

# HA1631S01/02/03/04 Series

Single CMOS Comparator  
(Push Pull/Open Drain Output)

R03DS0085EJ0500

Rev.5.00

Jul 01, 2015

## Description

The HA1631S01/02/03/04 are low power single CMOS Comparator featuring low voltage operation with typical current supply of 5  $\mu$ A/50  $\mu$ A. They are designed to operate from a single power supply. HA1631S01/02 have push-pull full swing outputs that allow direct connections to logic devices. The Open Drain version HA1631S03/04 enable Output Level shifting through external pull up resistors. Available in an ultra-small CMPAK-5 package, they occupy only 1/8 the area of the SOP-8 package.

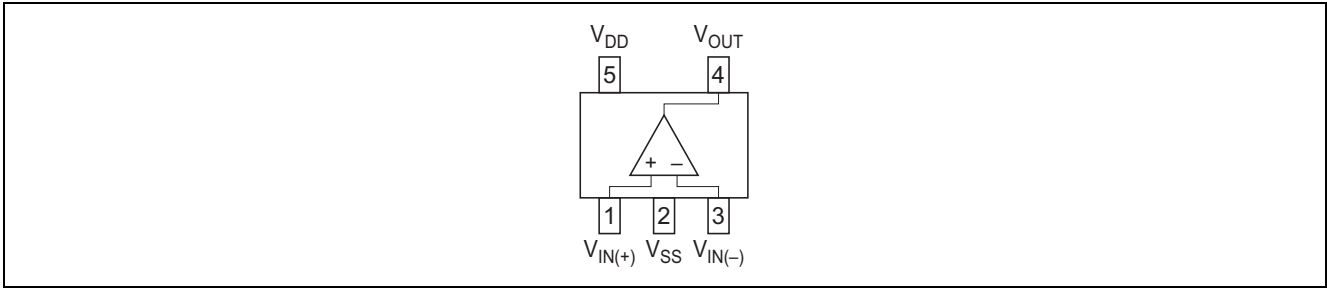
## Features

- Low supply current  
 HA1631S01/03 :  $I_{DDtyp} = 5 \mu A$  ( $V_{DD} = 3.0 V$ )  
 HA1631S02/04 :  $I_{DDtyp} = 50 \mu A$  ( $V_{DD} = 3.0 V$ )
- 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 CMPAK-5 and MPAK-5 package using Pb free lead frame

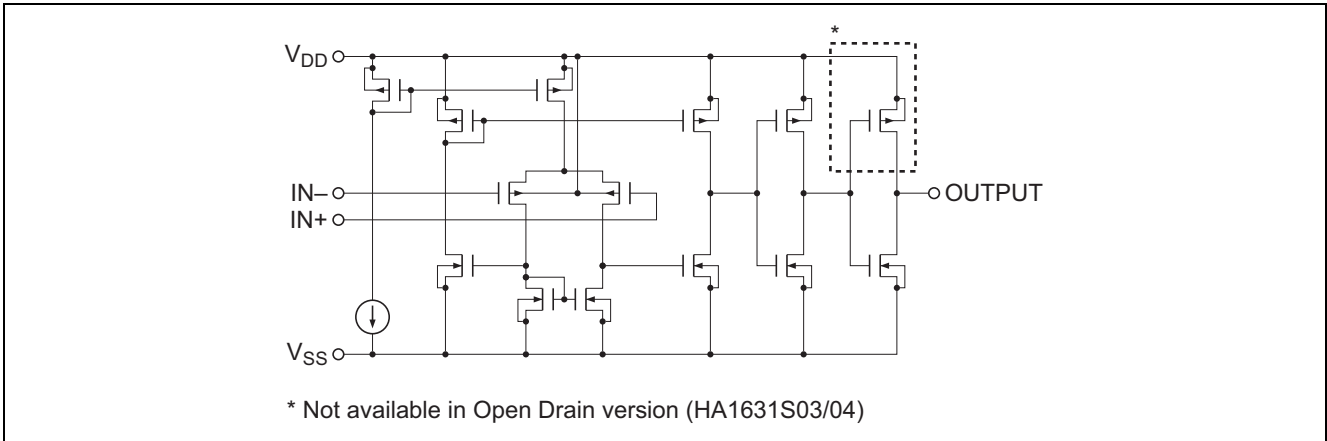
## Ordering Information

Type No.	Package Name	Package Code
HA1631S01CM	CMPAK-5	PTSP0005ZC-A
HA1631S02CM		
HA1631S03CM		
HA1631S04CM		
HA1631S01LP	MPAK-5	PLSP0005ZB-A
HA1631S02LP		
HA1631S03LP		
HA1631S04LP		

## Pin Arrangement



## Equivalent Circuit



## 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>	80/120	mW	CMPAK-5/MPAK-5
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)

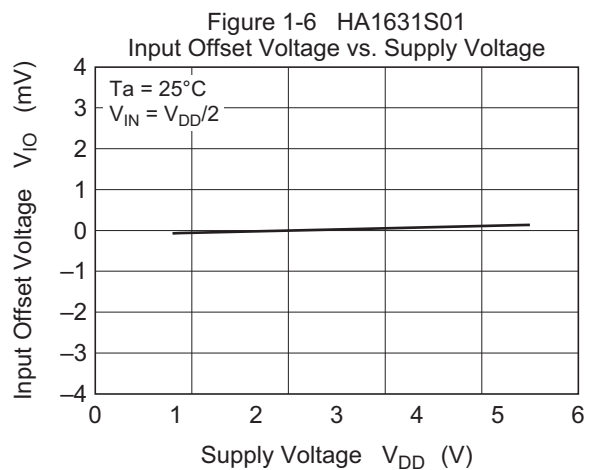
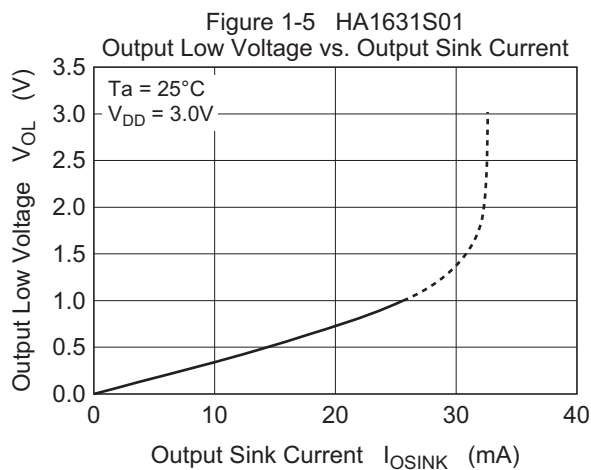
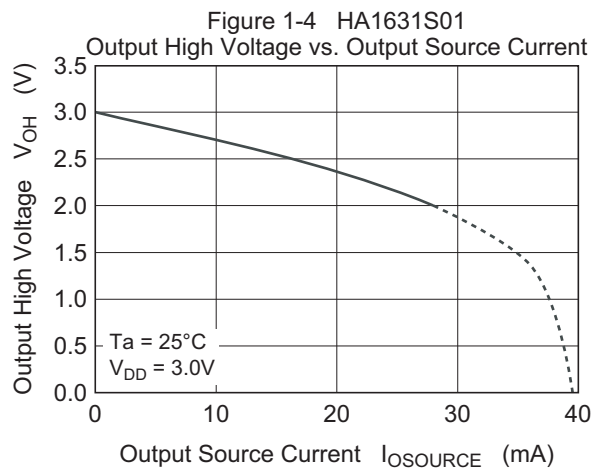
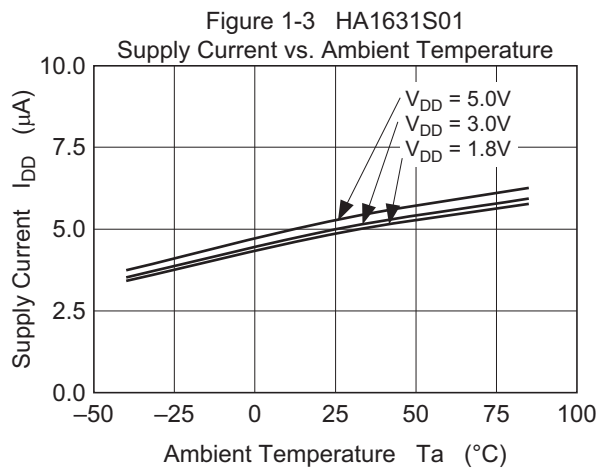
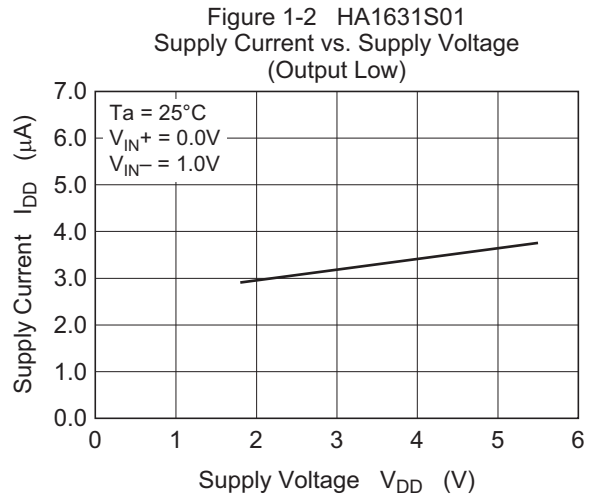
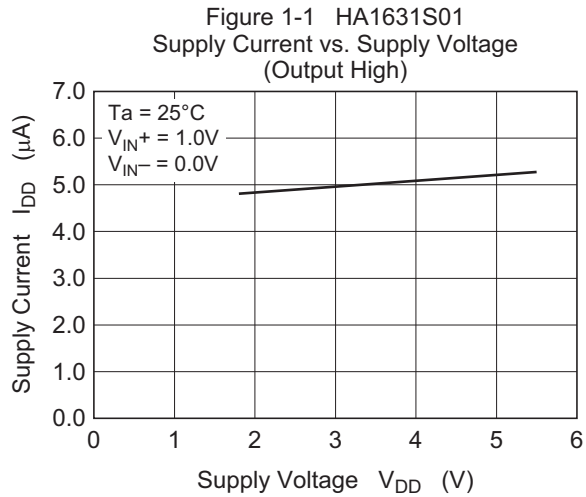
Item	Symbol	Min	Typ	Max	Unit	Test Conditions	
Input offset voltage	V <sub>IO</sub>	—	—	5	mV	V <sub>IN</sub> = V <sub>DD</sub> /2, R <sub>L</sub> = 1MΩ	
Input bias current	I <sub>IB</sub>	—	(1)	100	pA	V <sub>IN</sub> = V <sub>DD</sub> /2	
Input offset current	I <sub>IO</sub>	—	(1)	100	pA	V <sub>IN</sub> = V <sub>DD</sub> /2	
Common mode input voltage range	V <sub>CM</sub>	-0.1	—	2.1	V		
Supply current	HA1631S01/03	I <sub>DD</sub>	—	5	10	μA	V <sub>DD</sub> = 3V, V <sub>IN+</sub> = 1V, V <sub>IN-</sub> = 0V
	HA1631S02/04		—	50	100	μA	
Response time	HA1631S01	TP <sub>LH</sub>	—	(1.20)	—	μs	1V DC bias, 100mV overdrive, C <sub>L</sub> = 15pF
	HA1631S01/03	TP <sub>HL</sub>	—	(0.55)	—	μs	
	HA1631S01	t <sub>r</sub>	—	(24)	—	ns	
	HA1631S01/03	t <sub>f</sub>	—	(7)	—	ns	
	HA1631S02	TP <sub>LH</sub>	—	(0.33)	—	μs	
	HA1631S02/04	TP <sub>HL</sub>	—	(0.17)	—	μs	
	HA1631S02	t <sub>r</sub>	—	(12)	—	ns	
Output source current (HA1631S01/02)	I <sub>OSOURCE</sub>	6	13	—	mA	V <sub>out</sub> = 2.5V	
		7	14	—	mA	V <sub>out</sub> = 0.5V	
Common mode rejection ratio	HA1631S01/03	CMRR	60	80	—	dB	V <sub>IN1</sub> = 0V, V <sub>IN2</sub> = 2V
	HA1631S02/04		50	70	—	dB	
Power supply rejection ratio	PSRR	60	80	—	dB	V <sub>DD1</sub> = 1.8V, V <sub>DD2</sub> = 5.5V	
Output voltage high	V <sub>OH</sub>	V <sub>DD</sub> -0.1	—	—	V	R <sub>L</sub> = 10kΩ to V <sub>SS</sub>	
Output voltage low	V <sub>OL</sub>	—	—	0.1	V	R <sub>L</sub> = 10kΩ to V <sub>DD</sub>	
Output leakage current (Only for HA1631S03/04)	I <sub>LO</sub>	—	(0.1)	—	nA	V <sub>IN+</sub> = 1V, V <sub>IN-</sub> = 0V, V <sub>O</sub> = 3V	
Operating voltage range	V <sub>opr</sub>	1.8	—	5.5	V		

