

# 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.

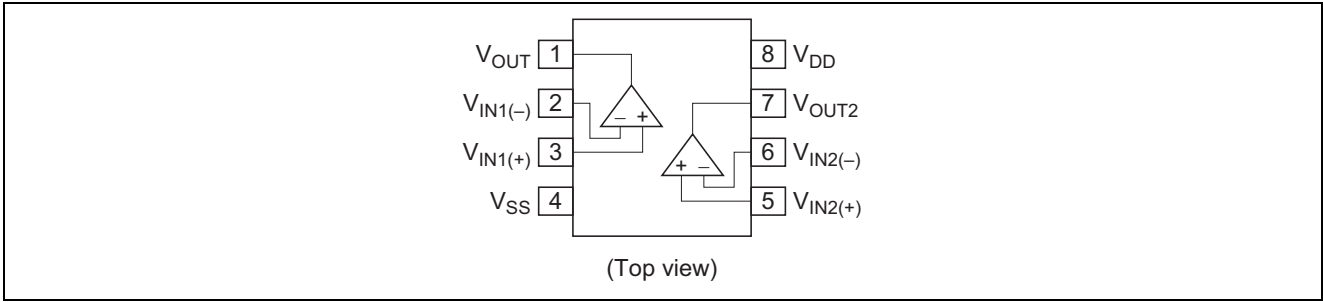
### Features

- 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

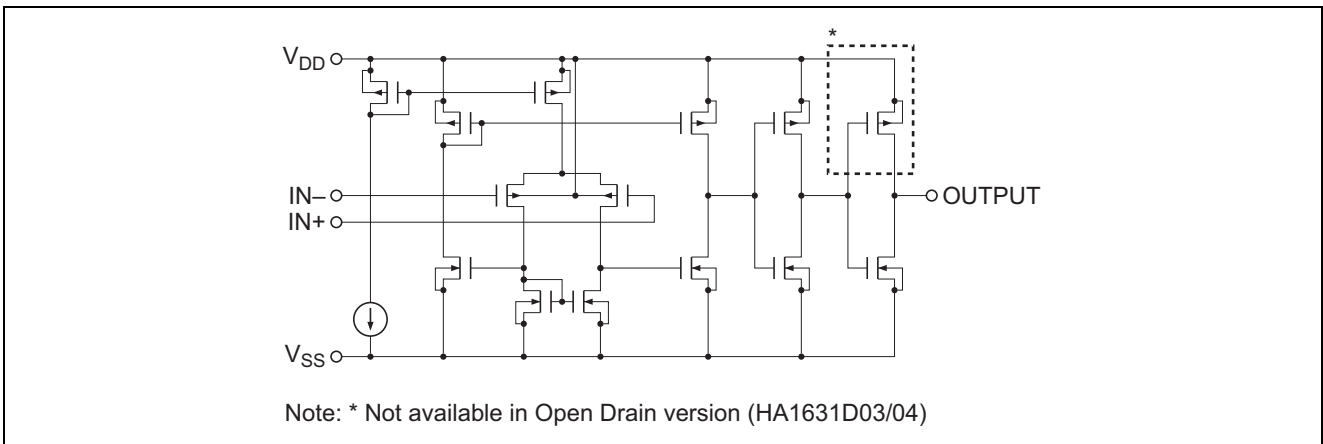
### Ordering Information

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	T <sub>opr</sub>	-40 to +85	°C	
Storage temperature	T <sub>stg</sub>	-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	
		Output sink current	I <sub>OSINK</sub>	7	14	—	mA
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	V <sub>opr</sub>	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)

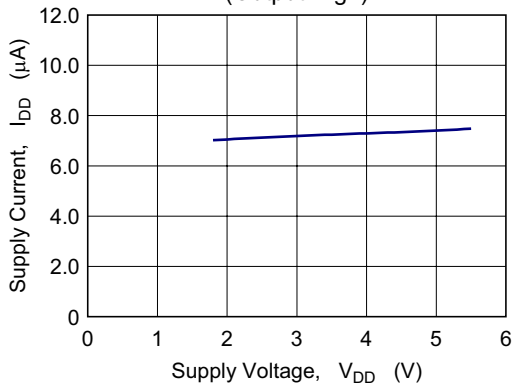


Figure 1-2 HA1631D01  
Supply Current vs. Supply Voltage  
(Output Low)

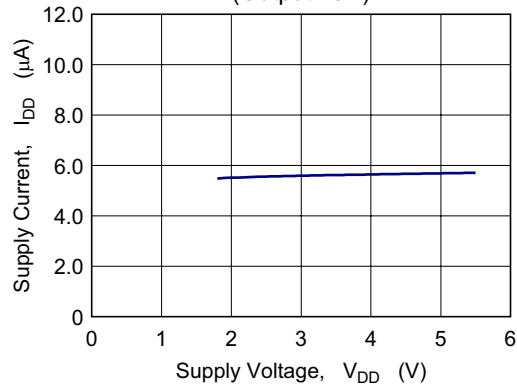


Figure 1-3 HA1631D01  
Supply Current vs. Ambient Temperature

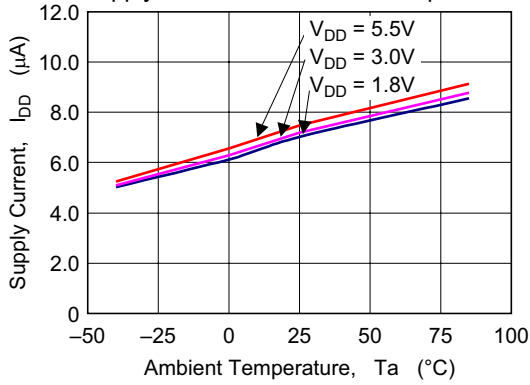


Figure 1-4 HA1631D01  
Output High Voltage vs. Output Source Current

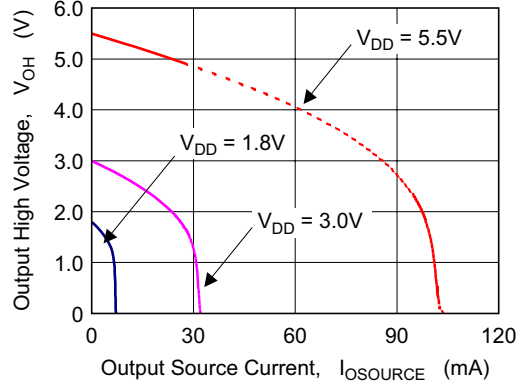


Figure 1-5 HA1631D01  
Output Low Voltage vs. Output Sink Current

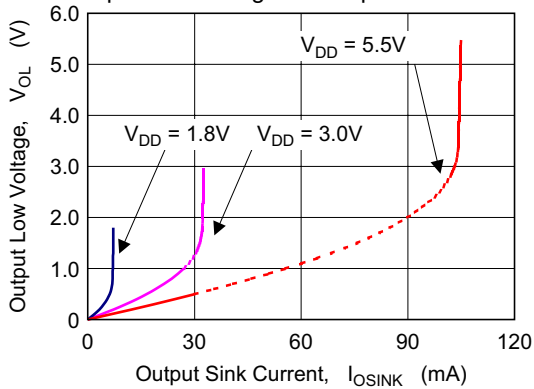
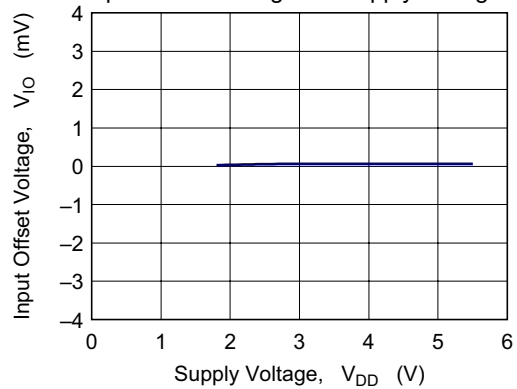
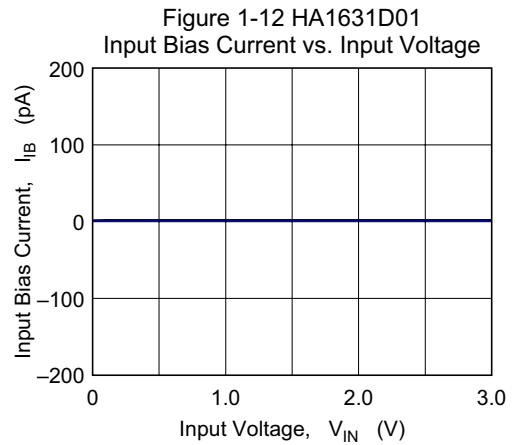
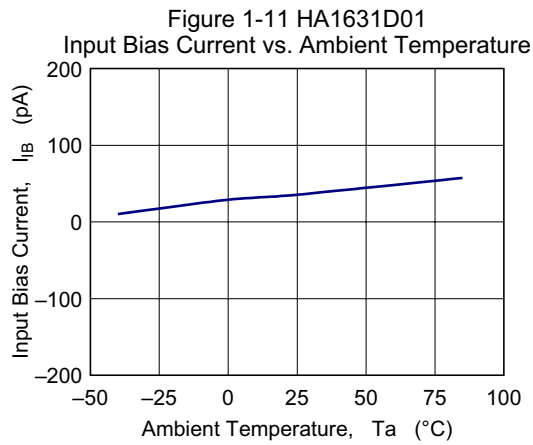
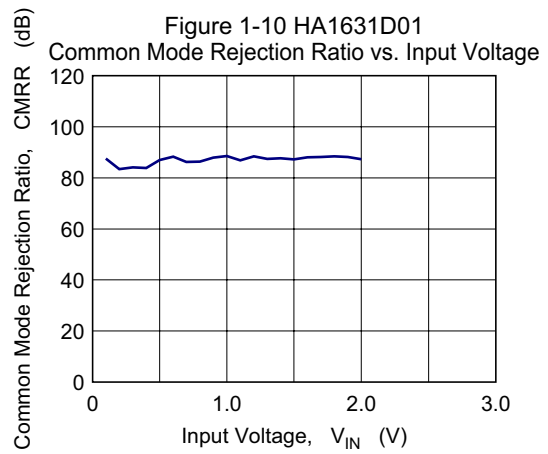
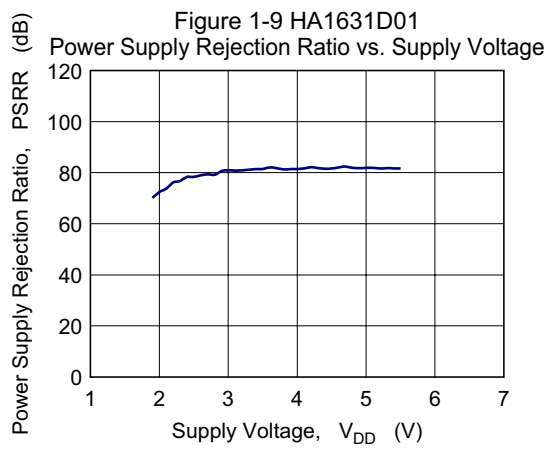
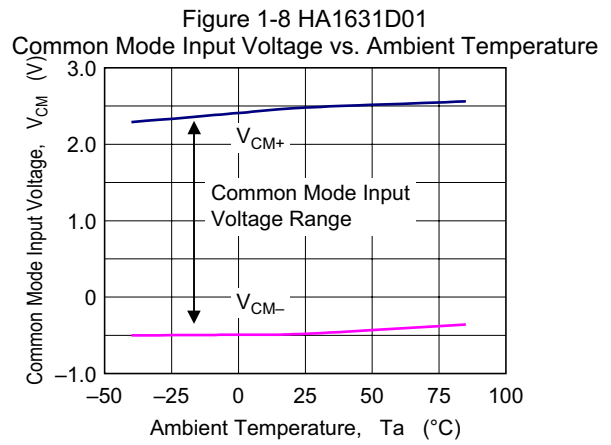
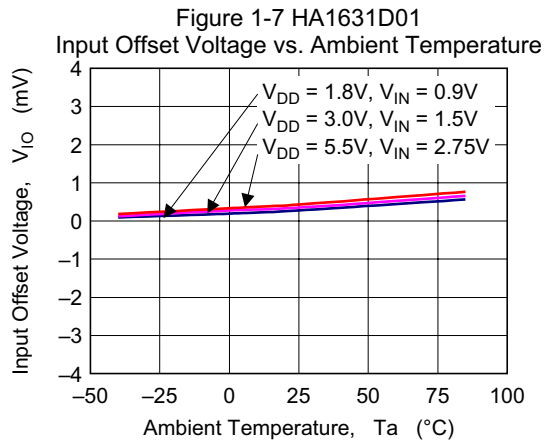


