

# HA1631D01/02/03/04 Series

## Dual CMOS Comparator (Push Pull/Open Drain Output)

REJ03D0804-0200

Rev.2.00

Nov 20, 2006

### Description

The HA1631D01/02/03/04 are low power dual CMOS Comparator featuring low voltage operation with typical current supply of 10  $\mu$ A/100  $\mu$ A. They are designed to operate from a single power supply and have push-pull full swing outputs that allow direct connections to logic devices. The Open Drain version HA1631D03/04 enable Output Level shifting through external pull up resistors. Available in MMPAK-8 and TSSOP-8 package.

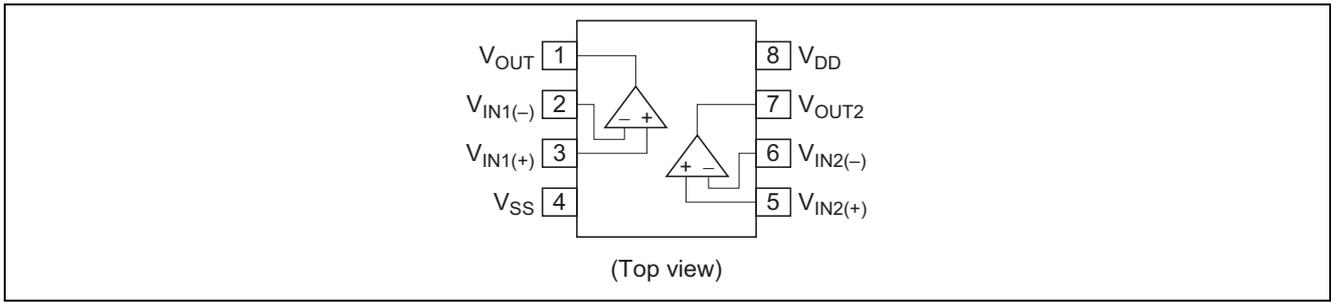
### Features

- Low supply current  
 HA1631D01/03 :  $I_{DDtyp} = 5 \mu A$  (per comparators)  
 HA1631D02/04 :  $I_{DDtyp} = 50 \mu A$  (per comparators)
- Low voltage operation :  $V_{DD} = 1.8$  to  $5.5$  V
- Low input offset voltage :  $V_{IOmax} = 5$  mV
- Low input bias current :  $I_{IBtyp} = 1$  pA
- Maximum output voltage :  $V_{OHmin} = 2.9$  V (at  $V_{DD} = 3.0$  V)
- Input common voltage range includes ground
- On-chip ESD protection
- Available in MMPAK-8, TSSOP-8 package using Pb free lead frame

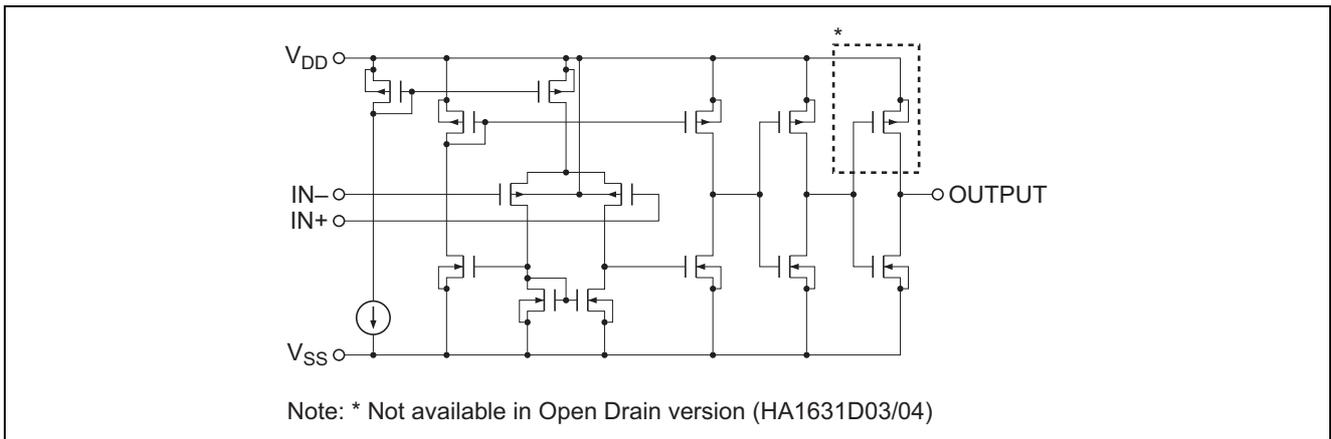
### Ordering Information

Type No.	Package Name	Package Code
HA1631D01T	TTP-8DAV	PTSP0008JC-B
HA1631D02T		
HA1631D03T		
HA1631D04T		
HA1631D01MM	MMPAK-8	PLSP0008JC-A
HA1631D02MM		
HA1631D03MM		
HA1631D04MM		

## Pin Arrangement



## Equivalent Circuit (1/2)



## Absolute Maximum Ratings

(Ta = 25°C)

Item	Symbol	Ratings	Unit	Remarks
Supply voltage	V <sub>DD</sub>	7.0	V	
Differential input voltage	V <sub>IN(diff)</sub>	-V <sub>DD</sub> to +V <sub>DD</sub>	V	Note 1
Input voltage	V <sub>IN</sub>	-0.1 to +V <sub>DD</sub>	V	
Output current	I <sub>OUT</sub>	28	mA	Note 2
Power dissipation	P <sub>T</sub>	192	mW	TSSOP-8
Operating temperature	Topr	-40 to +85	°C	
Storage temperature	Tstg	-55 to +125	°C	

Notes: 1. Do not apply input voltage exceeding V<sub>DD</sub> or 7 V.

2. The maximum output current is the maximum allowable value for continuous operation.

## Electrical Characteristics

(Ta = 25°C, V<sub>DD</sub> = 3.0 V, V<sub>SS</sub> = 0 V)

Item	Symbol	Min	Typ	Max	Unit	Test Conditions	
Input offset voltage	V <sub>IO</sub>	—	—	5	mV	V <sub>IN</sub> = V <sub>DD</sub> /2, R <sub>L</sub> = 1 MΩ	
Input bias current	I <sub>IB</sub>	—	(1)	—	pA	V <sub>IN</sub> = V <sub>DD</sub> /2	
Input offset current	I <sub>IO</sub>	—	(1)	—	pA	V <sub>IN</sub> = V <sub>DD</sub> /2	
Common mode input voltage range	V <sub>CM</sub>	-0.1	—	2.1	V		
Supply current	HA1631D01/03	I <sub>DD</sub>	—	10	20	μA	V <sub>DD</sub> = 3 V, V <sub>IN+</sub> = 1 V, V <sub>IN-</sub> = 0 V
	HA1631D02/04		—	100	200	μA	
Response time	HA1631D01	TP <sub>LH</sub>	—	(1.20)	—	μs	1 V DC bias, 100 mV overdrive, C <sub>L</sub> = 15 pF
	HA1631D01/03	TP <sub>HL</sub>	—	(0.55)	—	μs	
	HA1631D01	t <sub>r</sub>	—	(24)	—	ns	
	HA1631D01/03	t <sub>f</sub>	—	(7)	—	ns	
	HA1631D02	TP <sub>LH</sub>	—	(0.33)	—	μs	
	HA1631D02/04	TP <sub>HL</sub>	—	(0.17)	—	μs	
	HA1631D02	t <sub>r</sub>	—	(12)	—	ns	
Output source current (Only for HA1631D01/02)	I <sub>OSOURCE</sub>	6	13	—	mA	V <sub>out</sub> = 2.5 V	
		7	14	—	mA	V <sub>out</sub> = 0.5 V	
Common mode rejection ratio	HA1631D01/03	CMRR	60	80	—	dB	V <sub>IN1</sub> = 0 V, V <sub>IN2</sub> = 2 V
	HA1631D02/04		50	70	—	dB	
Power supply rejection ratio	PSRR	60	80	—	dB	V <sub>DD1</sub> = 1.8 V, V <sub>DD2</sub> = 5 V	
Output voltage high (Only for HA1631D01/02)	V <sub>OH</sub>	V <sub>DD</sub> -0.1	—	—	V	R <sub>L</sub> = 10 kΩ to V <sub>SS</sub>	
Output voltage low	V <sub>OL</sub>	—	—	0.1	V	R <sub>L</sub> = 10 kΩ to V <sub>DD</sub>	
Output leakage current (Only for HA1631D03/04)	I <sub>LO</sub>	—	—	0.1	μA	V <sub>IN+</sub> = 1 V, V <sub>IN-</sub> = 0 V, V <sub>O</sub> = 3 V	
Operating voltage range	Vopr	1.8	—	5.5	V		

Note: ( ): Design specification

## Table of Graphs

Electrical Characteristics			HA1631D01 Figure	HA1631D02 Figure	HA1631D03 Figure	HA1631D04 Figure	Test Circuit No.
Supply current	$I_{DD}$	vs. Supply voltage(Out H)	1-1	2-1	3-1	4-1	1
		vs. Supply voltage(Out L)	1-2	2-2	3-2	4-2	2
		vs. Temperature(Out H)	1-3	2-3	3-3	4-3	1
		vs. Frequency(Out H)	1-26	2-26	3-20	4-20	15
Output high voltage	$V_{OH}$	vs. Rload	1-19	2-19	—	—	4
Output source current	$I_{SOURCE}$	vs. Output high voltage	1-4	2-4	—	—	3
Output low voltage	$V_{OL}$	vs. Rload	1-18	2-18	3-15	4-15	6
Output sink current	$I_{OSINK}$	vs. Output low voltage	1-5	2-5	3-4	4-4	5
Input offset voltage	$V_{IO}$	vs. Supply voltage	1-6	2-6	3-5	4-5	8
		vs. Temperature	1-7	2-7	3-6	4-6	7
Common mode input voltage range	$V_{CM}$	vs. Temperature	1-8	2-8	3-7	4-7	9
Power supply rejection ratio	PSRR	vs. Supply voltage	1-9	2-9	3-8	4-8	11
Common mode rejection ratio	CMRR	vs. Input voltage	1-10	2-10	3-9	4-9	12
Input bias current	$I_{IB}$	vs. Temperature	1-11	2-11	3-10	4-10	10
		vs. Input voltage( $V_{DD} = 3\text{ V}$ )	1-12	2-12	3-11	4-11	10
		vs. Input voltage( $V_{DD} = 7\text{ V}$ )	1-13	2-13	3-12	4-12	10
Falling time	$t_f$	vs. Temperature	1-14	2-14	3-13	4-13	13
		vs. Cload	1-16	2-16	3-14	4-14	13
		Time waveform	1-21	2-21	3-16	4-16	13
Rising time	$t_r$	vs. Temperature	1-15	2-15	—	—	13
		vs. Cload	1-17	2-17	—	—	13
		Time waveform	1-20	2-20	—	—	13
Propagation delay time	$TP_{LH}$	Time waveform	1-22	2-22	—	—	13
	$TP_{HL}$	Time waveform	1-23	2-23	3-17	4-17	13
Cross talk	$V_{OUT}(CH1)$	vs. Input voltage	1-24	2-24	3-18	4-18	14
	$V_{OUT}(CH2)$	vs. Input voltage	1-25	2-25	3-19	4-19	14

Main Characteristics

(unless otherwise noted,  $V_{DD} = 3\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_a = 25^\circ\text{C}$ )

Figure 1-1 HA1631D01  
Supply Current vs. Supply Voltage  
(Output High)

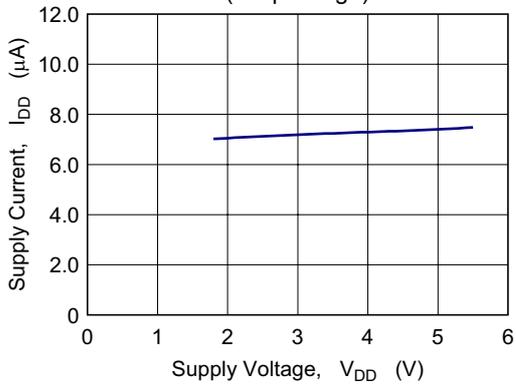


Figure 1-2 HA1631D01  
Supply Current vs. Supply Voltage  
(Output Low)