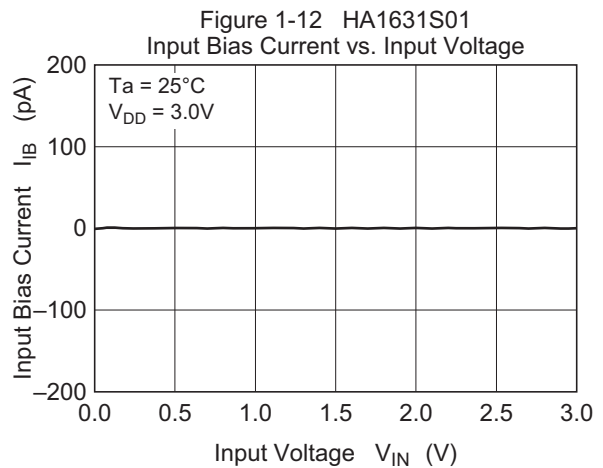
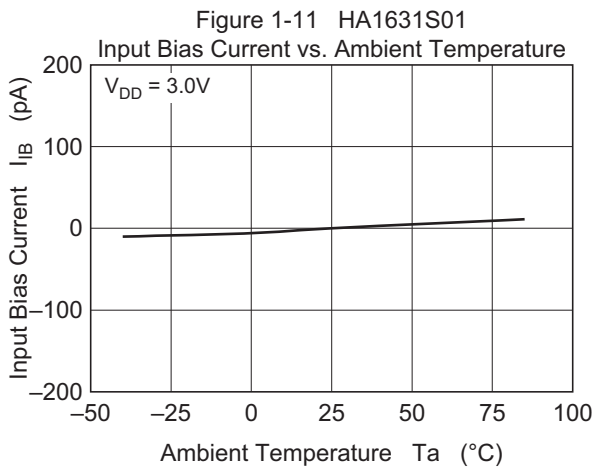
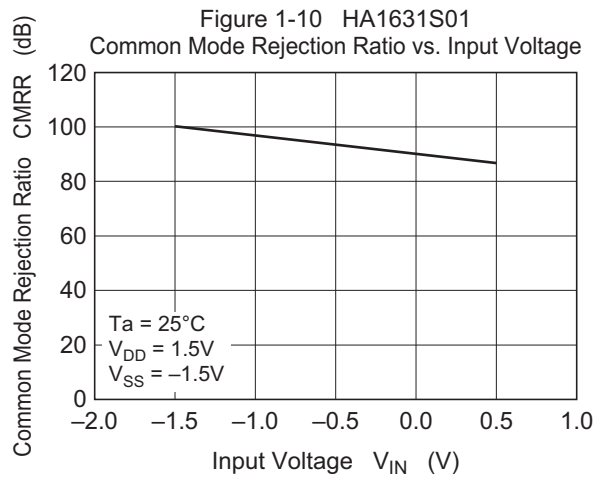
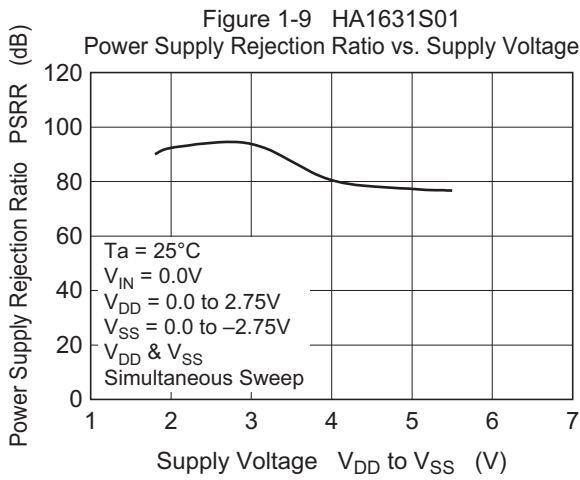
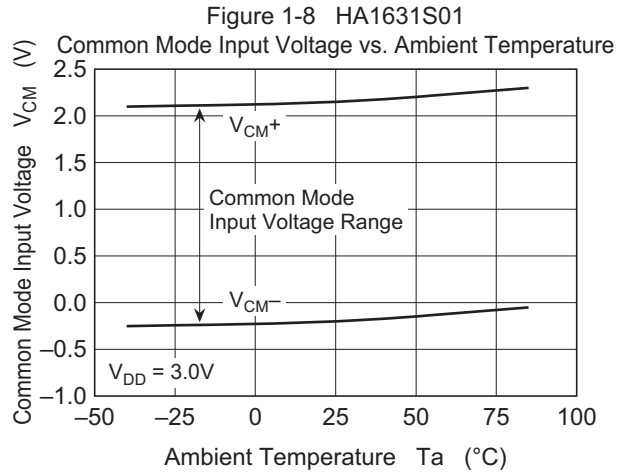
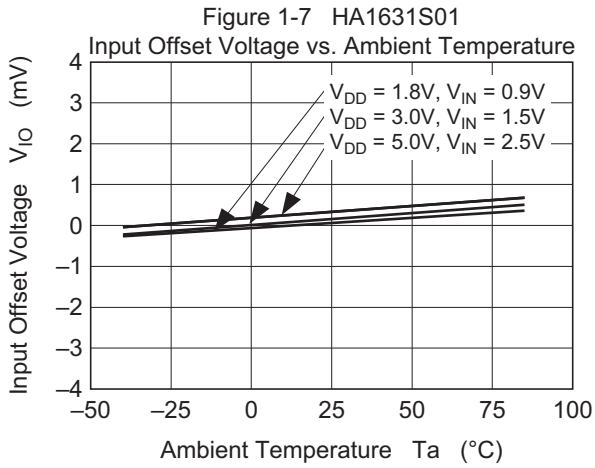
Note: ( ): Design specification

## Table of Graphs

Electrical Characteristics			HA1631S01 Figure	HA1631S02 Figure	HA1631S03 Figure	HA1631S04 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
Output high voltage	$V_{OH}$	vs. Rload	1-18	2-18	3-4	4-4	4
Output source current	$I_{OSOURCE}$	vs. Output high voltage	1-4	2-4	—	—	5
Output low voltage	$V_{OL}$	vs. Rload	1-17	2-17	3-14	4-14	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	1-12	2-12	3-11	4-11	10
Falling time	$t_f$	vs. Temperature	1-13	2-13	3-12	4-12	13
		vs. Cload	1-15	2-15	3-13	4-13	13
		Time waveform	1-20	2-20	3-15	4-15	13
Rising time	$t_r$	vs. Temperature	1-14	2-14	—	—	13
		vs. Cload	1-16	2-16	—	—	13
		Time waveform	1-19	2-19	—	—	13
Propagation delay time	$TP_{LH}$	Time waveform	1-21	2-21	—	—	13
	$TP_{HL}$	Time waveform	1-22	2-22	3-16, 3-17	4-16, 4-17	13

Main Characteristics





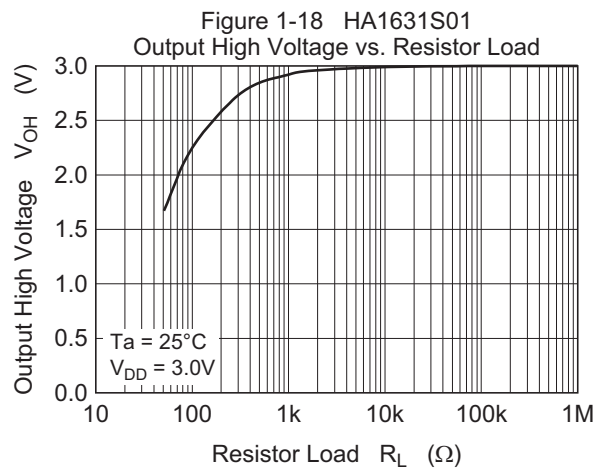
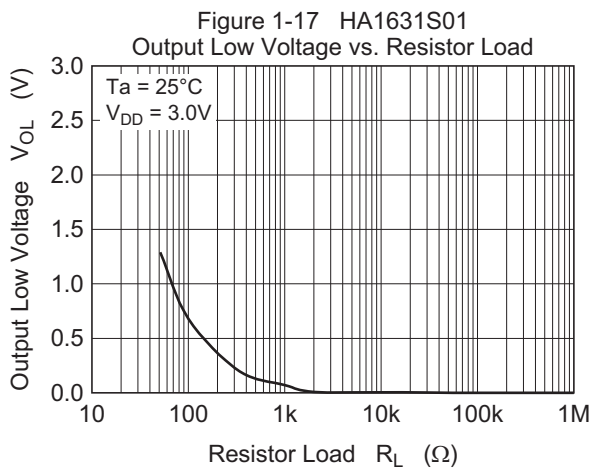
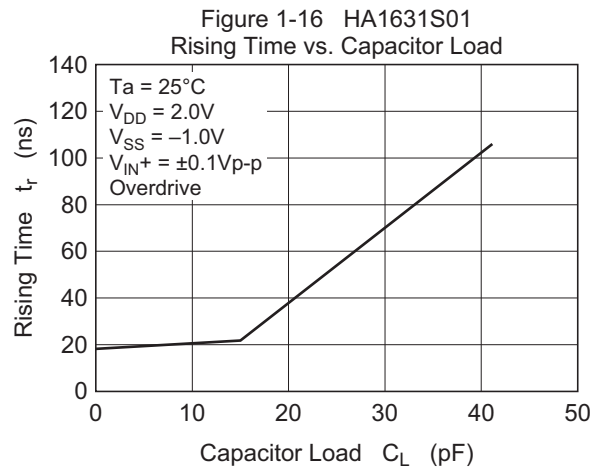
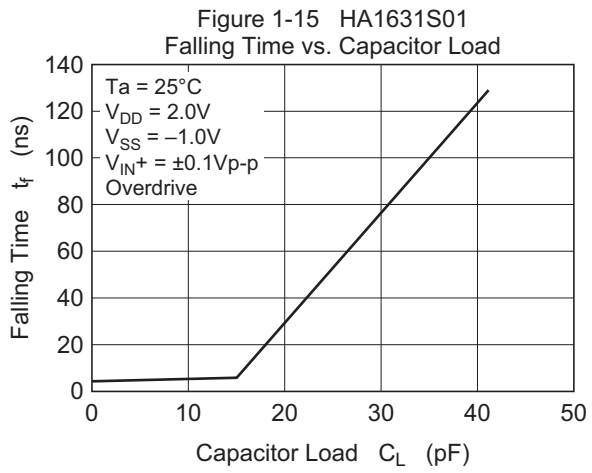
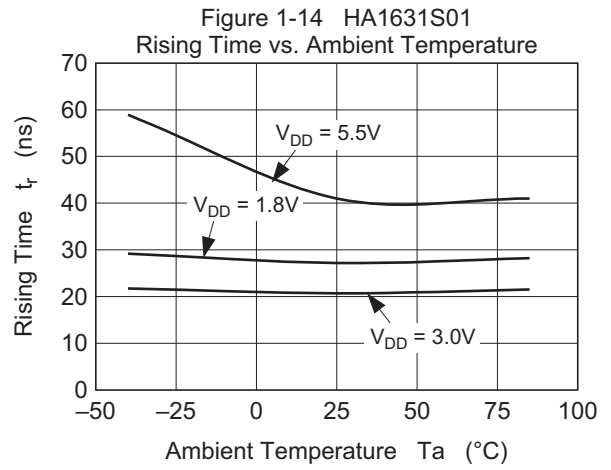
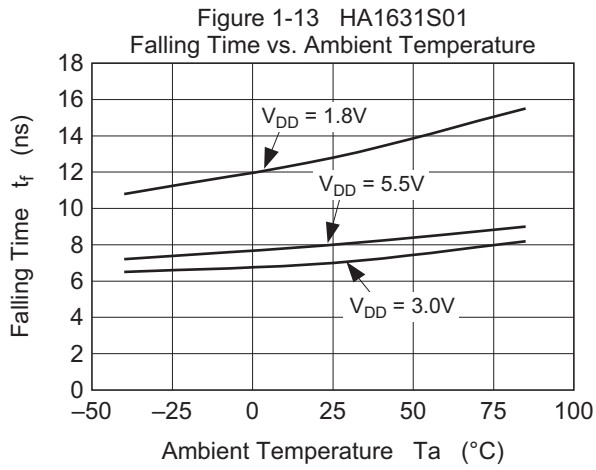


