

# HA1631S01/02/03/04 Series

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

REJ03D0056-0100Z

Rev.1.00

2003.08.08

### 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

### Outline



CMPAK-5V

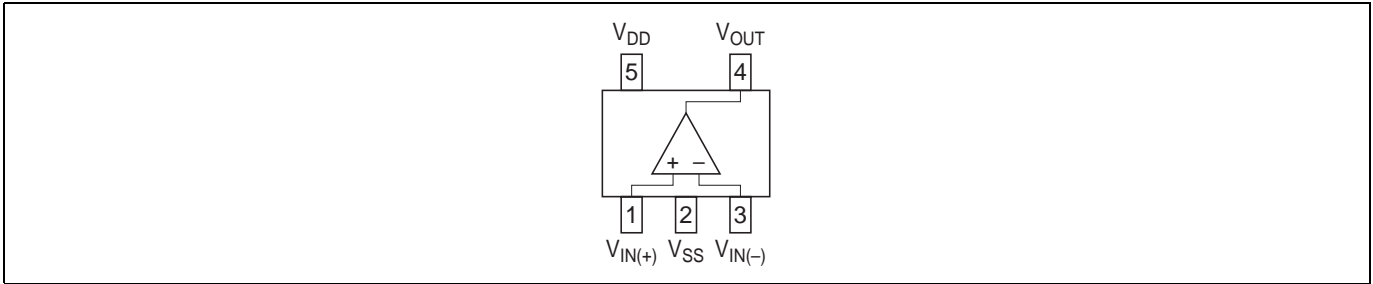
HA1631S01CM  
HA1631S02CM  
HA1631S03CM  
HA1631S04CM



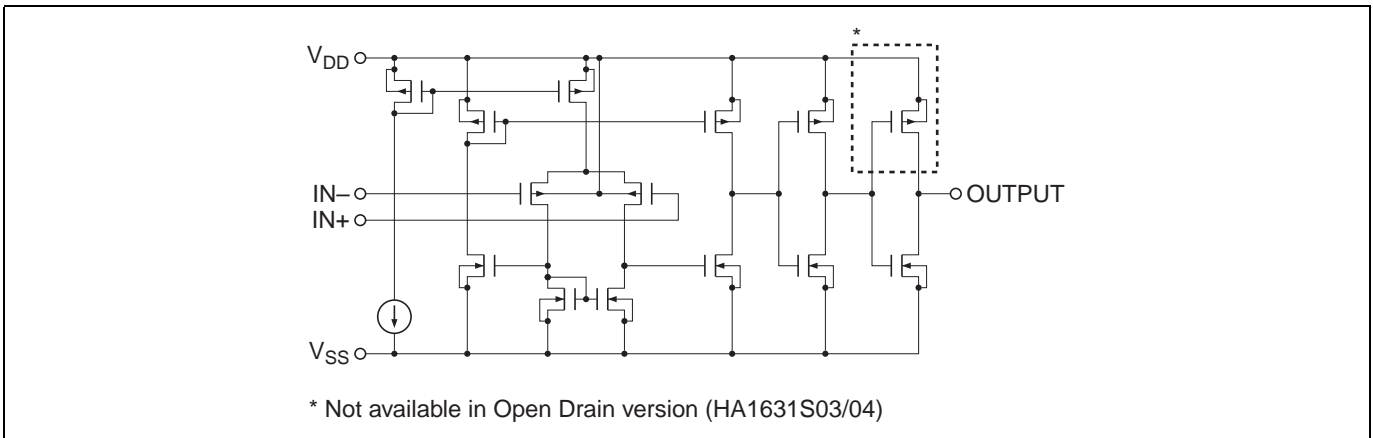
MPAK-5V

HA1631S01LP  
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/MPAK
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
		I <sub>OSINK</sub>	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		

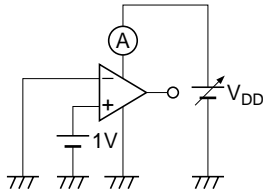
Note: ( ): Design specification

Table of Graphs

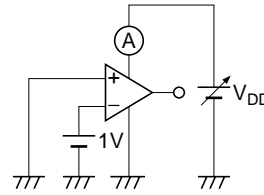
Electrical Characteristics			HA1631S01 Figure	HA1631S02 Figure	HA1631S03 Figure	HA1631S04 Figure	Test Circuit No.
Supply current	$I_{DD}$	vs. Supply voltage(Out H)	1-1	2-1	3-1	4-1	1
		vs. Supply voltage(Out L)	1-2	2-2	3-2	4-2	2
		vs. Temperature(Out H)	1-3	2-3	3-3	4-3	1
Output high voltage	$V_{OH}$	vs. 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

Test Circuits

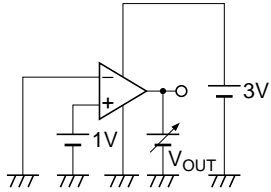
1. Supply Current,  $I_{DD}$  (Output High)



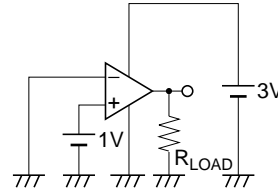
2. Supply Current,  $I_{DD}$  (Output Low)



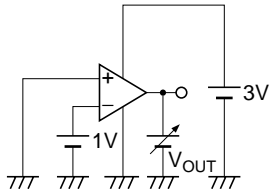
3. Output Source Current,  $I_{OSOURCE}$



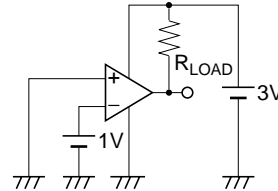
4. Output High Voltage,  $V_{OH}$  (Output High)



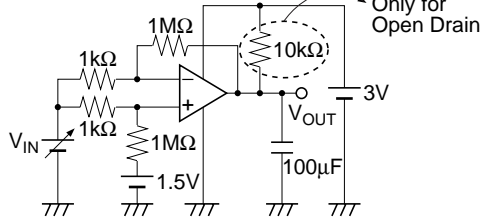
5. Output Sink Current,  $I_{OSINK}$



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

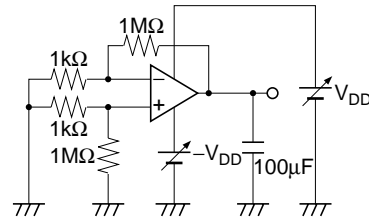


7. Input Offset Voltage,  $V_{IO}$

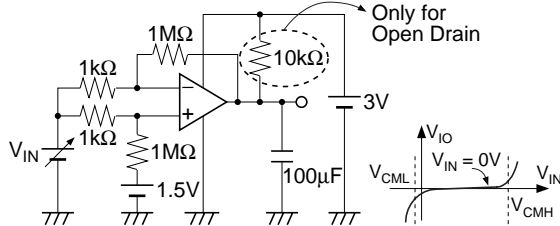


Note:  $V_{IO} = V_{OUT} - 1.5V$

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

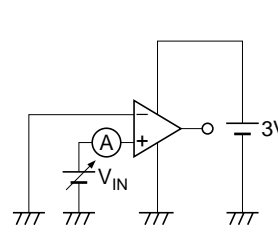


9. Common Mode Input Voltage Range,  $V_{CM}$

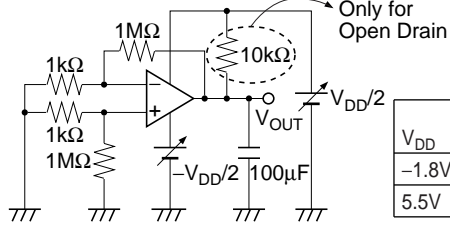


Note:  $V_{CML}$  and  $V_{CMH}$  are values of  $V_{IN}$  when  $V_{IO}$  changes more than 50dB taking  $V_{IN} = 0V$  as reference.