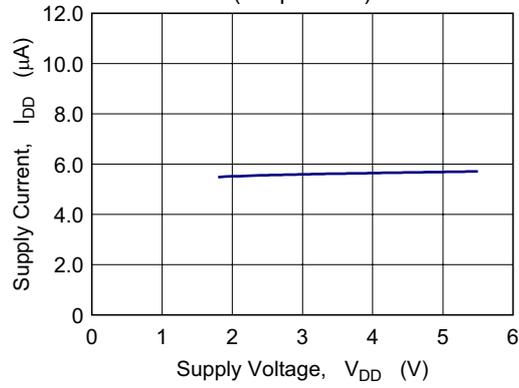


Figure 1-3 HA1631D01  
Supply Current vs. Ambient Temperature

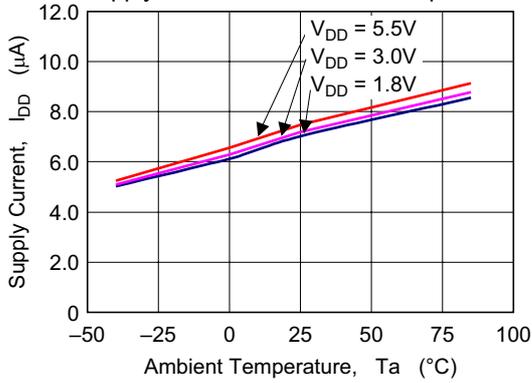


Figure 1-4 HA1631D01  
Output High Voltage vs. Output Source Current

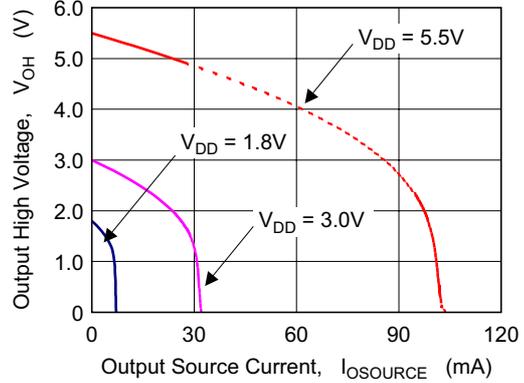


Figure 1-5 HA1631D01  
Output Low Voltage vs. Output Sink Current

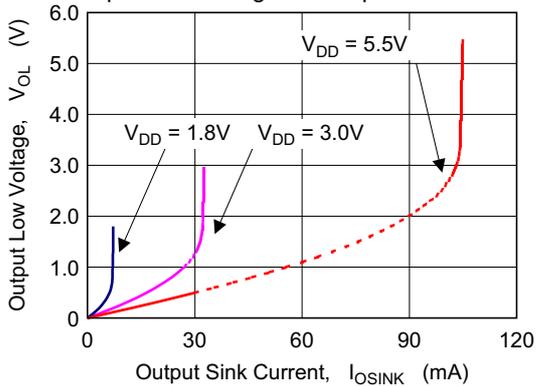
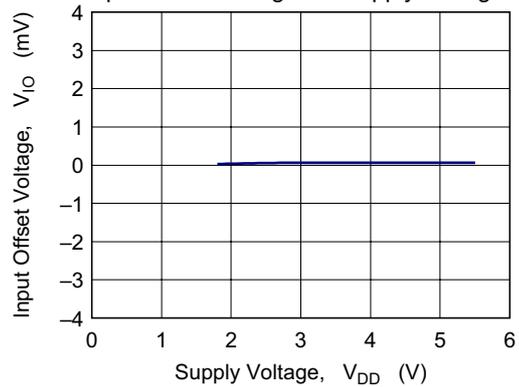
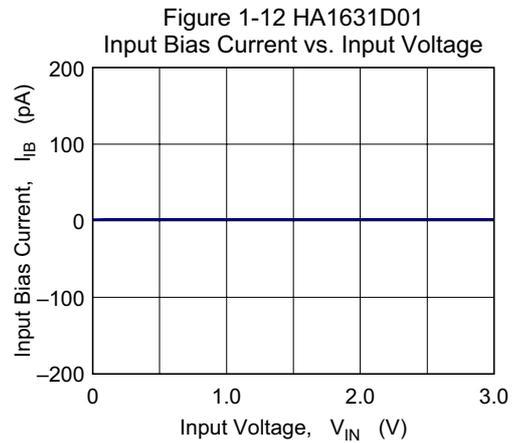
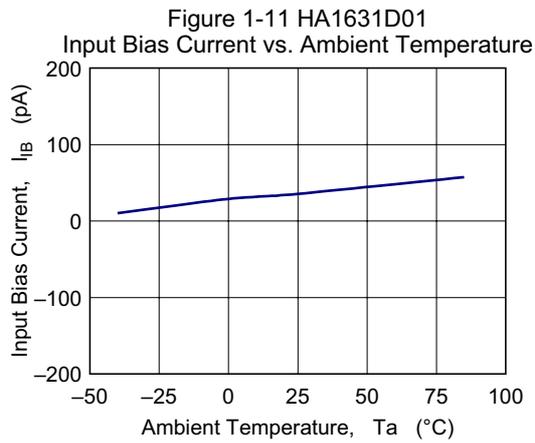
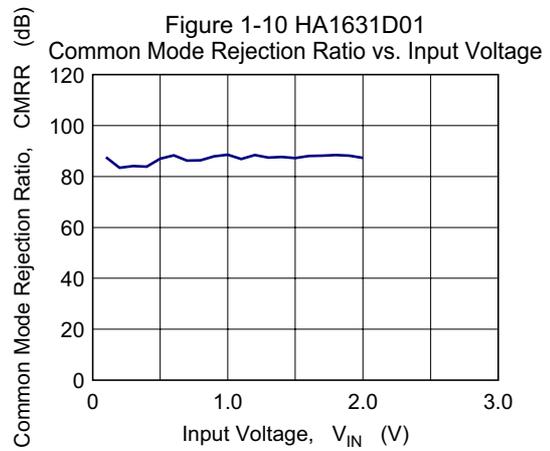
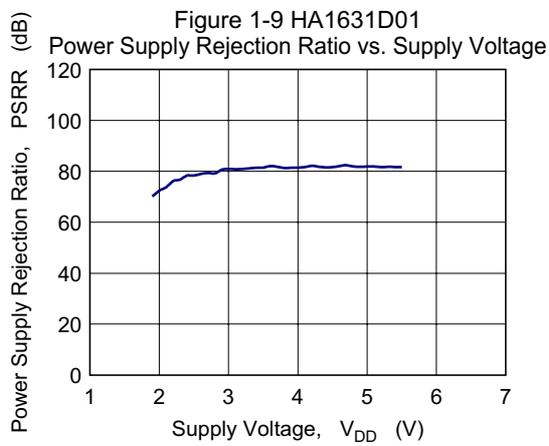
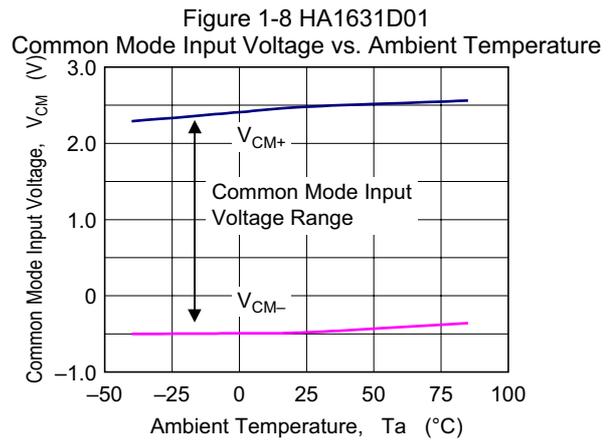
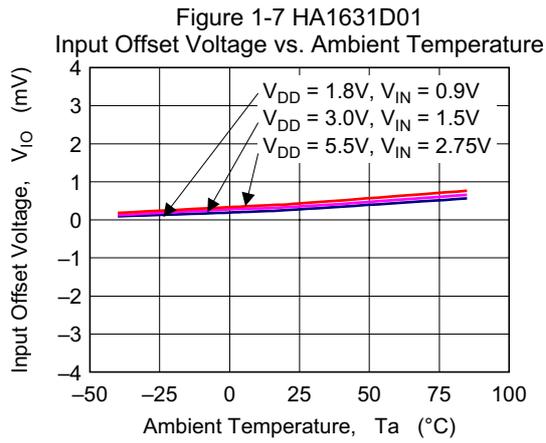


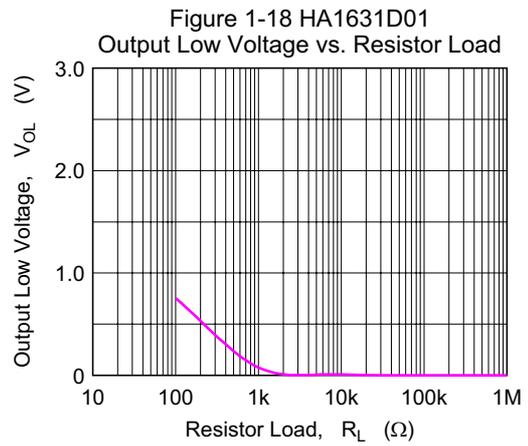
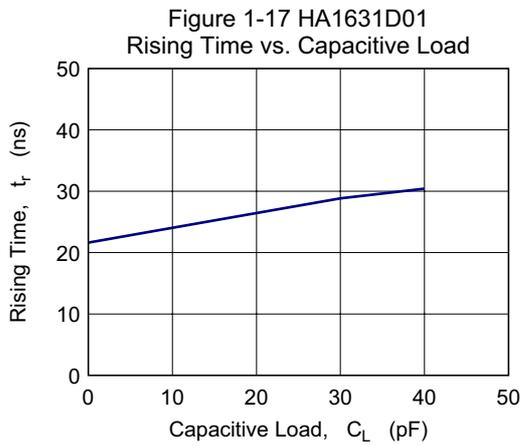
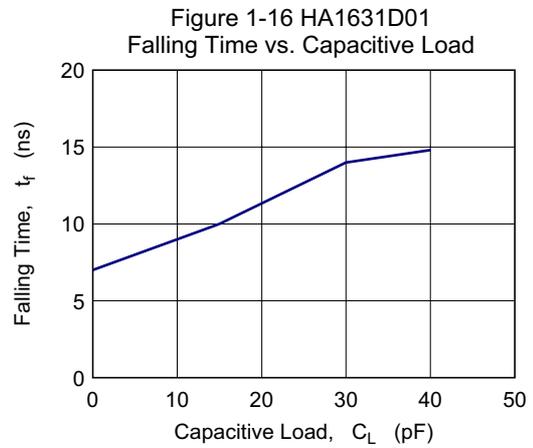
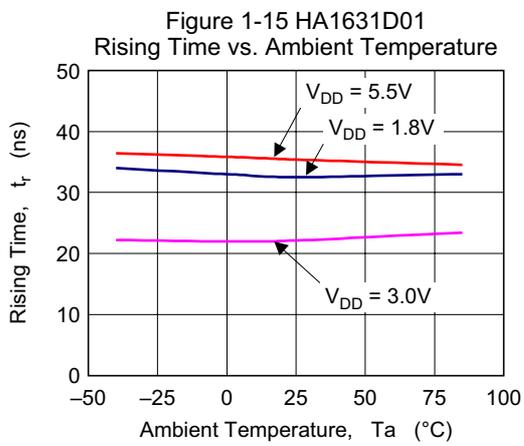
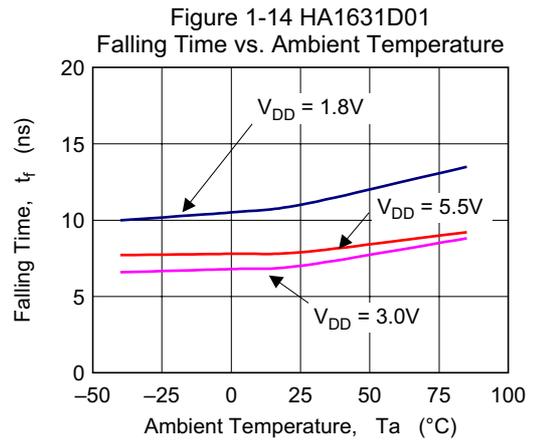
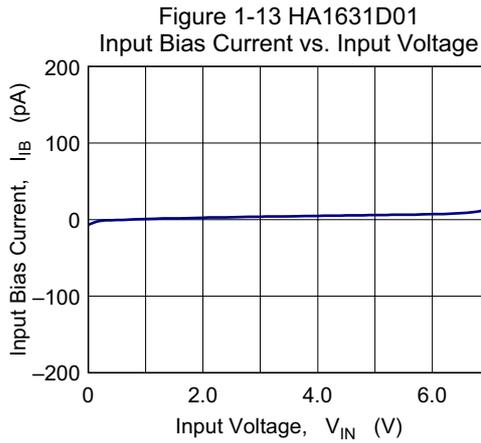
Figure 1-6 HA1631D01  
Input Offset Voltage vs. Supply Voltage



