

HA1630Q01/02/03 Series

Low Voltage Operation CMOS Quad Operational Amplifier

REJ03D0802-0100

Rev.1.00

Mar 10, 2006

Description

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

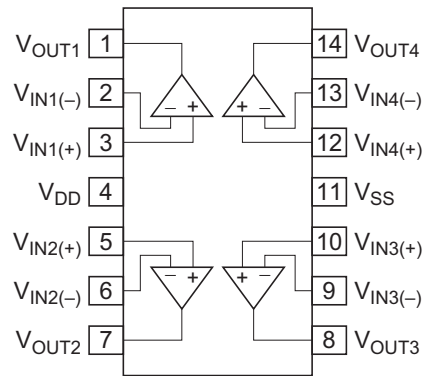
Features

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

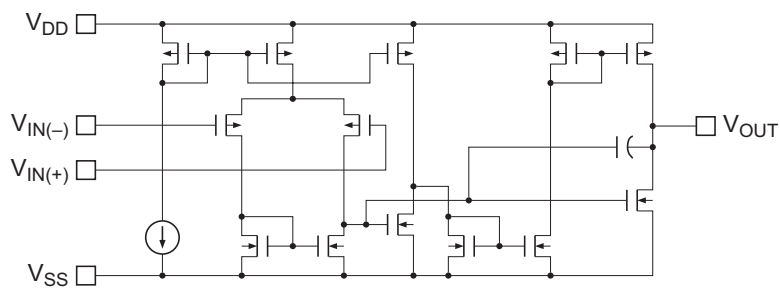
Ordering Information

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

Pin Arrangement



Equivalent Circuit (per one channel)



Absolute Maximum Ratings

(Ta = 25°C)

Items	Symbol	Ratings	Unit	Note
Supply voltage	V _{DD}	7	V	
Differential input voltage	V _{IN(diff)}	−V _{DD} to +V _{DD}	V	
Input voltage	V _{IN}	−0.3 to +V _{DD}	V	1
Power dissipation	P _T	400	mW	
Operating temp. Range	Topr	−40 to +85	°C	
Storage temp. Range	Tstg	−55 to +125	°C	

Note: 1. Do not apply Input Voltage exceeding V_{DD} or 7 V.

Electrical Characteristics

(V_{DD} = 3.0 V, Ta = 25°C)

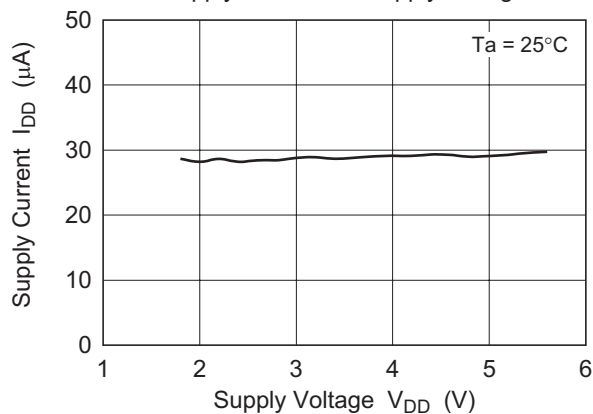
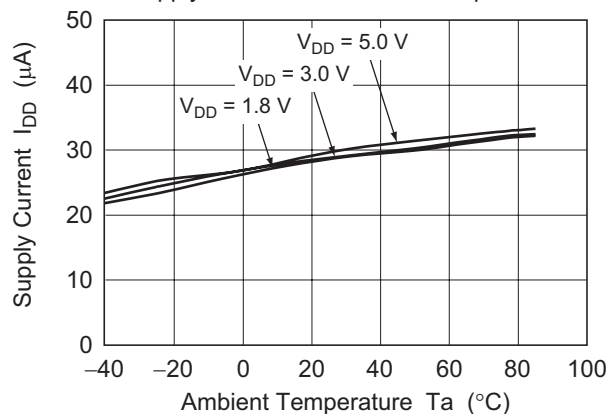
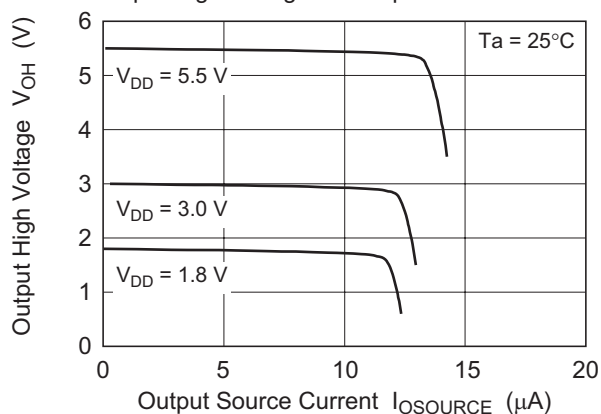
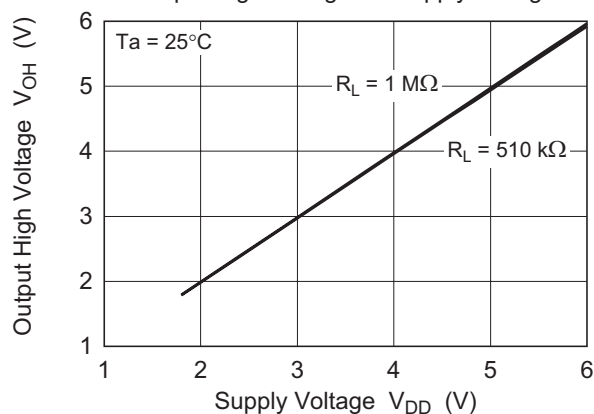
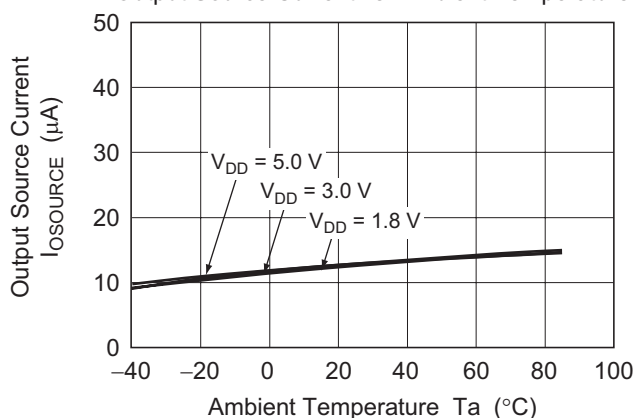
Items	Symbol	Min	Typ	Max	Unit	Test Condition
Input offset voltage	V _{IO}	—	—	4.0	mV	V _{in} = 1.5 V
Input offset current	I _{IO}	—	(1.0)	—	pA	V _{in} = 1.5 V
Input bias current	I _{IB}	—	(1.0)	—	pA	V _{in} = 1.5 V
Output high voltage	V _{OH}	2.9	—	—	V	R _L = 1 MΩ
Output source current	I _{O SOURCE}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

Note: 1. () : Design specification

Table of Graphs

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

Main Characteristics (HA1630Q01)

Figure 1-1. HA1630Q01
Supply Current vs. Supply VoltageFigure 1-2. HA1630Q01
Supply Current vs. Ambient TemperatureFigure 1-3. HA1630Q01
Output High Voltage vs. Output Source CurrentFigure 1-4. HA1630Q01
Output High Voltage vs. Supply VoltageFigure 1-5. HA1630Q01
Output Source Current vs. Ambient Temperature

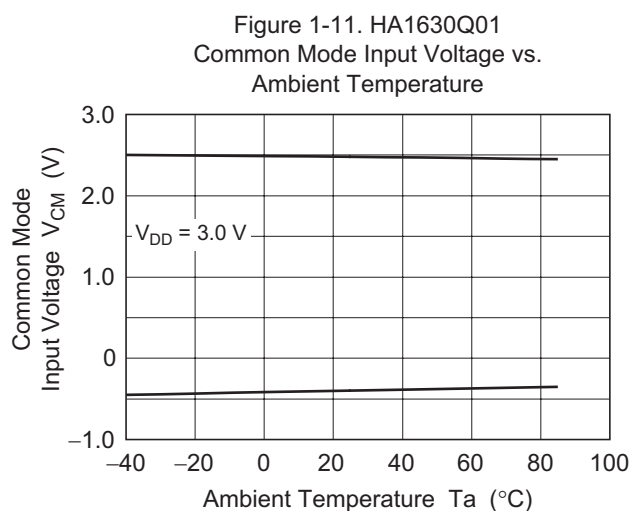
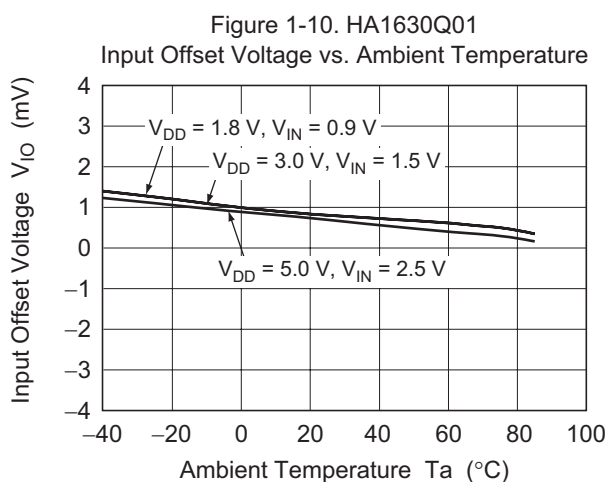
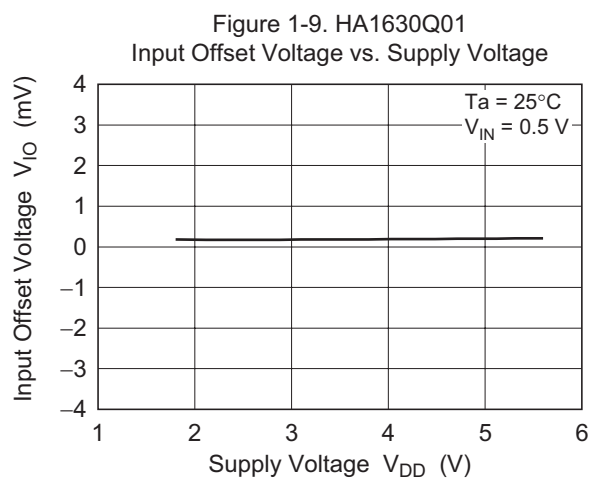
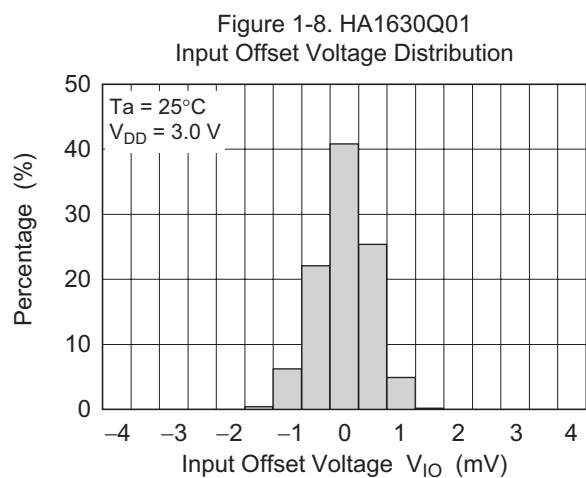
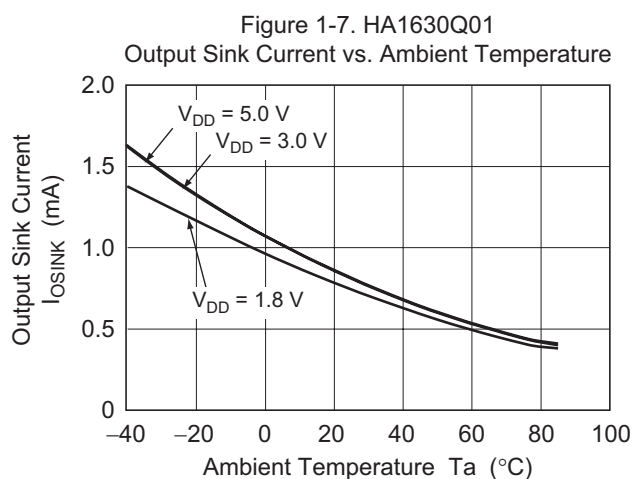
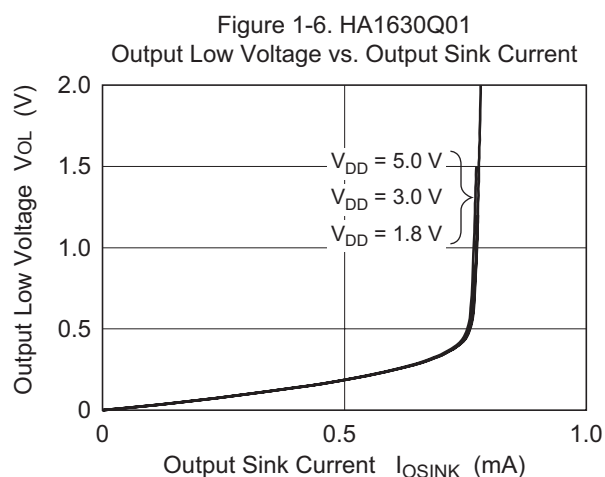