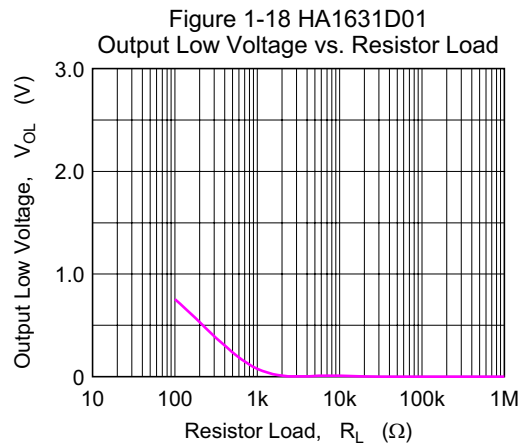
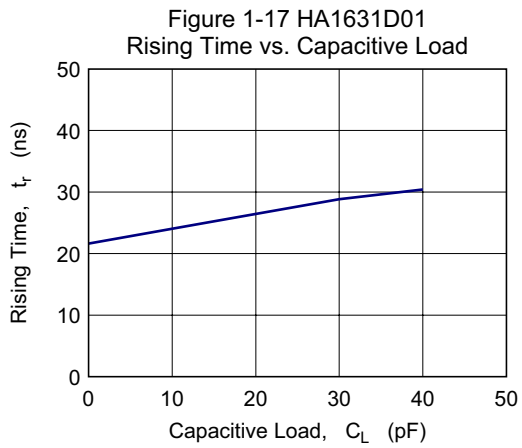
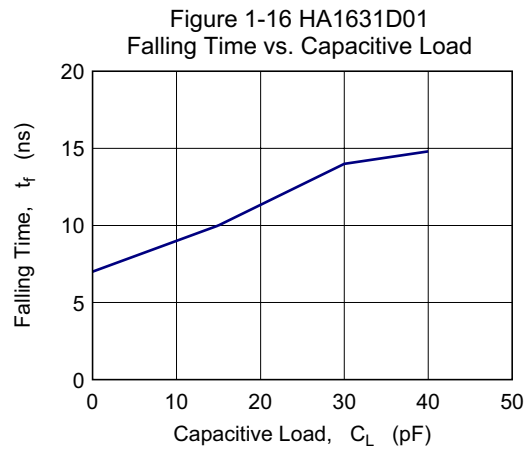
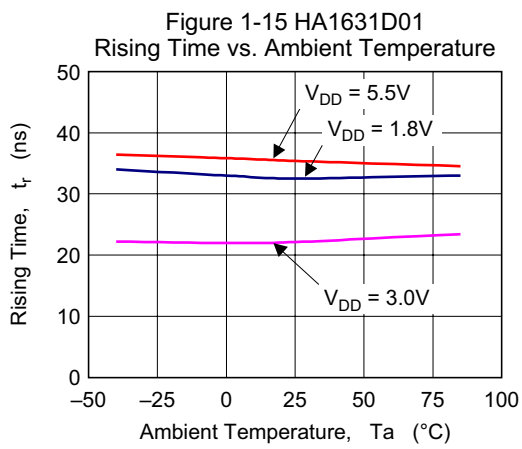
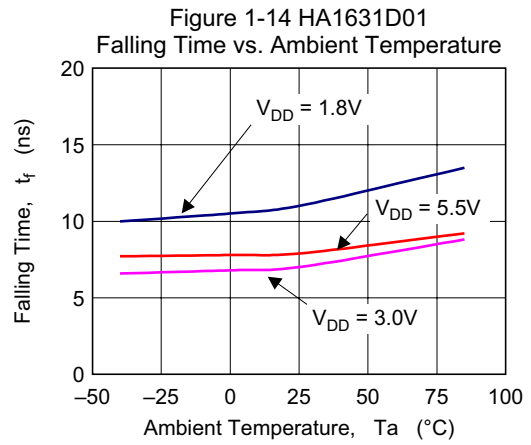
Figure 1-6 HA1631D01  
Input Offset Voltage vs. Supply Voltage



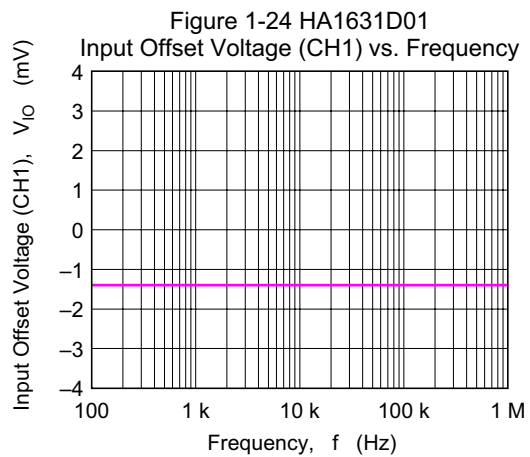
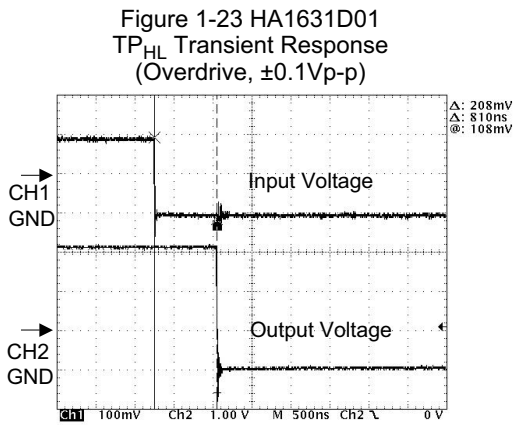
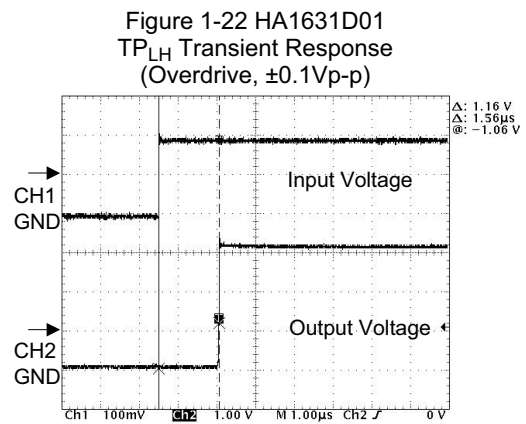
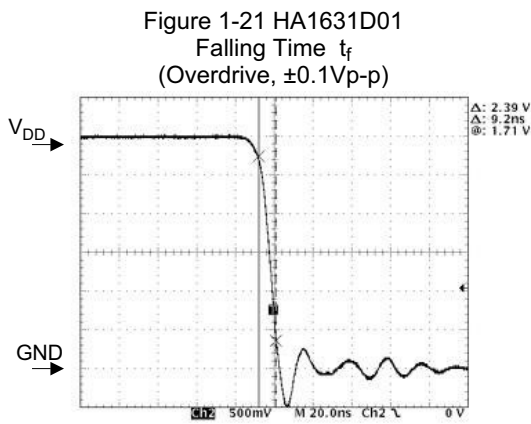
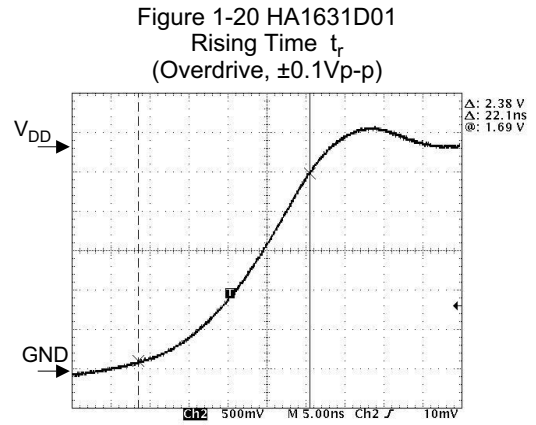
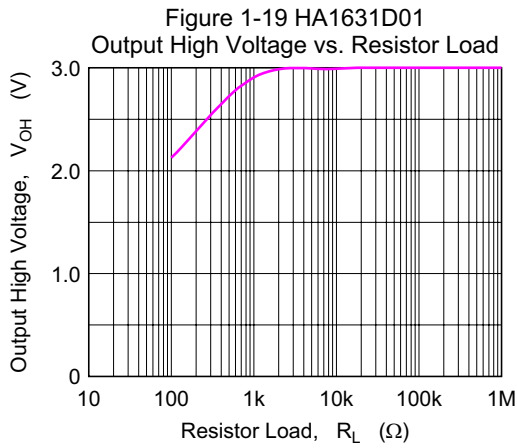
(unless otherwise noted,  $V_{DD} = 3\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_a = 25^\circ\text{C}$ )