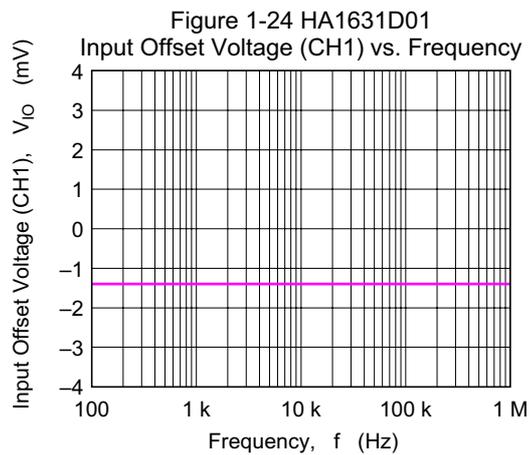
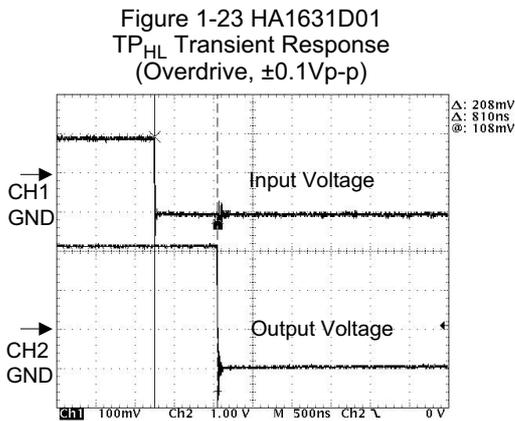
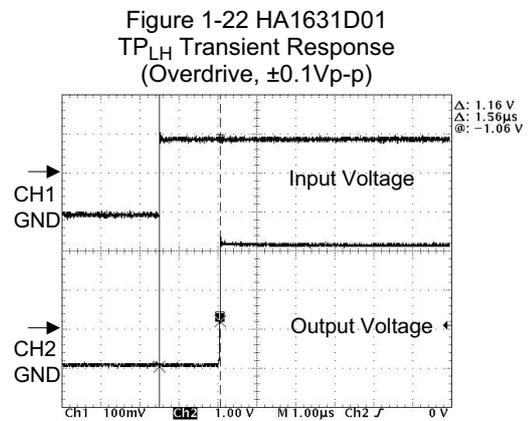
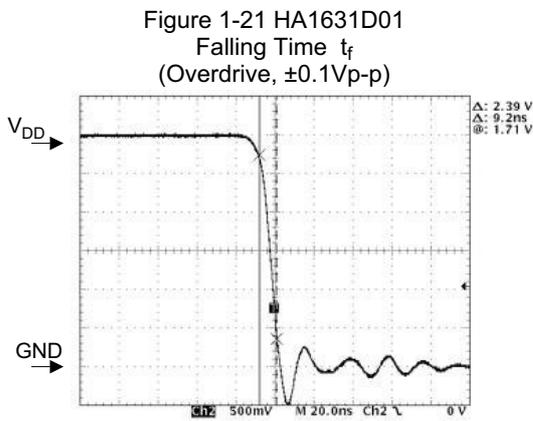
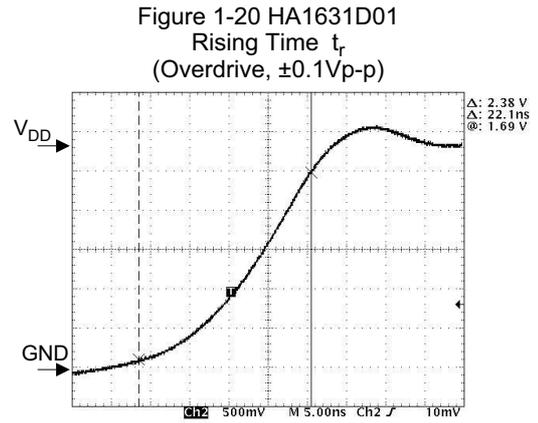
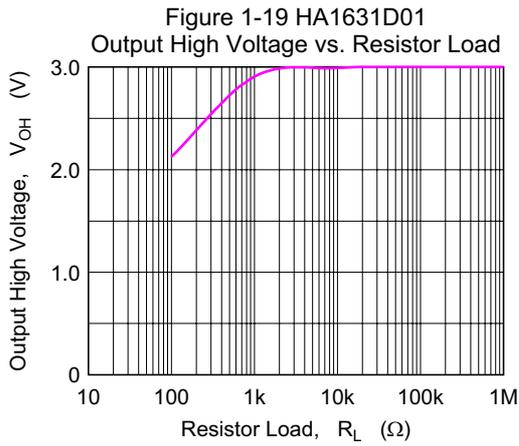
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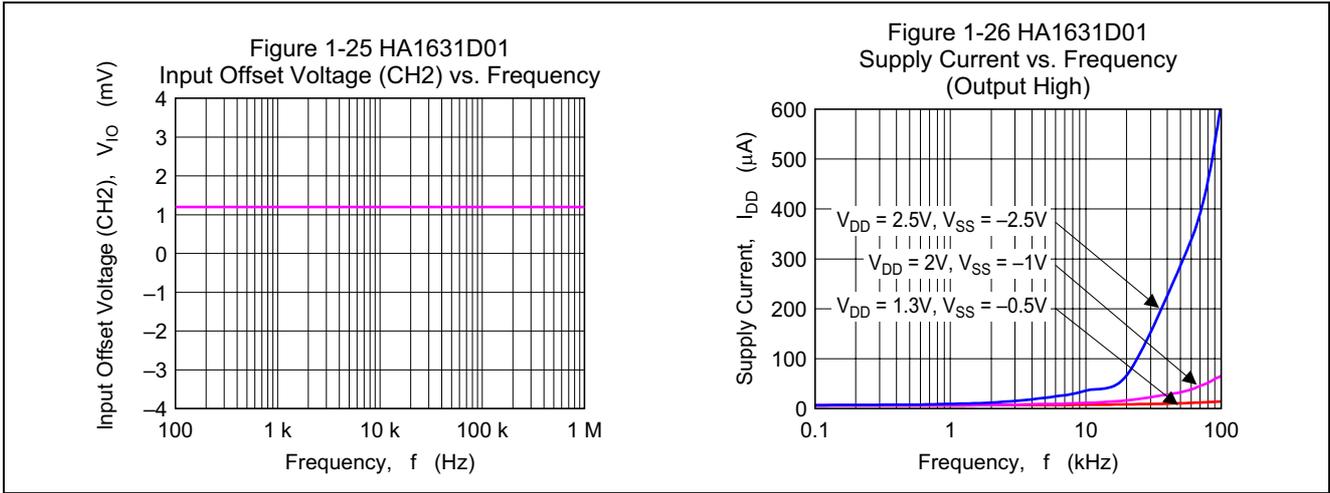
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(unless otherwise noted,  $V_{DD} = 3\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_a = 25^\circ\text{C}$ )

Figure 2-1 HA1631D02  
Supply Current vs. Supply Voltage  
(Output High)

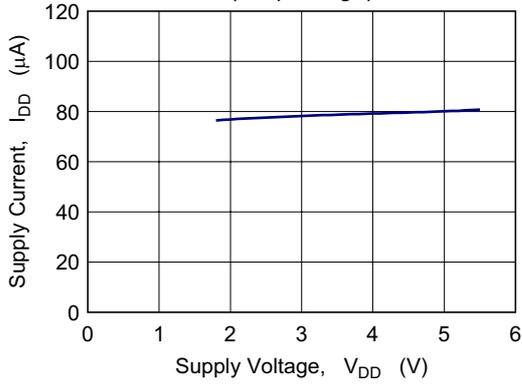


Figure 2-2 HA1631D02  
Supply Current vs. Supply Voltage  
(Output Low)