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

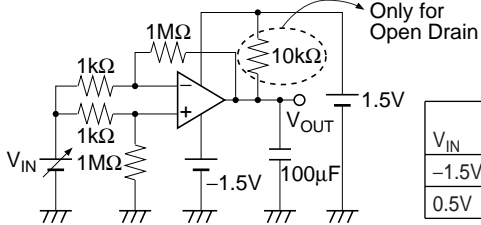


11. Power Supply Rejection Ratio, PSRR



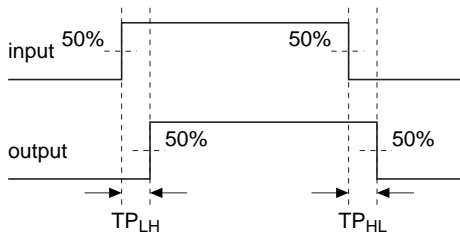
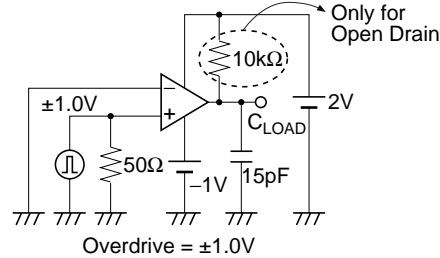
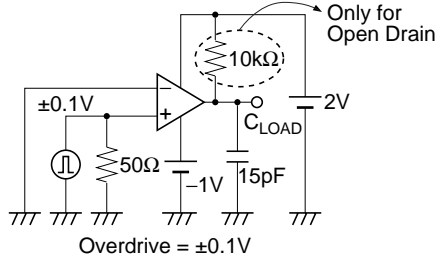
$V_{DD}$	Measure Point	Calculate $V_{IO}$	PSRR Calculation
-1.8V	$V_{OUT1}$	$V_{IO1} = V_{OUT1}/1000$	$PSRR = \left  20 \log_{10} \frac{ (V_{IO2} - V_{IO1}) }{5.5V - 1.8V} \right $
5.5V	$V_{OUT2}$	$V_{IO2} = V_{OUT2}/1000$	

12. Common Mode Rejection Ratio, CMRR

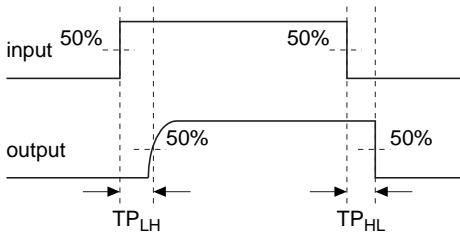
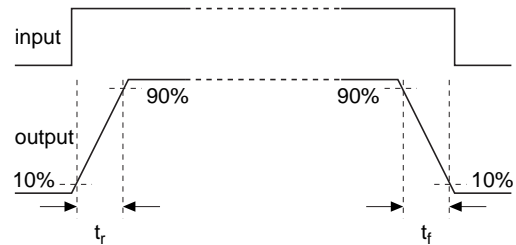


$V_{IN}$	Measure Point	Calculate $V_{IO}$	CMRR Calculation
-1.5V	$V_{OUT1}$	$V_{IO1} = V_{OUT1}/1000$	$CMRR = \left  20 \log_{10} \frac{ (V_{IO2} - V_{IO1}) }{0.5V - (-1.5V)} \right $
0.5V	$V_{OUT2}$	$V_{IO2} = V_{OUT2}/1000$	

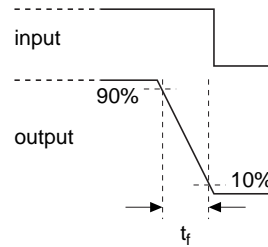
13. Falling Time, Rising Time, Propagation Delay Time  $TP_{LH}$ ,  $TP_{HL}$



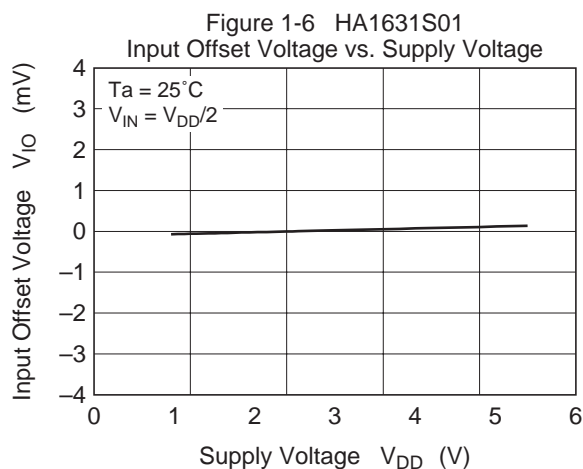
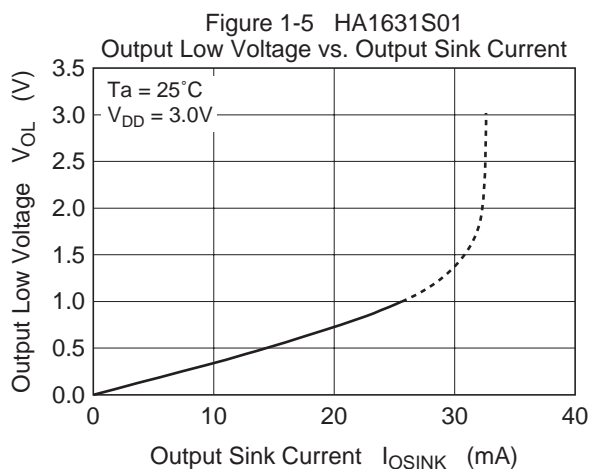
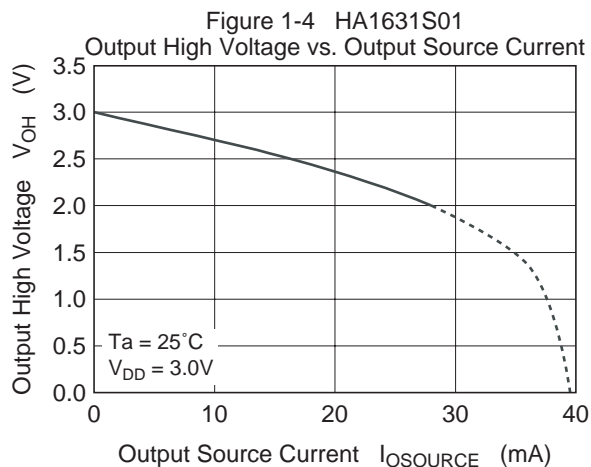
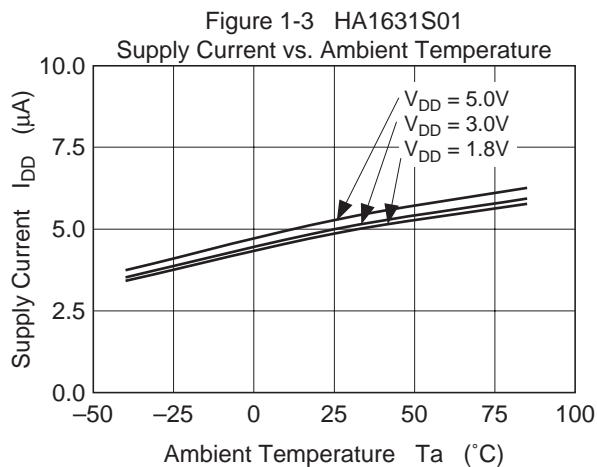
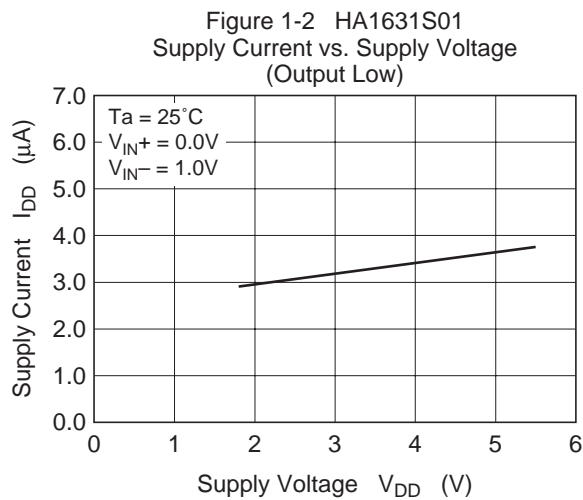
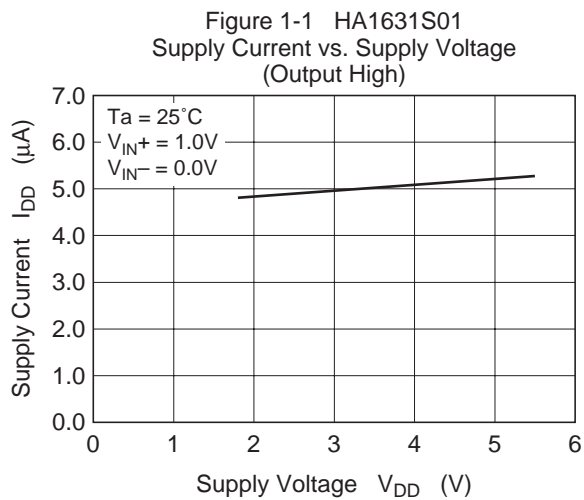
Only for Push Pull HA1631S01/02