Figure 1-12. HA1630Q01
Power Supply Rejection Ratio vs. Frequency

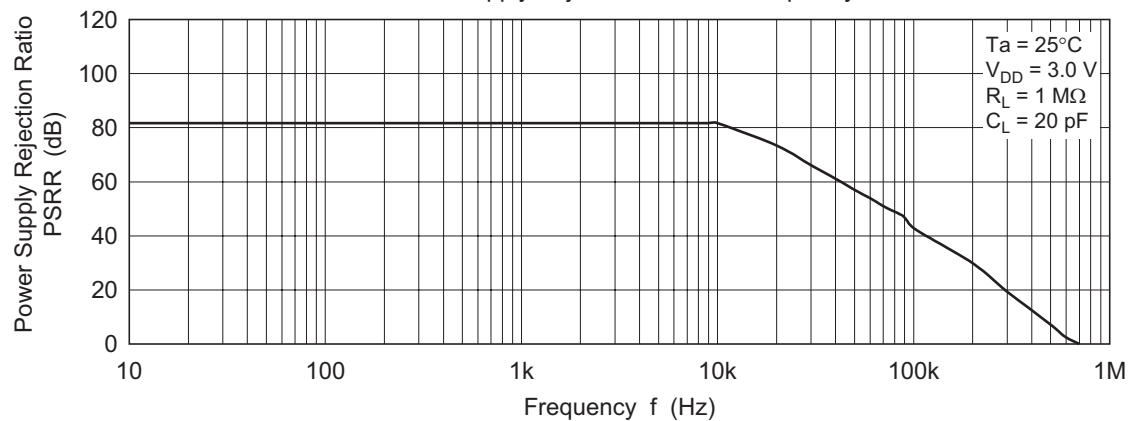


Figure 1-13. HA1630Q01
Common Mode Rejection Ratio vs. Frequency

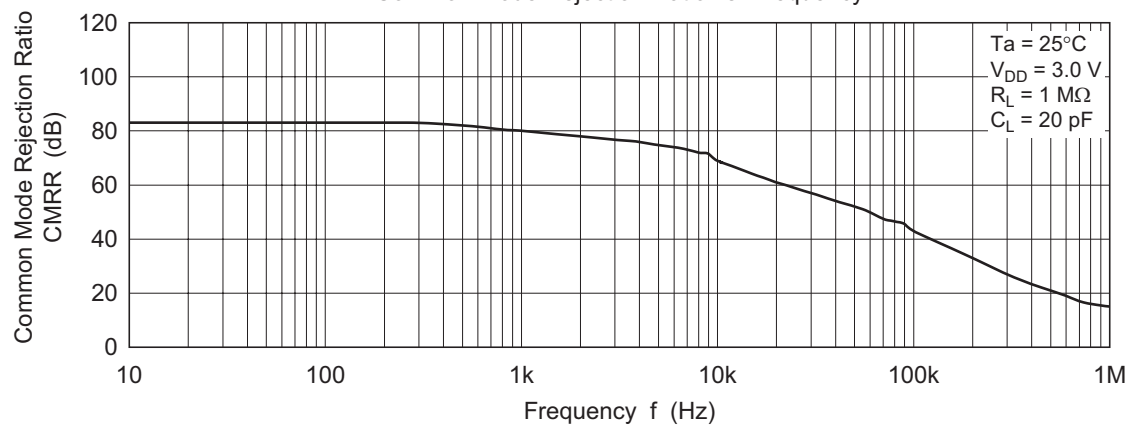


Figure 1-14. HA1630Q01
Open Loop Voltage Gain and Phase Angle vs. Frequency

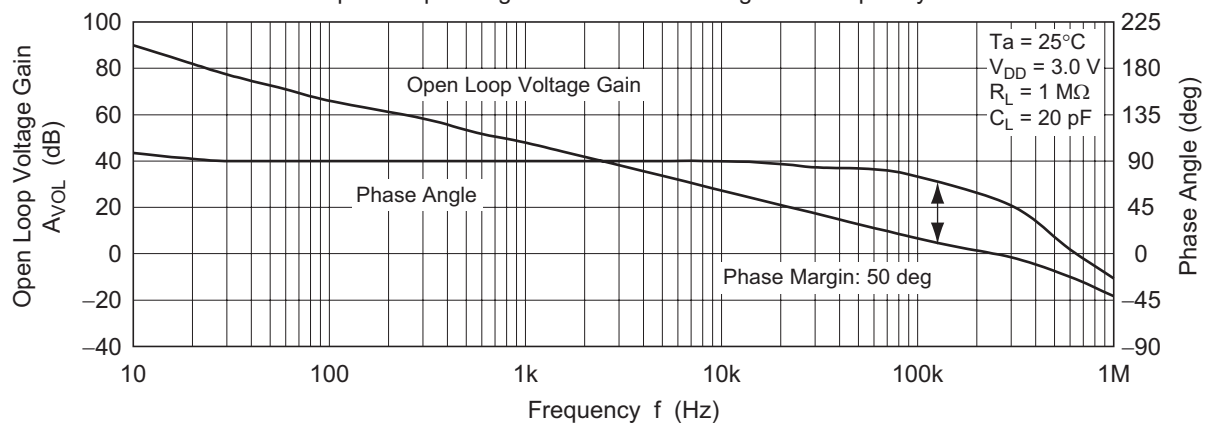


Figure 1-15. HA1630Q01
Input Bias Current vs. Ambient Temperature

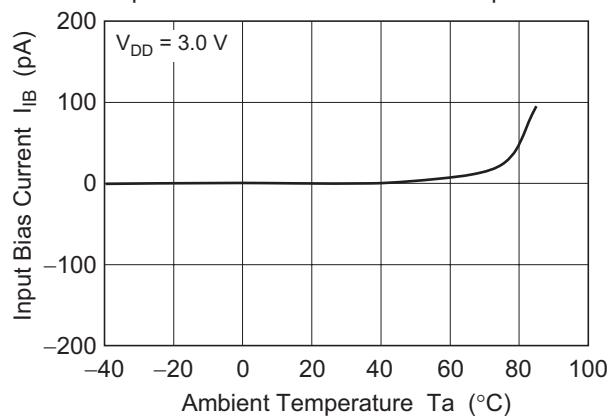


Figure 1-16. HA1630Q01
Input Bias Current vs. Input Voltage

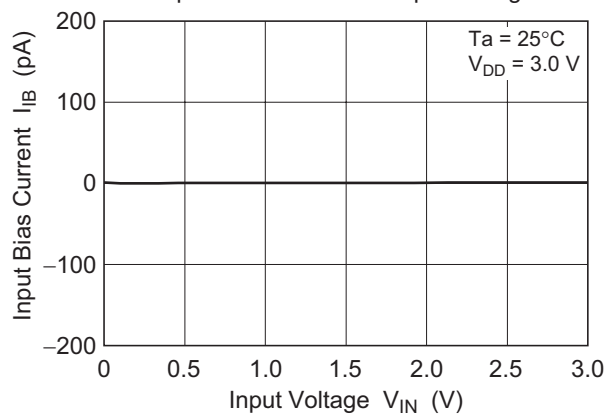


Figure 1-17. HA1630Q01
Slew Rate (rising) vs. Ambient Temperature

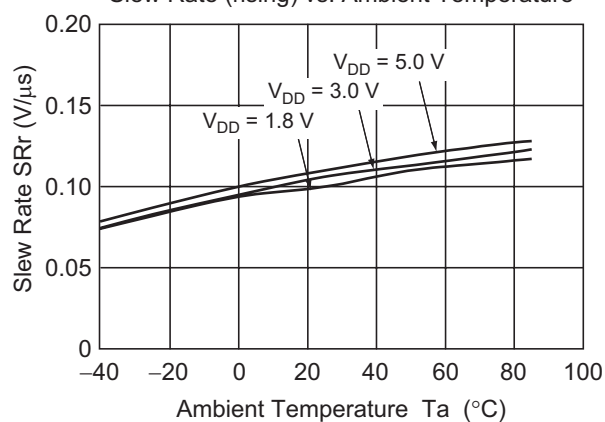


Figure 1-18. HA1630Q01
Slew Rate (falling) vs. Ambient Temperature

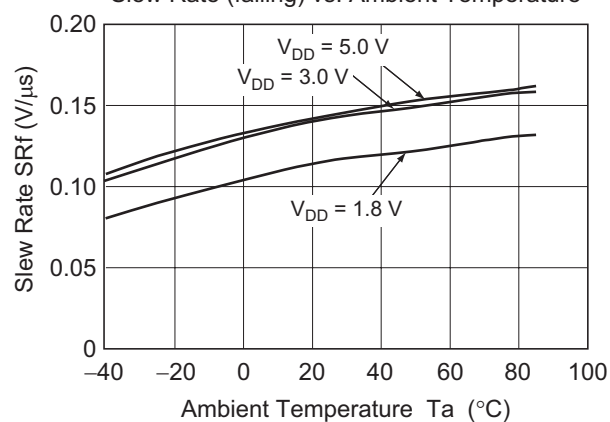


Figure 1-19. HA1630Q01
Large Signal Transient Response

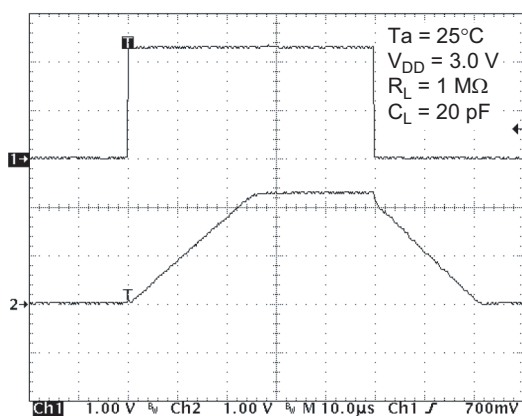


Figure 1-20. HA1630Q01
Small Signal Transient Response

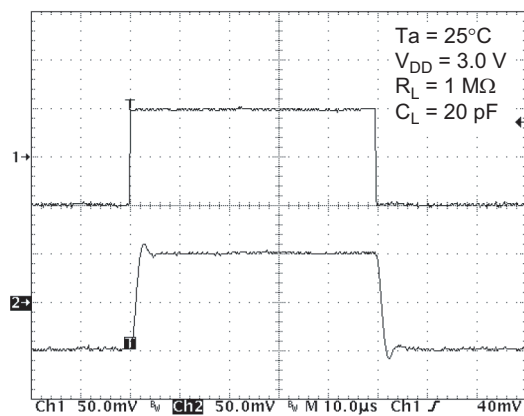


Figure 1-21. HA1630Q01
Voltage Output p-p vs. Frequency

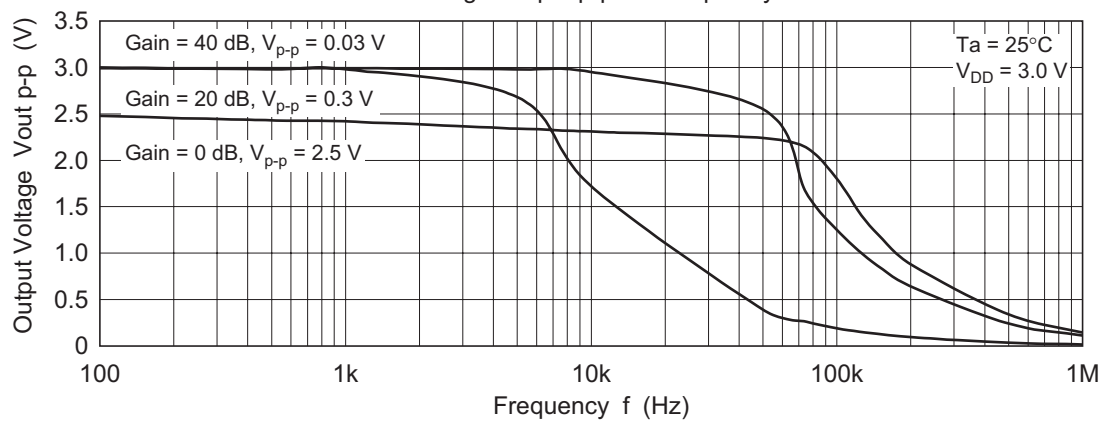
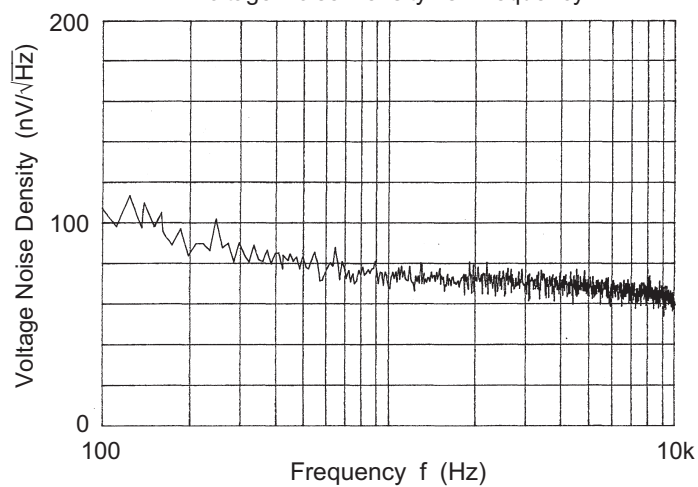
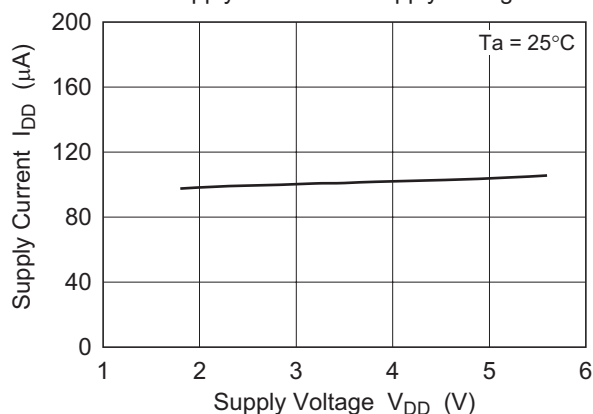
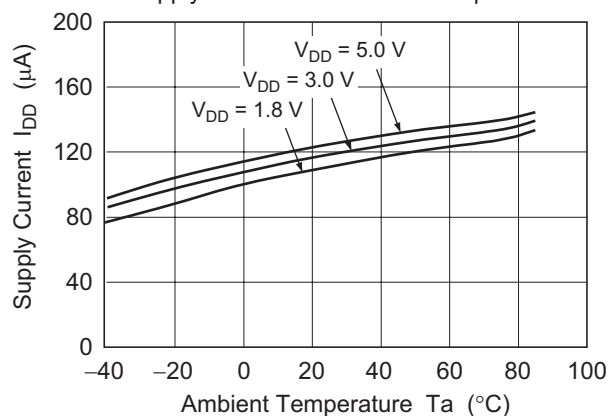
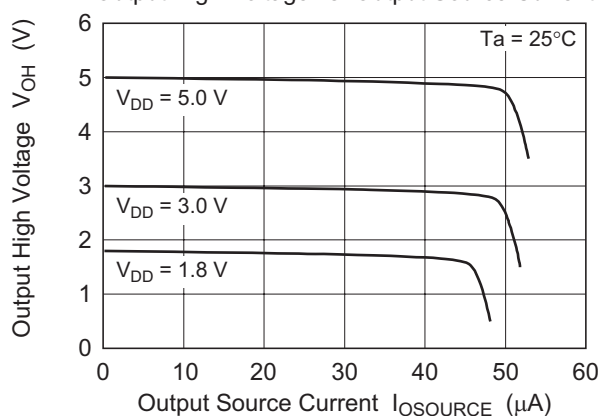
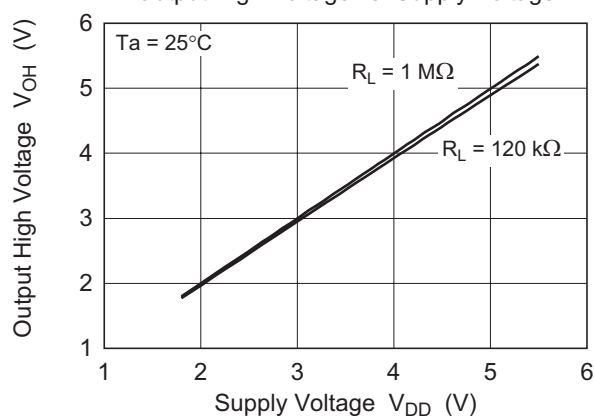
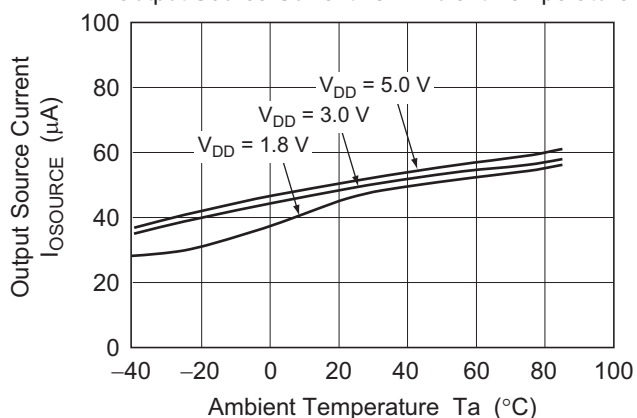


Figure 1-22. HA1630Q01
Voltage Noise Density vs. Frequency



Main Characteristics (HA1630Q02)

Figure 2-1. HA1630Q02
Supply Current vs. Supply VoltageFigure 2-2. HA1630Q02
Supply Current vs. Ambient TemperatureFigure 2-3. HA1630Q02
Output High Voltage vs. Output Source CurrentFigure 2-4. HA1630Q02
Output High Voltage vs. Supply VoltageFigure 2-5. HA1630Q02
Output Source Current vs. Ambient Temperature