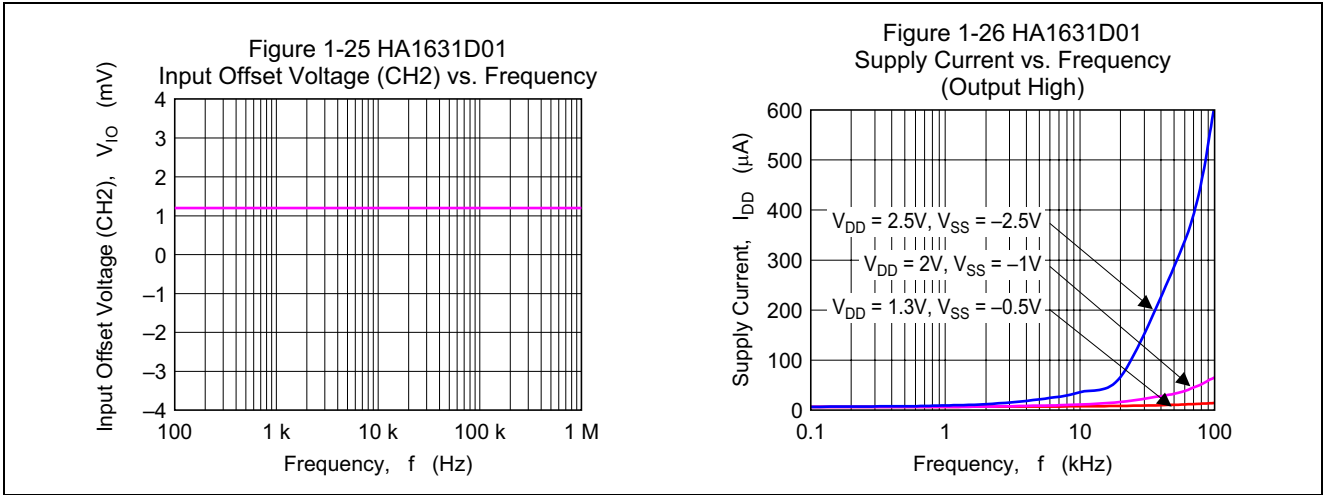
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(unless otherwise noted,  $V_{DD} = 3\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_a = 25^\circ\text{C}$ )

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

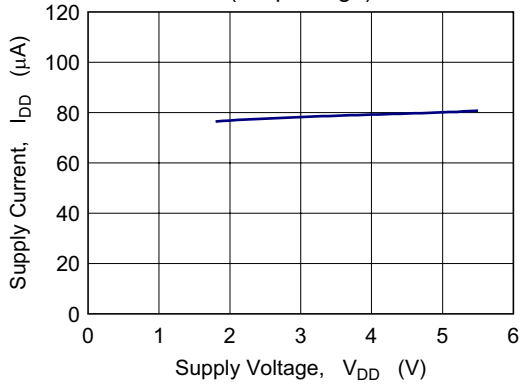


Figure 2-2 HA1631D02  
Supply Current vs. Supply Voltage  
(Output Low)

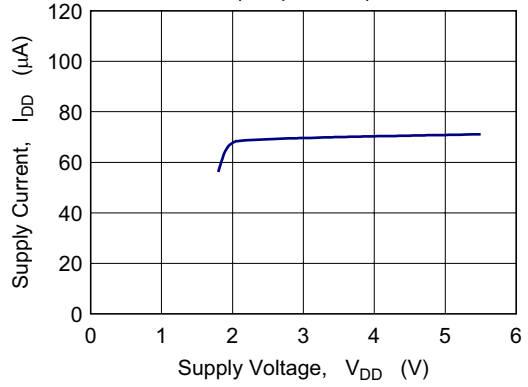


Figure 2-3 HA1631D02  
Supply Current vs. Ambient Temperature

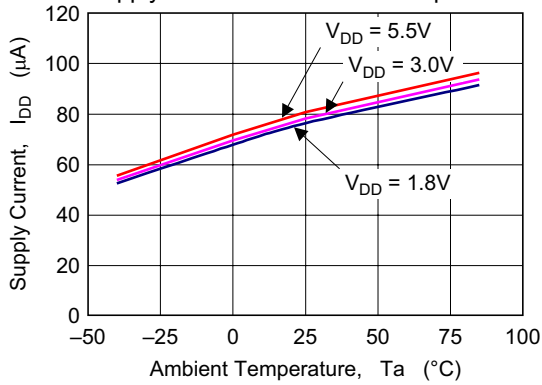


Figure 2-4 HA1631D02  
Output High Voltage vs. Output Source Current

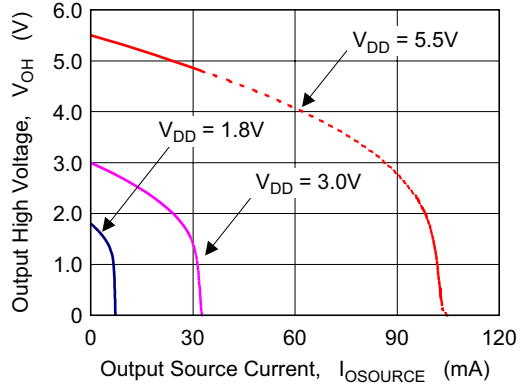


Figure 2-5 HA1631D02  
Output Low Voltage vs. Output Sink Current

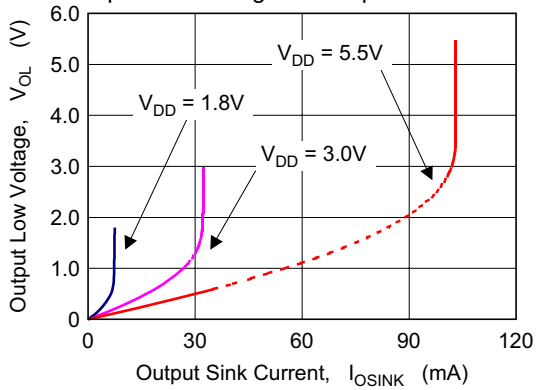
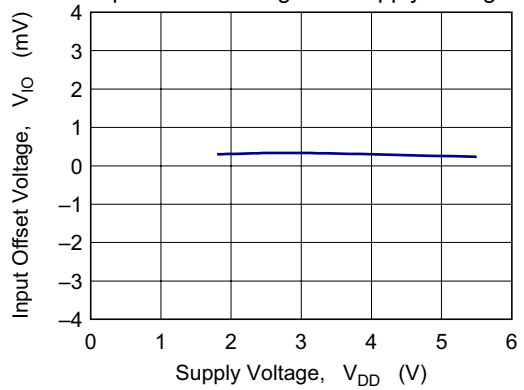
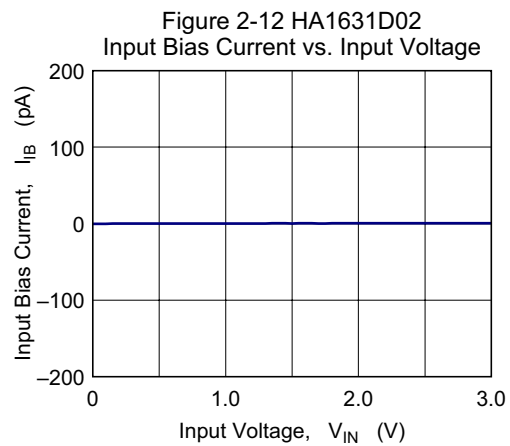
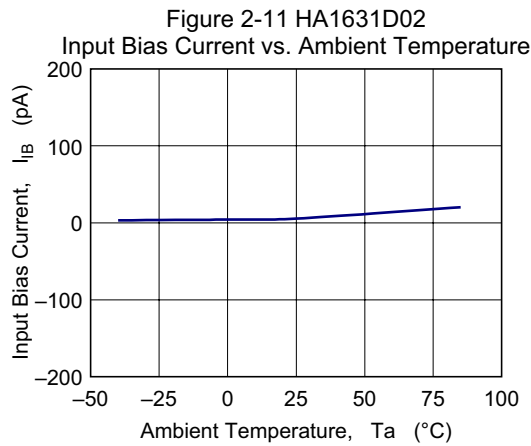
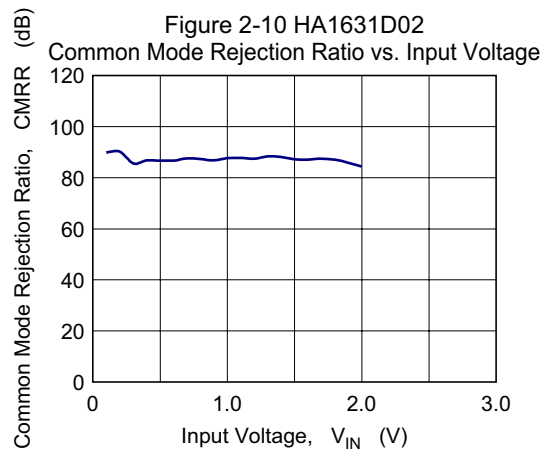
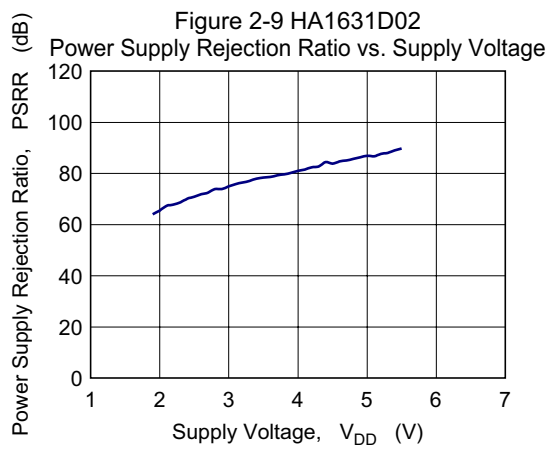
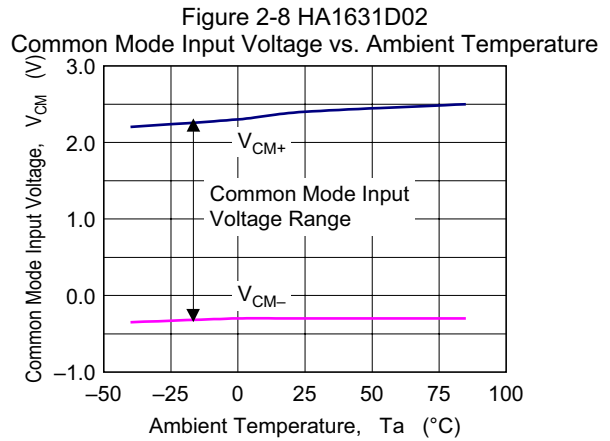
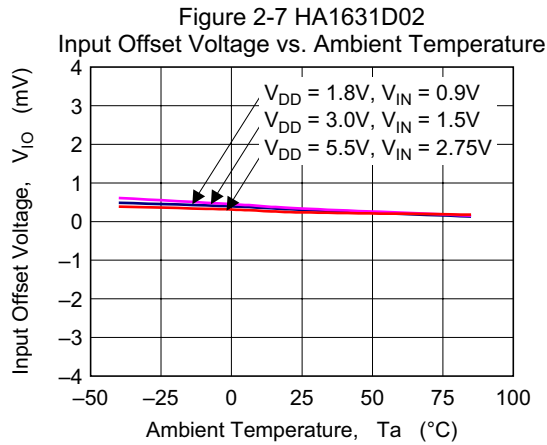