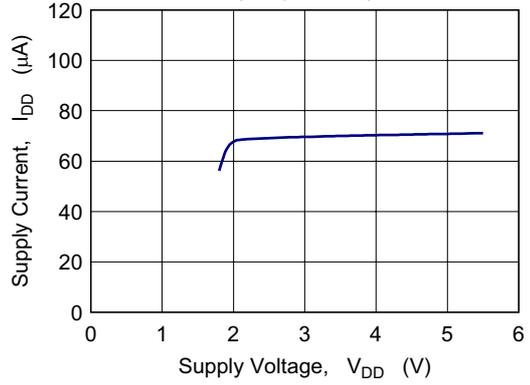


Figure 2-3 HA1631D02  
Supply Current vs. Ambient Temperature

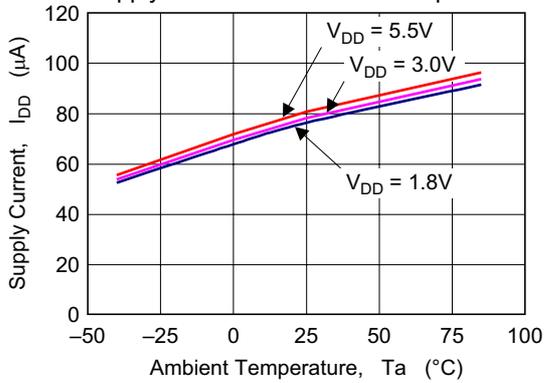


Figure 2-4 HA1631D02  
Output High Voltage vs. Output Source Current

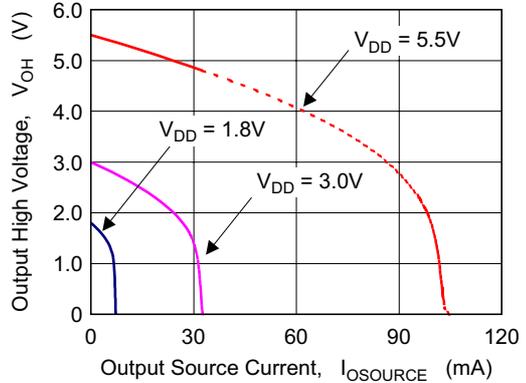


Figure 2-5 HA1631D02  
Output Low Voltage vs. Output Sink Current

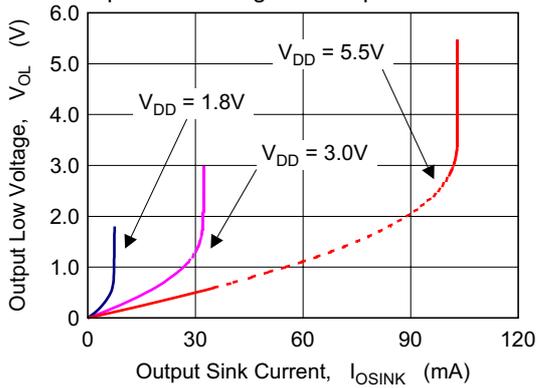
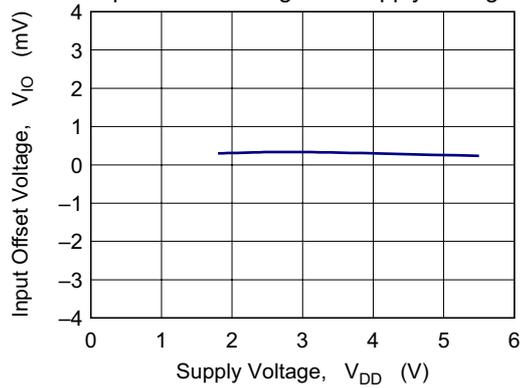
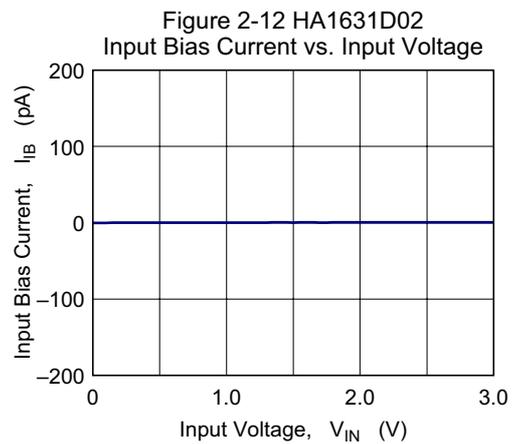
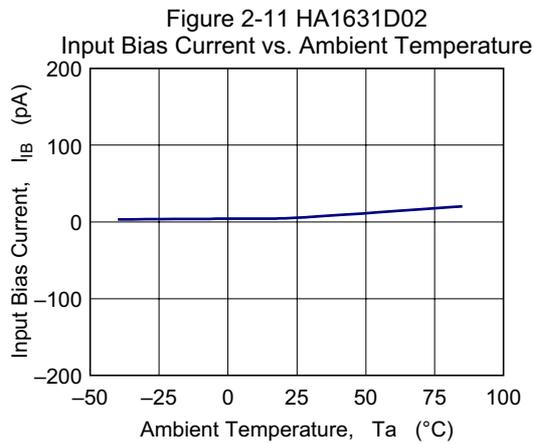
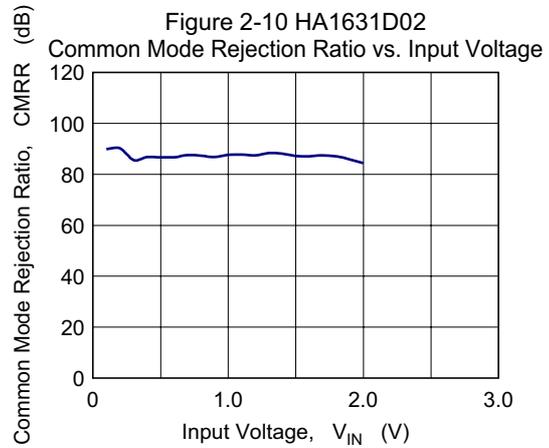
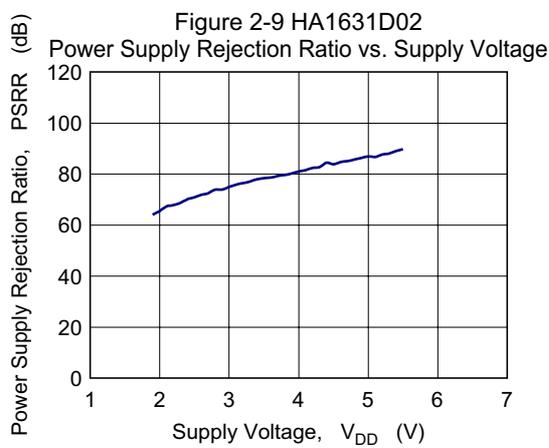
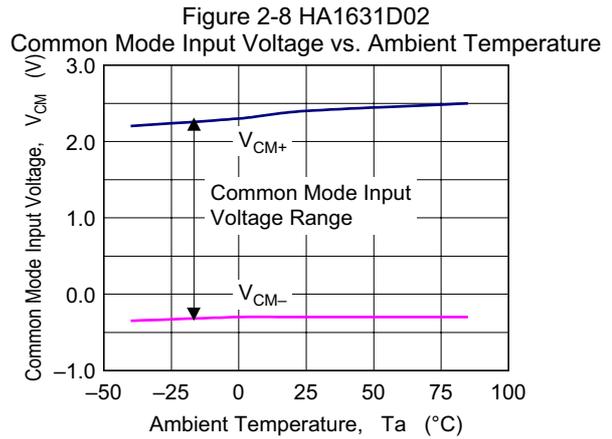
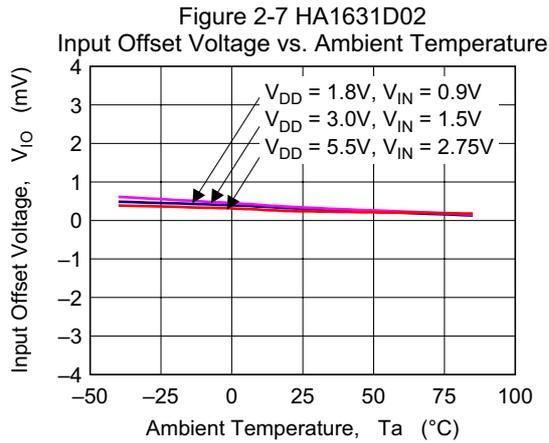


Figure 2-6 HA1631D02  
Input Offset Voltage vs. Supply Voltage



(unless otherwise noted,  $V_{DD} = 3\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_a = 25^\circ\text{C}$ )



(unless otherwise noted,  $V_{DD} = 3\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_a = 25^\circ\text{C}$ )

Figure 2-13 HA1631D02  
Input Bias Current vs. Input Voltage

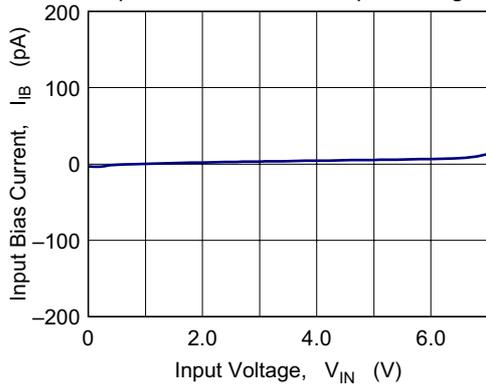


Figure 2-14 HA1631D02  
Falling Time vs. Ambient Temperature

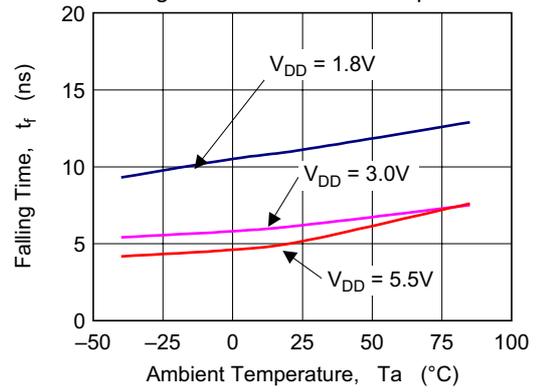


Figure 2-15 HA1631D02  
Rising Time vs. Ambient Temperature

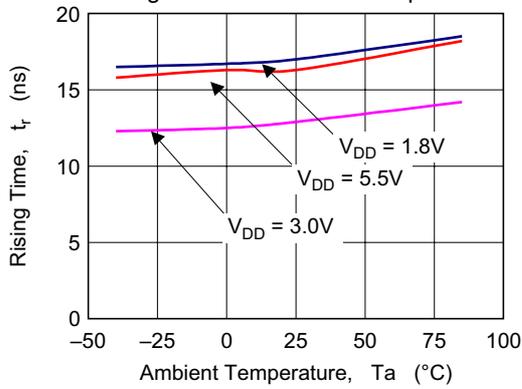


Figure 2-16 HA1631D02  
Falling Time vs. Capacitive Load

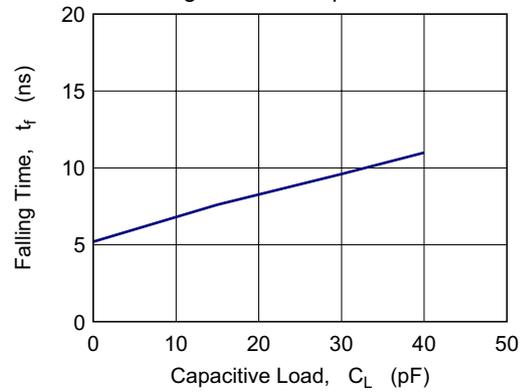


Figure 2-17 HA1631D02  
Rising Time vs. Capacitive Load

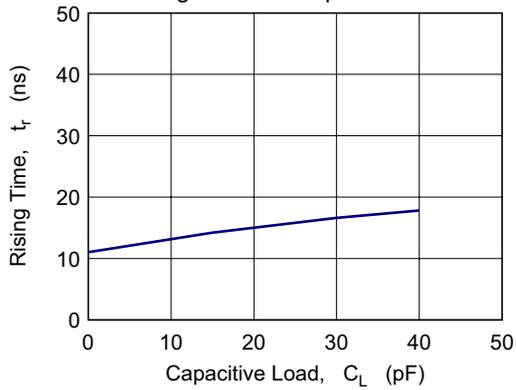
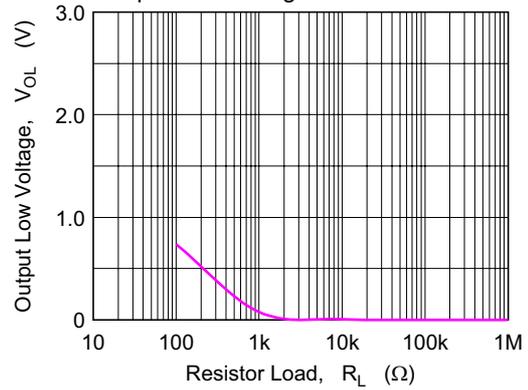
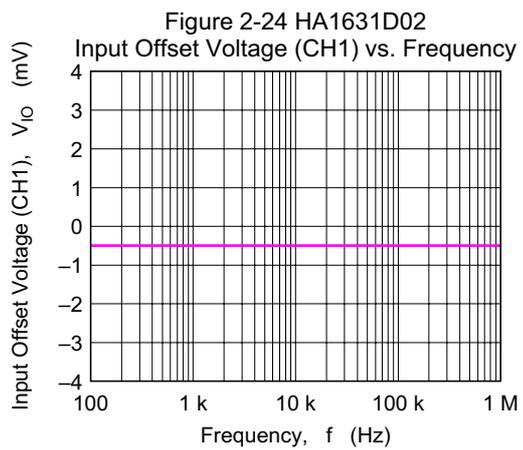
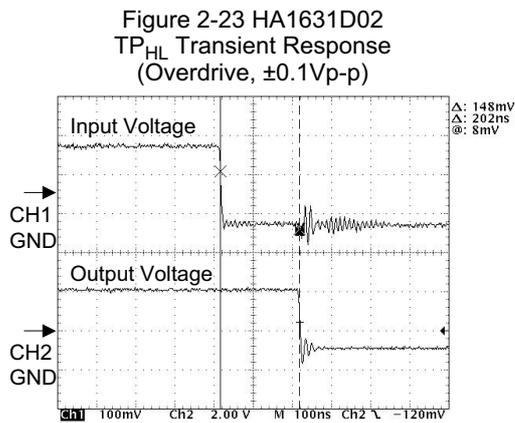
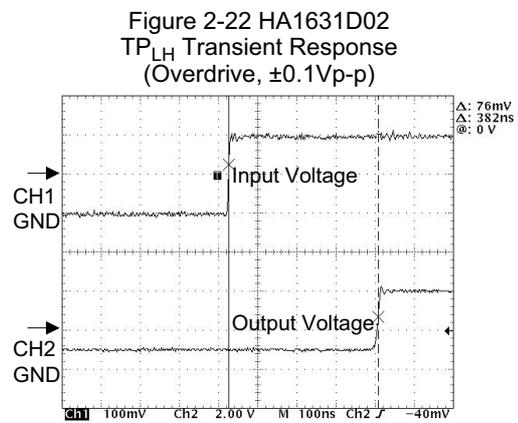
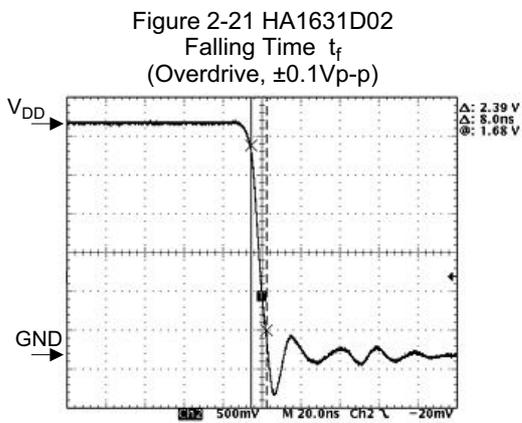
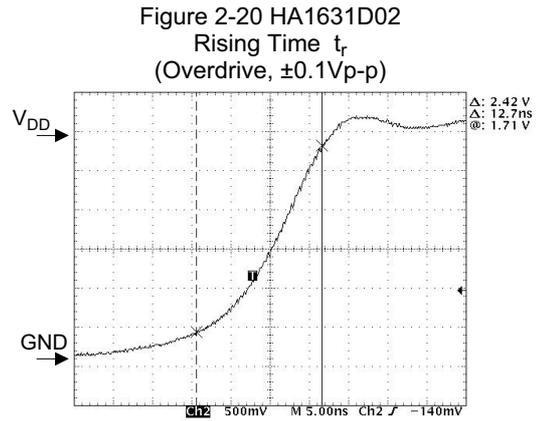
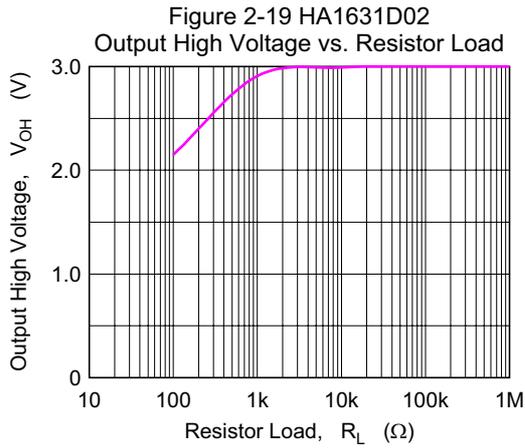