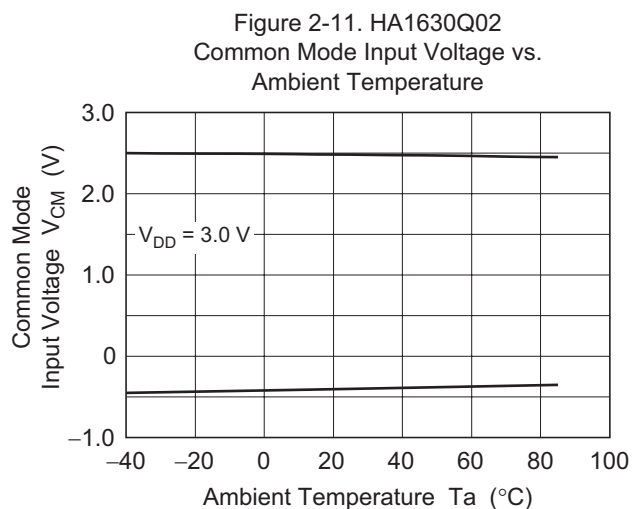
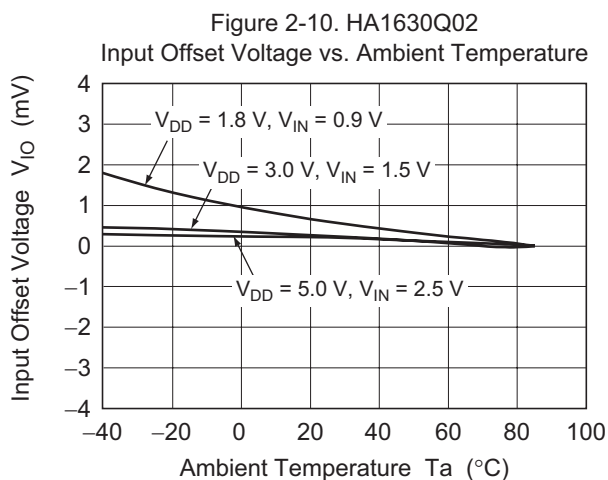
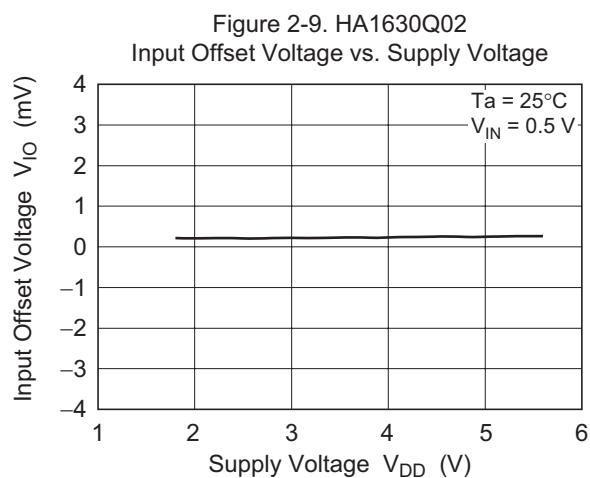
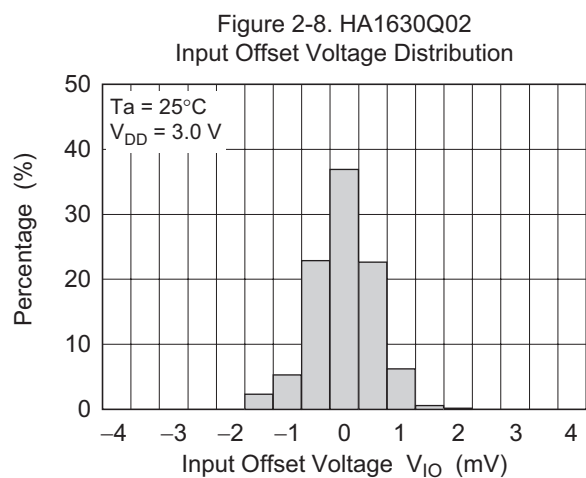
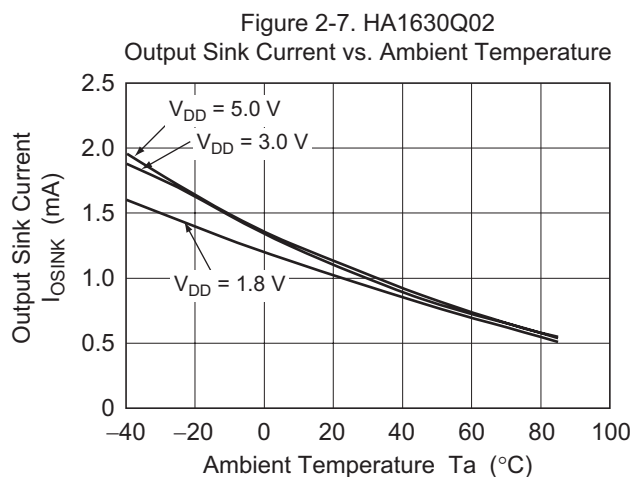
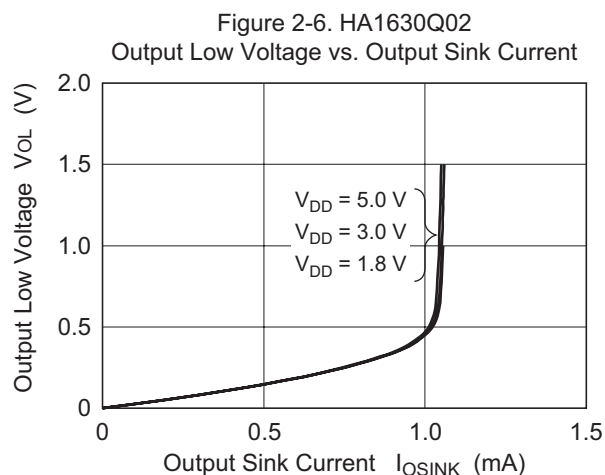