Figure 2-6 HA1631D02  
Input Offset Voltage vs. Supply Voltage



(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

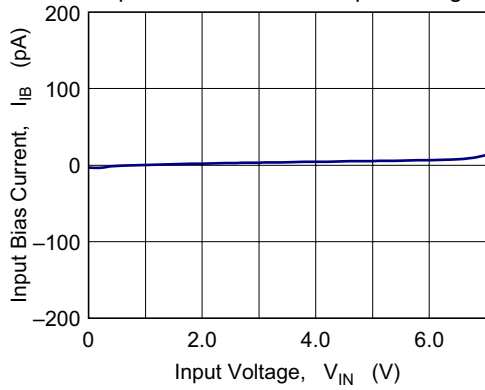


Figure 2-14 HA1631D02  
Falling Time vs. Ambient Temperature

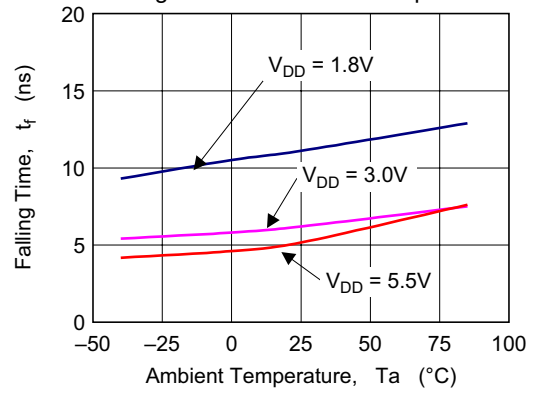


Figure 2-15 HA1631D02  
Rising Time vs. Ambient Temperature

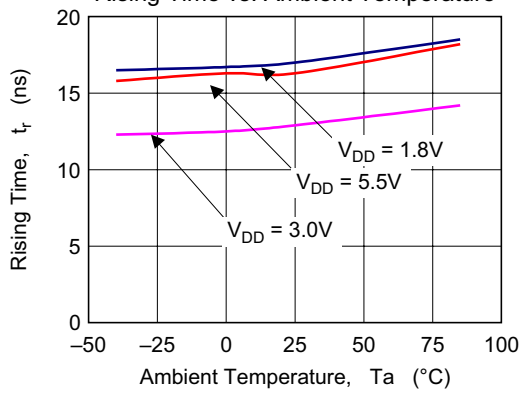


Figure 2-16 HA1631D02  
Falling Time vs. Capacitive Load

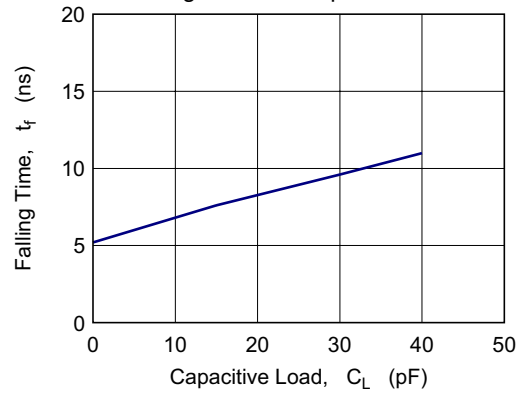


Figure 2-17 HA1631D02  
Rising Time vs. Capacitive Load

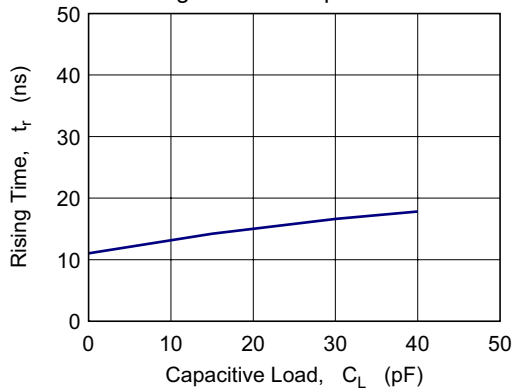
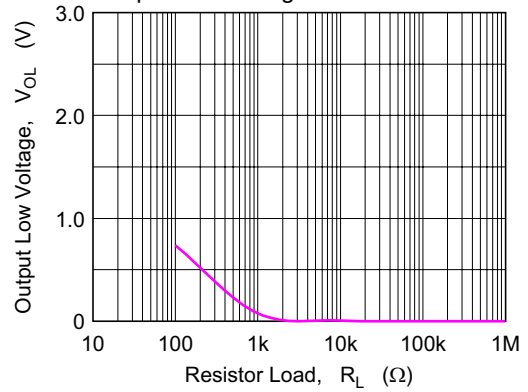
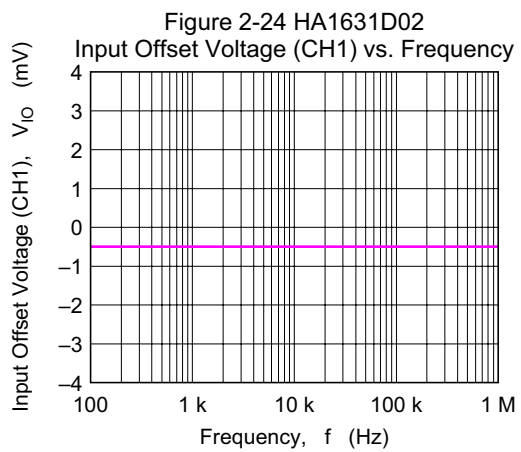
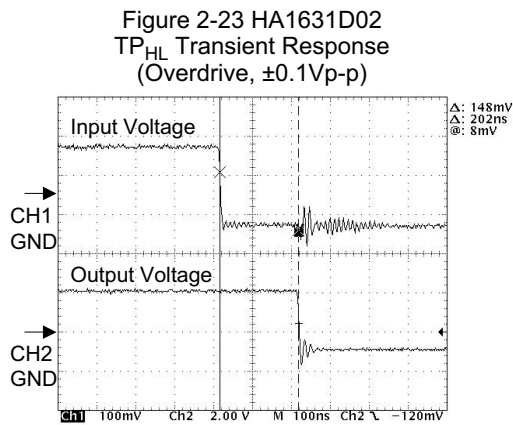
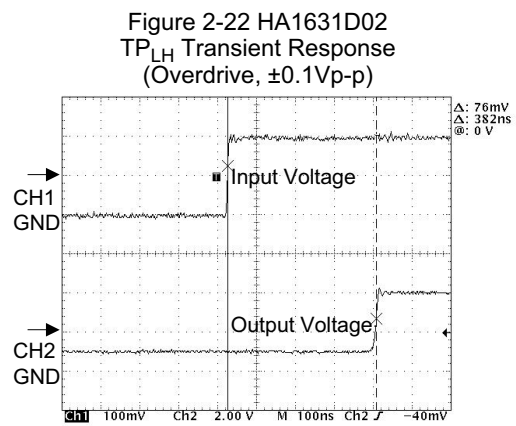
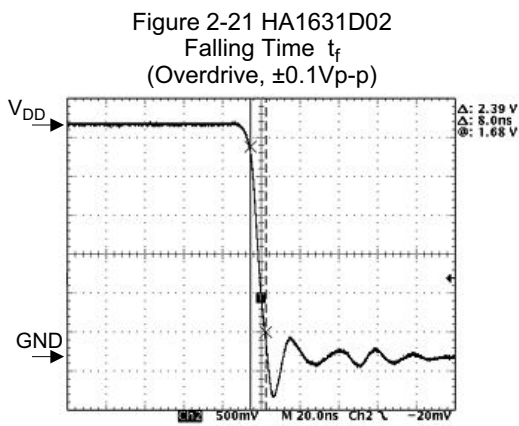
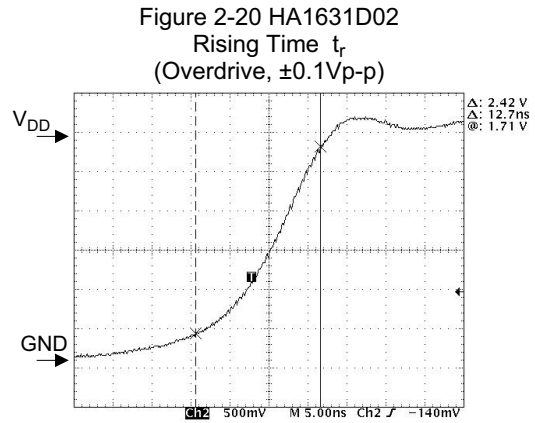
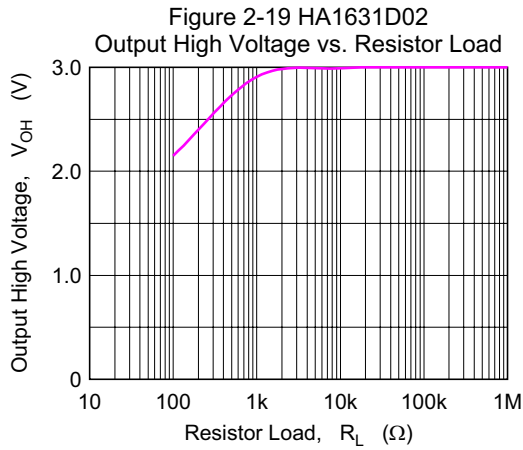


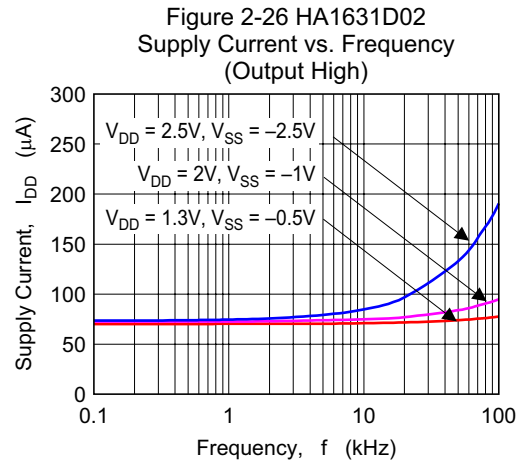
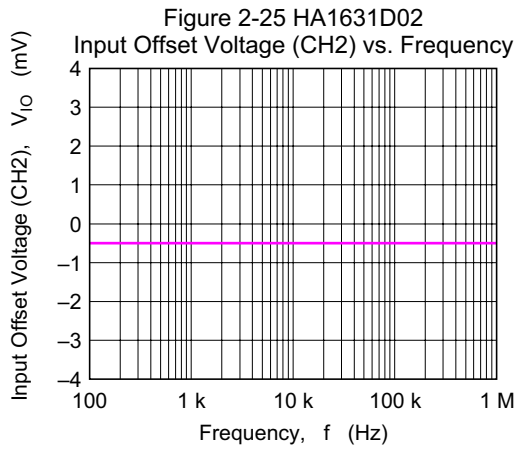
Figure 2-18 HA1631D02  
Output Low Voltage vs. Resistor Load



(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)

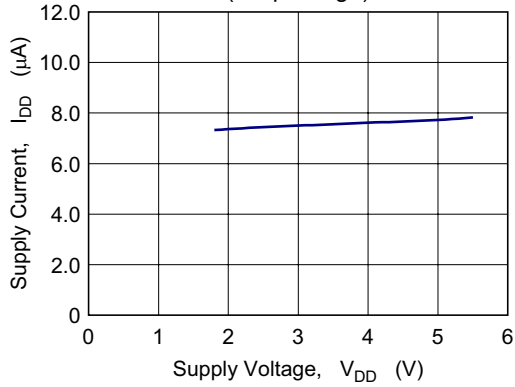


Figure 3-2 HA1631D03  
Supply Current vs. Supply Voltage  
(Output Low)