Figure 1-19 HA1631S01  
Rising Time,  $t_r$   
(Overdrive =  $\pm 0.1V_{p-p}$ )

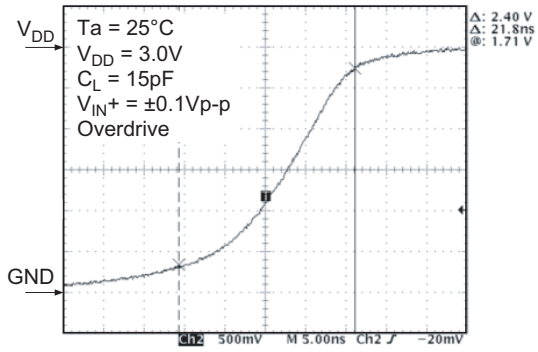


Figure 1-20 HA1631S01  
Falling Time,  $t_f$   
(Overdrive =  $\pm 0.1V_{p-p}$ )

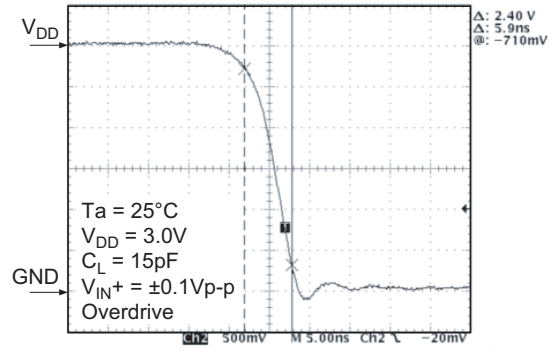


Figure 1-21 HA1631S01  
 $TP_{LH}$  Transient Response  
(Overdrive =  $\pm 0.1V_{p-p}$ )

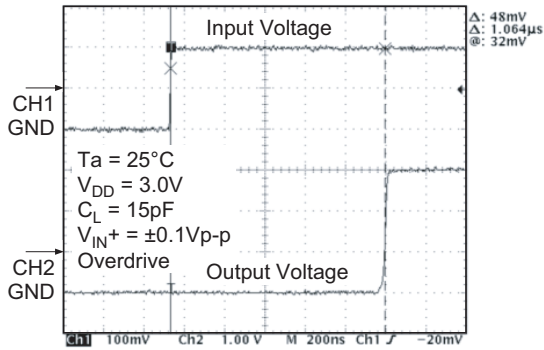
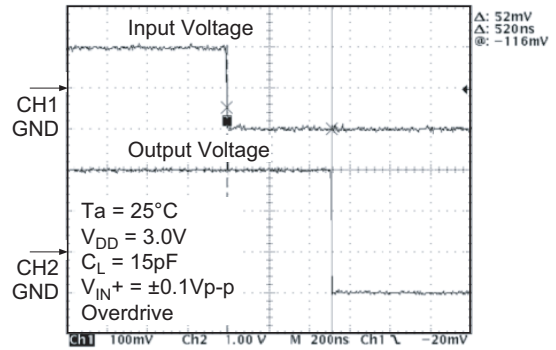
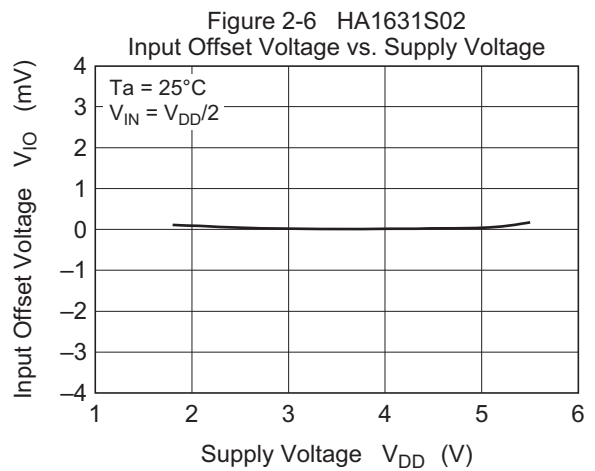
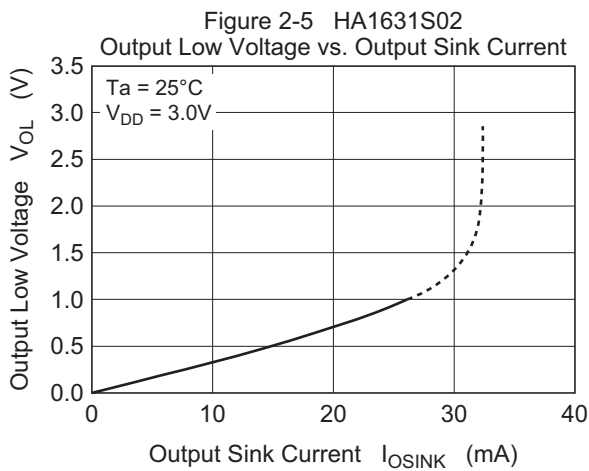
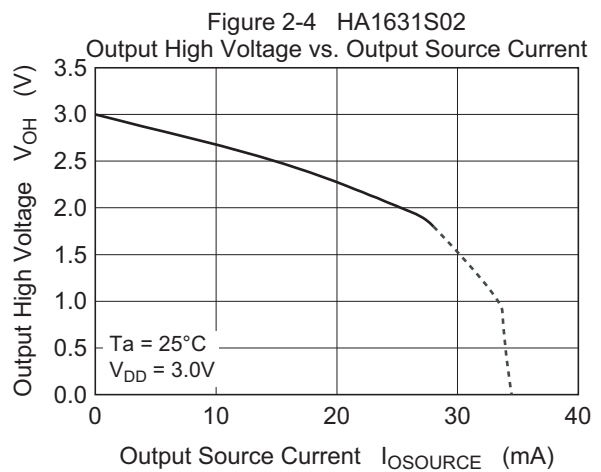
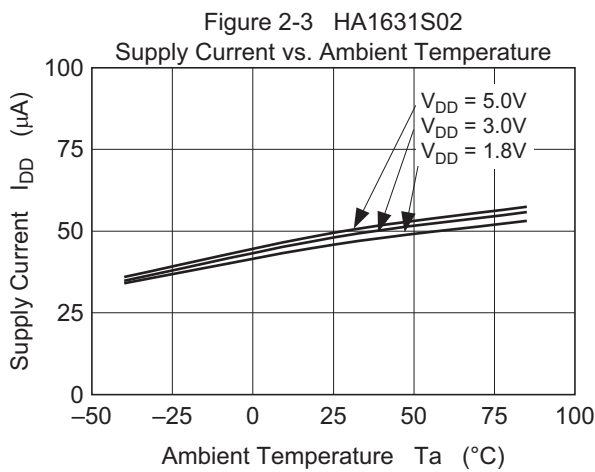
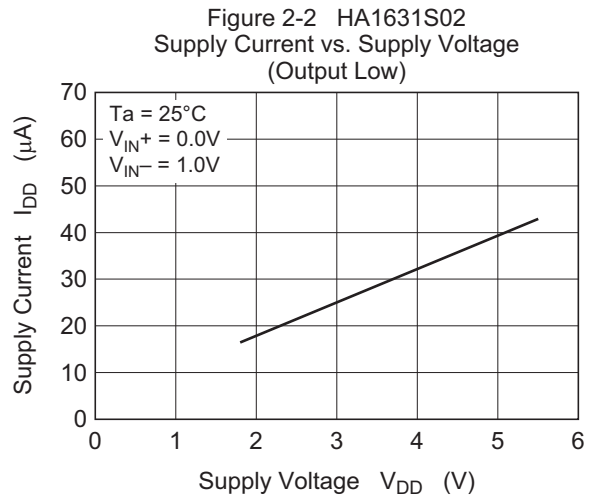
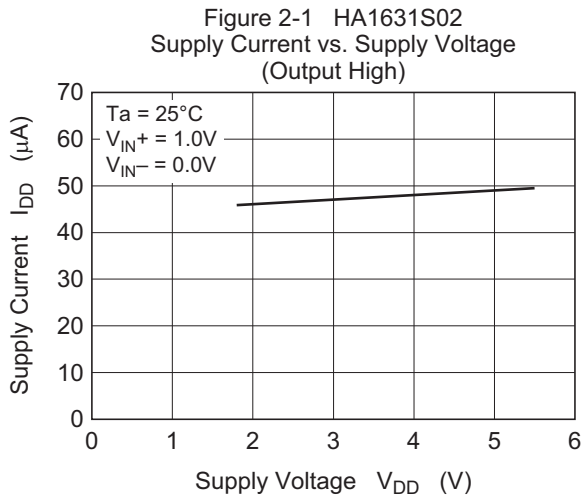
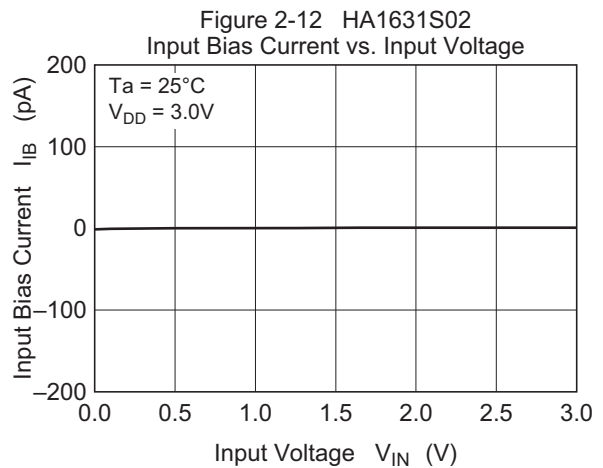
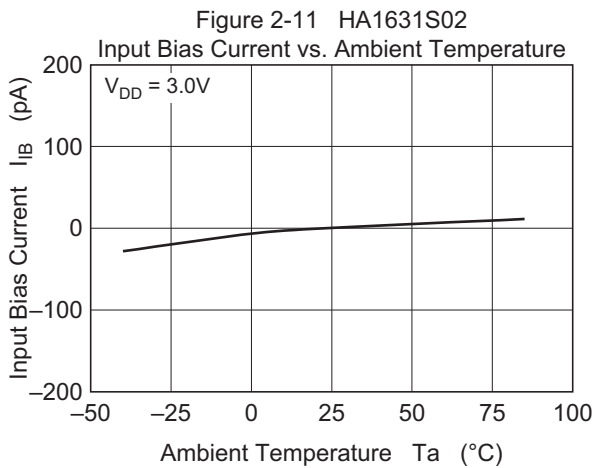
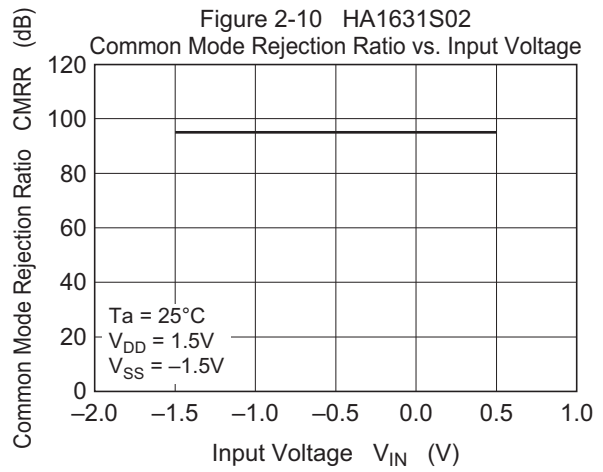
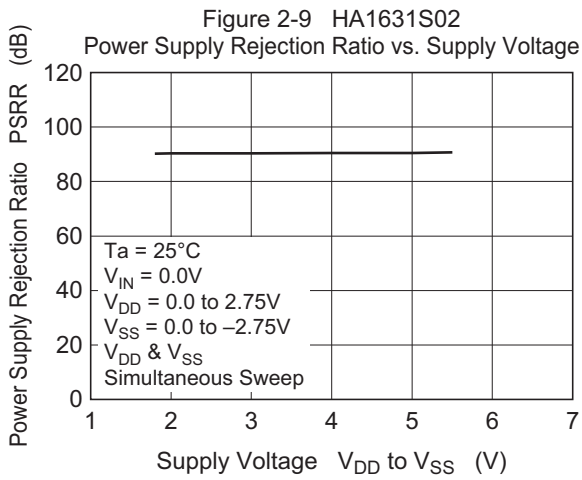
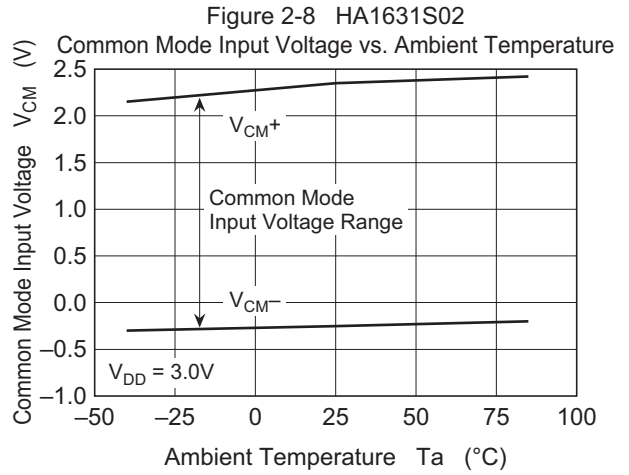
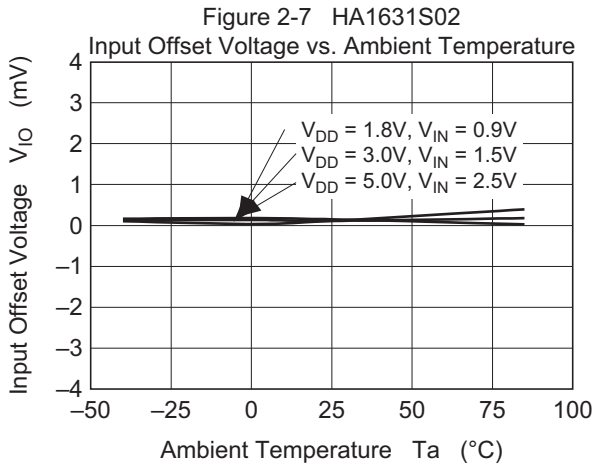