Figure 2-12. HA1630Q02
Power Supply Rejection Ratio vs. Frequency

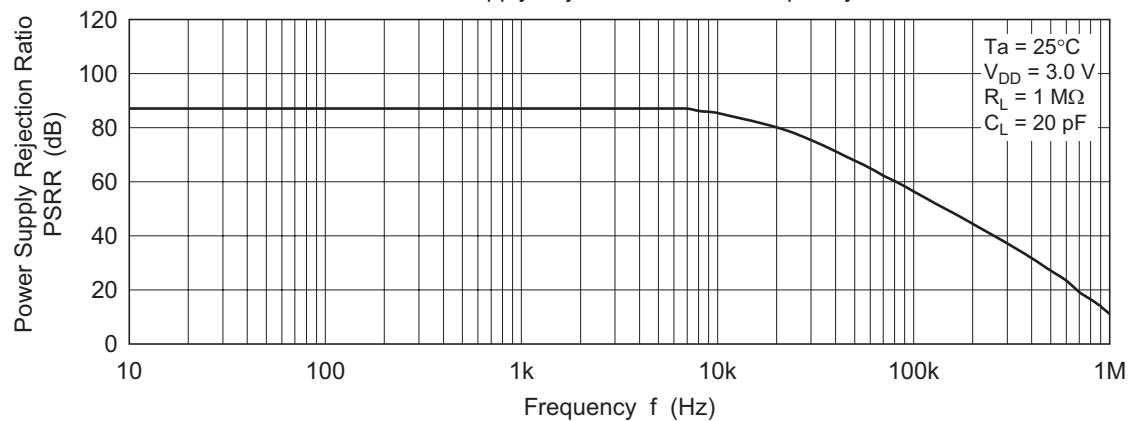


Figure 2-13. HA1630Q02
Common Mode Rejection Ratio vs. Frequency

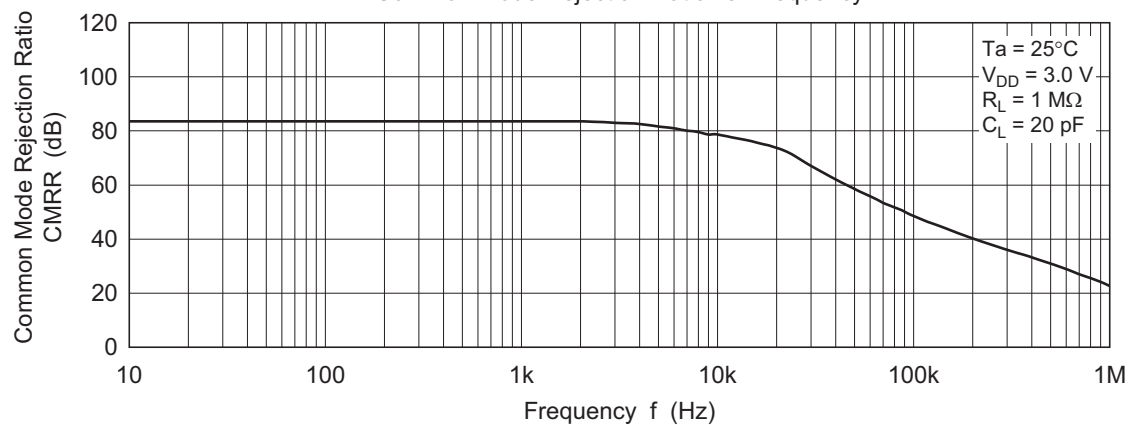


Figure 2-14. HA1630Q02
Open Loop Voltage Gain and Phase Angle vs. Frequency

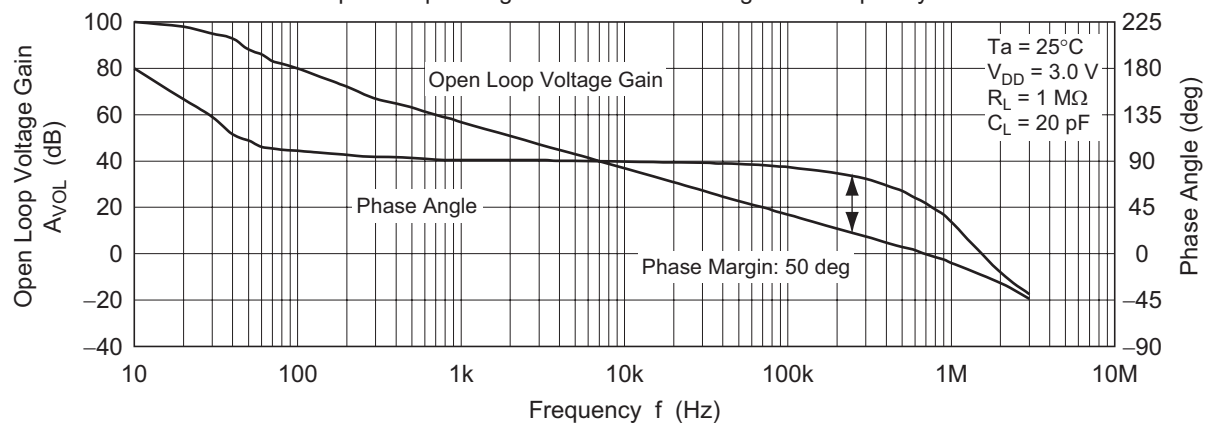


Figure 2-15. HA1630Q02
Input Bias Current vs. Ambient Temperature

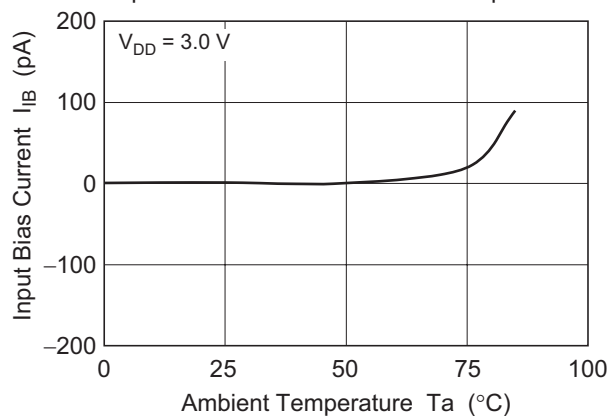


Figure 2-16. HA1630Q02
Input Bias Current vs. Input Voltage

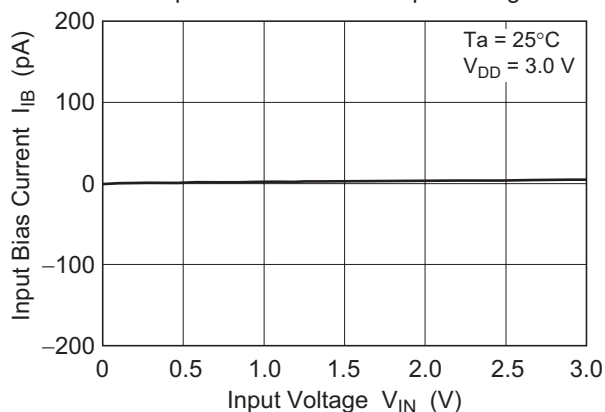


Figure 2-17. HA1630Q02
Slew Rate (rising) vs. Ambient Temperature

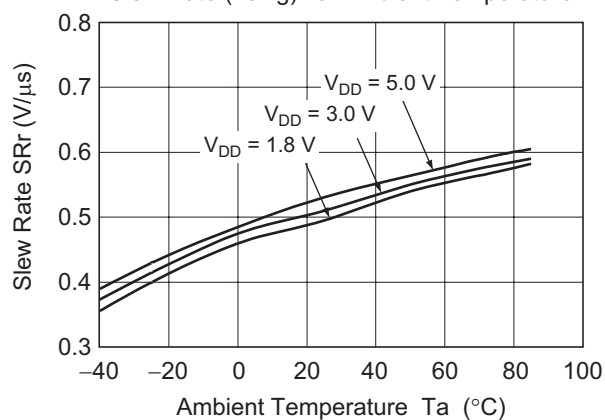


Figure 2-18. HA1630Q02
Slew Rate (falling) vs. Ambient Temperature

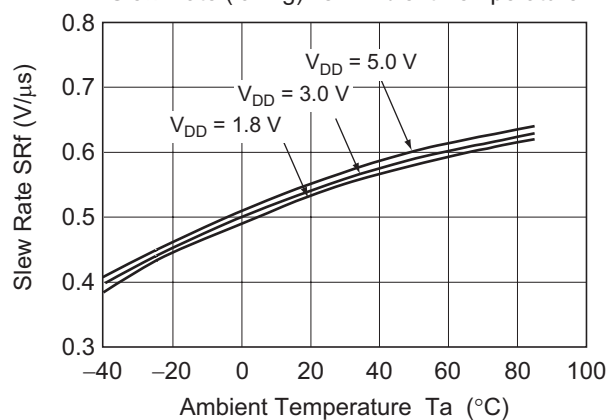


Figure 2-19. HA1630Q02
Large Signal Transient Response