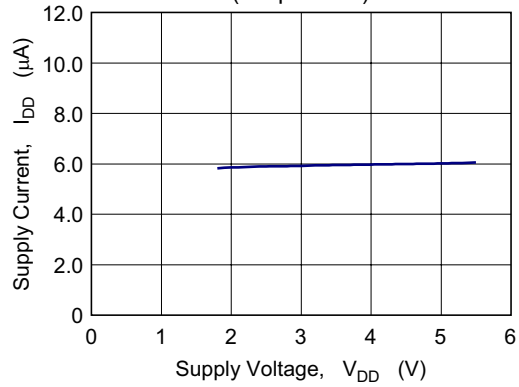


Figure 3-3 HA1631D03  
Supply Current vs. Ambient Temperature

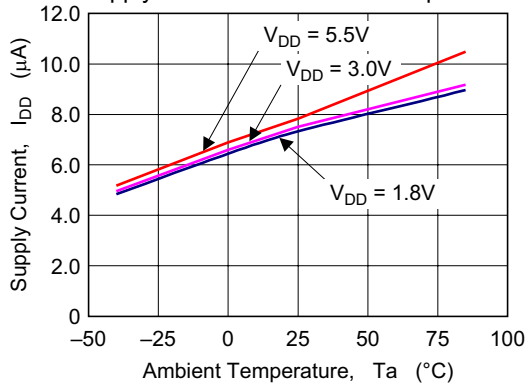


Figure 3-4 HA1631D03  
Output Low Voltage vs. Output Sink Current

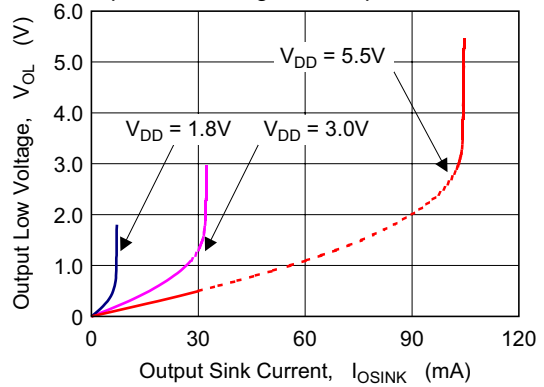


Figure 3-5 HA1631D03  
Input Offset Voltage vs. Supply Voltage

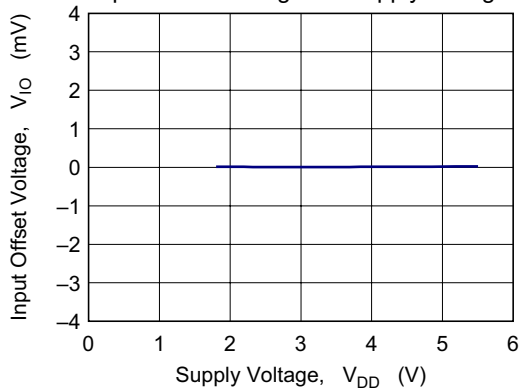
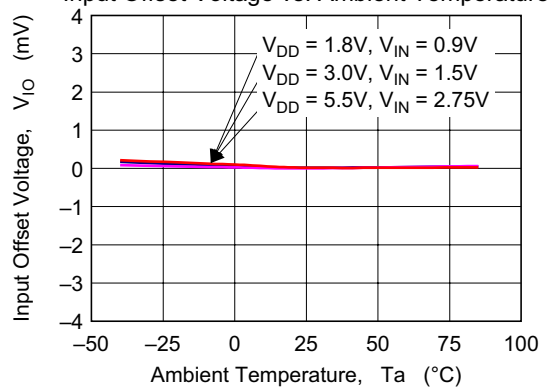


Figure 3-6 HA1631D03  
Input Offset Voltage vs. Ambient Temperature



(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

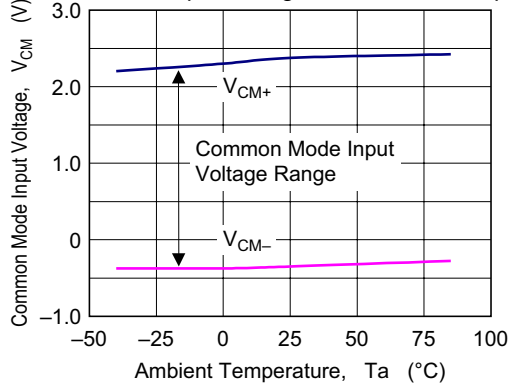


Figure 3-8 HA1631D03  
Power Supply Rejection Ratio vs. Supply Voltage

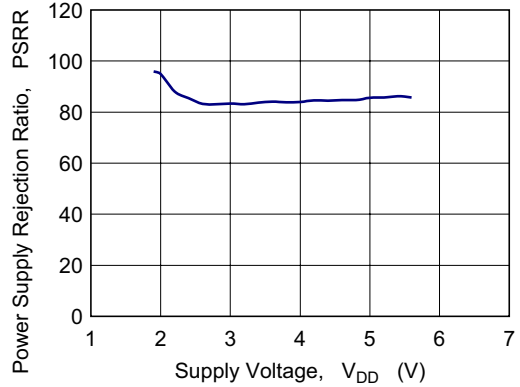


Figure 3-9 HA1631D03  
Common Mode Rejection Ratio vs. Input Voltage

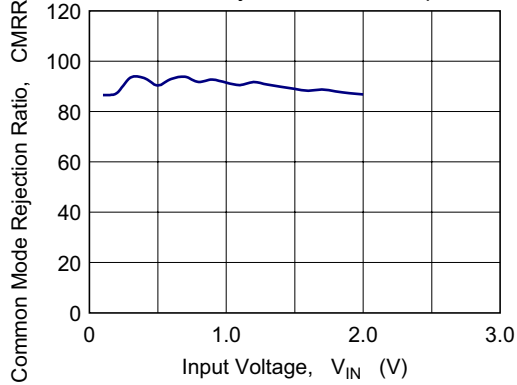


Figure 3-10 HA1631D03  
Input Bias Current vs. Ambient Temperature

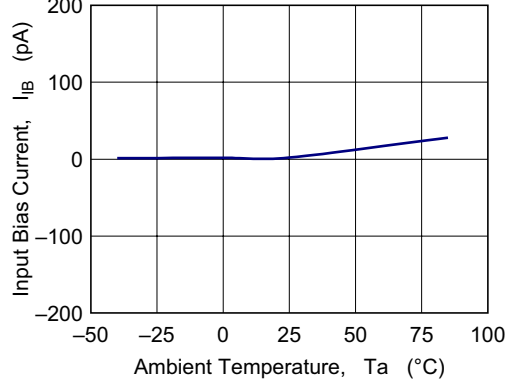


Figure 3-11 HA1631D03  
Input Bias Current vs. Input Voltage

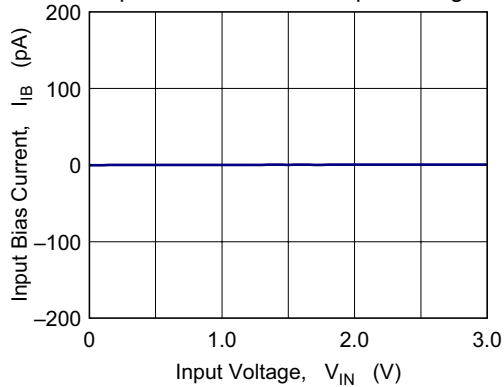
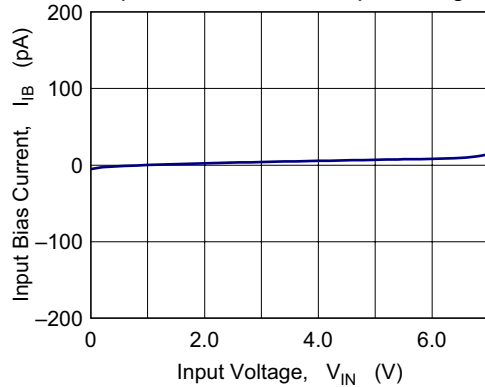
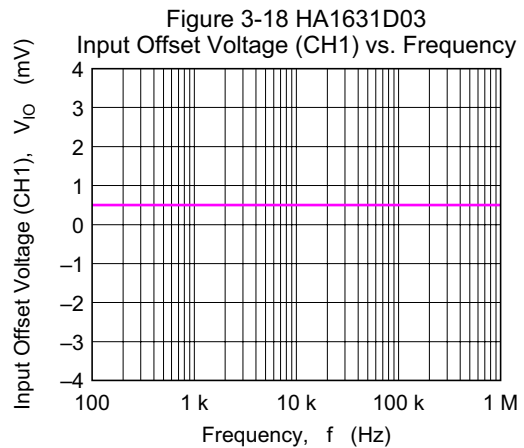
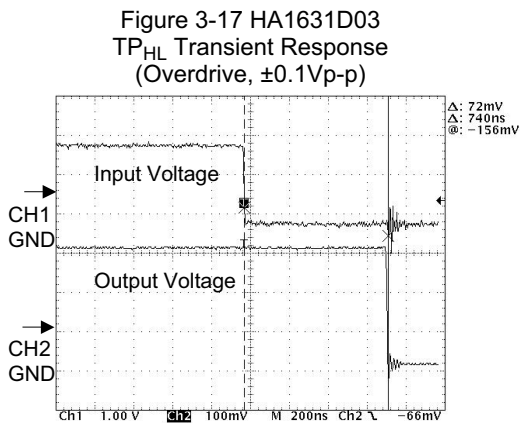
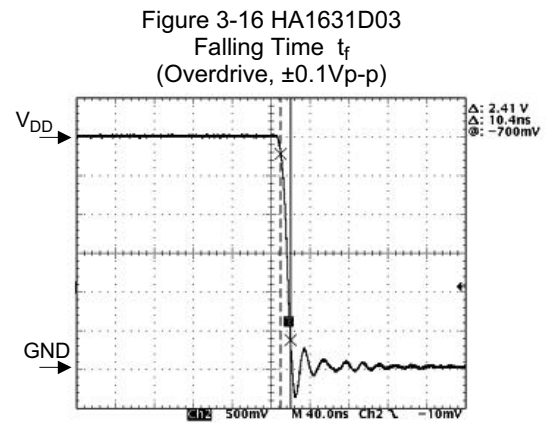
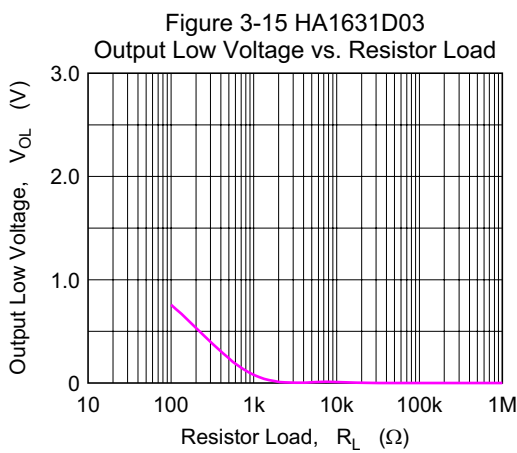
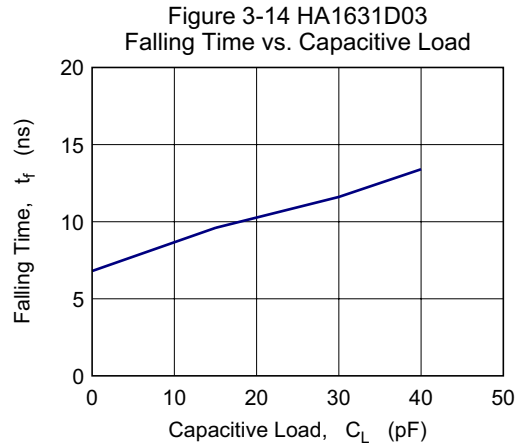
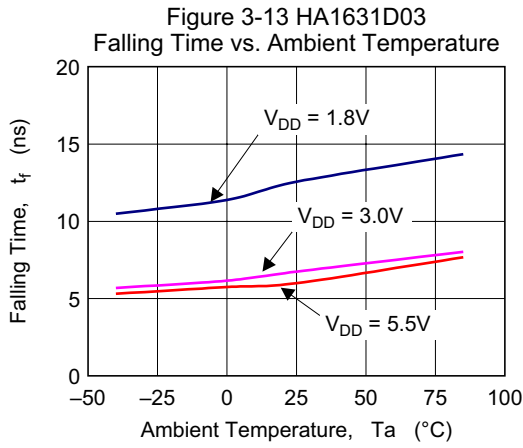