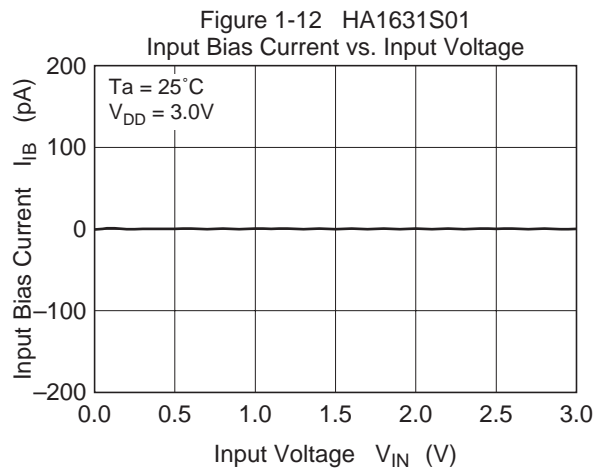
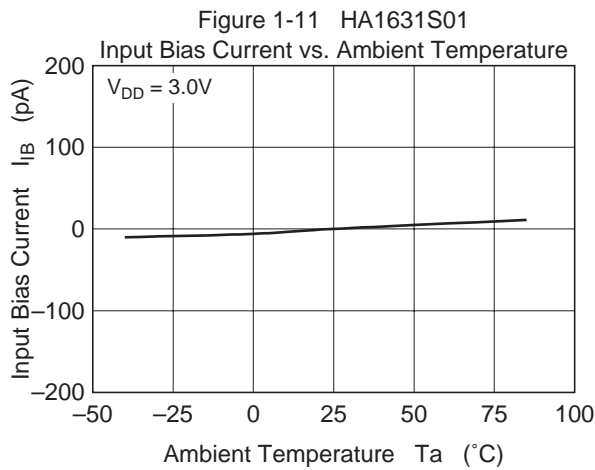
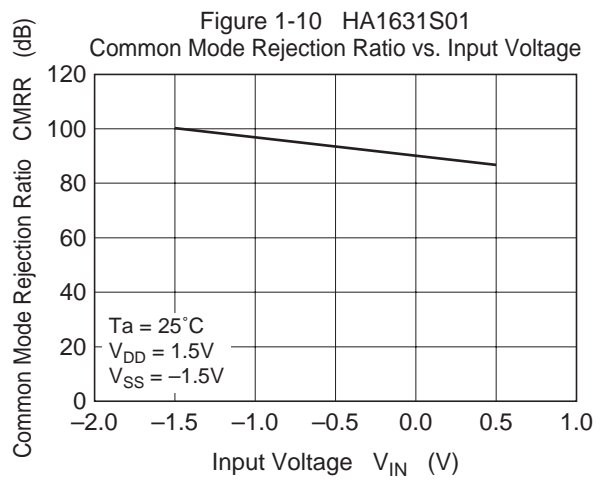
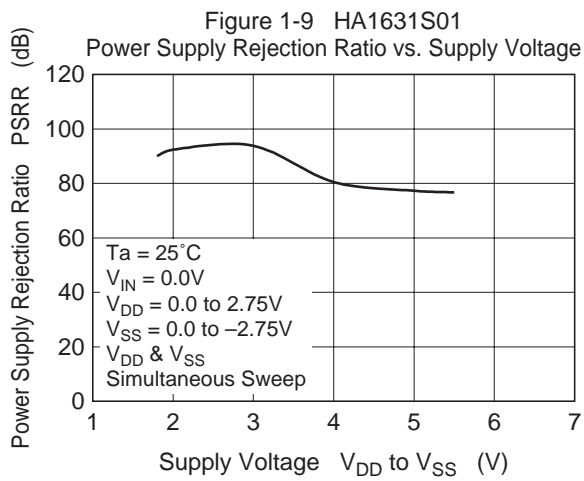
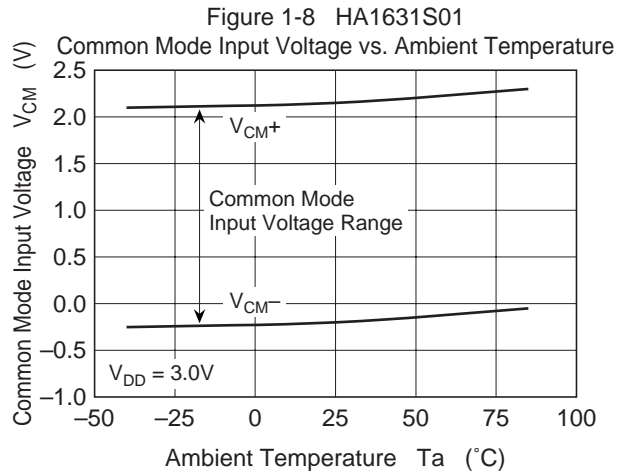
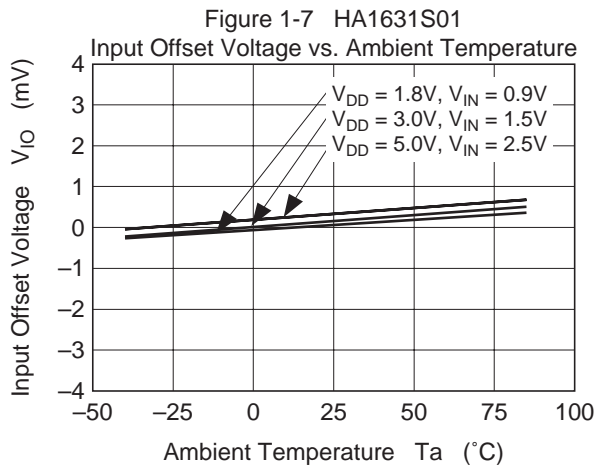


Only for Open Drain HA1631S03/04



Main Characteristics







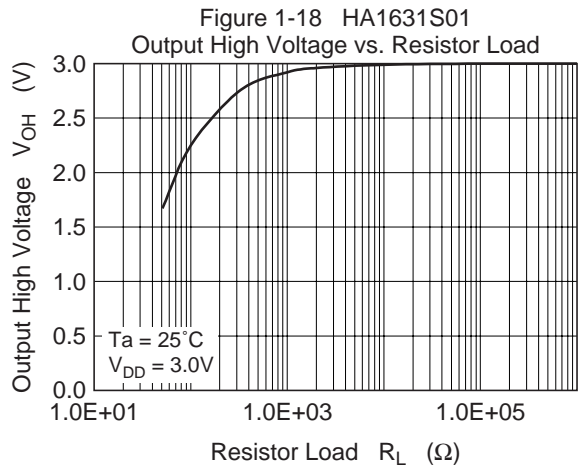
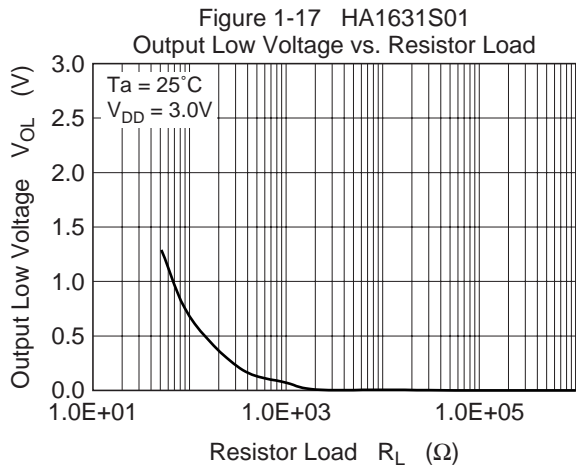
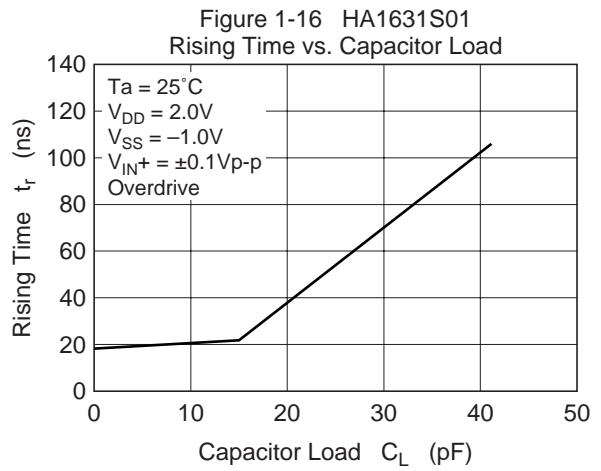
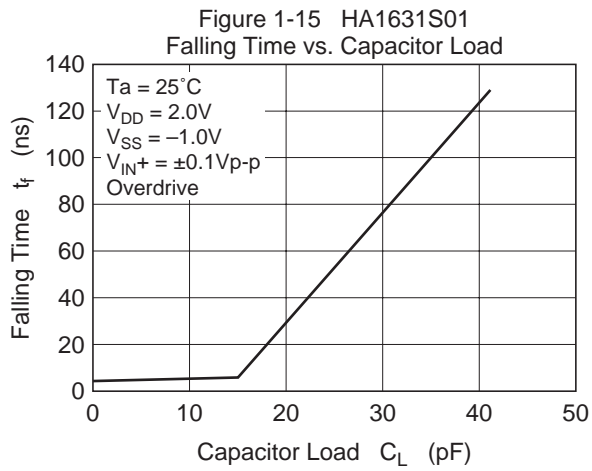
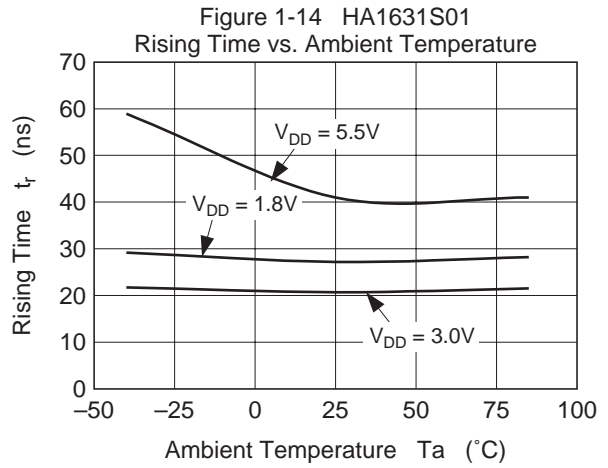
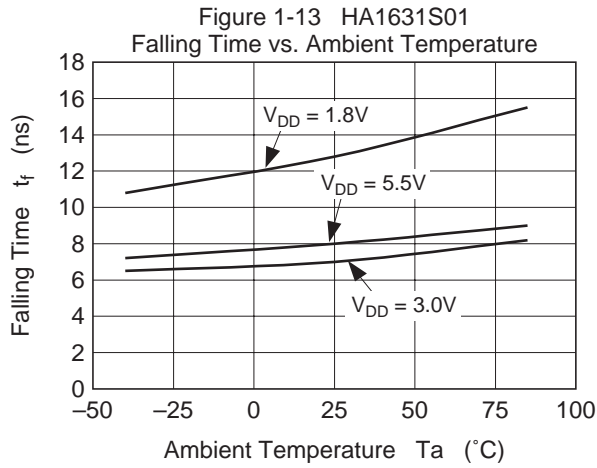