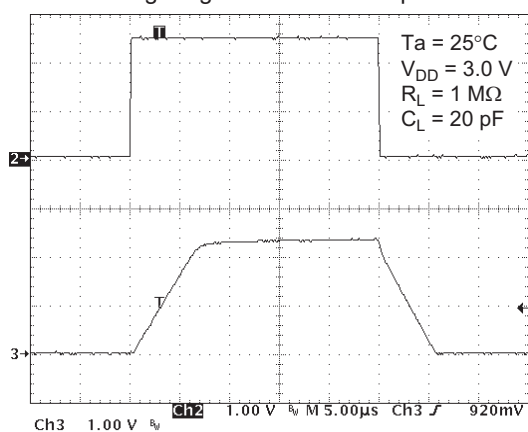


Figure 2-20. HA1630Q02
Small Signal Transient Response

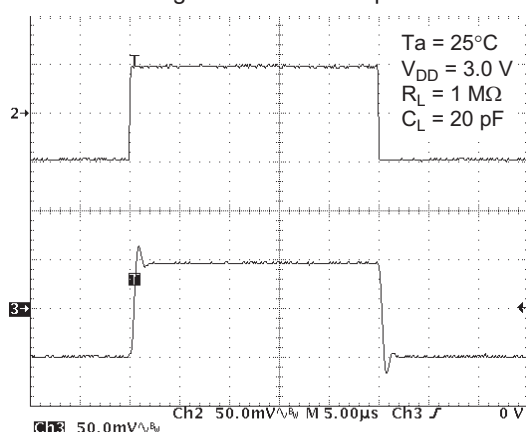


Figure 2-21. HA1630Q02
Total Harmonic Distortion + Noise vs.
Output Voltage p-p

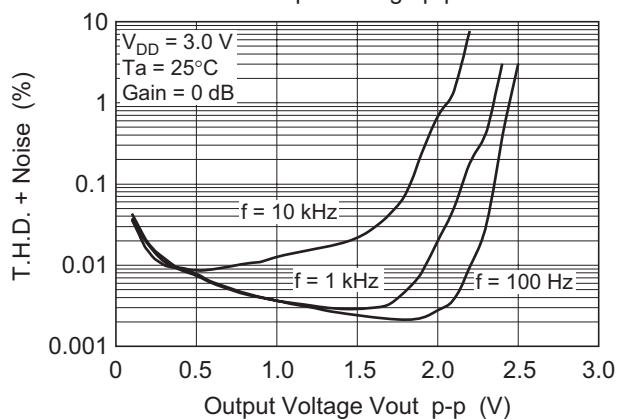


Figure 2-22. HA1630Q02
Total Harmonic Distortion + Noise vs.
Output Voltage p-p

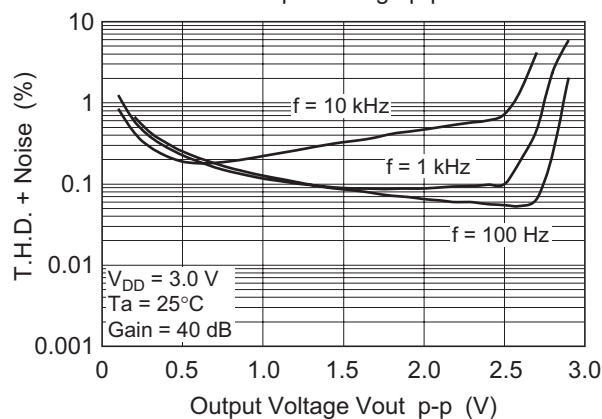


Figure 2-23. HA1630Q02
Voltage Output p-p vs. Frequency

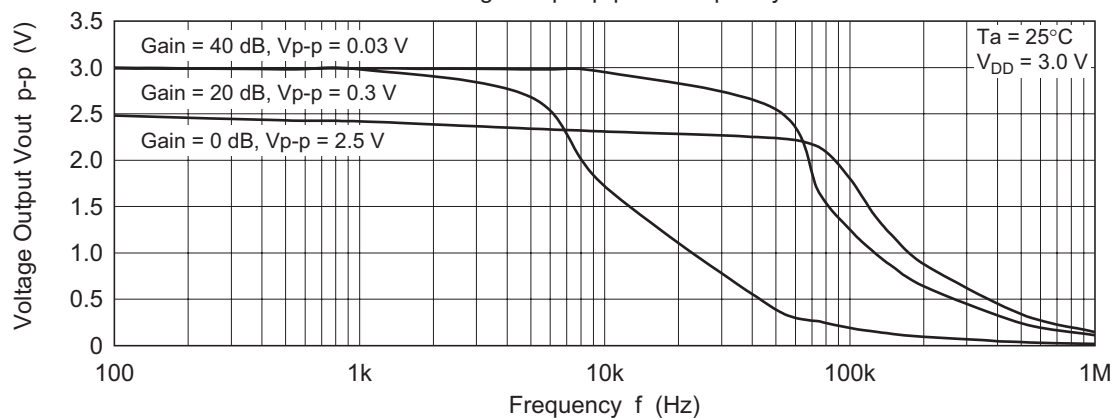
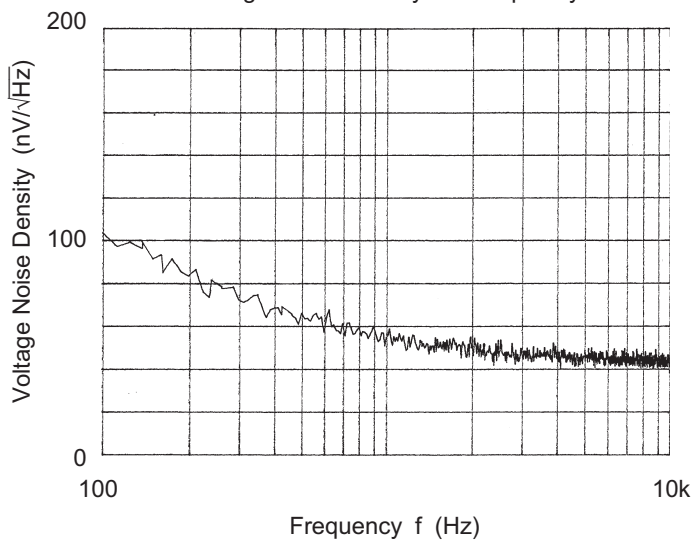
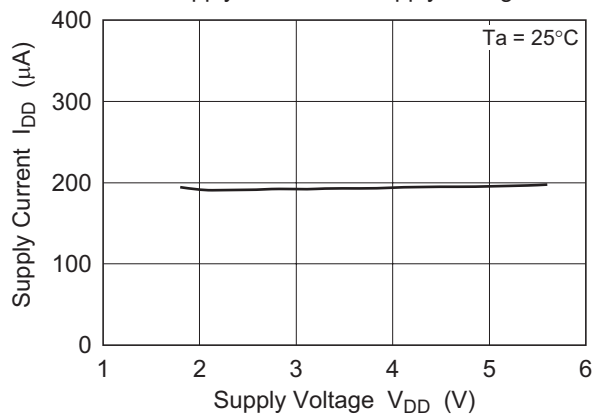
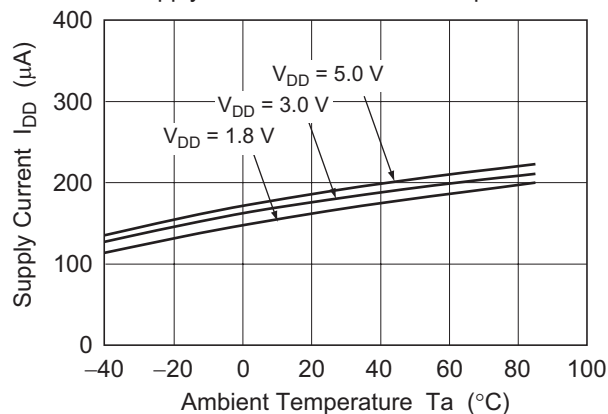
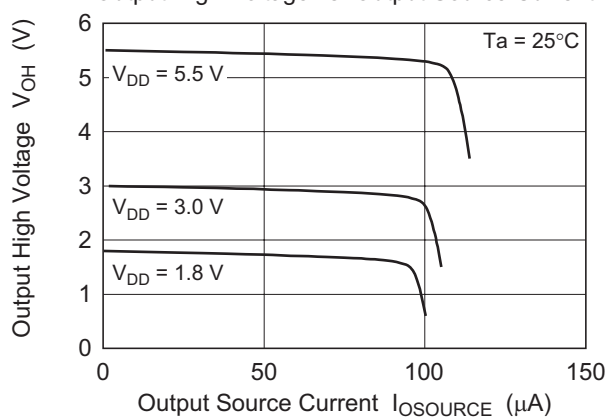
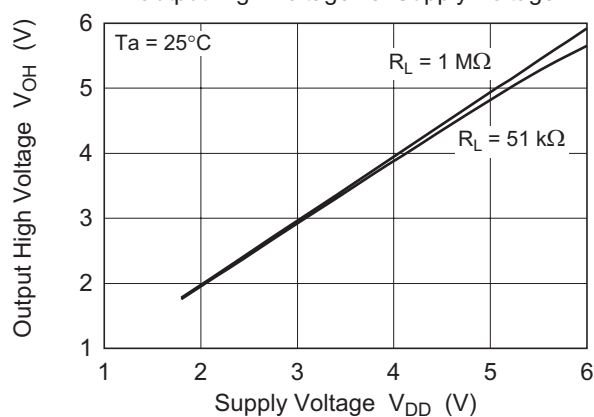
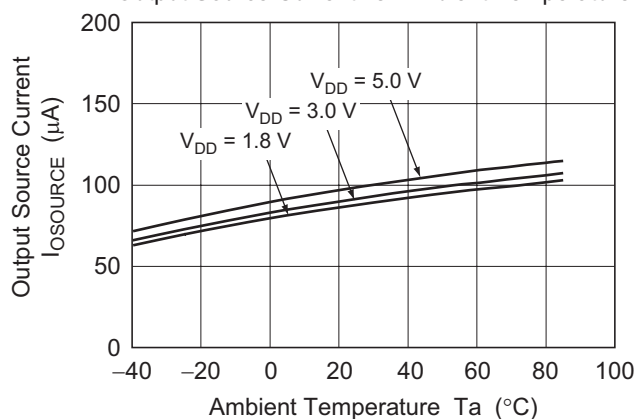


Figure 2-24. HA1630Q02
Voltage Noise Density vs. Frequency



Main Characteristics (HA1630Q03)