Figure 1-22 HA1631S01  
 $TP_{HL}$  Transient Response  
(Overdrive =  $\pm 0.1V_{p-p}$ )









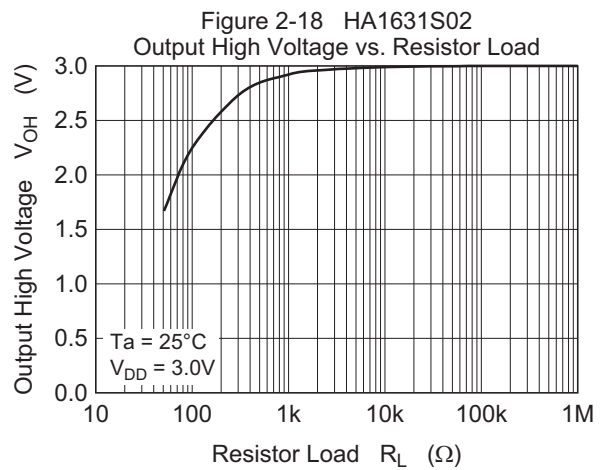
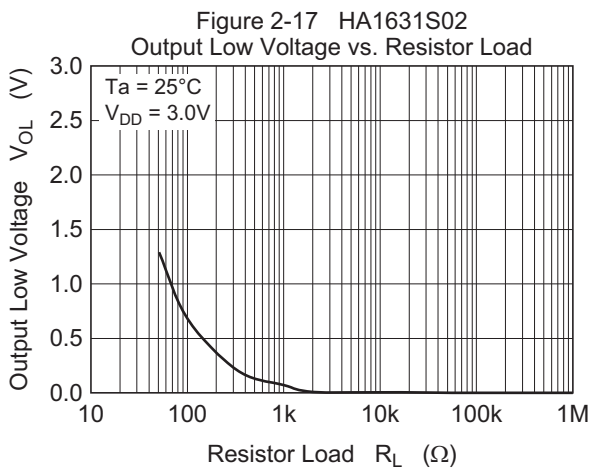
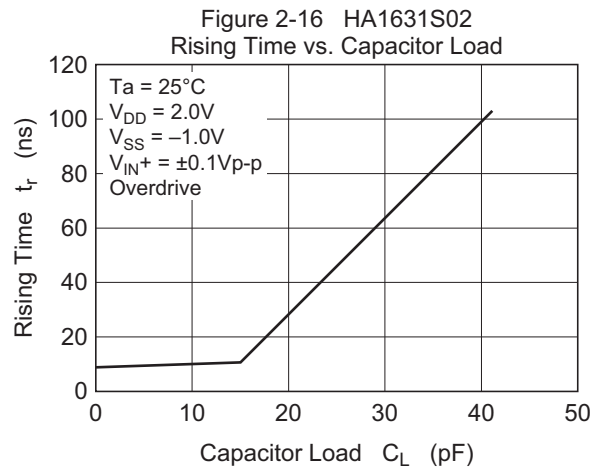
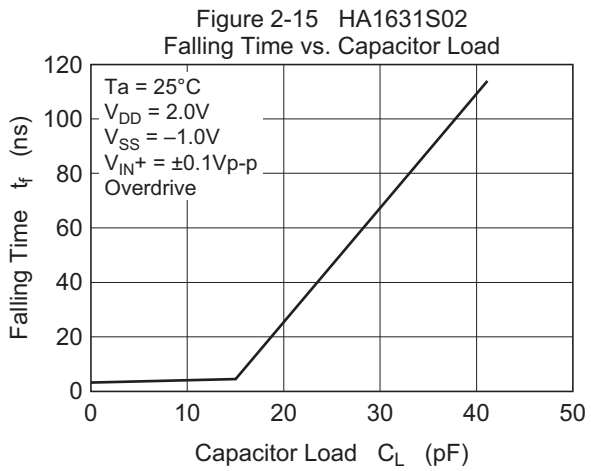
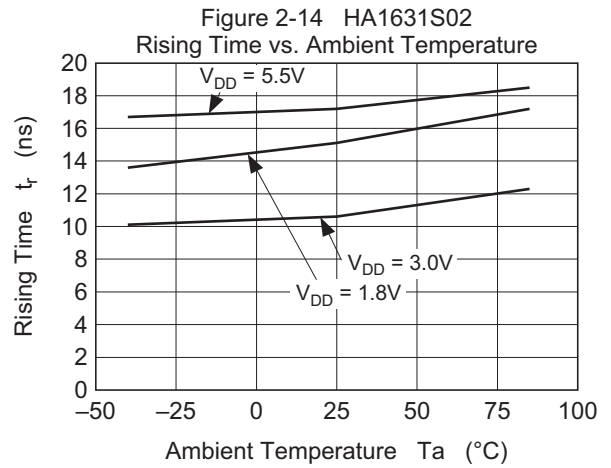
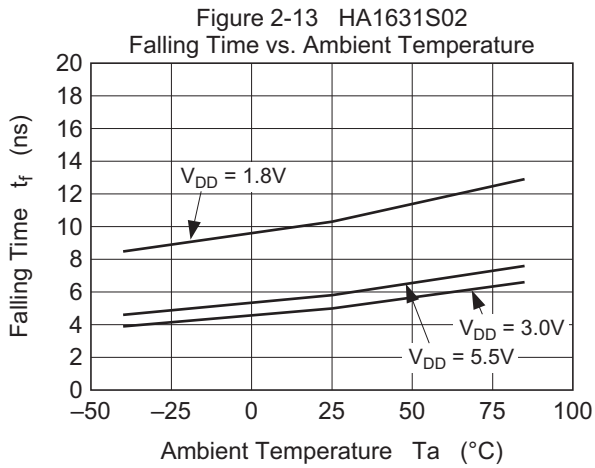


Figure 2-19 HA1631S02  
Rising Time,  $t_r$   
(Overdrive =  $\pm 0.1V_{p-p}$ )

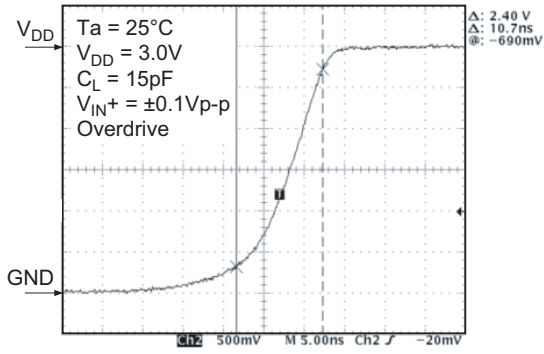


Figure 2-20 HA1631S02  
Falling Time,  $t_f$   
(Overdrive =  $\pm 0.1V_{p-p}$ )