Figure 1-19 HA1631S01  
Rising Time,  $t_r$   
(Overdrive =  $\pm 0.1V_{p-p}$ )

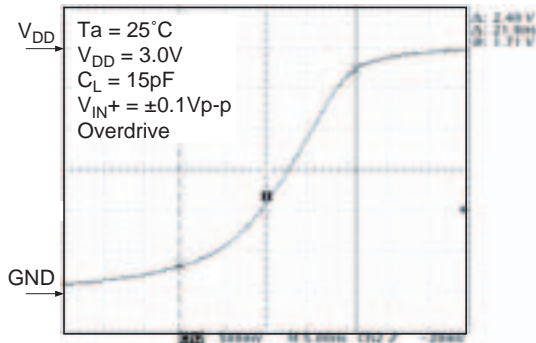


Figure 1-20 HA1631S01  
Falling Time,  $t_f$   
(Overdrive =  $\pm 0.1V_{p-p}$ )

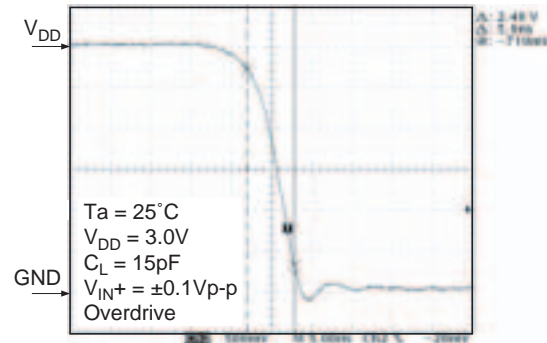


Figure 1-21 HA1631S01  
 $TP_{LH}$  Transient Response  
(Overdrive =  $\pm 0.1V_{p-p}$ )

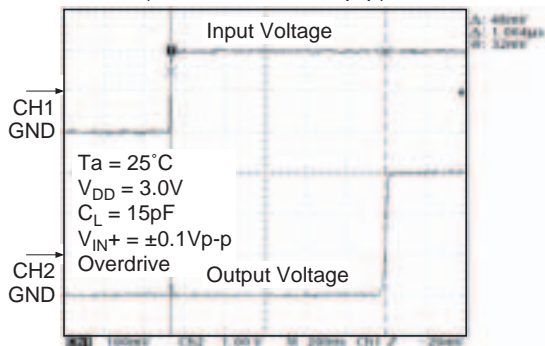


Figure 1-22 HA1631S01  
 $TP_{HL}$  Transient Response  
(Overdrive =  $\pm 0.1V_{p-p}$ )

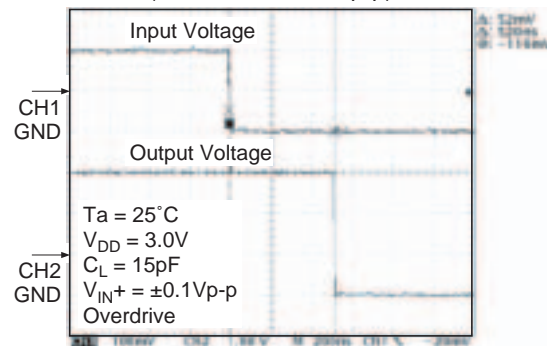


Figure 2-1 HA1631S02  
Supply Current vs. Supply Voltage  
(Output High)

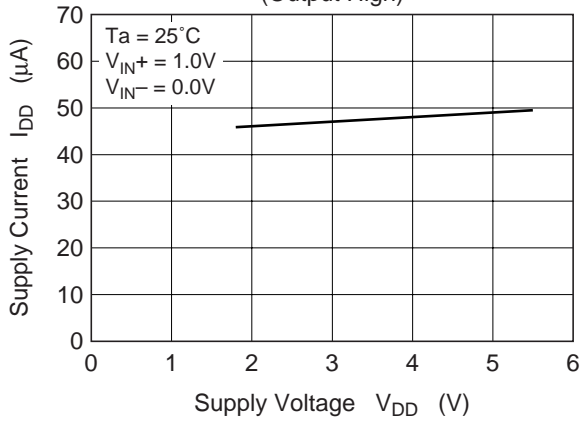


Figure 2-2 HA1631S02  
Supply Current vs. Supply Voltage  
(Output Low)

