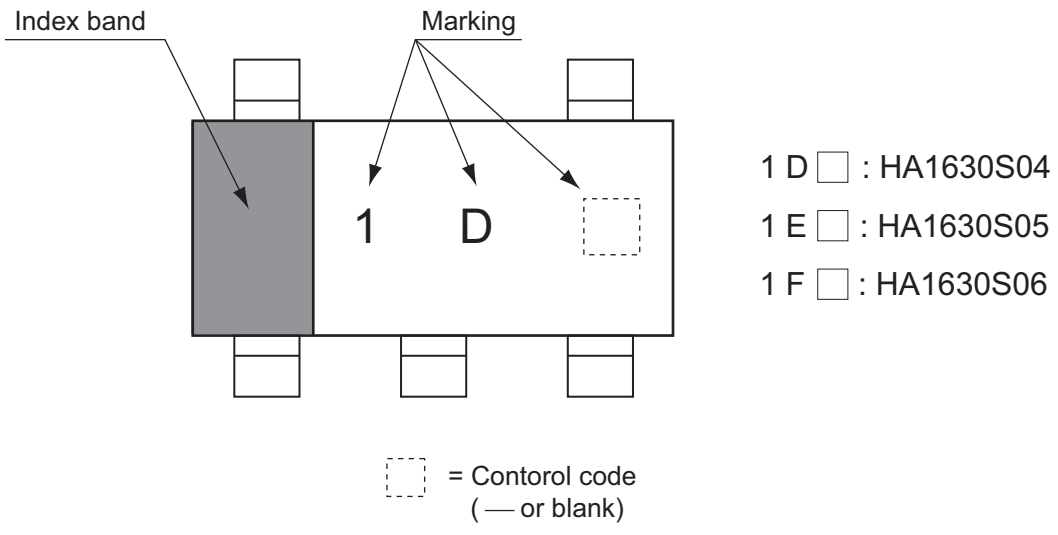
Package	Tape width	W1	W2
MPAK-5	8	11.4	9
CMPAK-5	8	11.4	9



[Ordering Information]

Ordering Unit
3,000 pcs

Mark Indication



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