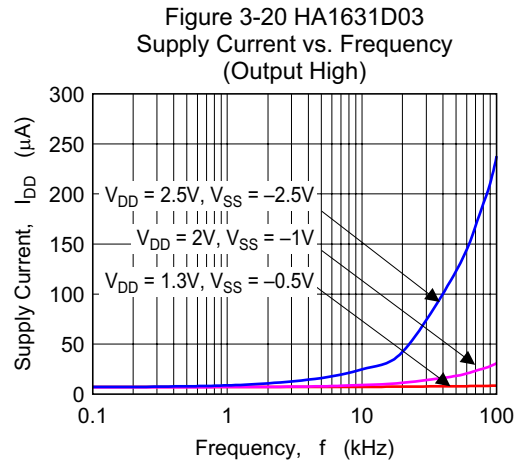
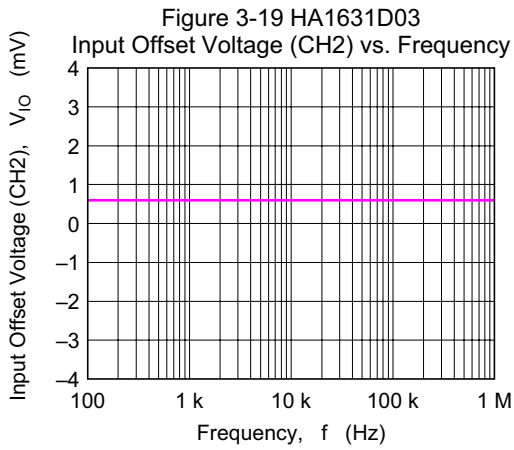
Figure 3-12 HA1631D03  
Input Bias Current vs. Input Voltage



(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)

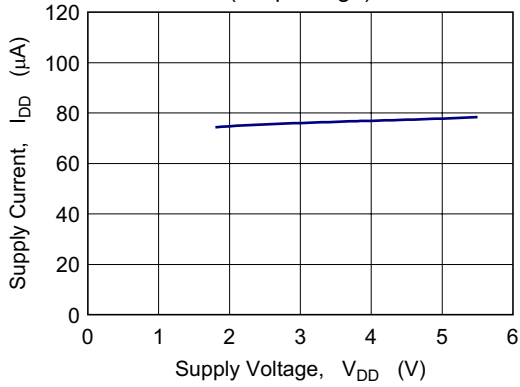


Figure 4-2 HA1631D04  
Supply Current vs. Supply Voltage  
(Output Low)

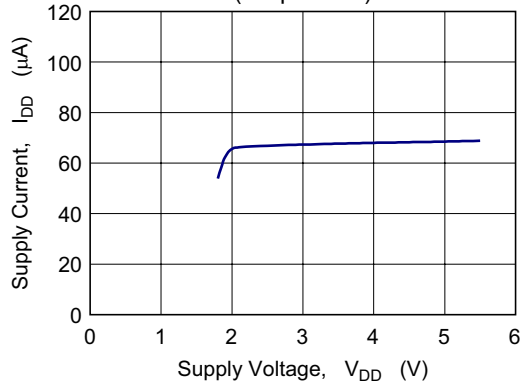


Figure 4-3 HA1631D04  
Supply Current vs. Ambient Temperature

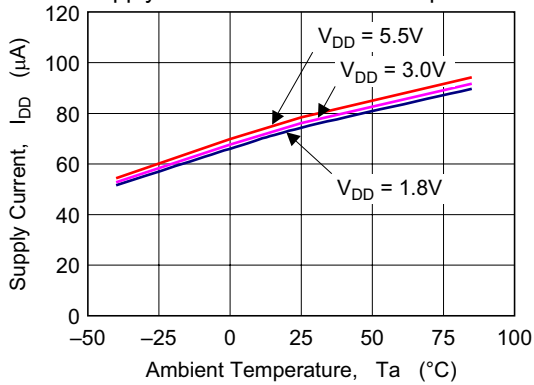


Figure 4-4 HA1631D04  
Output Low Voltage vs. Output Sink Current

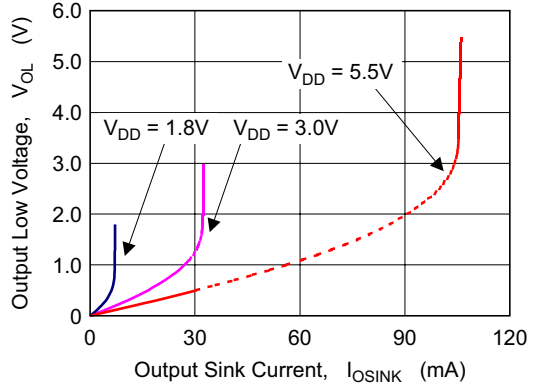


Figure 4-5 HA1631D04  
Input Offset Voltage vs. Supply Voltage

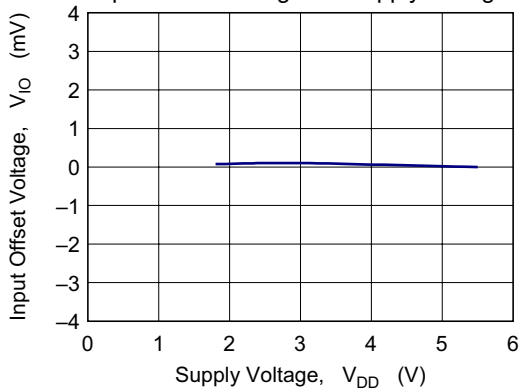
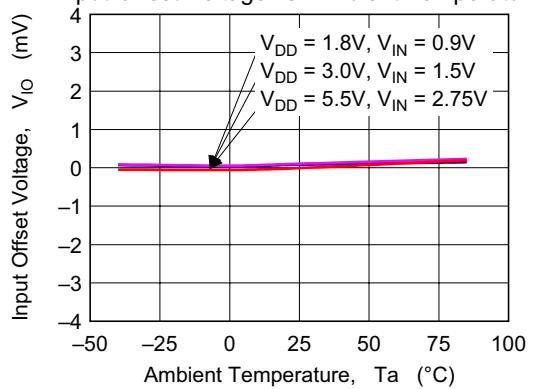
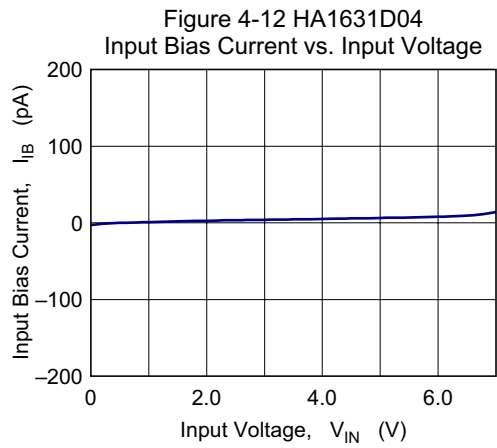
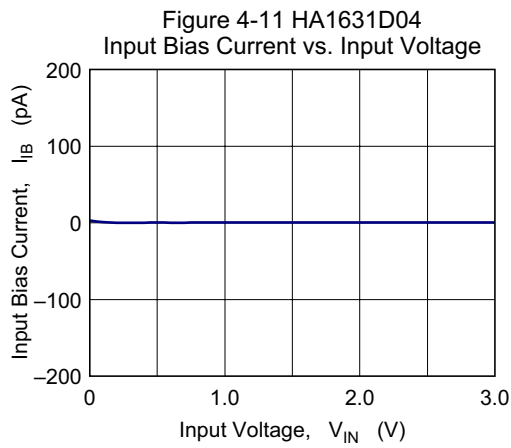
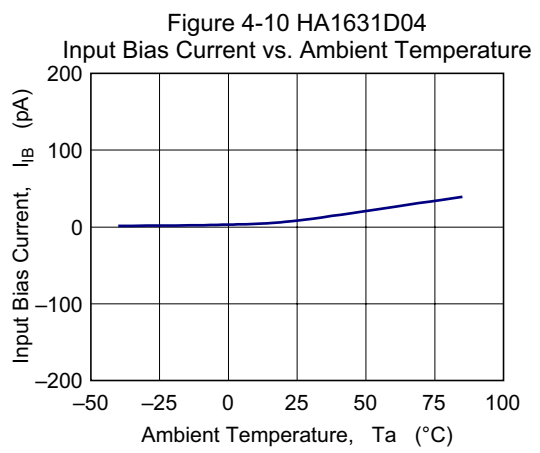
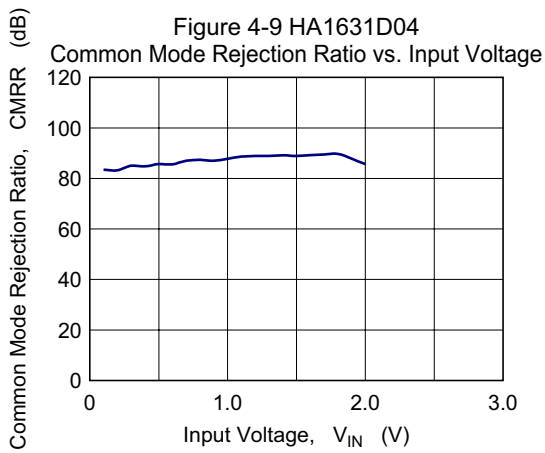
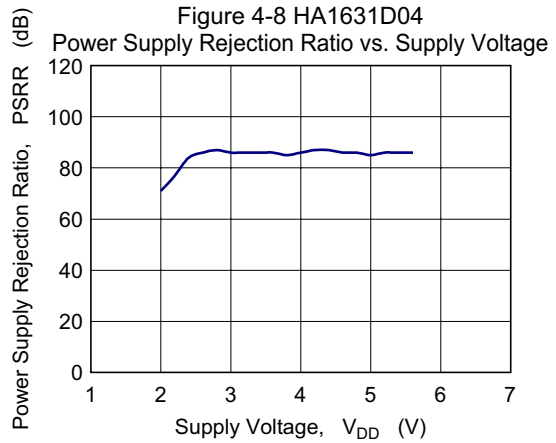
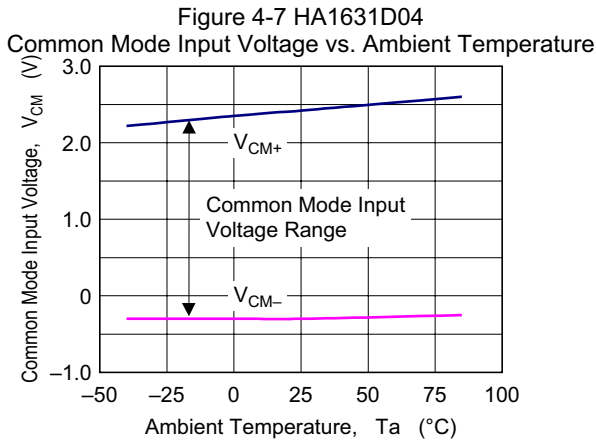