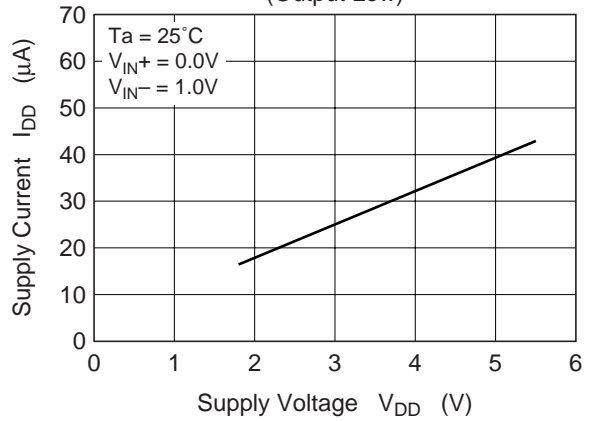


Figure 2-3 HA1631S02  
Supply Current vs. Ambient Temperature

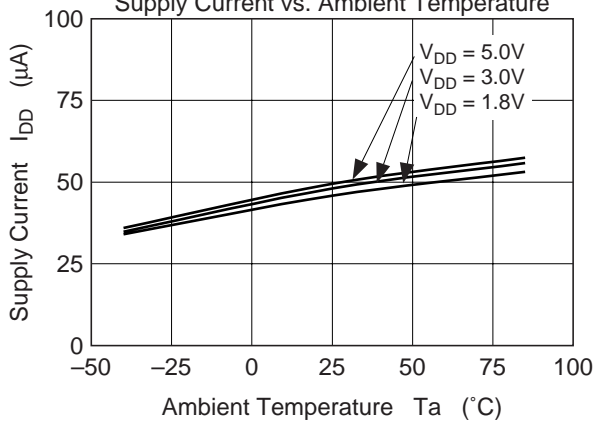


Figure 2-4 HA1631S02  
Output High Voltage vs. Output Source Current

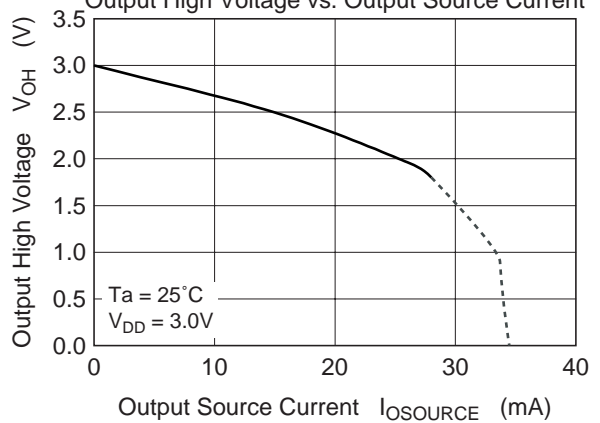


Figure 2-5 HA1631S02  
Output Low Voltage vs. Output Sink Current

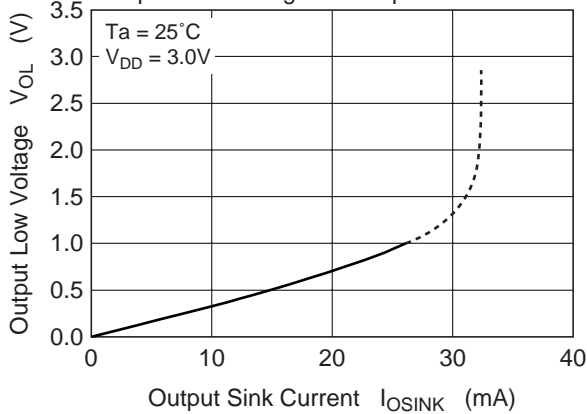
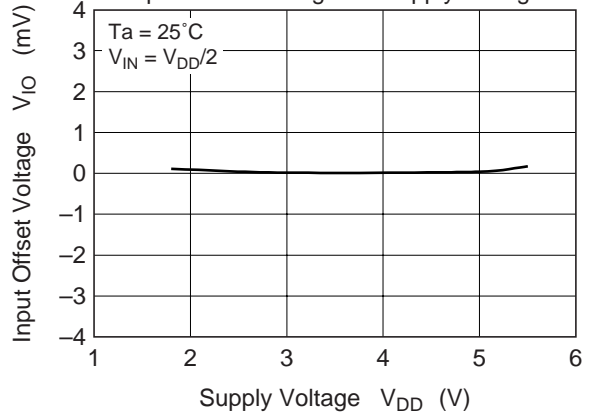
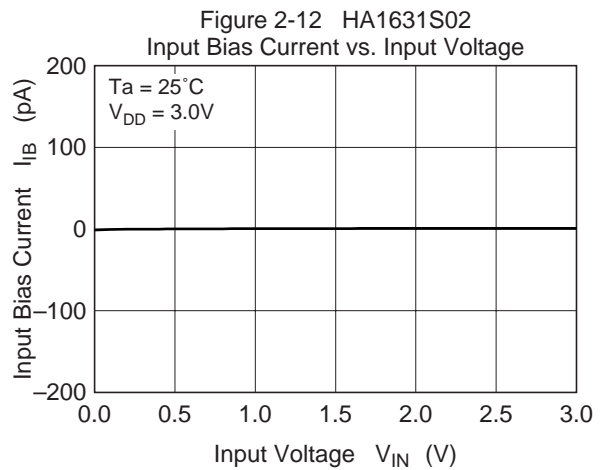
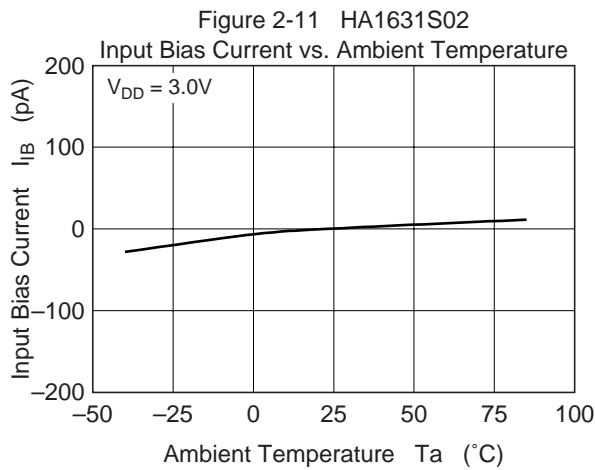
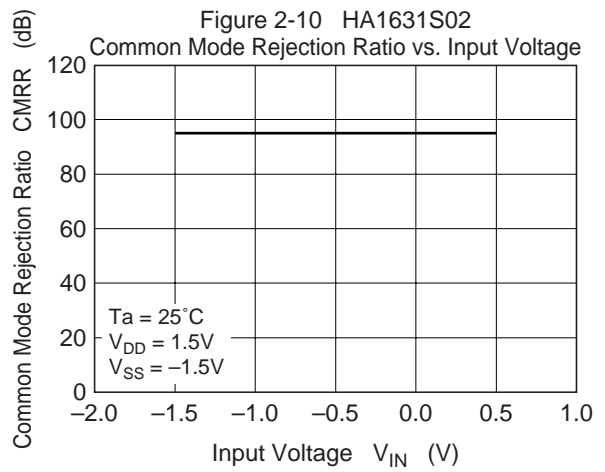
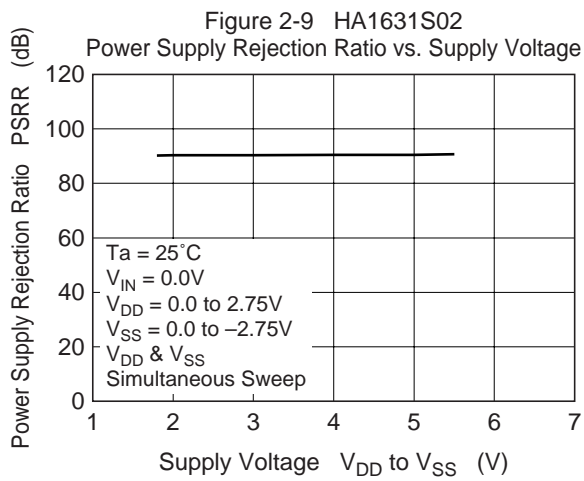
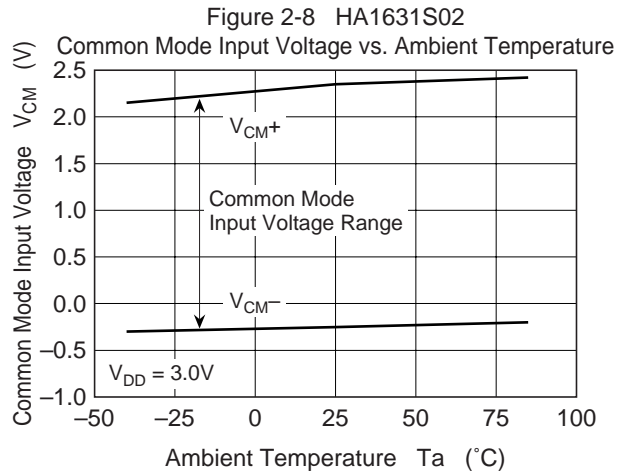
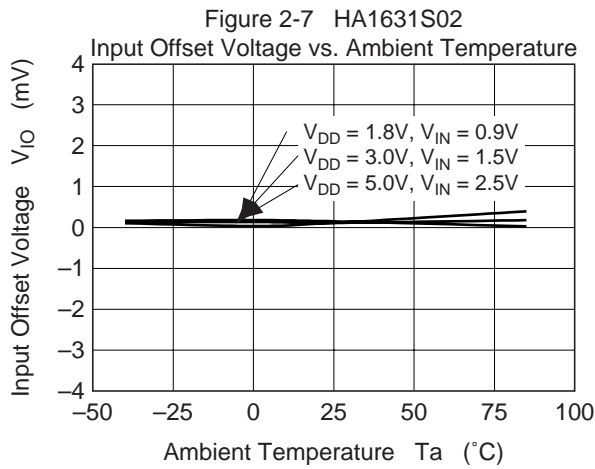