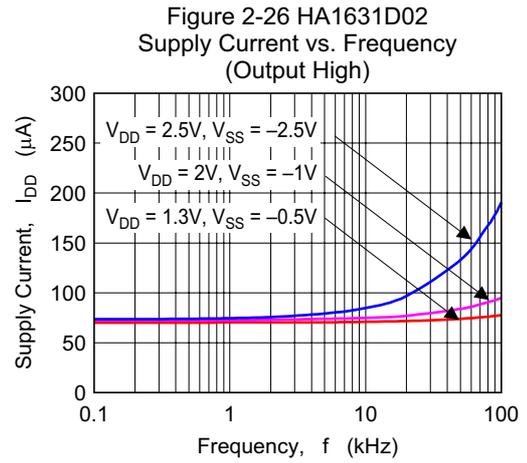
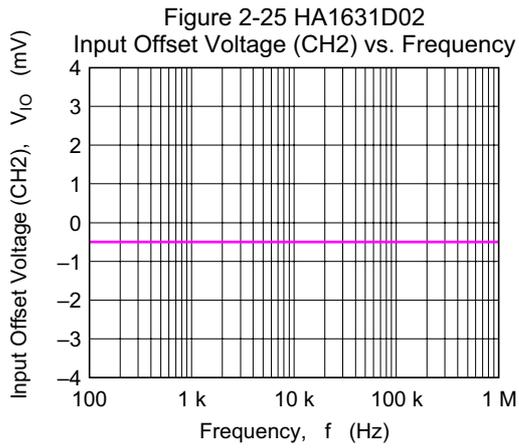
Figure 2-18 HA1631D02  
Output Low Voltage vs. Resistor Load



(unless otherwise noted,  $V_{DD} = 3\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_a = 25^\circ\text{C}$ )



(unless otherwise noted,  $V_{DD} = 3\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_a = 25^\circ\text{C}$ )



(unless otherwise noted,  $V_{DD} = 3\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_a = 25^\circ\text{C}$ )

Figure 3-1 HA1631D03  
Supply Current vs. Supply Voltage  
(Output High)

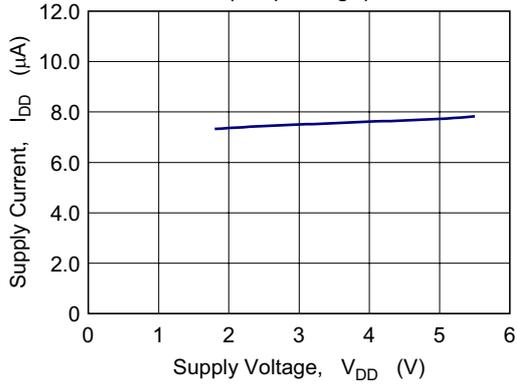


Figure 3-2 HA1631D03  
Supply Current vs. Supply Voltage  
(Output Low)

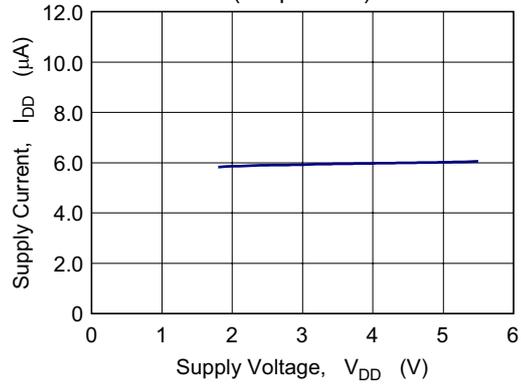


Figure 3-3 HA1631D03  
Supply Current vs. Ambient Temperature

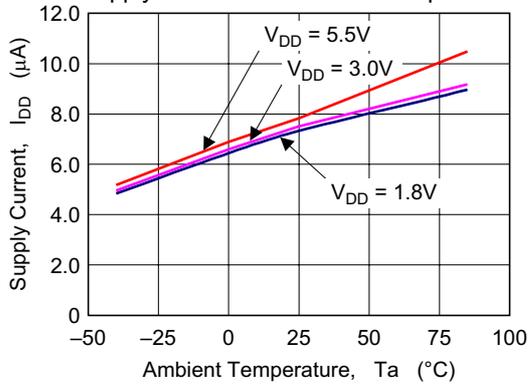


Figure 3-4 HA1631D03  
Output Low Voltage vs. Output Sink Current

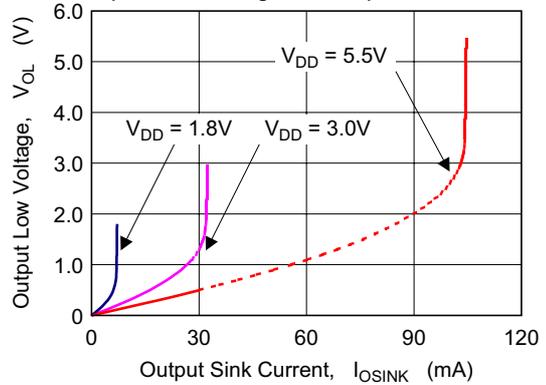


Figure 3-5 HA1631D03  
Input Offset Voltage vs. Supply Voltage

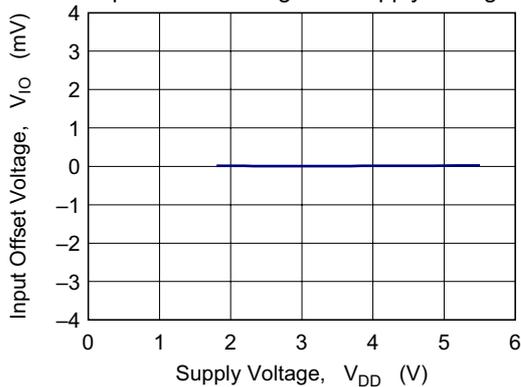
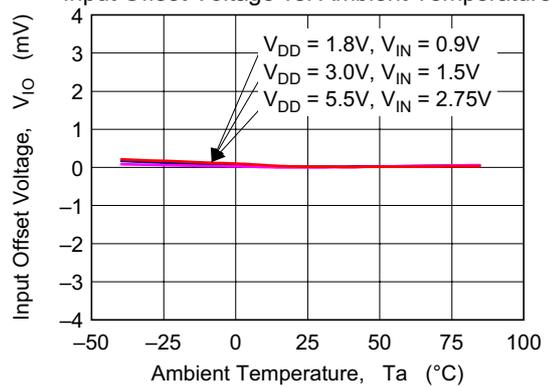


Figure 3-6 HA1631D03  
Input Offset Voltage vs. Ambient Temperature



(unless otherwise noted,  $V_{DD} = 3\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_a = 25^\circ\text{C}$ )