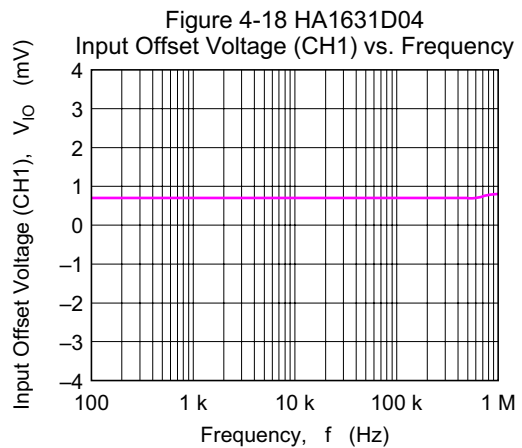
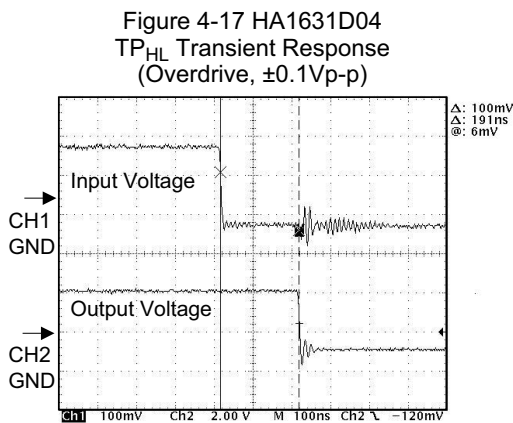
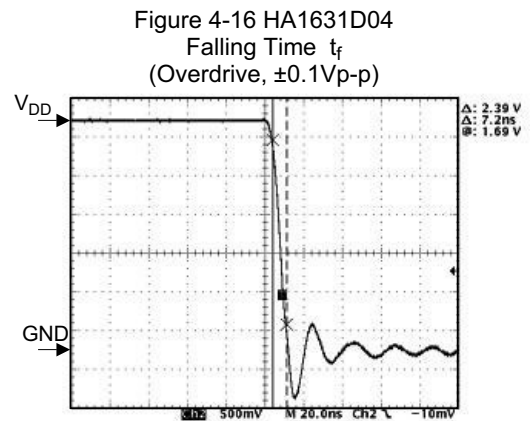
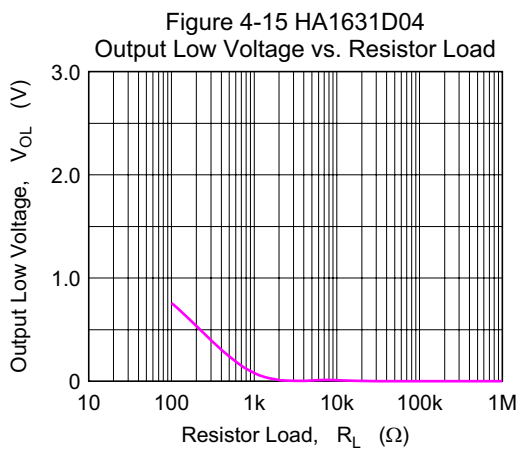
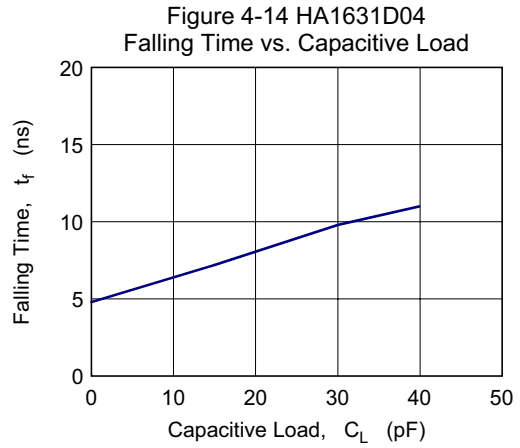
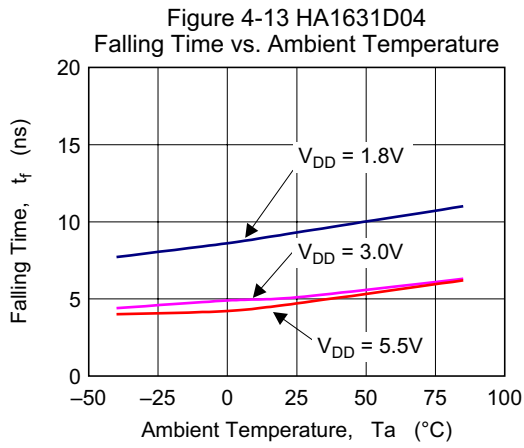
Figure 4-6 HA1631D04  
Input Offset Voltage vs. Ambient Temperature



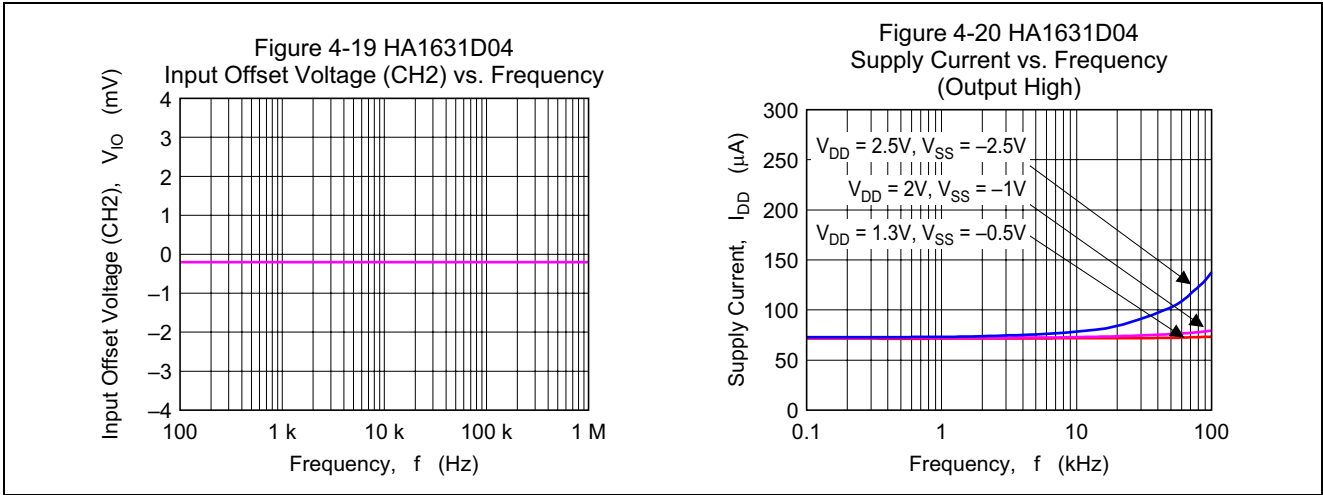
(unless otherwise noted,  $V_{DD} = 3\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_a = 25^\circ\text{C}$ )



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



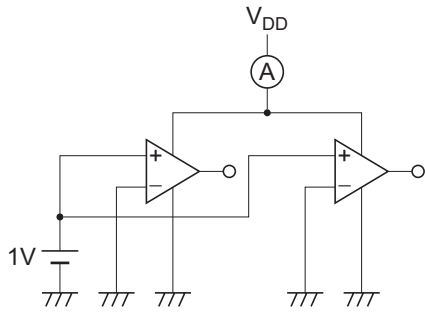
(unless otherwise noted,  $V_{DD} = 3\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_a = 25^\circ\text{C}$ )



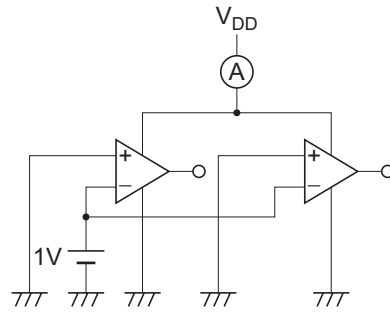
Test Circuits

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

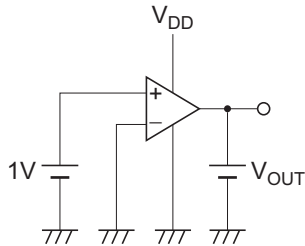
1. Supply Current,  $I_{DD}$  (Output High)



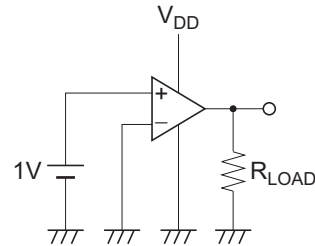
2. Supply Current,  $I_{DD}$  (Output Low)



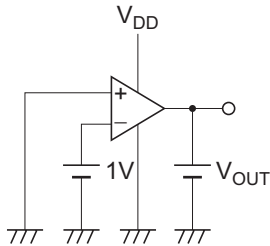
3. Output Source Current,  $I_{OSOURCE}$



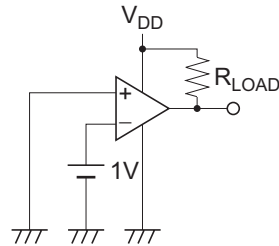
4. Output Voltage High,  $V_{OH}$



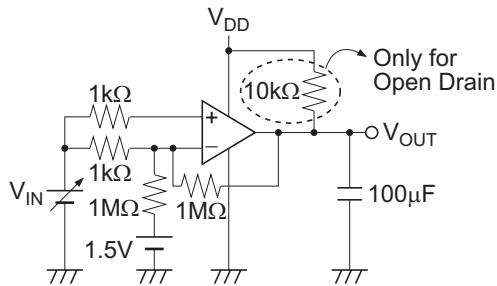
5. Output Sink Current,  $I_{OSINK}$



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

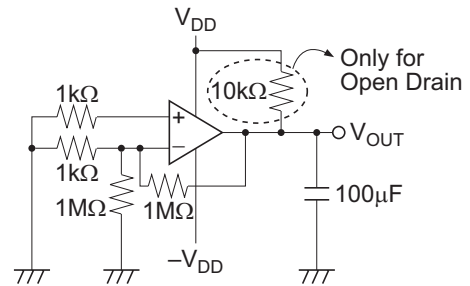


7. Input Offset Voltage,  $V_{IO}$



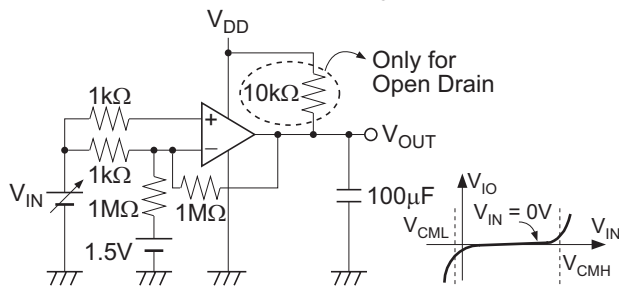
Note:  $V_{IO} = V_{OUT} - 1.5\text{ V}$