Figure 2-6 HA1631S02  
Input Offset Voltage vs. Supply Voltage





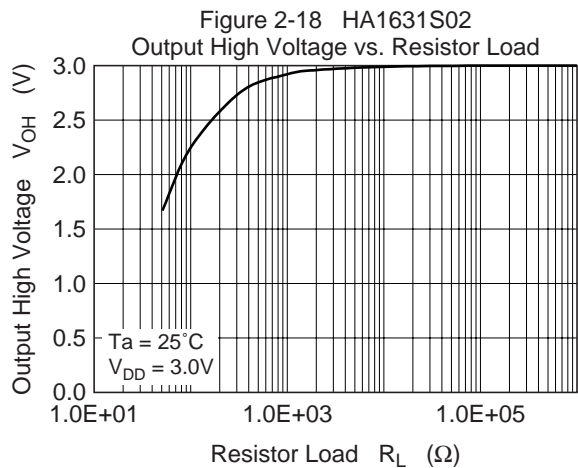
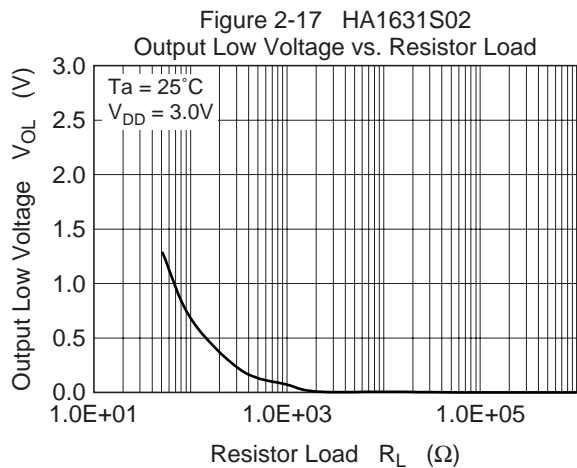
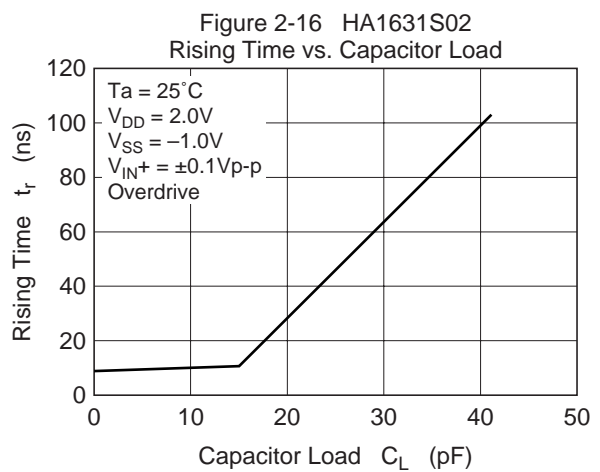
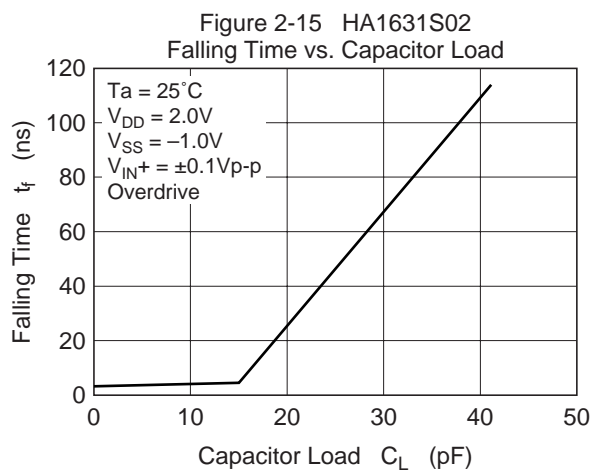
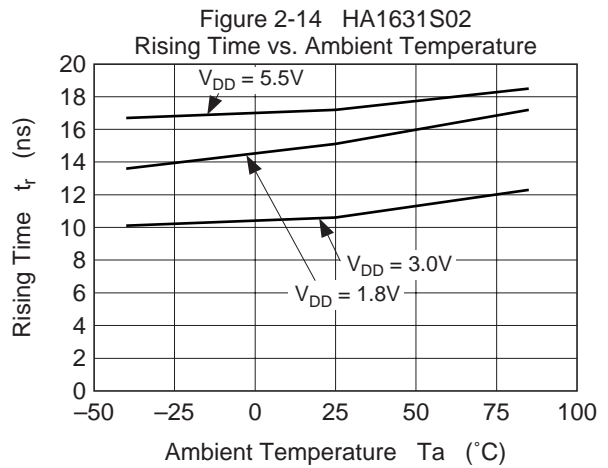
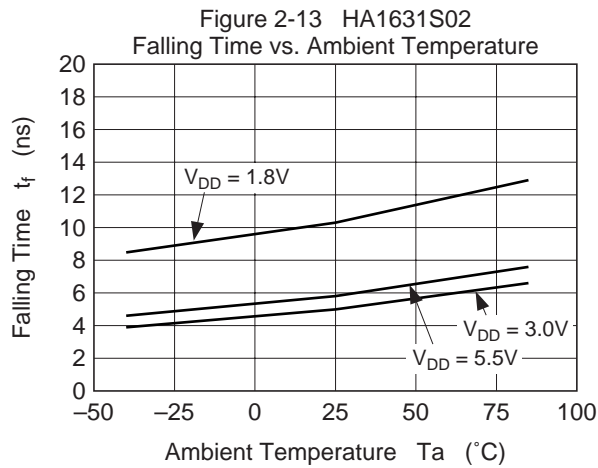


Figure 2-19 HA1631S02  
Rising Time,  $t_r$   
(Overdrive =  $\pm 0.1V_{p-p}$ )

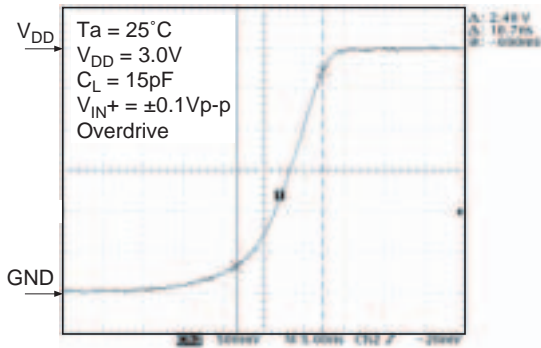


Figure 2-20 HA1631S02  
Falling Time,  $t_f$   
(Overdrive =  $\pm 0.1V_{p-p}$ )

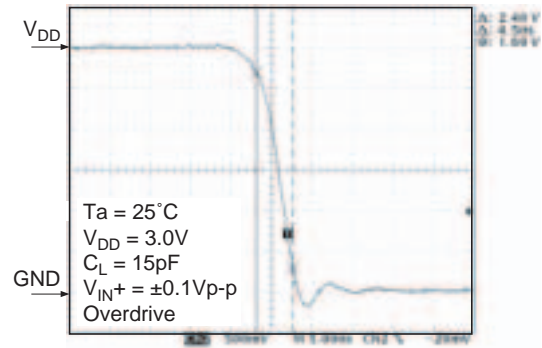


Figure 2-21 HA1631S02  
 $TP_{LH}$  Transient Response  
(Overdrive =  $\pm 0.1V_{p-p}$ )

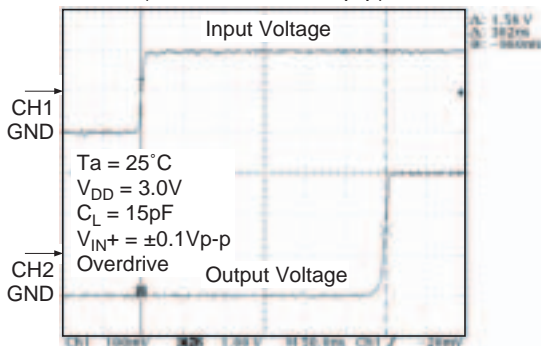


Figure 2-22 HA1631S02  
 $TP_{HL}$  Transient Response  
(Overdrive =  $\pm 0.1V_{p-p}$ )

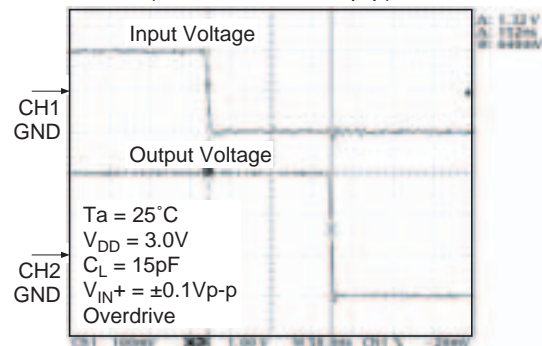


Figure 3-1 HA1631S03  
Supply Current vs. Supply Voltage  
(Output High)

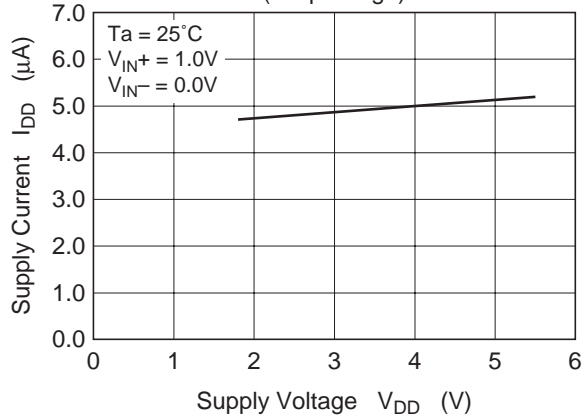


Figure 3-2 HA1631S03  
Supply Current vs. Supply Voltage  
(Output Low)