Figure 3-7 HA1631D03  
Common Mode Input Voltage vs. Ambient Temperature

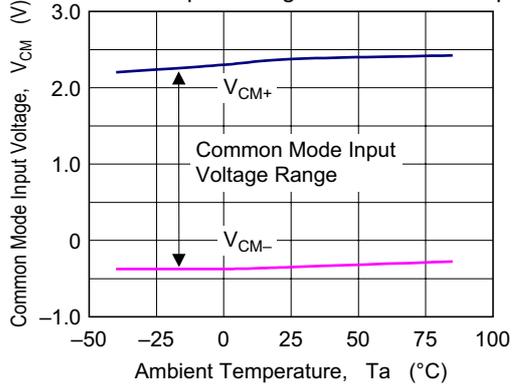


Figure 3-8 HA1631D03  
Power Supply Rejection Ratio vs. Supply Voltage

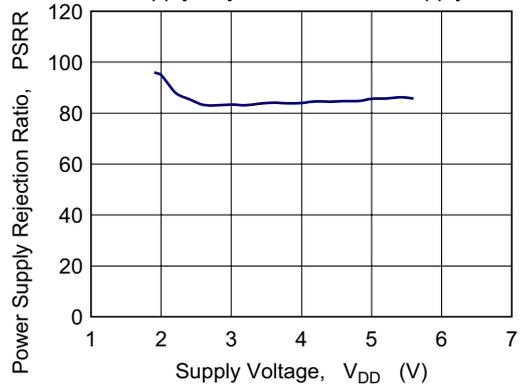


Figure 3-9 HA1631D03  
Common Mode Rejection Ratio vs. Input Voltage

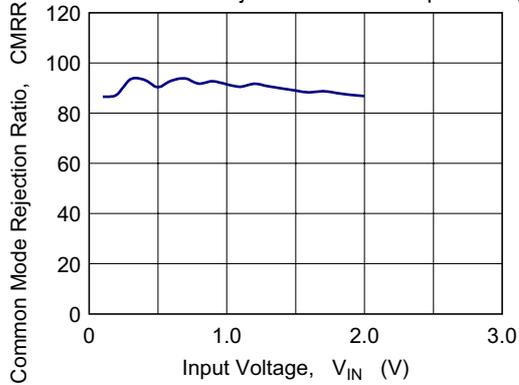


Figure 3-10 HA1631D03  
Input Bias Current vs. Ambient Temperature

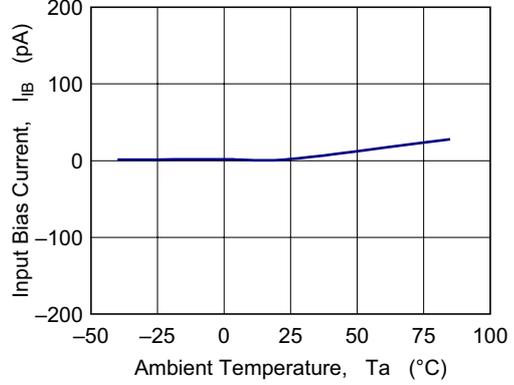


Figure 3-11 HA1631D03  
Input Bias Current vs. Input Voltage

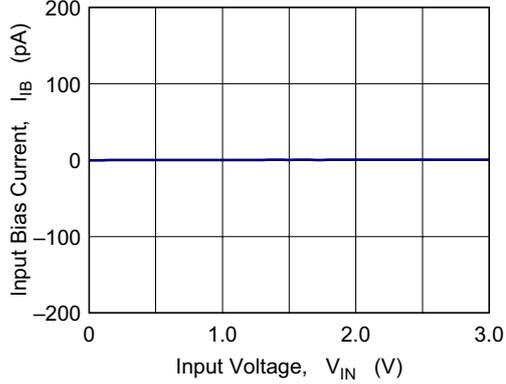
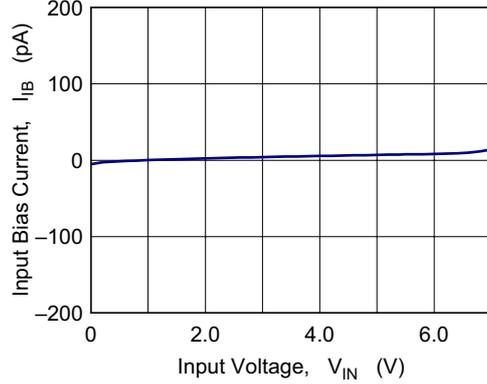
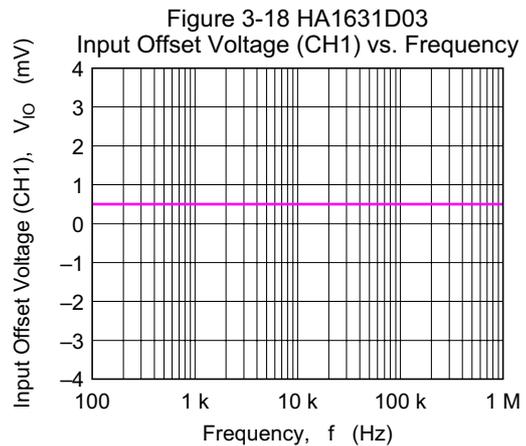
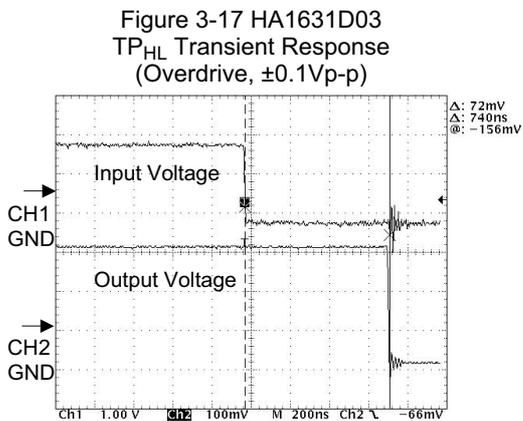
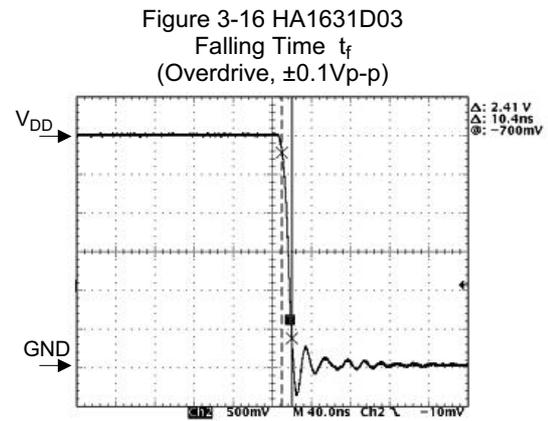
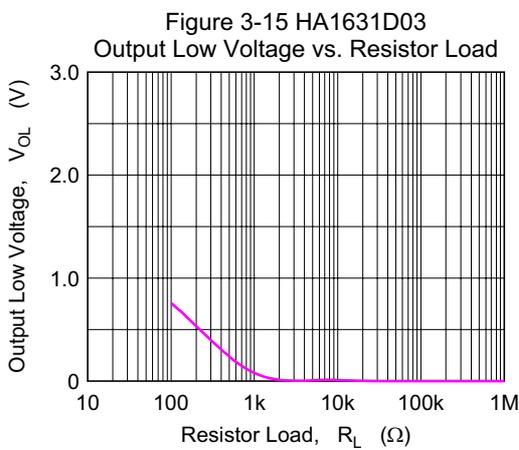
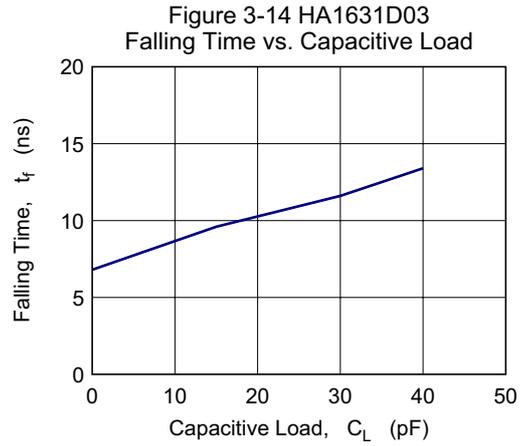
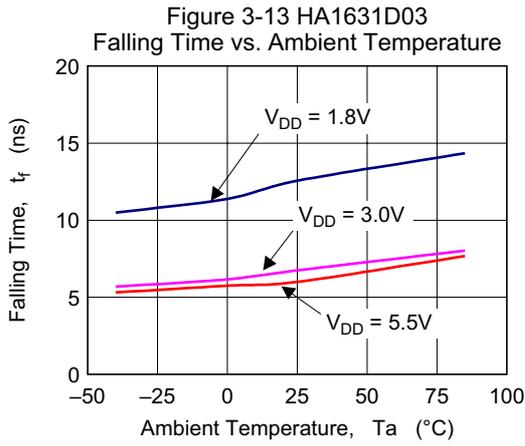


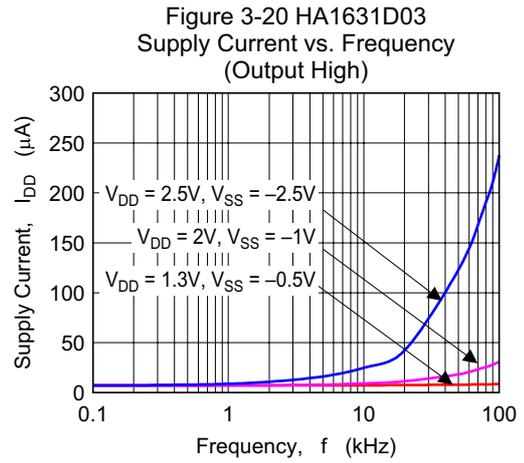
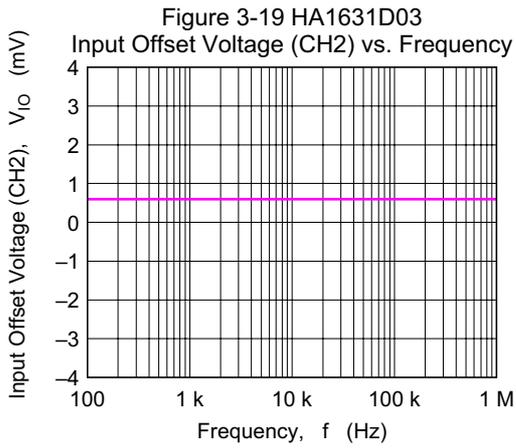
Figure 3-12 HA1631D03  
Input Bias Current vs. Input Voltage



(unless otherwise noted,  $V_{DD} = 3\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_a = 25^\circ\text{C}$ )



(unless otherwise noted,  $V_{DD} = 3\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_a = 25^\circ\text{C}$ )



(unless otherwise noted,  $V_{DD} = 3\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_a = 25^\circ\text{C}$ )

Figure 4-1 HA1631D04  
Supply Current vs. Supply Voltage  
(Output High)

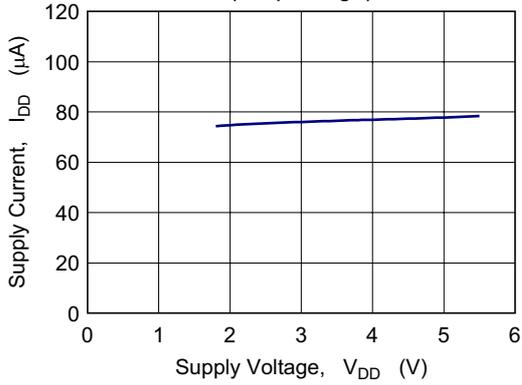


Figure 4-2 HA1631D04  
Supply Current vs. Supply Voltage  
(Output Low)

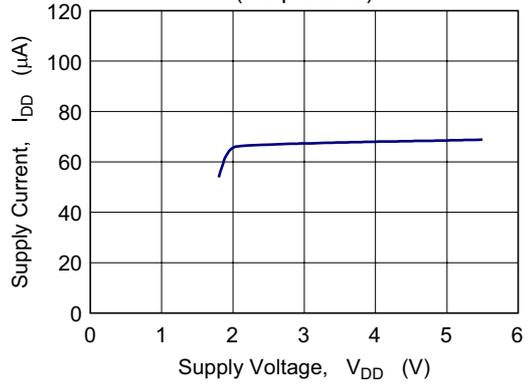


Figure 4-3 HA1631D04  
Supply Current vs. Ambient Temperature

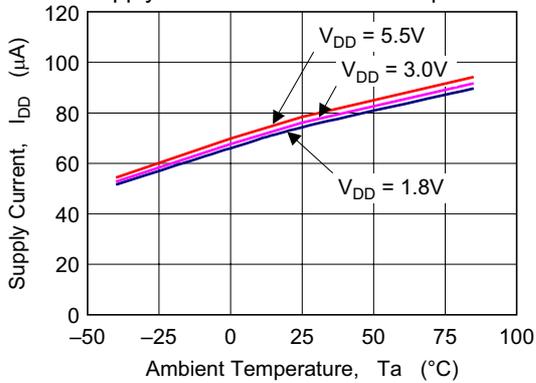


Figure 4-4 HA1631D04  
Output Low Voltage vs. Output Sink Current

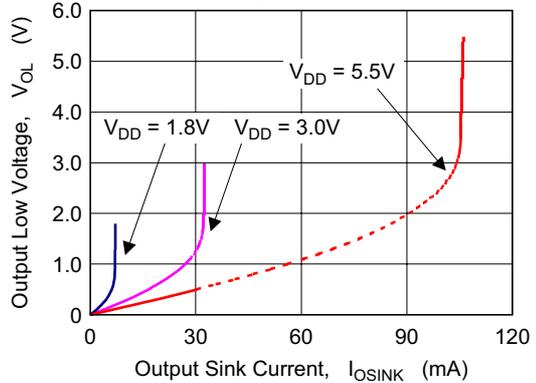


Figure 4-5 HA1631D04  
Input Offset Voltage vs. Supply Voltage

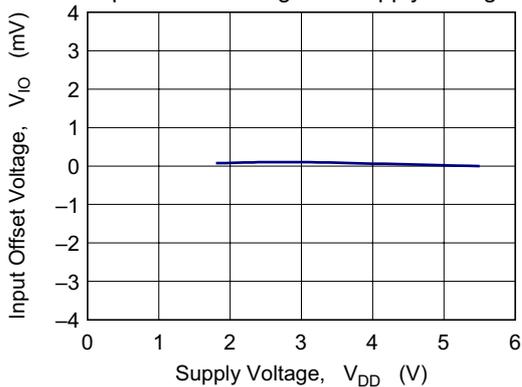
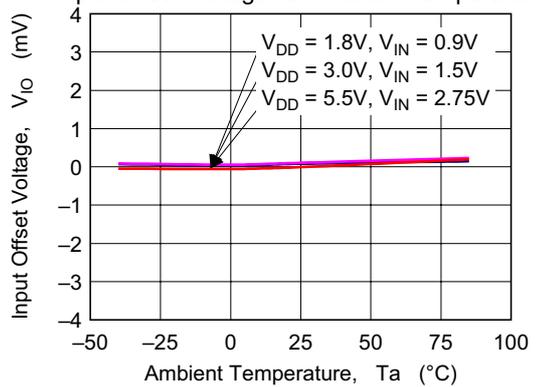
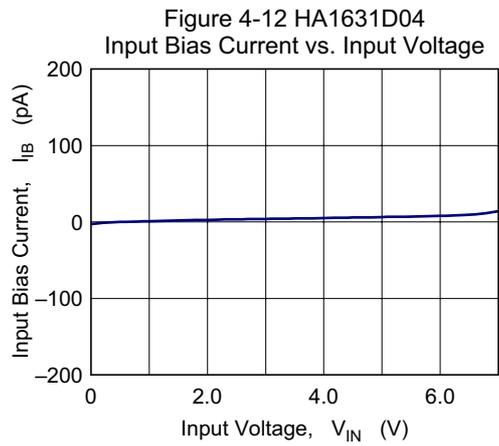
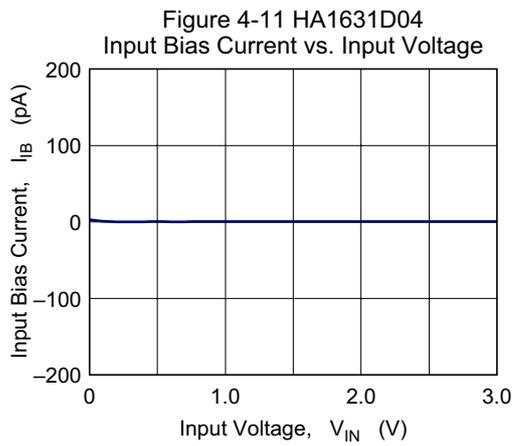
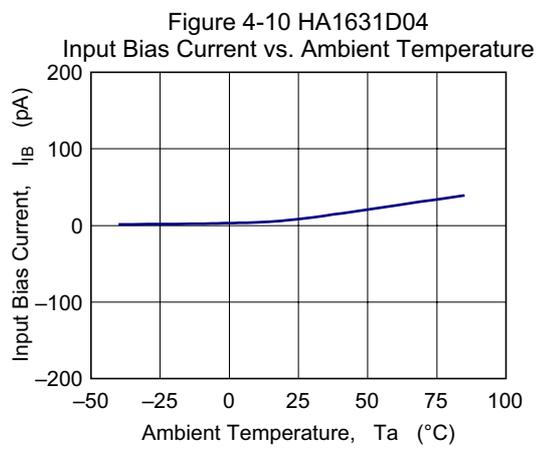
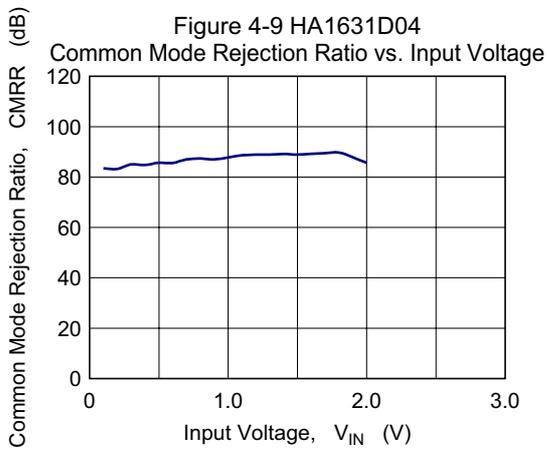
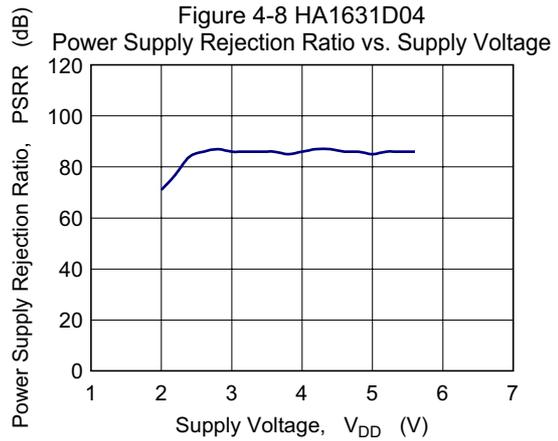
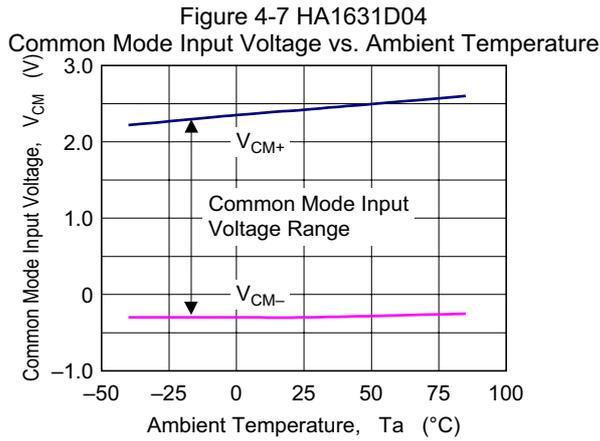