Figure 3-1. HA1630Q03
Supply Current vs. Supply VoltageFigure 3-2. HA1630Q03
Supply Current vs. Ambient TemperatureFigure 3-3. HA1630Q03
Output High Voltage vs. Output Source CurrentFigure 3-4. HA1630Q03
Output High Voltage vs. Supply VoltageFigure 3-5. HA1630Q03
Output Source Current vs. Ambient Temperature

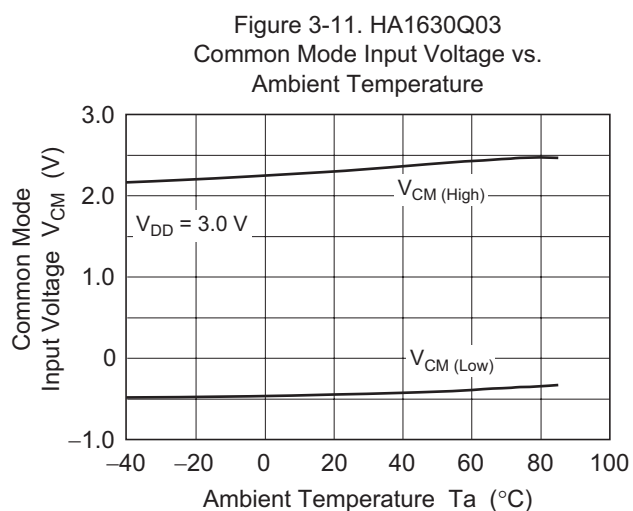
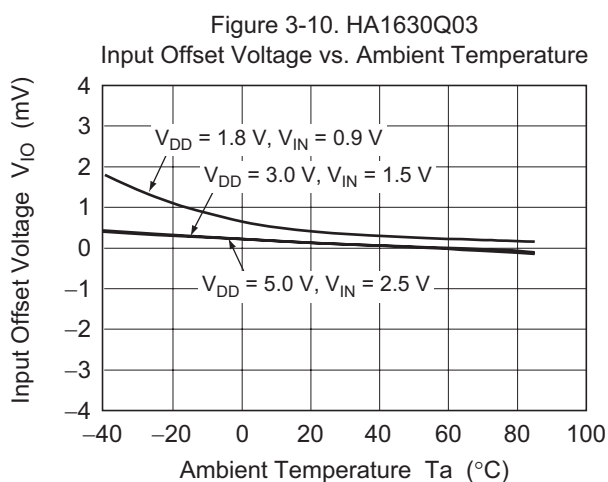
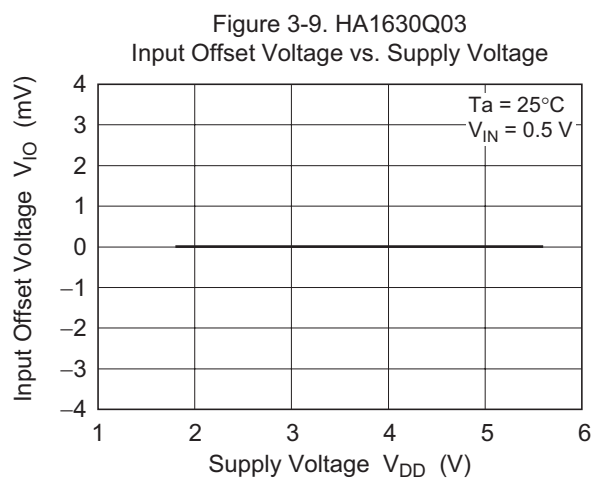
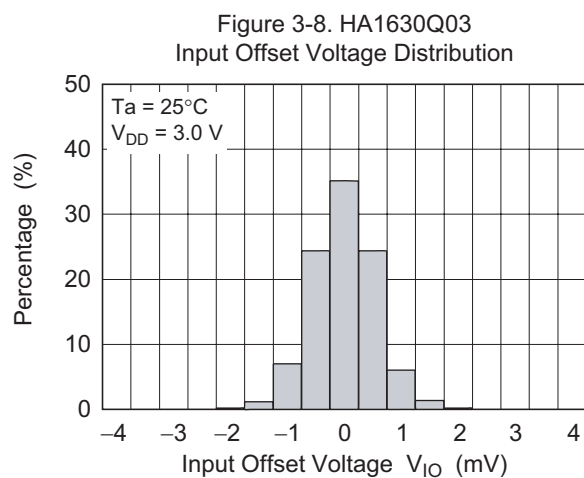
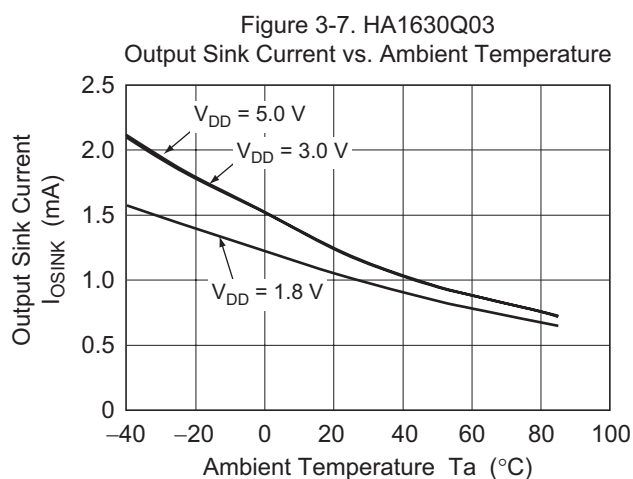
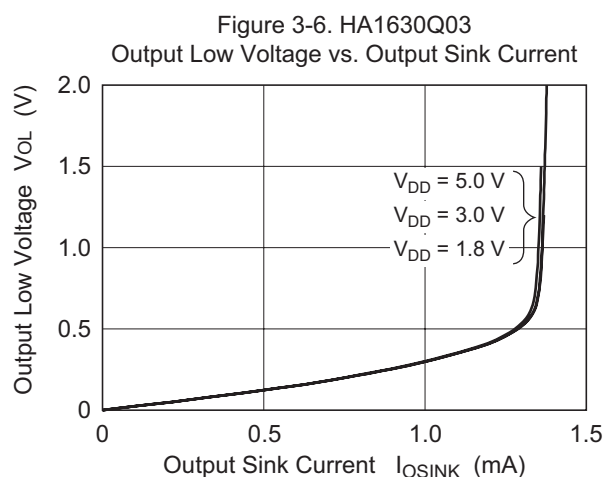


Figure 3-12. HA1630Q03
Power Supply Rejection Ratio vs. Frequency

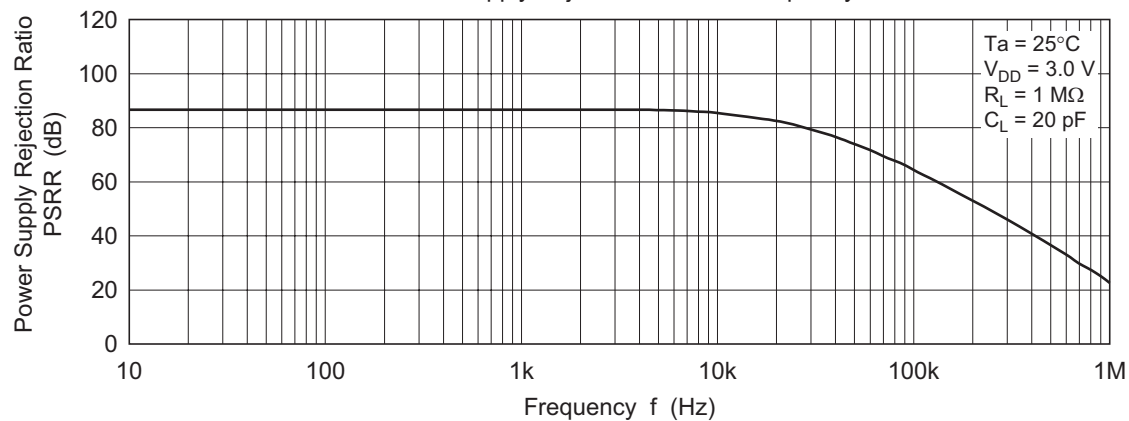


Figure 3-13. HA1630Q03
Common Mode Rejection Ratio vs. Frequency

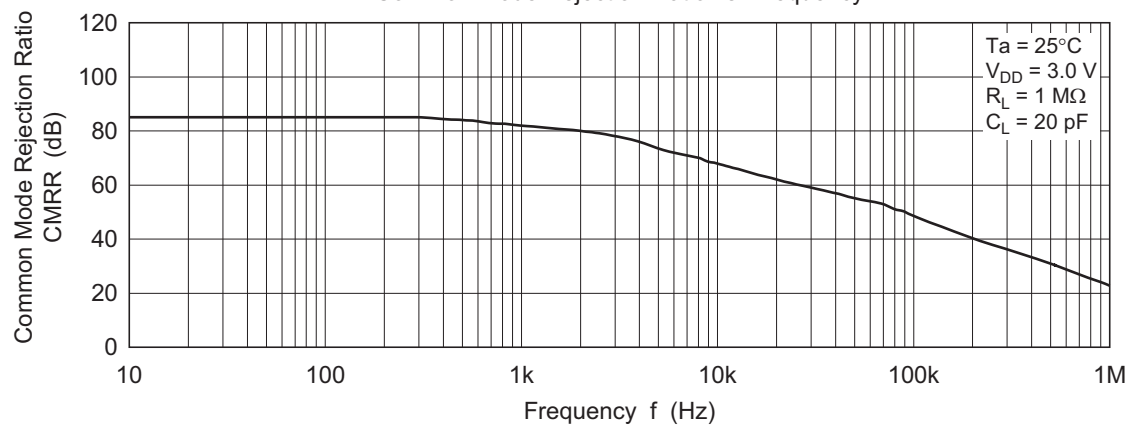
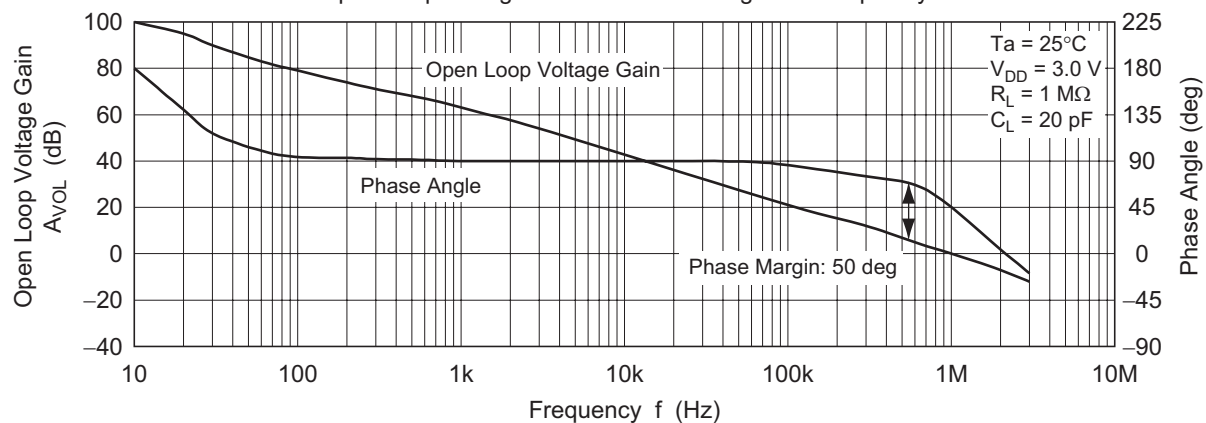