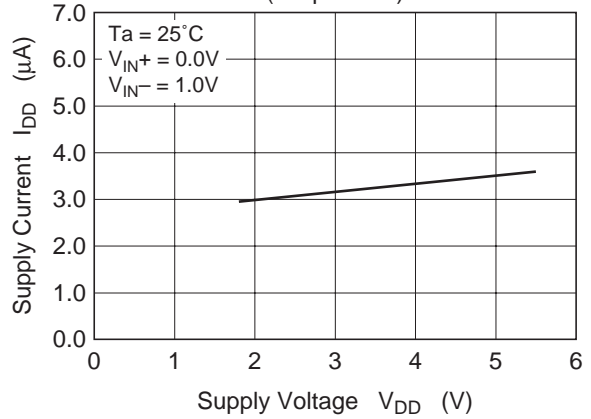


Figure 3-3 HA1631S03  
Supply Current vs. Ambient Temperature

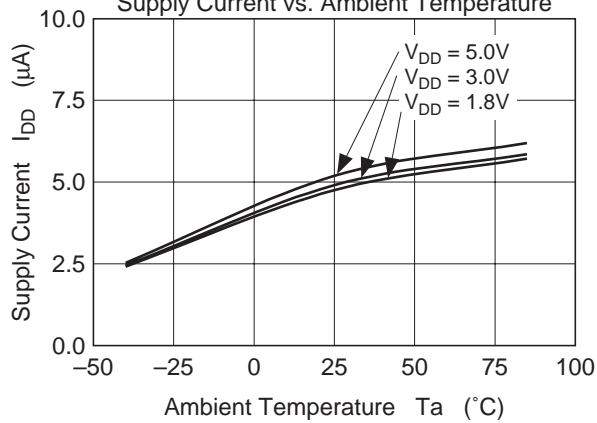


Figure 3-4 HA1631S03  
Output Low Voltage vs. Output Sink Current

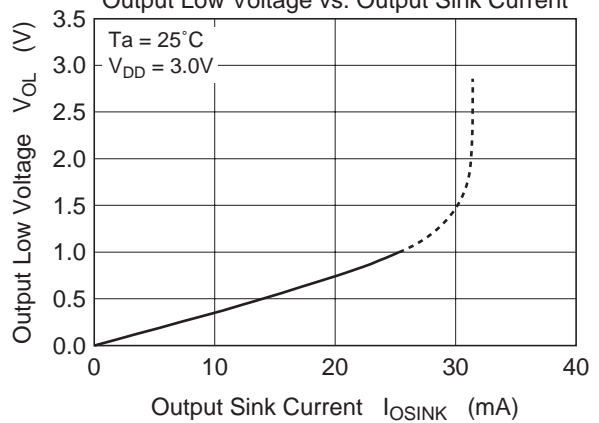


Figure 3-5 HA1631S03  
Input Offset Voltage vs. Supply Voltage

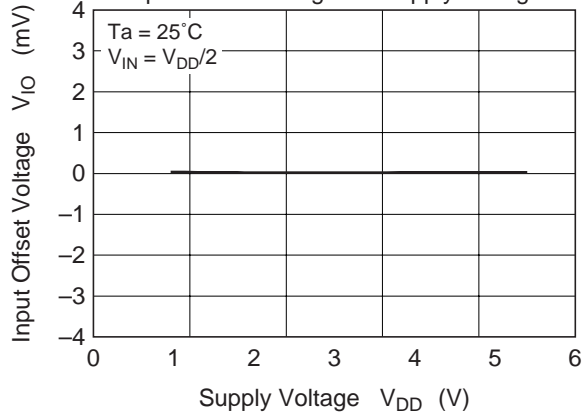
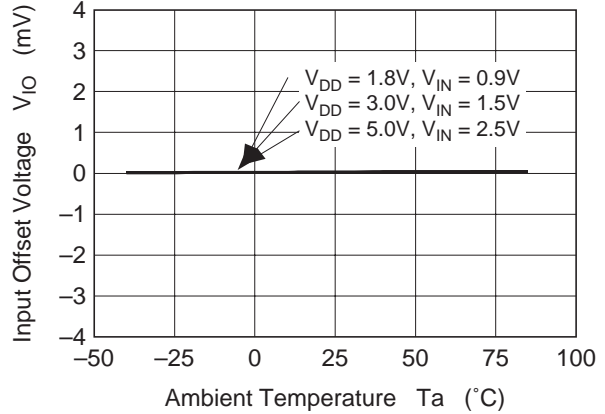


Figure 3-6 HA1631S03  
Input Offset Voltage vs. Ambient Temperature



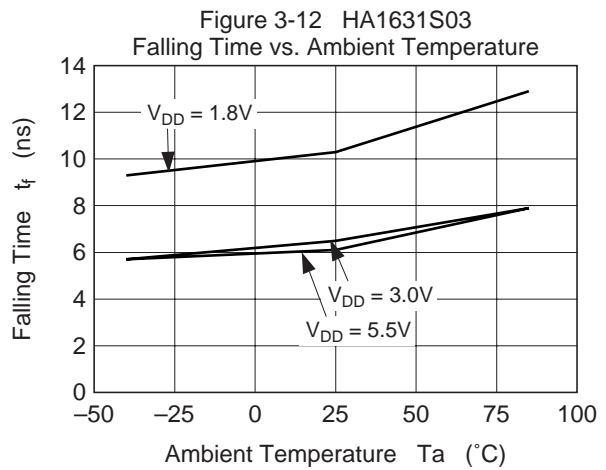
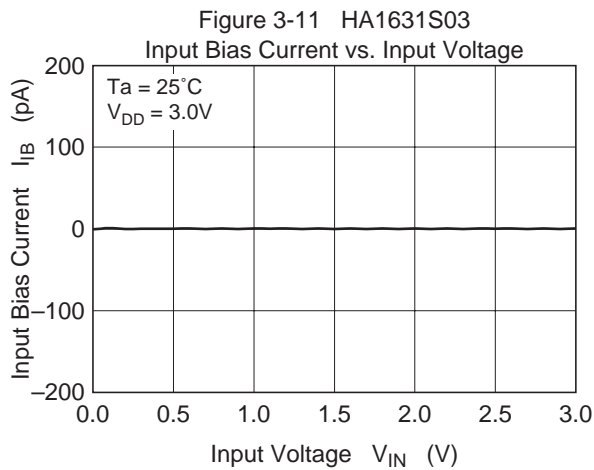
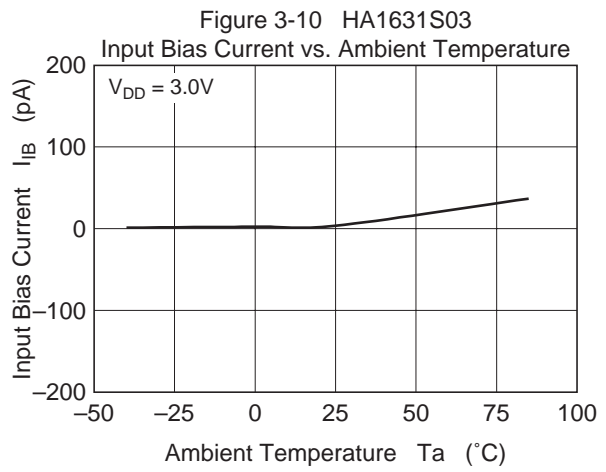
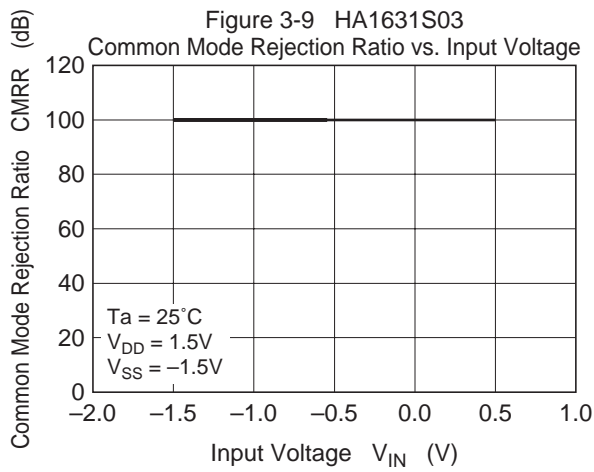
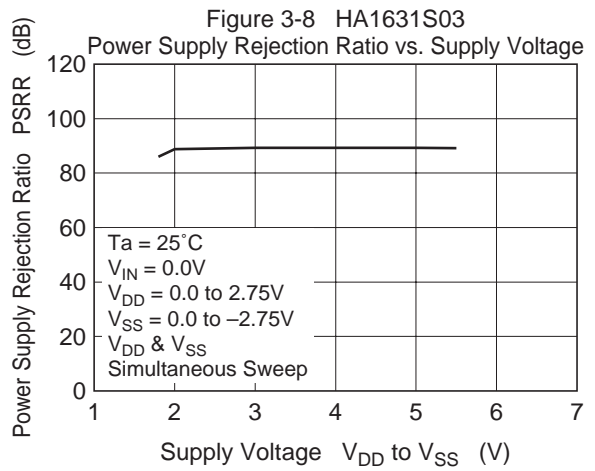
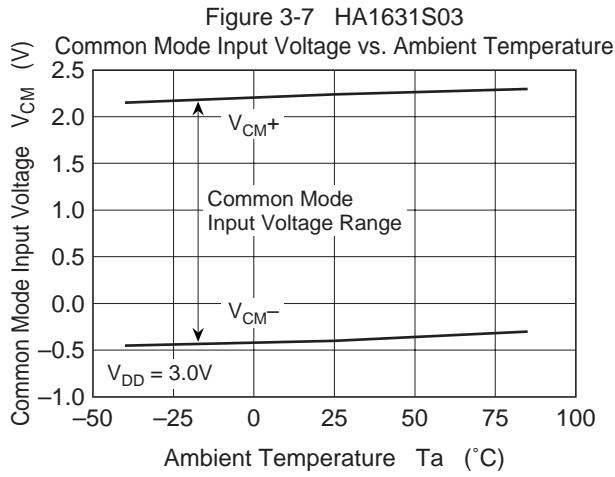