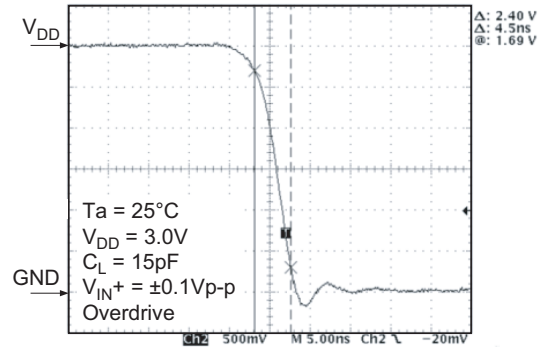


Figure 2-21 HA1631S02  
 $TP_{LH}$  Transient Response  
(Overdrive =  $\pm 0.1V_{p-p}$ )

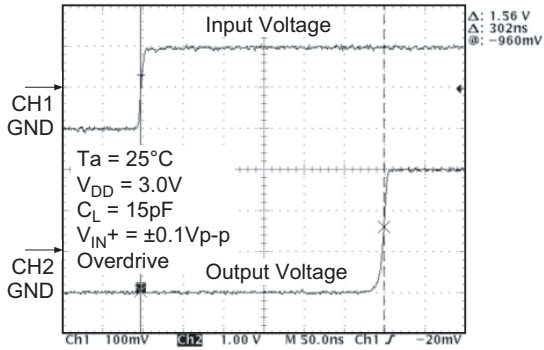


Figure 2-22 HA1631S02  
 $TP_{HL}$  Transient Response  
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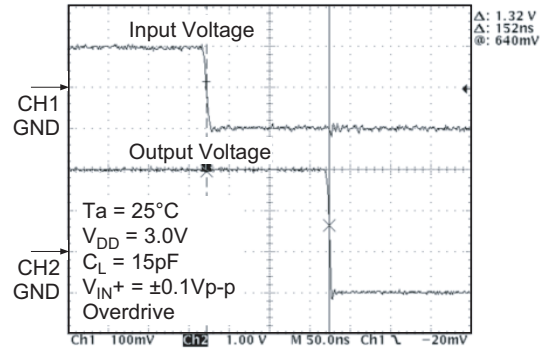


Figure 3-1 HA1631S03  
Supply Current vs. Supply Voltage  
(Output High)

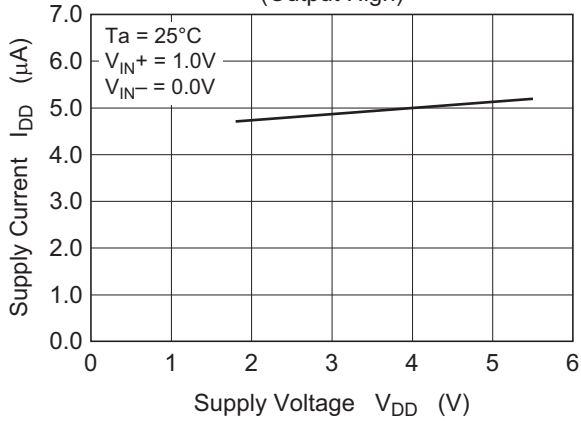


Figure 3-2 HA1631S03  
Supply Current vs. Supply Voltage  
(Output Low)

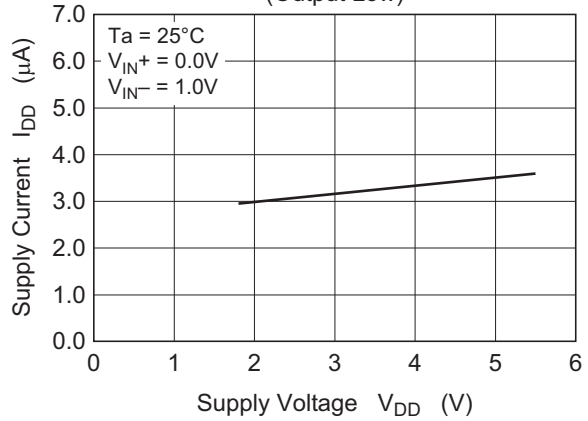


Figure 3-3 HA1631S03  
Supply Current vs. Ambient Temperature

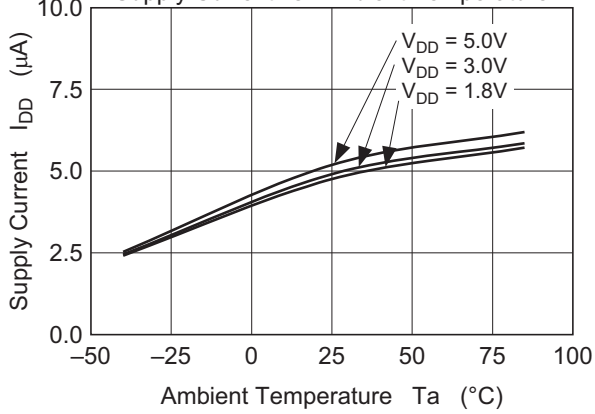


Figure 3-4 HA1631S03  
Output Low Voltage vs. Output Sink Current

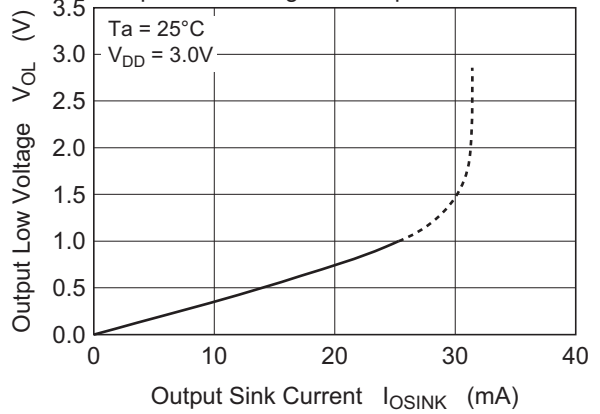


Figure 3-5 HA1631S03  
Input Offset Voltage vs. Supply Voltage

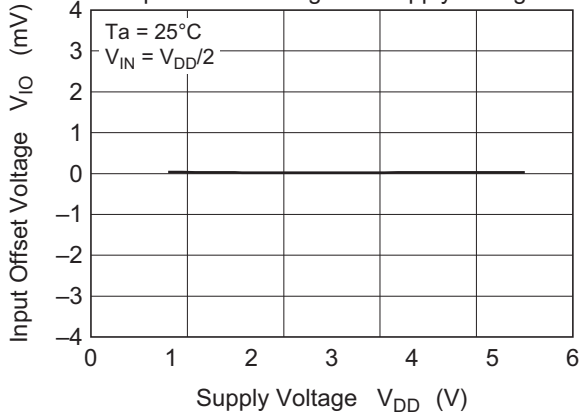
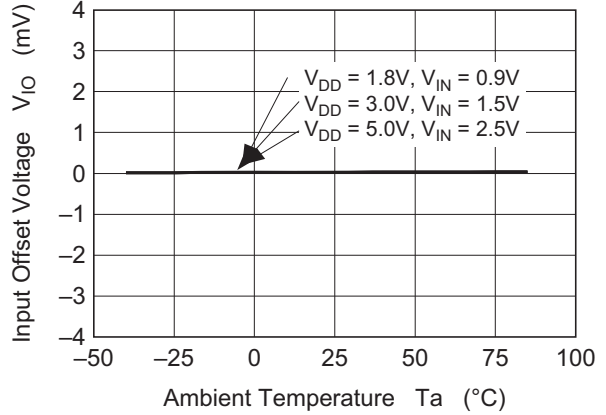
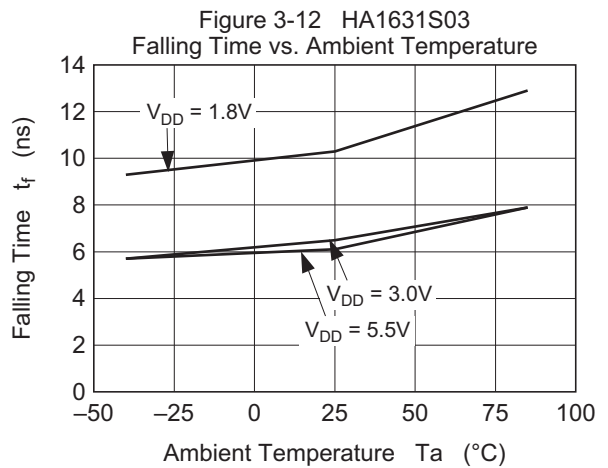
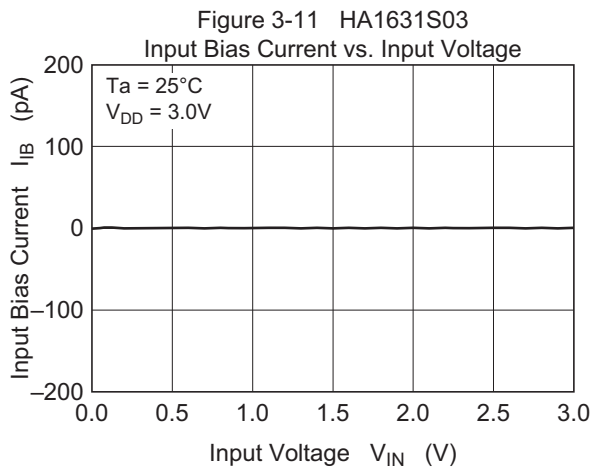
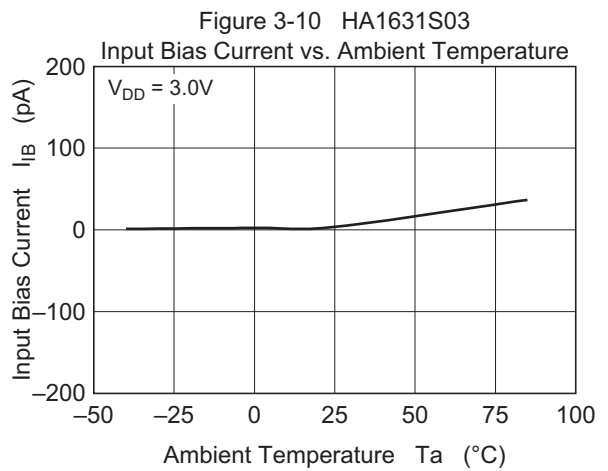
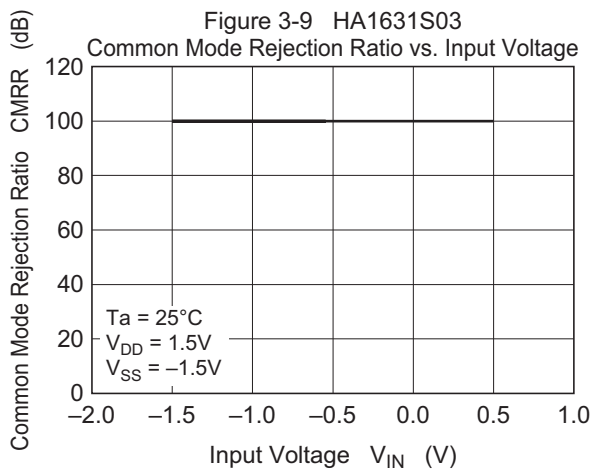
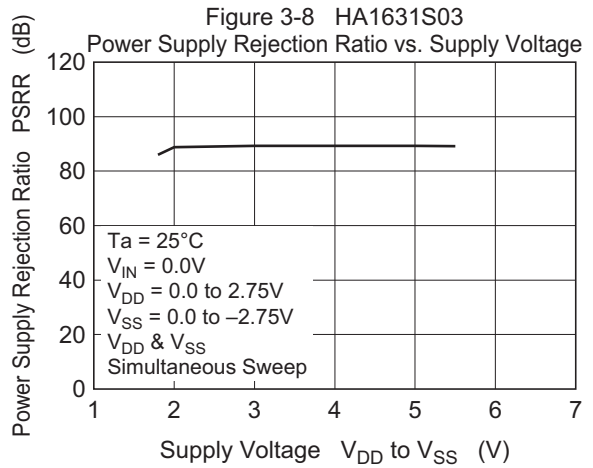
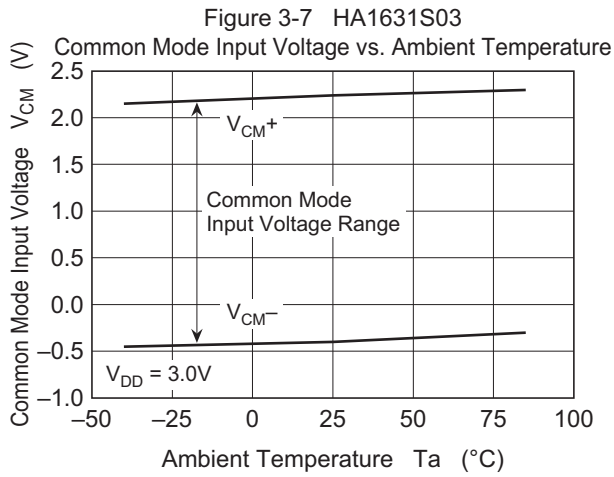