8. Input Offset Voltage vs. Supply Voltage



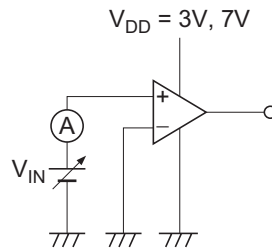
(unless otherwise noted,  $V_{DD} = 3\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $T_a = 25^\circ\text{C}$ )

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

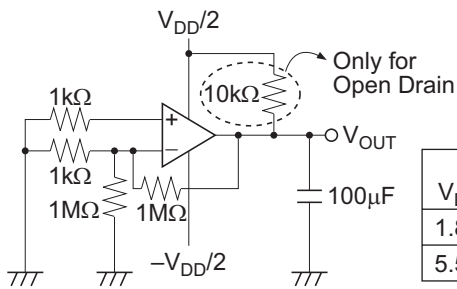


Note:  $V_{CML}$  and  $V_{CMH}$  are values of  $V_{IN}$  when  $V_{IO}$  changes more than 50dB taking  $V_{IN} = 0\text{ V}$  as reference.

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

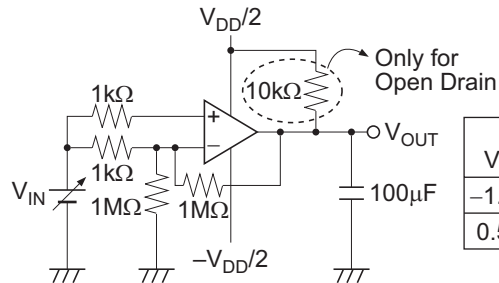


11. Power Supply Rejection Ratio, PSRR



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

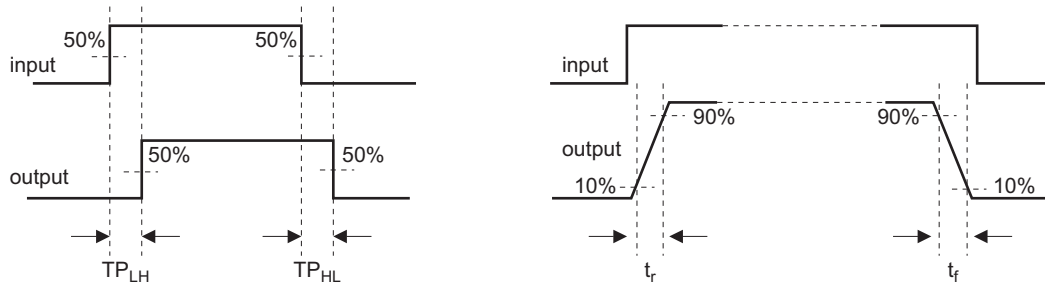
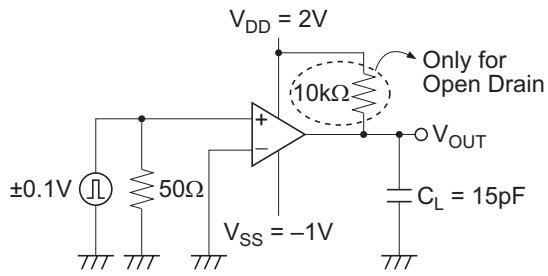
12. Common Mode Rejection Ratio, CMRR



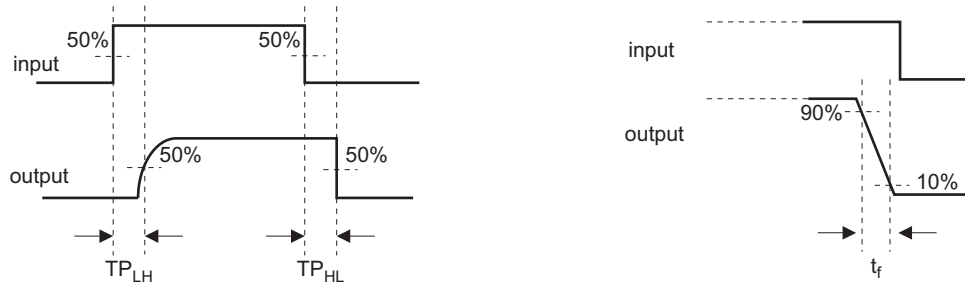
$V_{IN}$	Measure Point	Calculate $V_{IO}$	CMRR Calculation
-1.5V	$V_{OUT1}$	$V_{IO1} = V_{OUT1}/1000$	CMRR = $\left  20\log \frac{ (V_{IO2} - V_{IO1}) }{0.5\text{V} - (-1.5\text{V})} \right $
0.5V	$V_{OUT2}$	$V_{IO2} = V_{OUT2}/1000$	

(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  $TP_{HL}$ ,  $TP_{LH}$

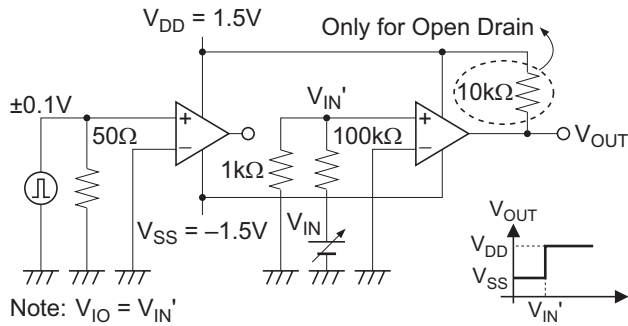


Only for Push Pull HA1631D01/02

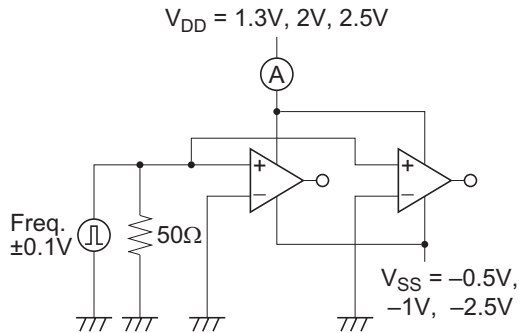


Only for Open Drain HA1631D03/04

14. Cross Talk

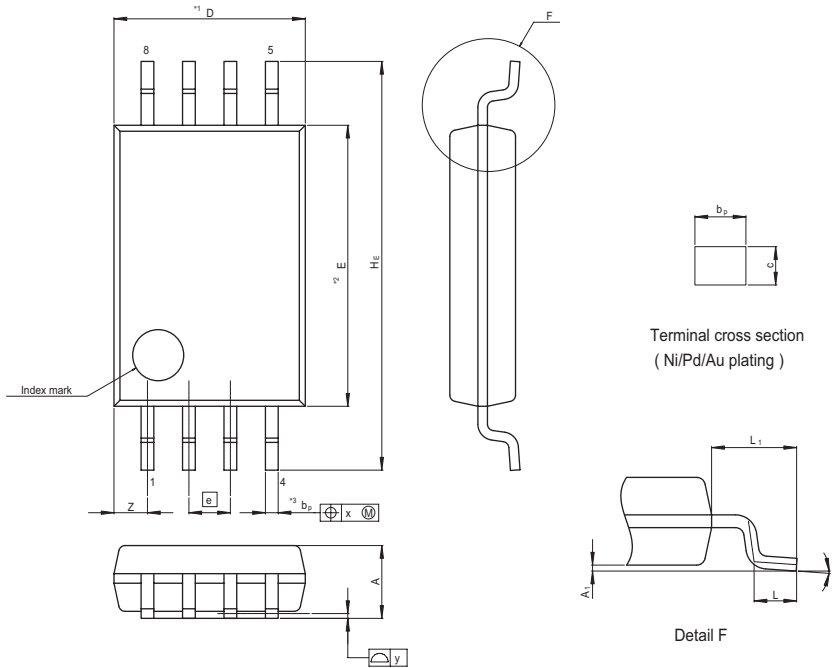


15. Supply Current,  $I_{DD}$  (Output High) vs. Frequency



Package Dimensions

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



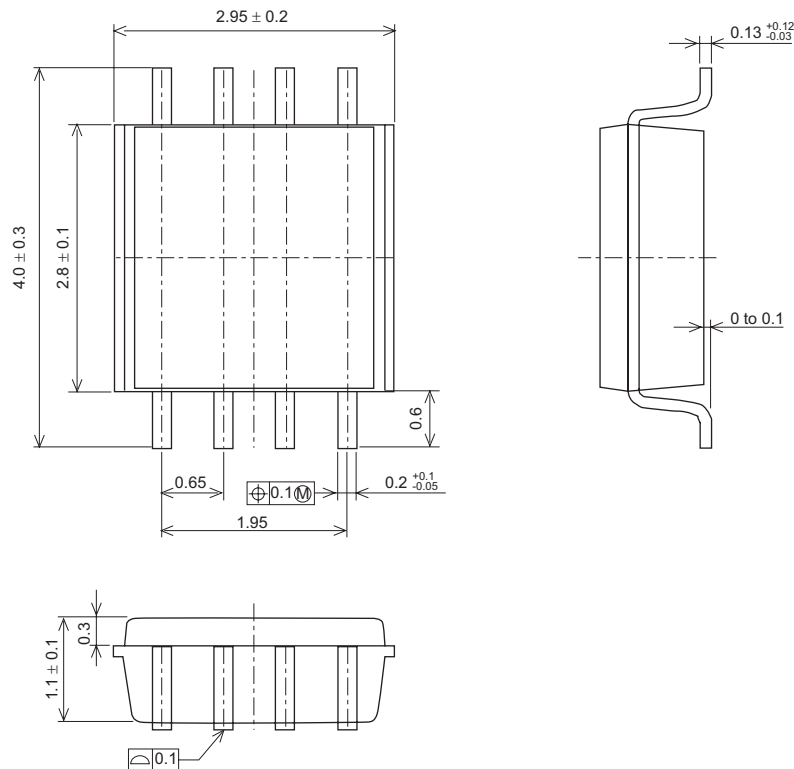
NOTE)  
 1. DIMENSIONS\*\*1 (Nom)\*AND\*\*2  
 DO NOT INCLUDE MOLD FLASH.  
 2. DIMENSION\*\*3\*DOES NOT  
 INCLUDE TRIM OFFSET.

Terminal cross section  
( Ni/Pd/Au plating )

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	RENESAS 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.)
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