Figure 3-14. HA1630Q03
Open Loop Voltage Gain and Phase Angle vs. Frequency



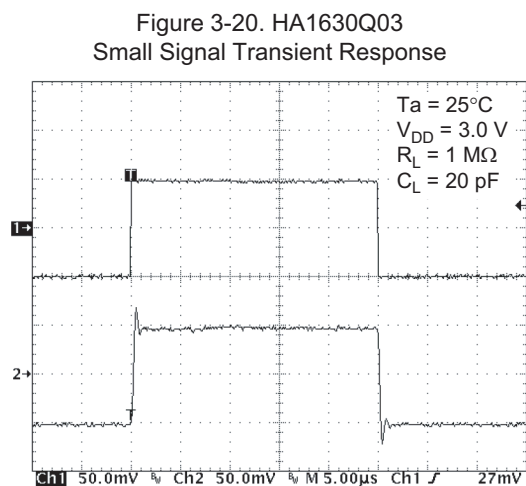
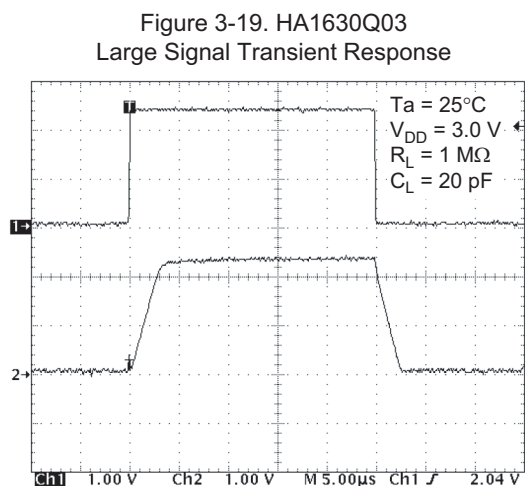
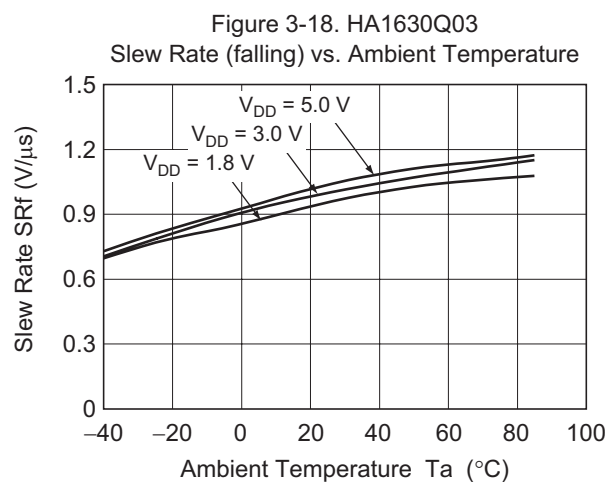
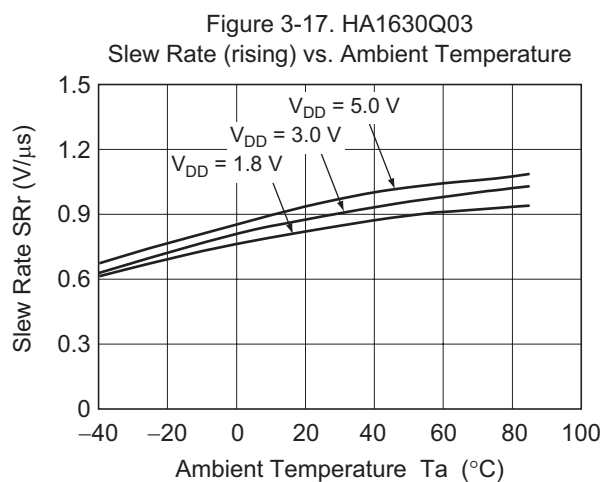
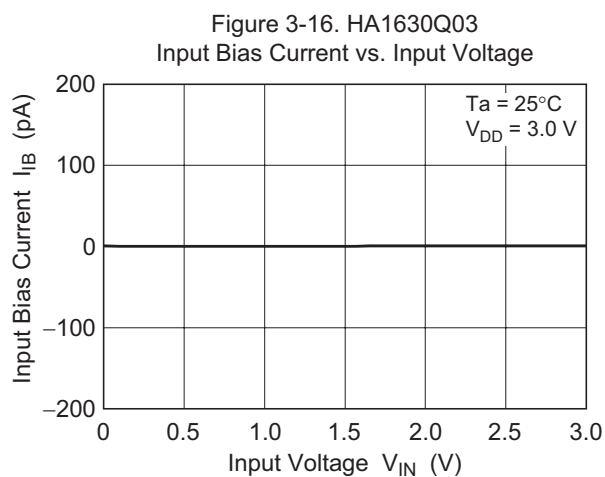
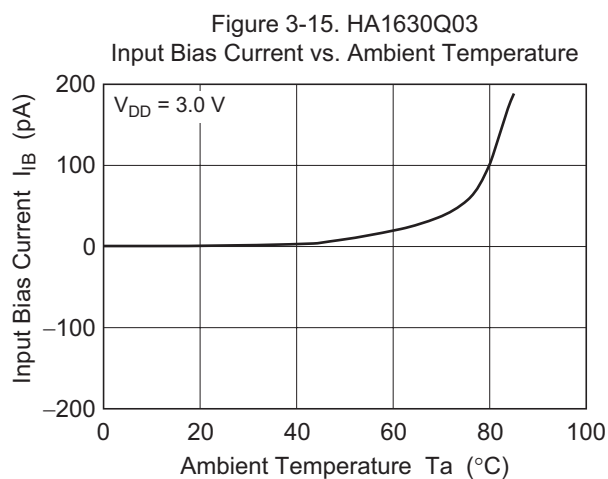


Figure 3-21. HA1630Q03
Total Harmonic Distortion + Noise vs.
Output Voltage p-p

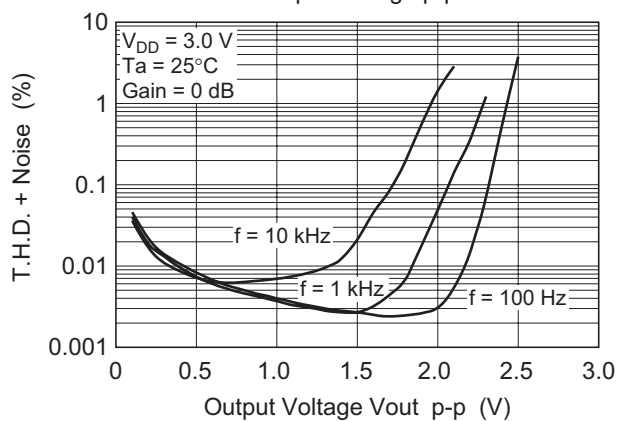


Figure 3-22. HA1630Q03
Total Harmonic Distortion + Noise vs.
Output Voltage p-p

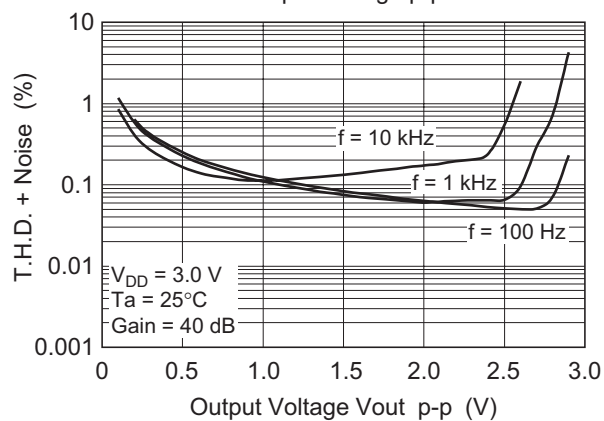


Figure 3-23. HA1630Q03
Voltage Output p-p vs. Frequency

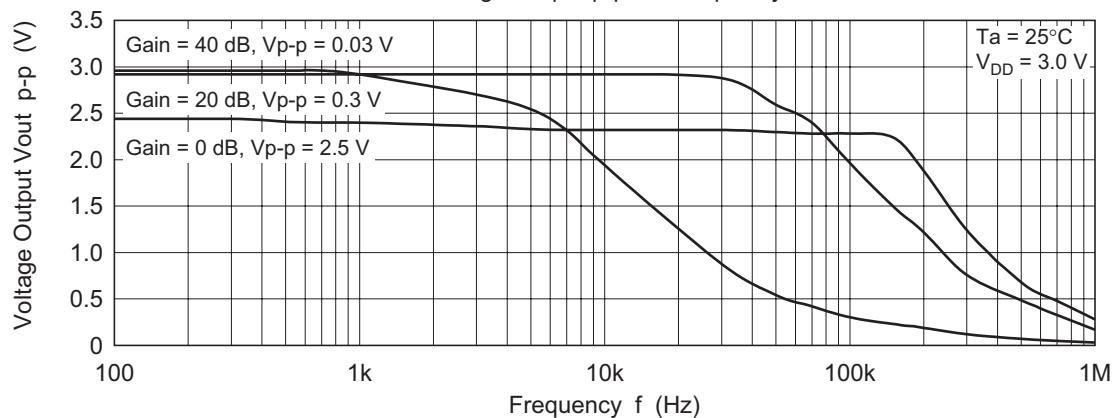
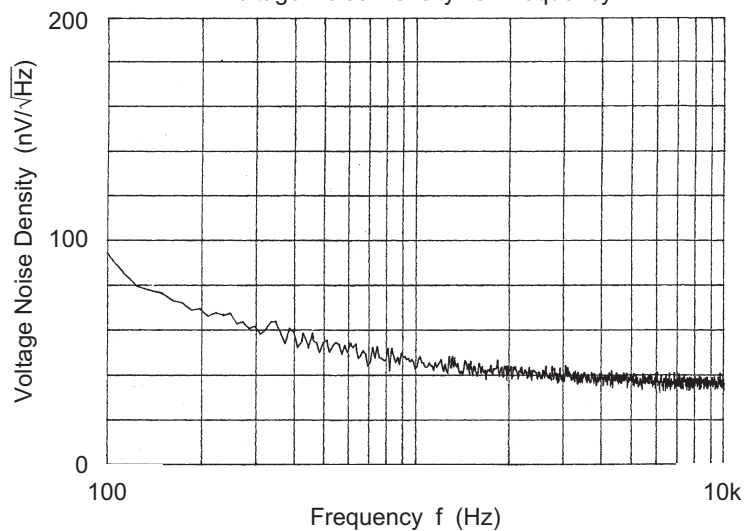
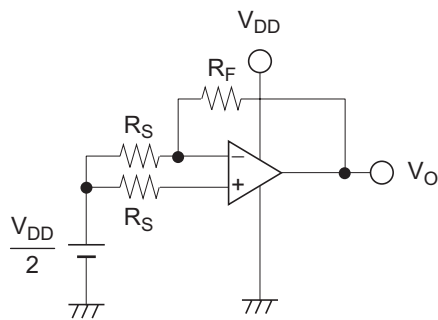