Figure 3-6 HA1631S03  
Input Offset Voltage vs. Ambient Temperature





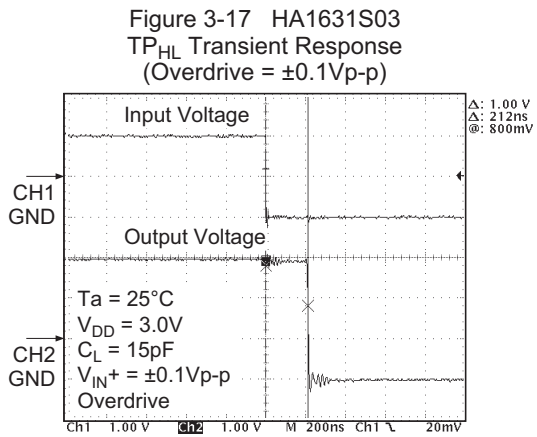
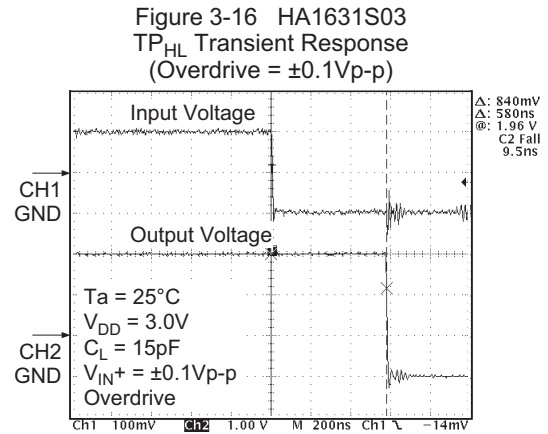
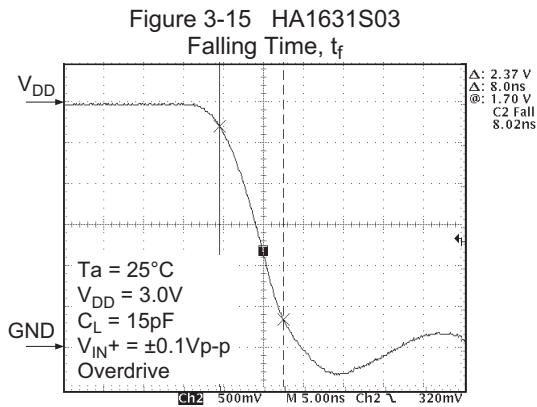
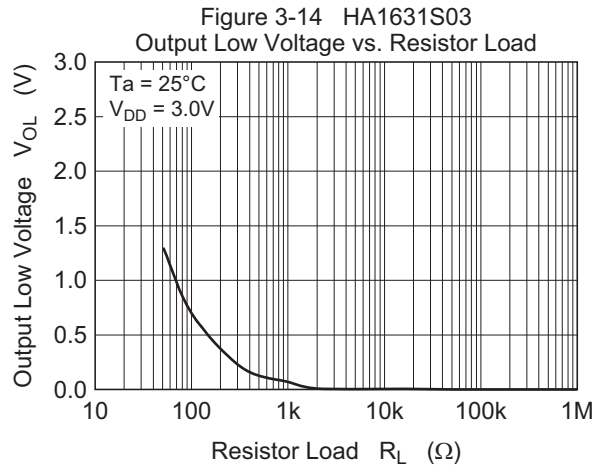
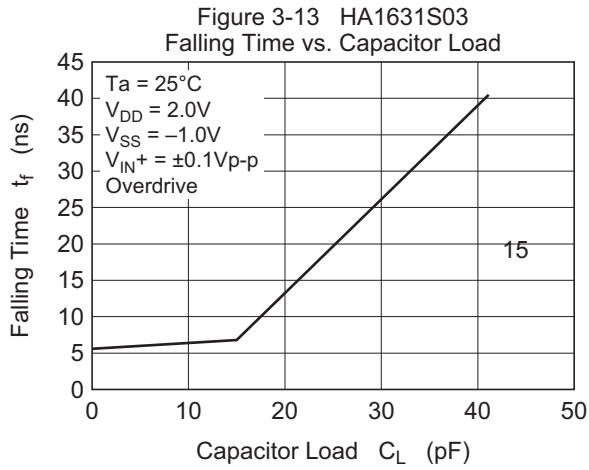


Figure 4-1 HA1631S04  
Supply Current vs. Supply Voltage  
(Output High)

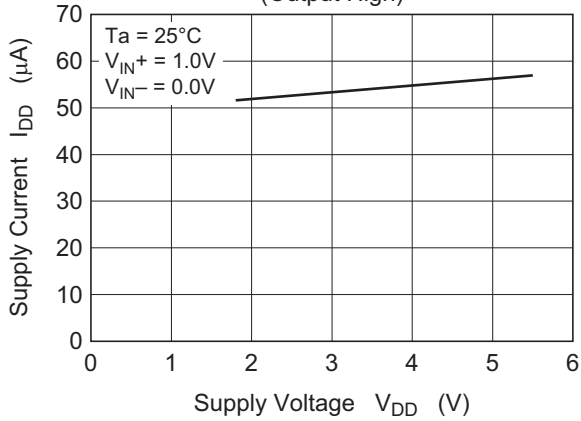


Figure 4-2 HA1631S04  
Supply Current vs. Supply Voltage  
(Output Low)