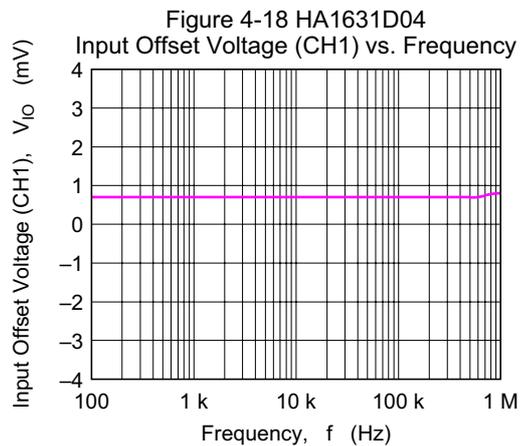
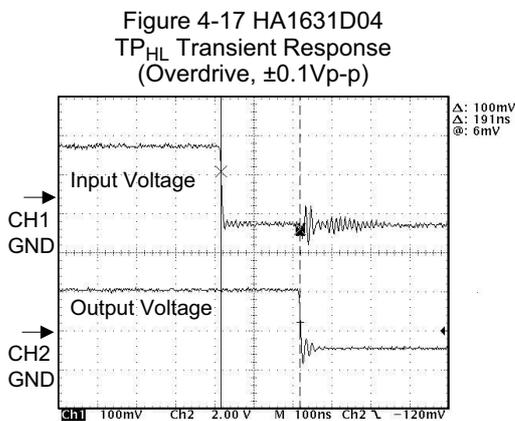
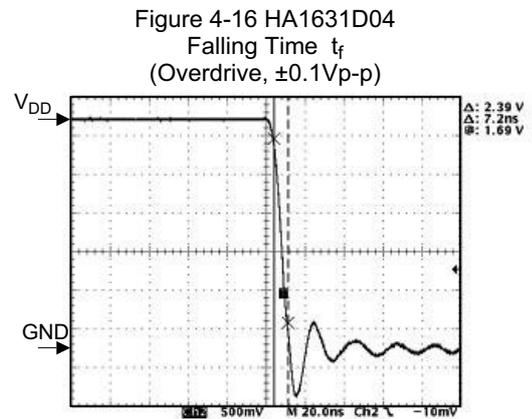
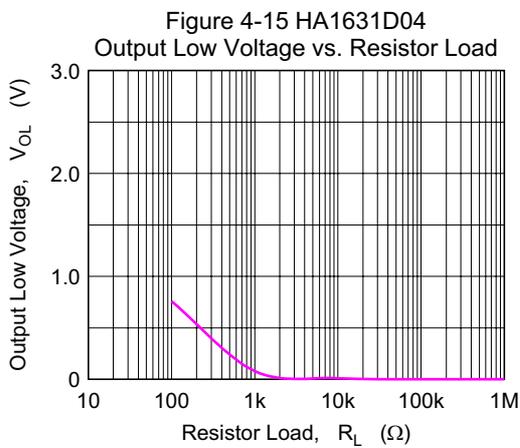
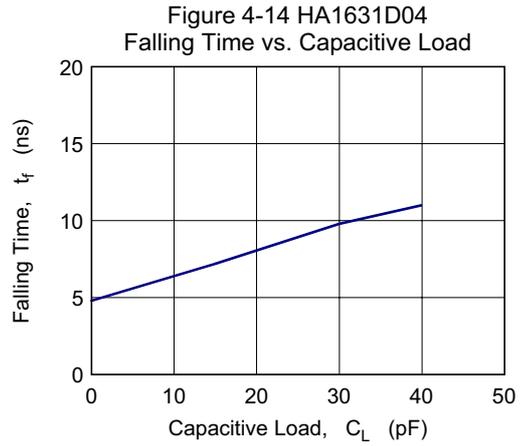
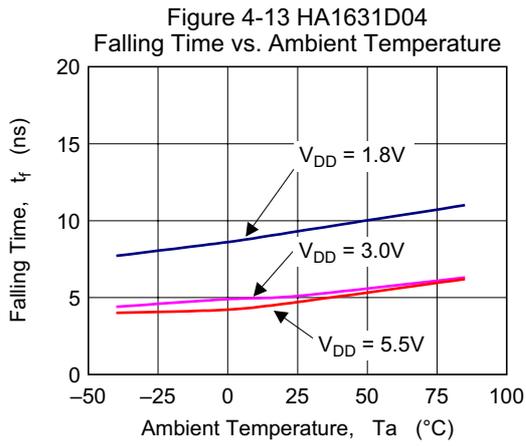
Figure 4-6 HA1631D04  
Input Offset Voltage vs. Ambient Temperature



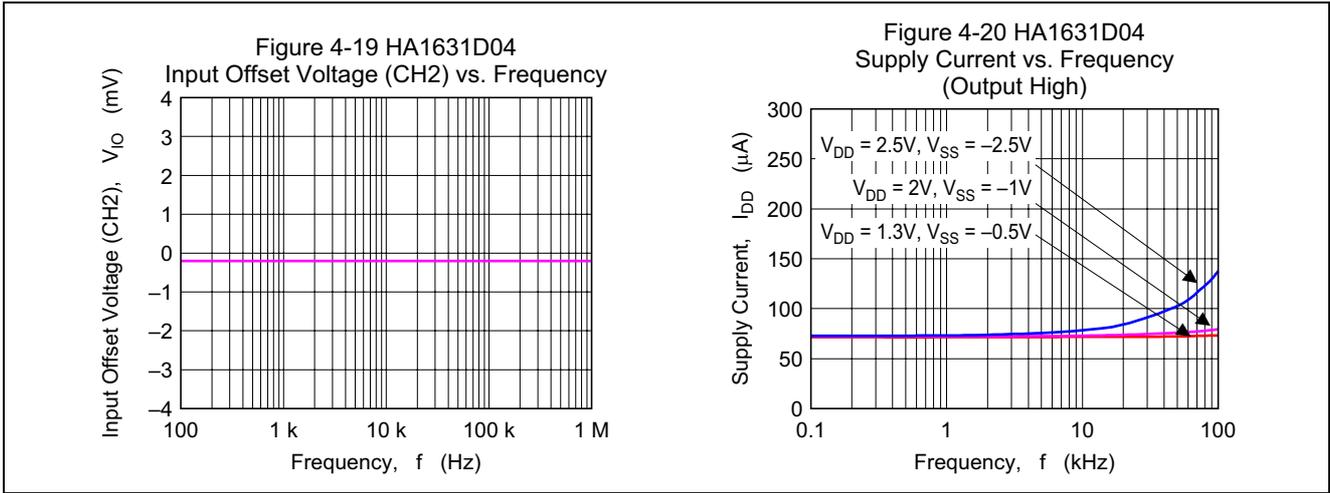
(unless otherwise noted,  $V_{DD} = 3\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_a = 25^\circ\text{C}$ )



(unless otherwise noted,  $V_{DD} = 3\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_a = 25^\circ\text{C}$ )



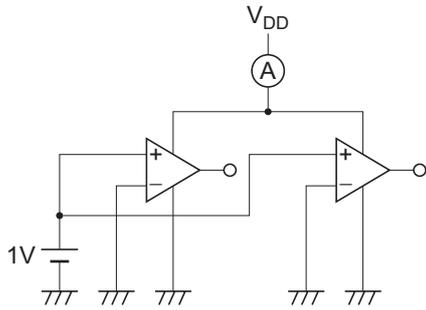
(unless otherwise noted,  $V_{DD} = 3\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_a = 25^\circ\text{C}$ )



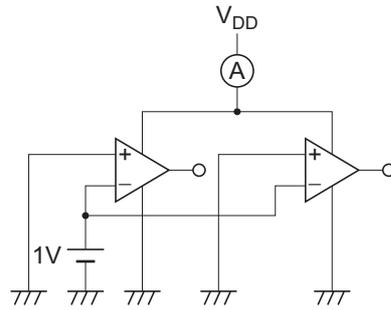
Test Circuits

(unless otherwise noted,  $V_{DD} = 3\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_a = 25^\circ\text{C}$ )

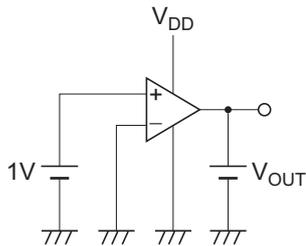
1. Supply Current,  $I_{DD}$  (Output High)



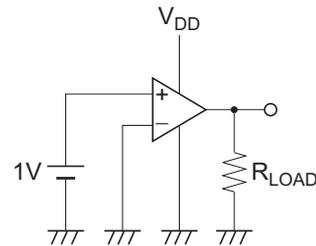
2. Supply Current,  $I_{DD}$  (Output Low)



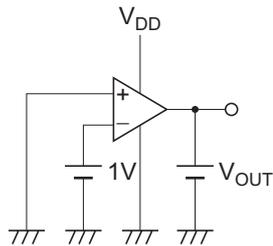
3. Output Source Current,  $I_{OSOURCE}$



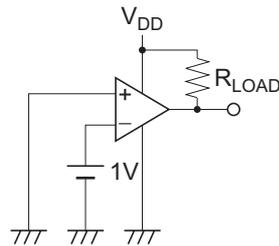
4. Output Voltage High,  $V_{OH}$



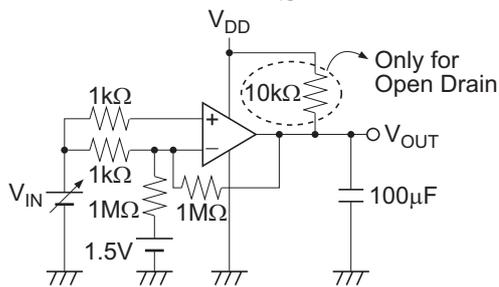
5. Output Sink Current,  $I_{OSINK}$



6. Output Voltage Low,  $V_{OL}$

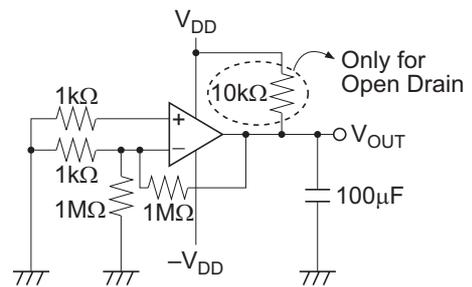


7. Input Offset Voltage,  $V_{IO}$



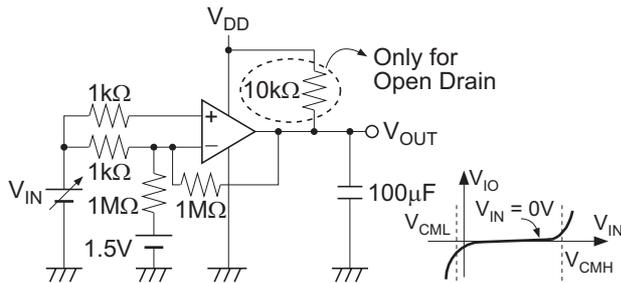
Note:  $V_{IO} = V_{OUT} - 1.5\text{ V}$

8. Input Offset Voltage vs. Supply Voltage



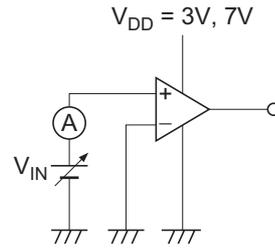
(unless otherwise noted,  $V_{DD} = 3\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_a = 25^\circ\text{C}$ )

9. Common Mode Input Voltage,  $V_{CM}$

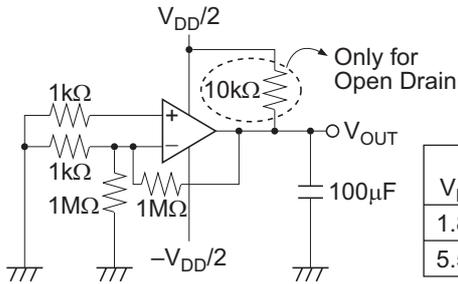


Note:  $V_{CML}$  and  $V_{CMH}$  are values of  $V_{IN}$  when  $V_{IO}$  changes more than 50dB taking  $V_{IN} = 0\text{ V}$  as reference.