Figure 3-24. HA1630Q03
Voltage Noise Density vs. Frequency



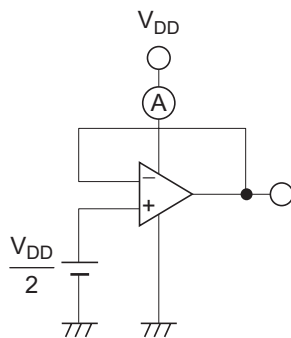
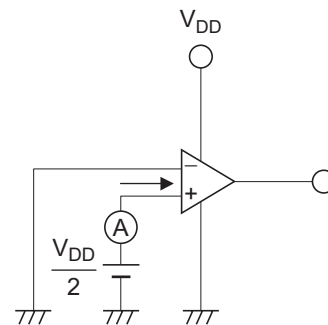
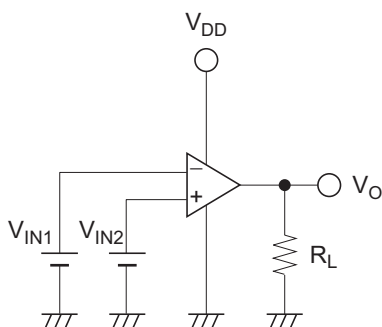
Test Circuits

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

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

 $PSRR$

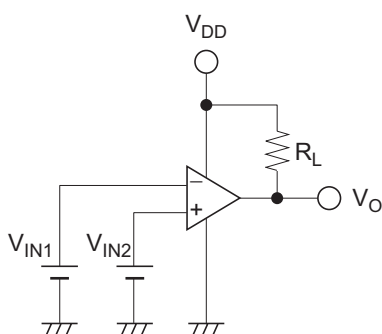
$$PSRR = -20 \log \left(\left| \frac{V_{O1} - V_{O2}}{V_{DD1} - V_{DD2}} \right| \times \frac{R_S}{R_S + R_F} \right)$$

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}  V_{OH}

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

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

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

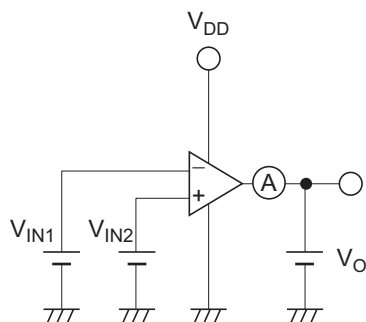
5. Output Low Voltage, V_{OL}  V_{OL}

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

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

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

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



$I_{OSOURCE}$

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

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

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

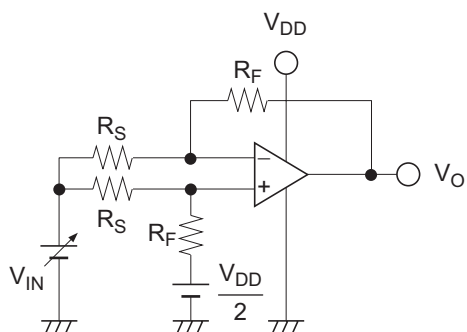
I_{OSINK}

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

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

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

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

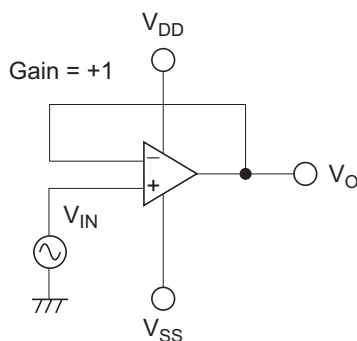
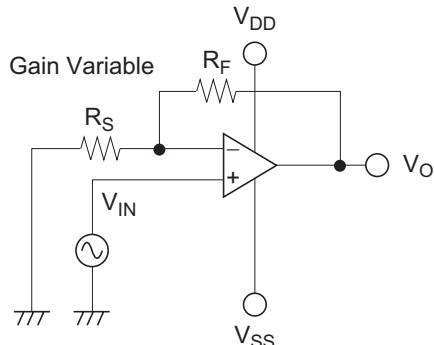


CMRR

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

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

8. Total Harmonic Distortion, THD



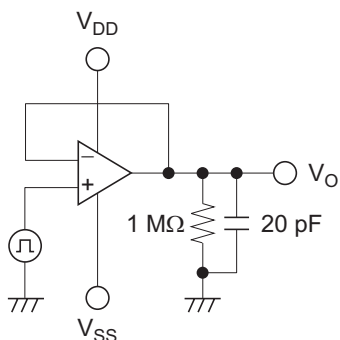
THD

Gain Variable

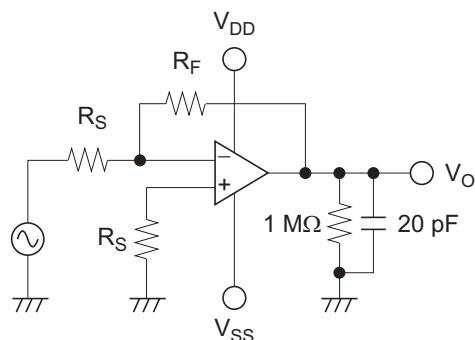
$$1 + R_F / R_S = 100$$

freq = 100 Hz, 1 kHz, 10 kHz

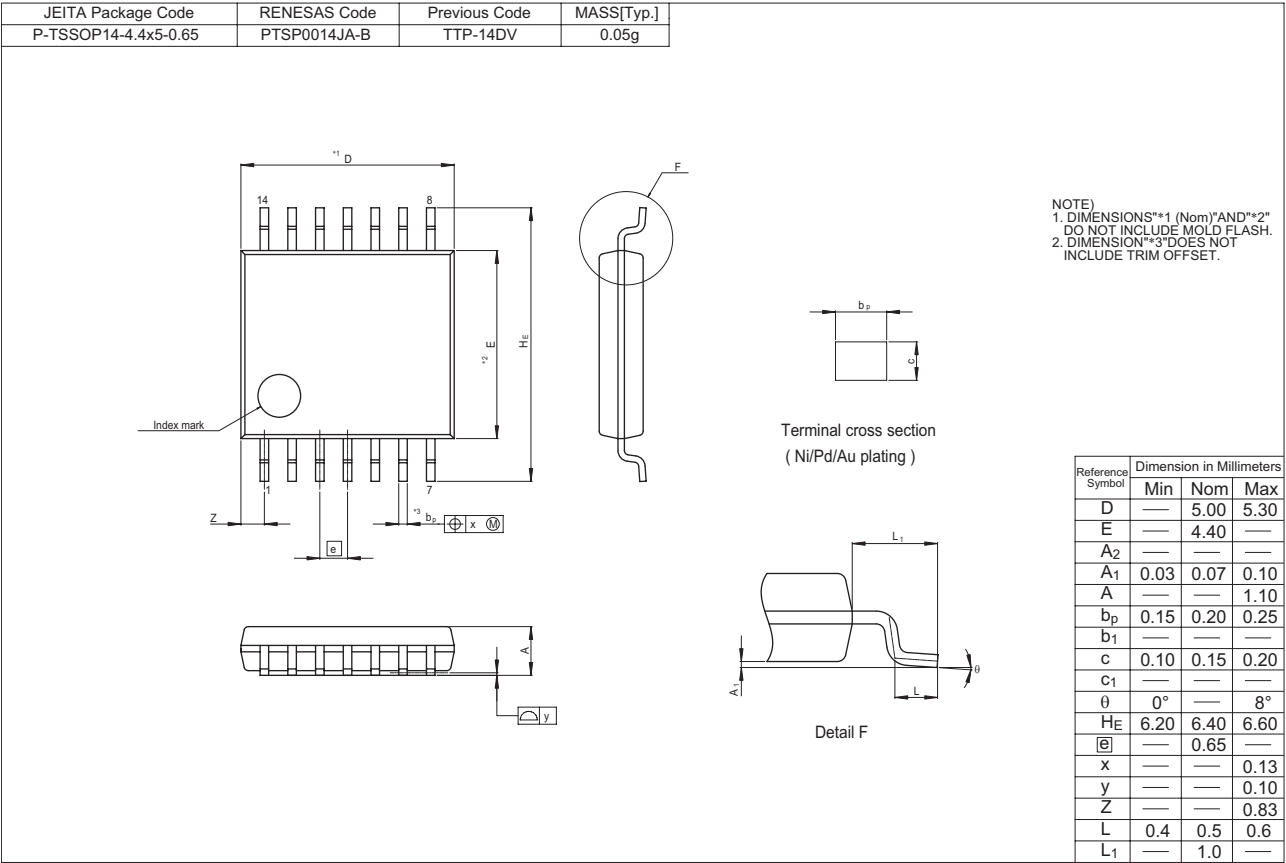
9. Slew Rate, SR



10. Gain, A_V & Phase, GBW



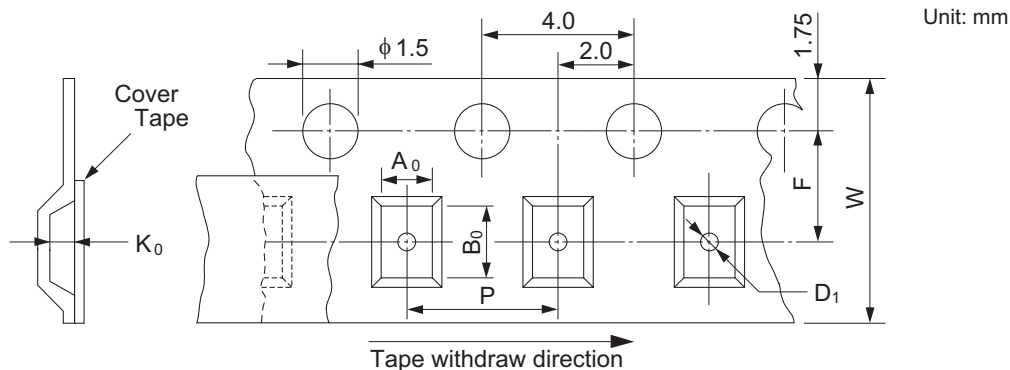
Package Dimensions



Taping & Reel Specification

[Taping]

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

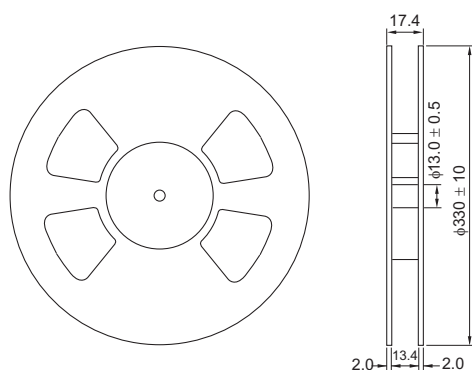


[Reel]

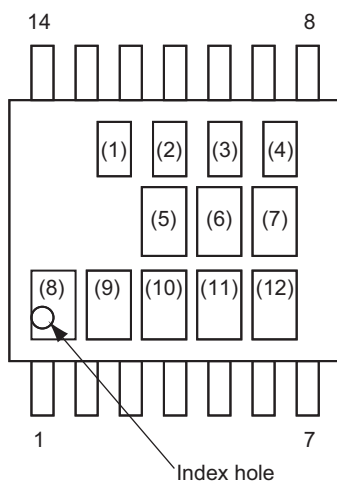
Package	Tape width	W1	W2
TSSOP-14	12	17.4	13.4

[Ordering Information]

Ordering Unit
2,000 pcs



Mark Indication



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

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Tel: <82> (2) 796-3115, Fax: <82> (2) 796-2145

Renesas Technology Malaysia Sdn. Bhd

Unit 906, Block B, Menara Amcorp, Amcorp Trade Centre, No.18, Jalan Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia
Tel: <603> 7955-9390, Fax: <603> 7955-9510