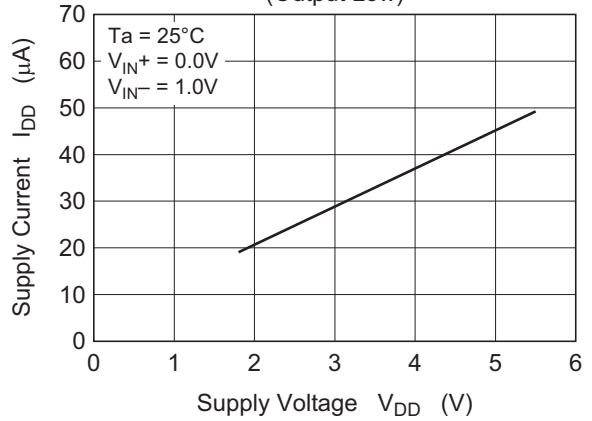


Figure 4-3 HA1631S04  
Supply Current vs. Ambient Temperature

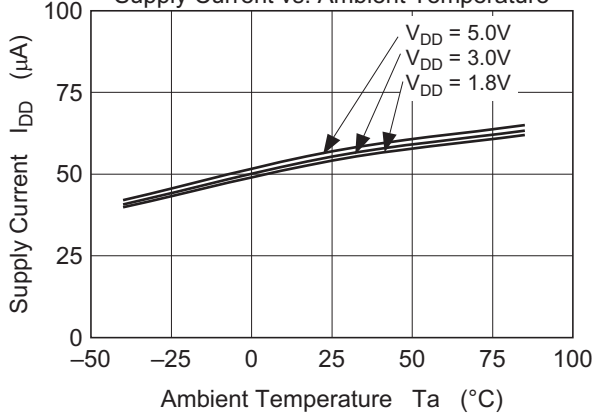


Figure 4-4 HA1631S04  
Output Low Voltage vs. Output Sink Current

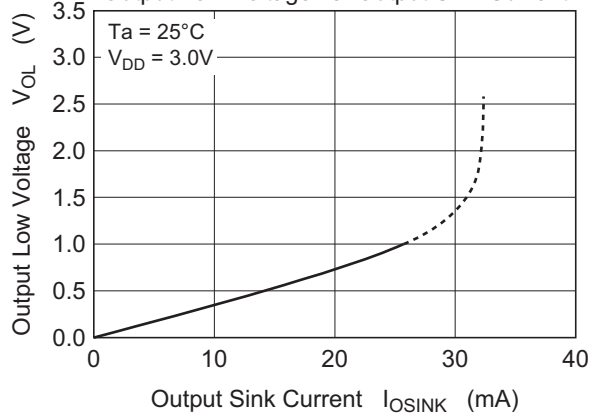


Figure 4-5 HA1631S04  
Input Offset Voltage vs. Supply Voltage

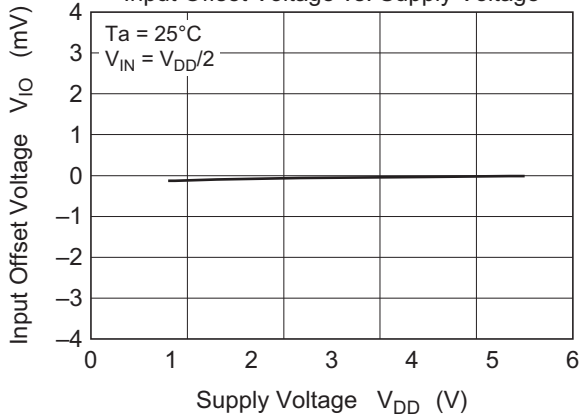
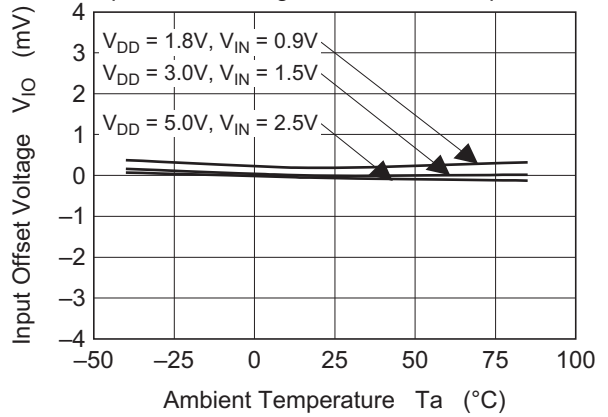
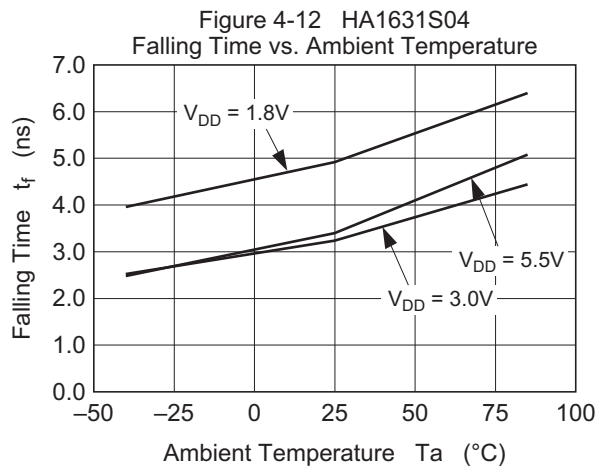
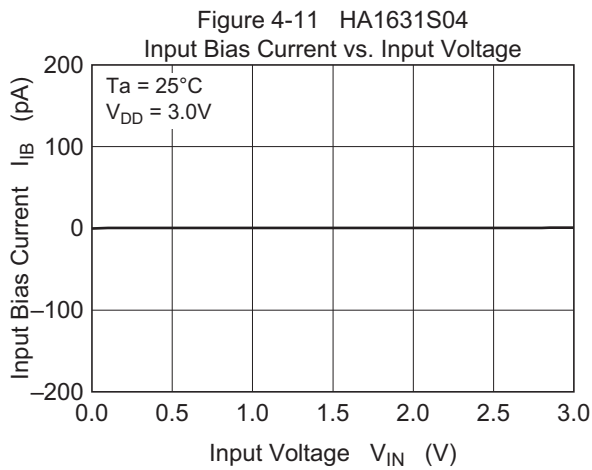
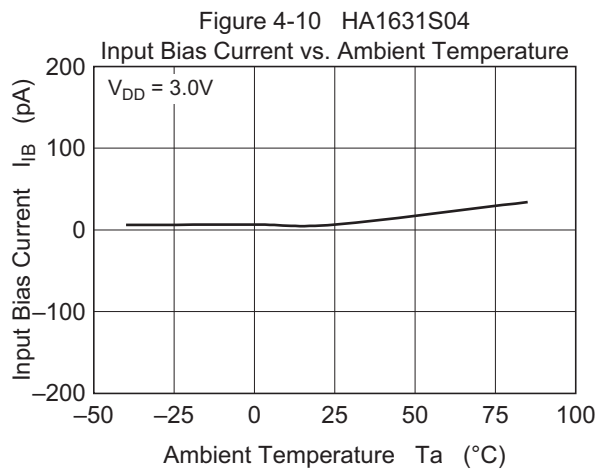
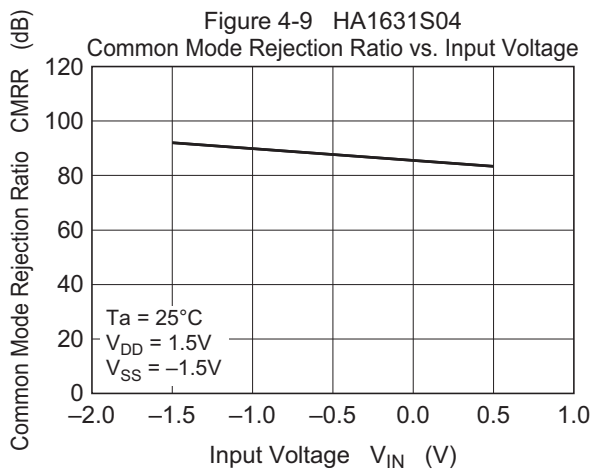
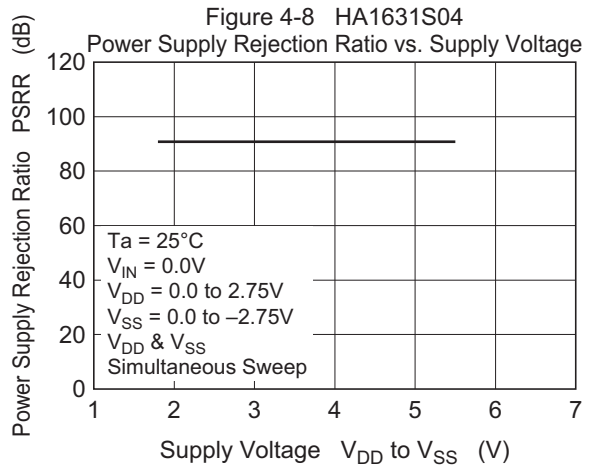
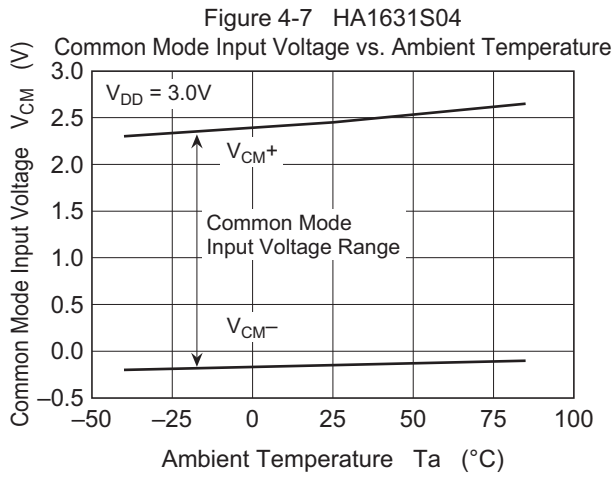
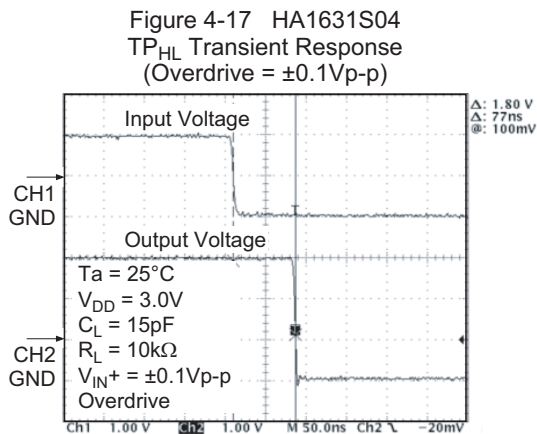
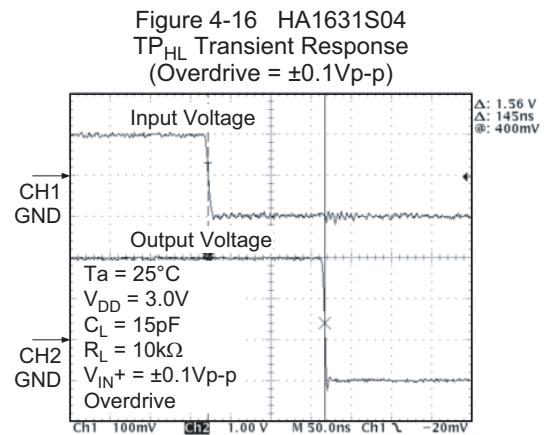
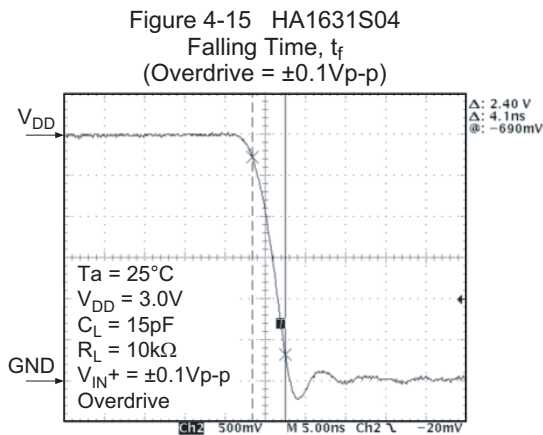
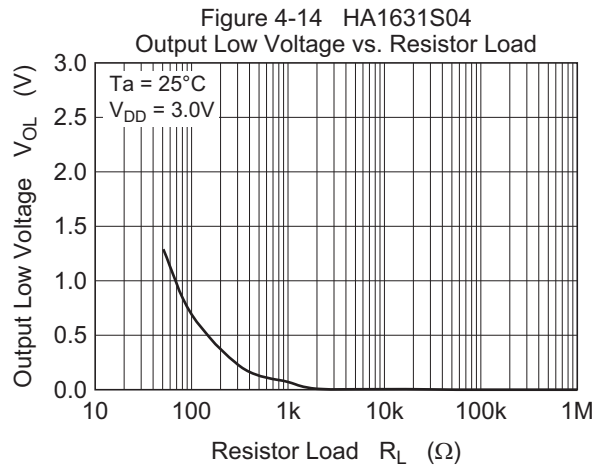
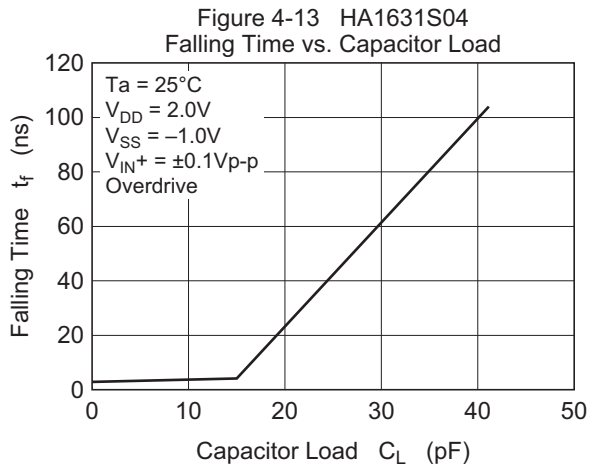


Figure 4-6 HA1631S04  
Input Offset Voltage vs. Ambient Temperature



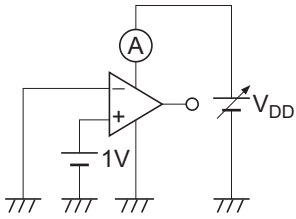




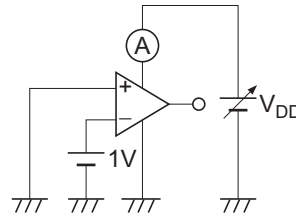


**Test Circuits**

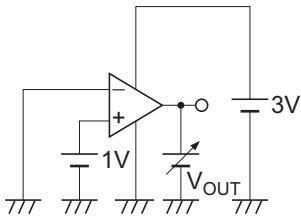
1. Supply Current,  $I_{DD}$  (Output High)



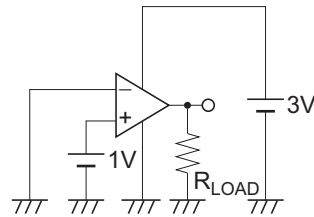
2. Supply Current,  $I_{DD}$  (Output Low)



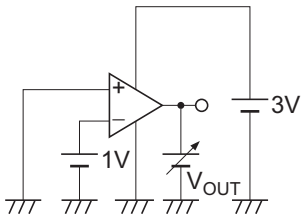
3. Output Source Current,  $I_{OSOURCE}$