10. Input Bias Current,  $I_{IB}$

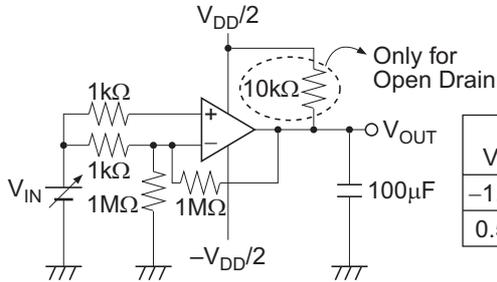


11. Power Supply Rejection Ratio, PSRR



$V_{DD}$	Measure Point	Calculate $V_{IO}$	PSRR Calculation
1.8V	$V_{OUT1}$	$V_{IO1} = V_{OUT1}/1000$	$\text{PSRR} = \left  20 \log \frac{ (V_{IO2} - V_{IO1}) }{5.5\text{V} - 1.8\text{V}} \right $
5.5V	$V_{OUT2}$	$V_{IO2} = V_{OUT2}/1000$	

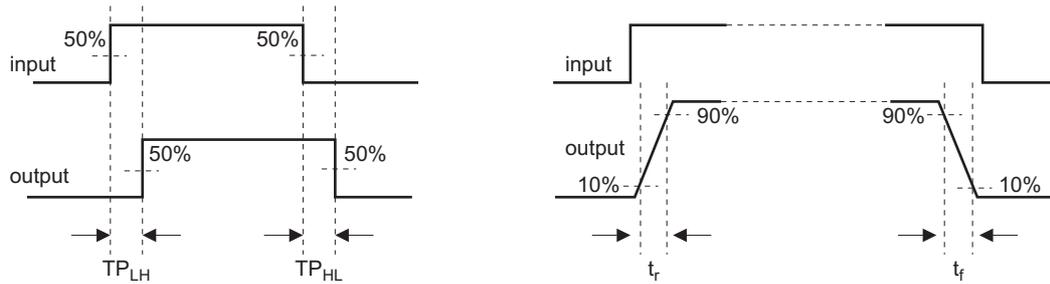
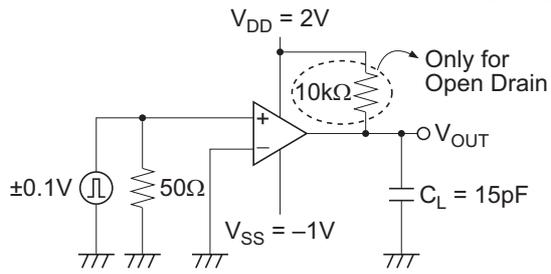
12. Common Mode Rejection Ratio, CMRR



$V_{IN}$	Measure Point	Calculate $V_{IO}$	CMRR Calculation
-1.5V	$V_{OUT1}$	$V_{IO1} = V_{OUT1}/1000$	$\text{CMRR} = \left  20 \log \frac{ (V_{IO2} - V_{IO1}) }{0.5\text{V} - (-1.5\text{V})} \right $
0.5V	$V_{OUT2}$	$V_{IO2} = V_{OUT2}/1000$	

(unless otherwise noted,  $V_{DD} = 3\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_a = 25^\circ\text{C}$ )

13. Response Time  $t_r$ ,  $t_f$  and Delay Time  $TP_{HL}$ ,  $TP_{LH}$

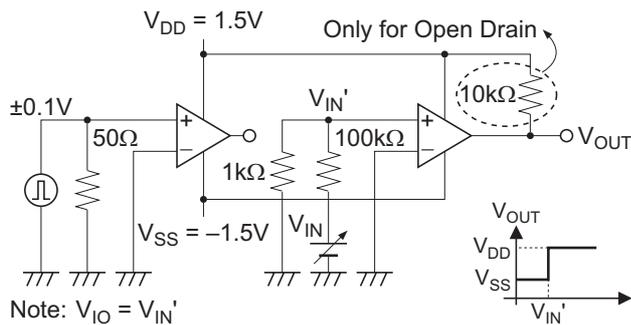


Only for Push Pull HA1631D01/02

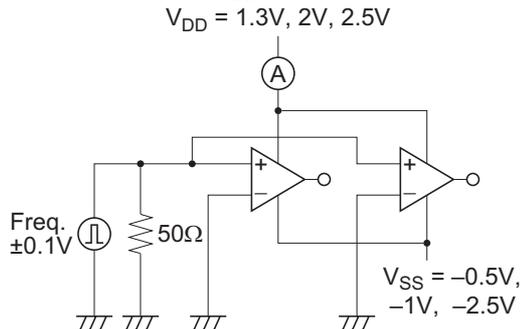


Only for Open Drain HA1631D03/04

14. Cross Talk

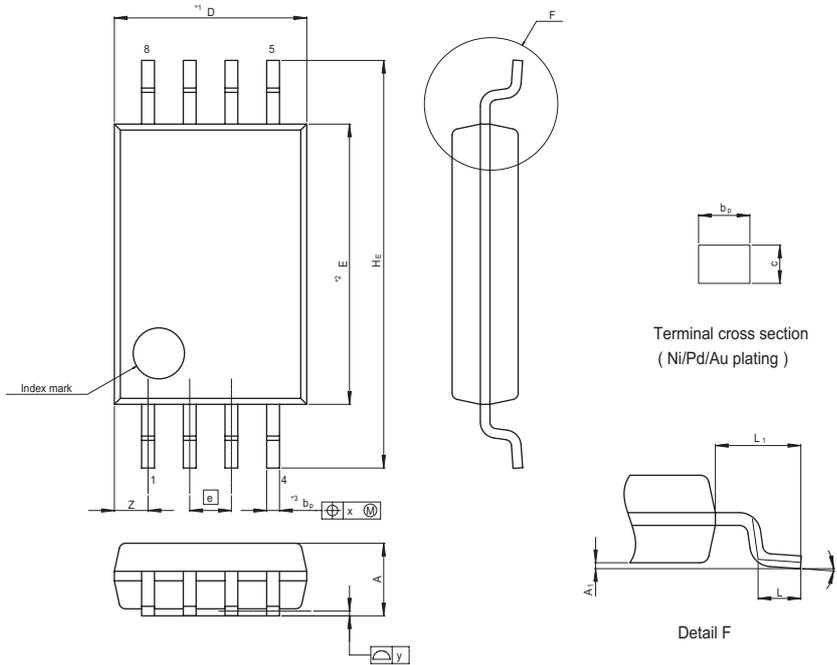


15. Supply Current,  $I_{DD}$  (Output High) vs. Frequency



Package Dimensions

JEITA Package Code	RENEASAS Code	Previous Code	MASS[Typ.]
P-TSSOP8-4.4x3-0.65	PTSP0008JC-B	TTP-8DAV	0.034g

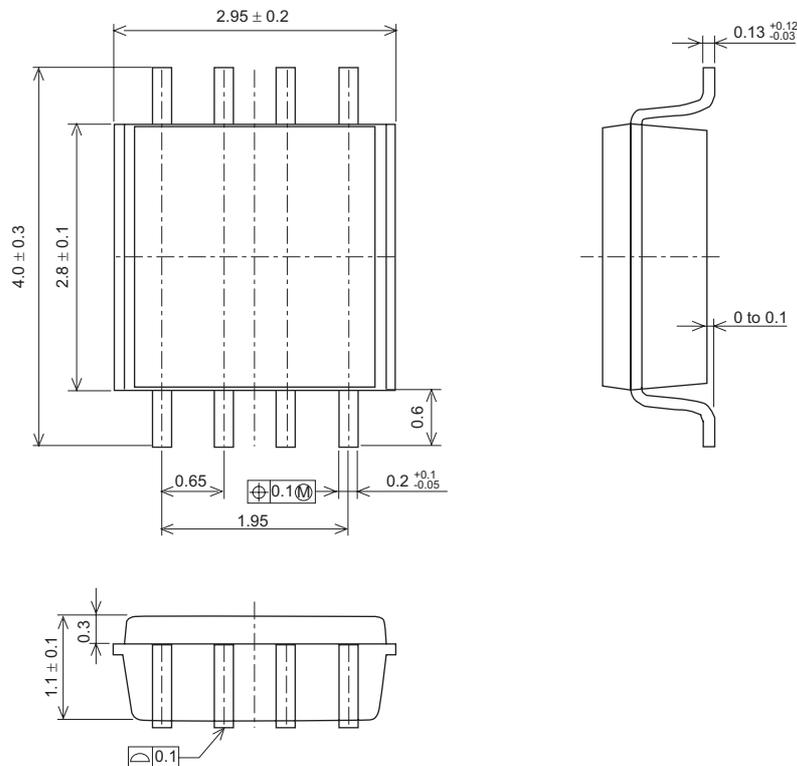


NOTE)  
 1. DIMENSIONS\*\*1 (Nom)\*AND\*\*2  
 DO NOT INCLUDE MOLD FLASH.  
 2. DIMENSION\*\*3\*DOES NOT  
 INCLUDE TRIM OFFSET.

Reference Symbol	Dimension in Millimeters		
	Min	Nom	Max
D	—	3.00	3.30
E	—	4.40	—
A <sub>2</sub>	—	—	—
A <sub>1</sub>	0.03	0.07	0.10
A	—	—	1.10
b <sub>p</sub>	0.15	0.20	0.25
b <sub>1</sub>	—	—	—
c	0.10	0.15	0.20
c <sub>1</sub>	—	—	—
θ	0°	—	8°
H <sub>E</sub>	6.20	6.40	6.60
Ⓜ	—	0.65	—
x	—	—	0.13
y	—	—	0.10
Z	—	—	0.805
L	0.40	0.50	0.60
L <sub>1</sub>	—	1.00	—

Package Name	JEITA Package Code	RENEASAS Code	Previous Code	MASS[Typ.]
MMPAK-8	P-LSOP8-2.8 x 2.95 - 0.65	PLSP0008JC-A	—	0.02 g

Unit: mm



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  - (2) surgical implantations
  - (3) healthcare intervention (e.g., excision, administration of medication, etc.)
  - (4) any other purposes that pose a direct threat to human lifeRenesas shall have no liability for damages arising out of the uses set forth in the above and purchasers who elect to use Renesas products in any of the foregoing applications shall indemnify and hold harmless Renesas Technology Corp., its affiliated companies and their officers, directors, and employees against any and all damages arising out of such applications.
9. You should use the products described herein within the range specified by Renesas, especially with respect to the maximum rating, operating supply voltage range, movement power voltage range, heat radiation characteristics, installation and other product characteristics. Renesas shall have no liability for malfunctions or damages arising out of the use of Renesas products beyond such specified ranges.
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To our customers,

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Renesas Electronics website: <http://www.renesas.com>

April 1<sup>st</sup>, 2010  
Renesas Electronics Corporation

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