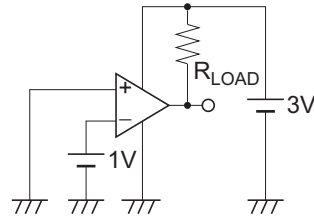
4. Output Voltage High,  $V_{OH}$



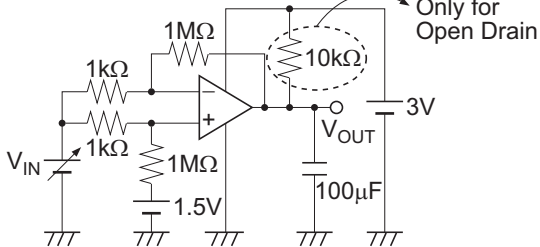
5. Output Sink Current,  $I_{OSINK}$



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

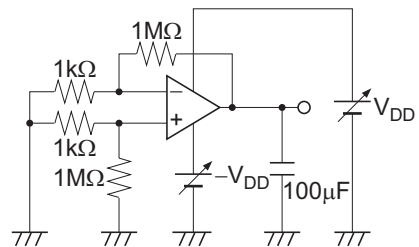


7. Input Offset Voltage,  $V_{IO}$

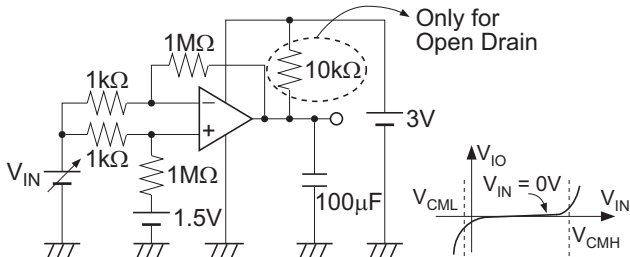


Note:  $V_{IO} = V_{OUT} - 1.5V$

8. Input Offset Voltage vs.  $V_{DD}$

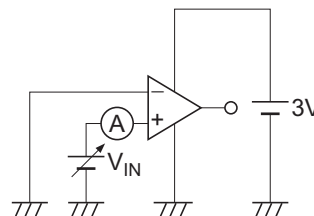


9. Common Mode Input Voltage Range,  $V_{CM}$

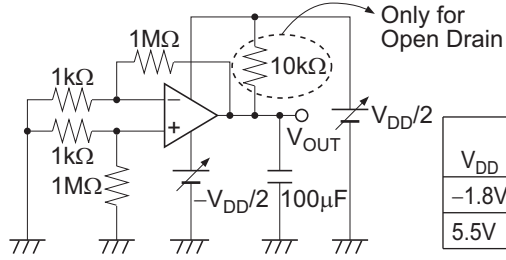


Note:  $V_{CML}$  and  $V_{CMH}$  are values of  $V_{IN}$  when  $V_{IO}$  changes more than 50dB taking  $V_{IN} = 0V$  as reference.

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

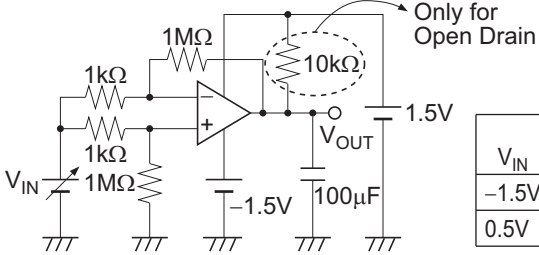


11. Power Supply Rejection Ratio, PSRR



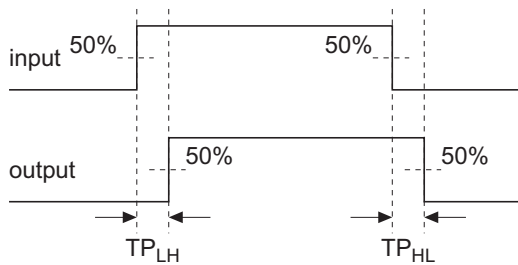
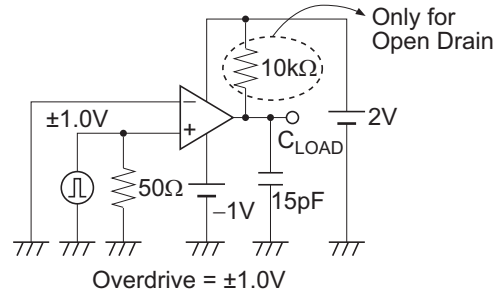
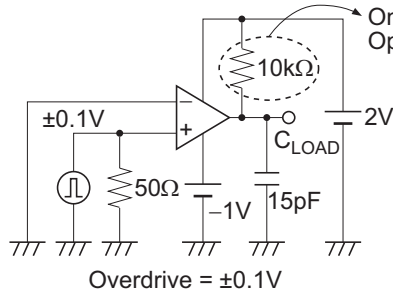
$V_{DD}$	Measure Point	Calculate $V_{IO}$	PSRR Calculation
-1.8V	$V_{OUT1}$	$V_{IO1} = V_{OUT1}/1000$	$PSRR = \left  20 \log_{10} \frac{ (V_{IO2} - V_{IO1}) }{5.5V - 1.8V} \right $
5.5V	$V_{OUT2}$	$V_{IO2} = V_{OUT2}/1000$	

12. Common Mode Rejection Ratio, CMRR

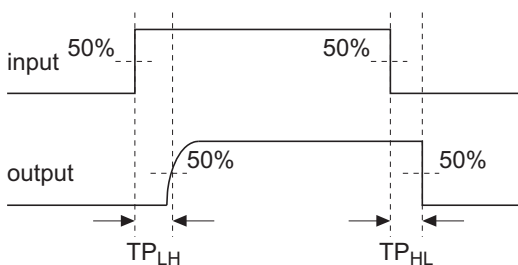
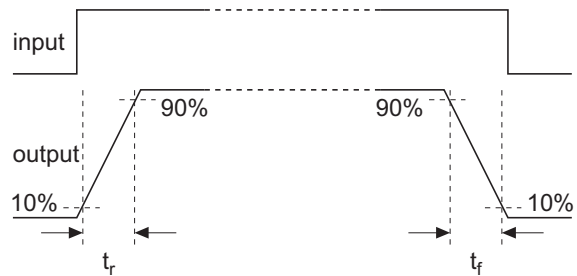


$V_{IN}$	Measure Point	Calculate $V_{IO}$	CMRR Calculation
-1.5V	$V_{OUT1}$	$V_{IO1} = V_{OUT1}/1000$	$CMRR = \left  20 \log_{10} \frac{ (V_{IO2} - V_{IO1}) }{0.5V - (-1.5V)} \right $
0.5V	$V_{OUT2}$	$V_{IO2} = V_{OUT2}/1000$	

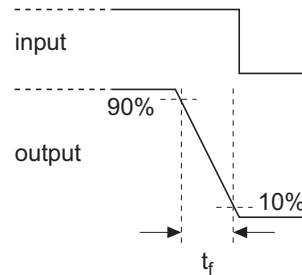
13. Falling Time, Rising Time, Propagation Delay Time  $TP_{LH}$ ,  $TP_{HL}$



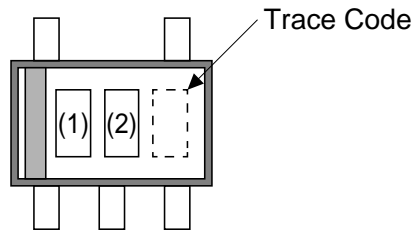
Only for Push Pull HA1631S01/02



Only for Open Drain HA1631S03/04



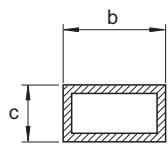
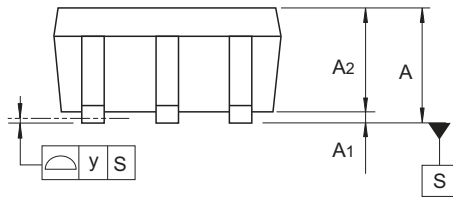
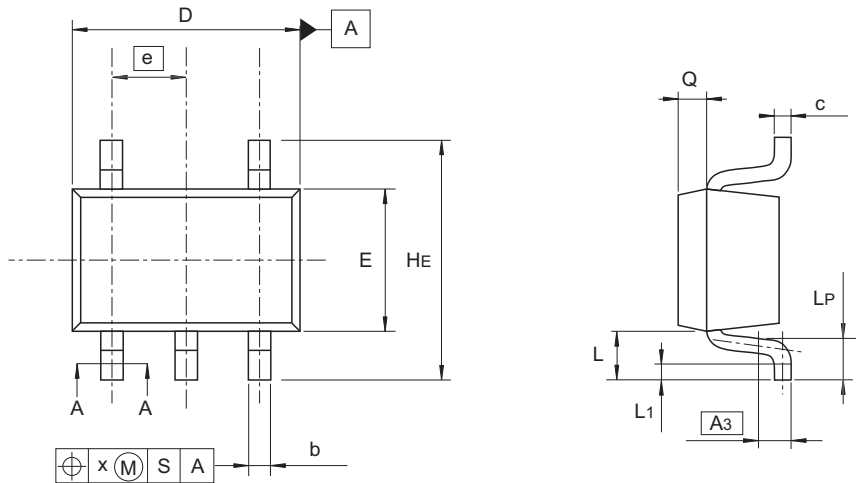
**Mark Indication**



		(1)	(2)
HA1631S01CM	HA1631S01LP	0	A
HA1631S02CM	HA1631S02LP	0	B
HA1631S03CM	HA1631S03LP	0	C
HA1631S04CM	HA1631S04LP	0	D

### Package Dimensions

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

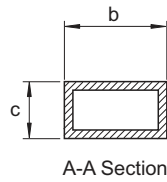
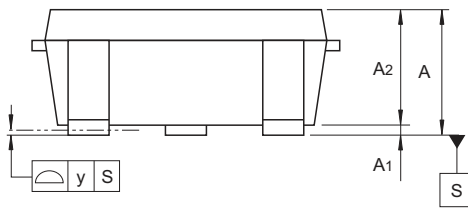
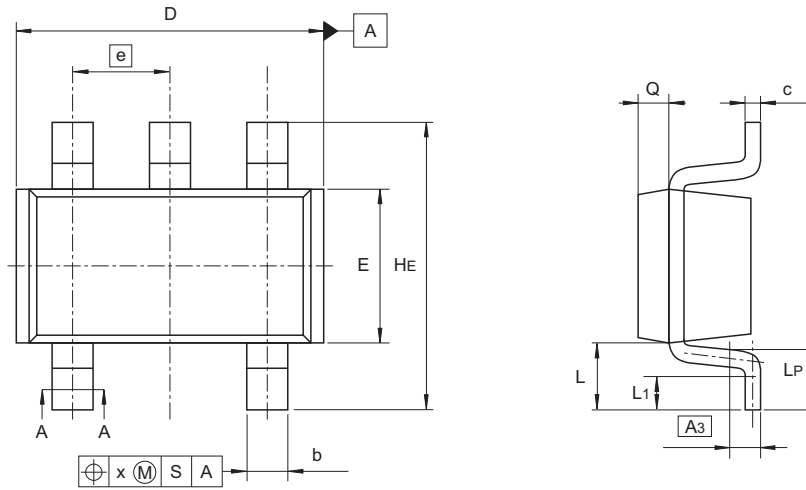


A-A Section

Reference Symbol	Dimensions in millimeters		
	Min	Nom	Max
A	0.8	—	1.1
A <sub>1</sub>	0	—	0.1
A <sub>2</sub>	0.8	0.9	1.0
A <sub>3</sub>	—	0.25	—
b	0.15	0.22	0.3
c	0.1	0.13	0.15
D	1.8	2.0	2.2
E	1.15	1.25	1.35
e	—	0.65	—
H <sub>E</sub>	1.8	2.1	2.4
L	0.3	—	0.7
L <sub>1</sub>	0.1	—	0.5
L <sub>P</sub>	0.2	—	0.6
x	—	—	0.05
y	—	—	0.05
Q	—	0.25	—

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



Reference Symbol	Dimensions in millimeters		
	Min	Nom	Max
A	1.0	—	1.4
A <sub>1</sub>	0	—	0.1
A <sub>2</sub>	1.0	1.1	1.3
A <sub>3</sub>	—	0.25	—
b	0.35	0.4	0.5
c	0.11	0.16	0.26
D	2.8	2.95	3.1
E	1.5	1.6	1.8
e	—	0.95	—
HE	2.5	2.8	3.0
L	0.3	—	0.7
L <sub>1</sub>	0.1	—	0.5
LP	0.2	—	0.6
x	—	—	0.05
y	—	—	0.05
Q	—	0.3	—

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