Figure 3-13 HA1631S03  
Falling Time vs. Capacitor Load

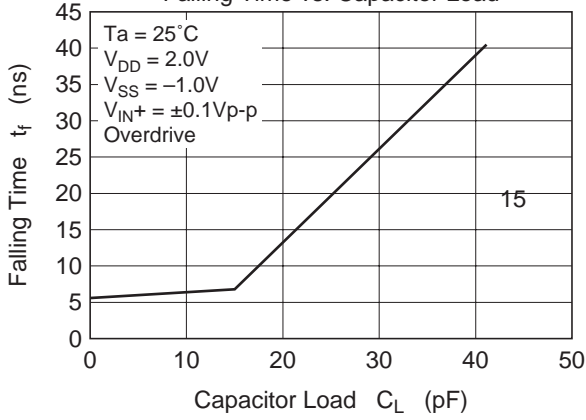


Figure 3-14 HA1631S03  
Output Low Voltage vs. Resistor Load

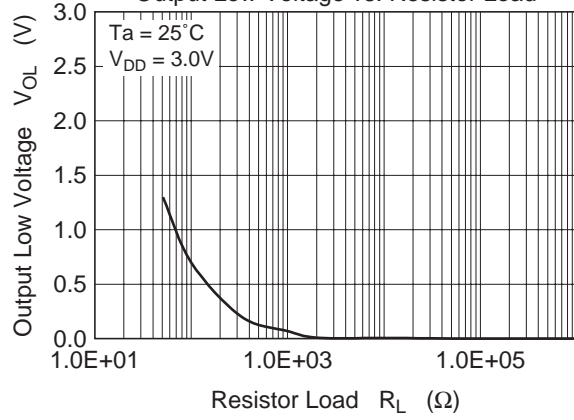


Figure 3-15 HA1631S03  
Falling Time,  $t_f$

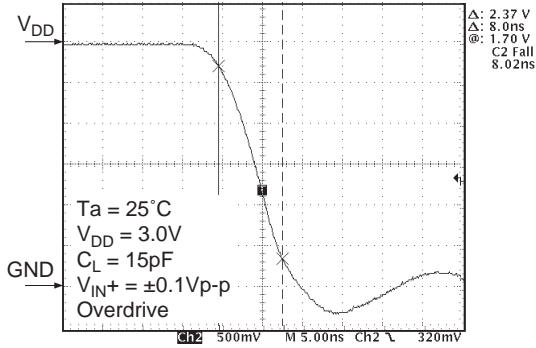


Figure 3-16 HA1631S03  
 $TP_{HL}$  Transient Response  
(Overdrive =  $\pm 0.1Vp-p$ )

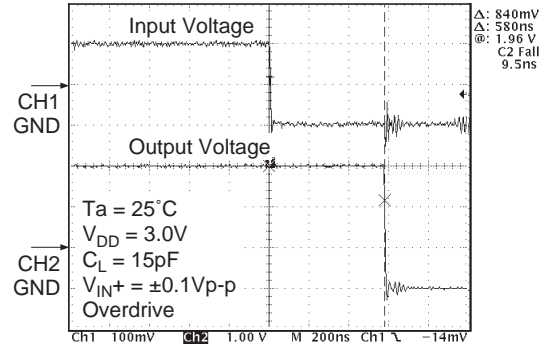


Figure 3-17 HA1631S03  
 $TP_{HL}$  Transient Response  
(Overdrive =  $\pm 0.1Vp-p$ )

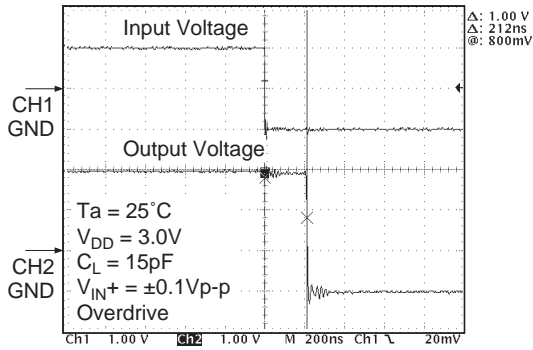


Figure 4-1 HA1631S04  
Supply Current vs. Supply Voltage  
(Output High)

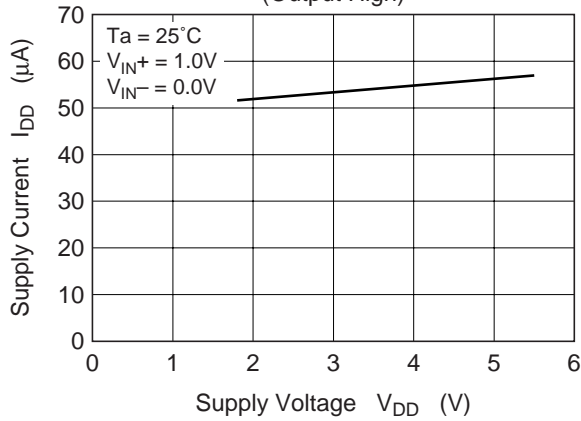


Figure 4-2 HA1631S04  
Supply Current vs. Supply Voltage  
(Output Low)

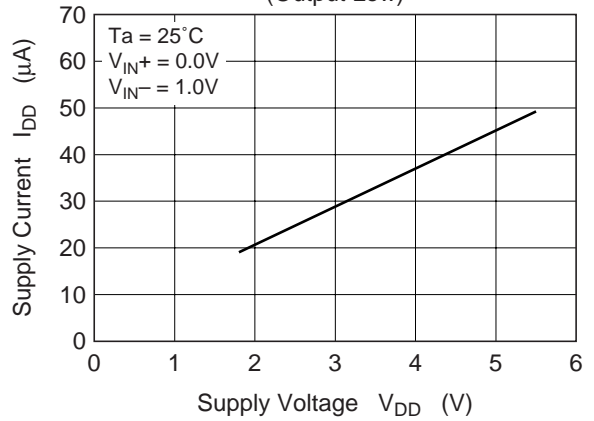


Figure 4-3 HA1631S04  
Supply Current vs. Ambient Temperature

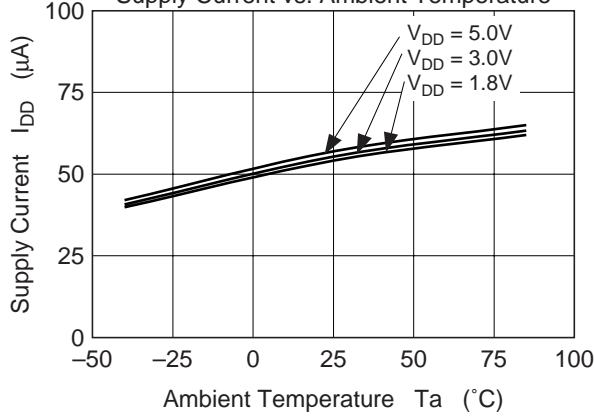


Figure 4-4 HA1631S04  
Output Low Voltage vs. Output Sink Current

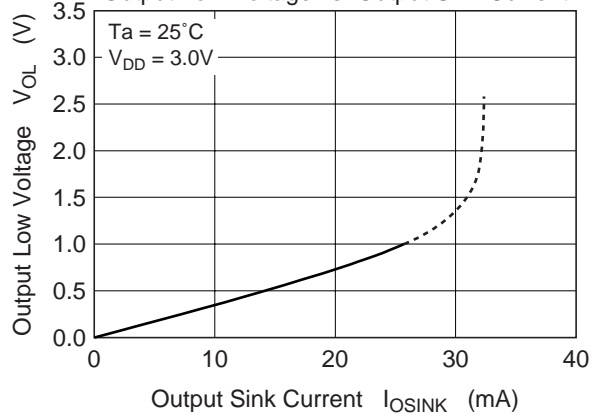


Figure 4-5 HA1631S04  
Input Offset Voltage vs. Supply Voltage

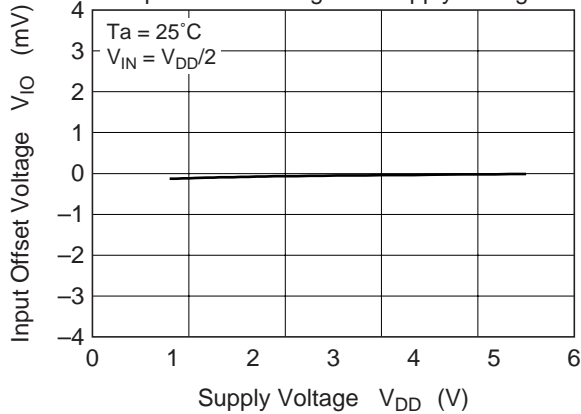
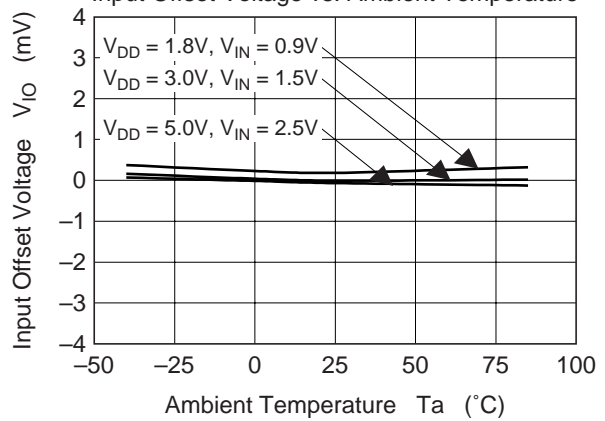
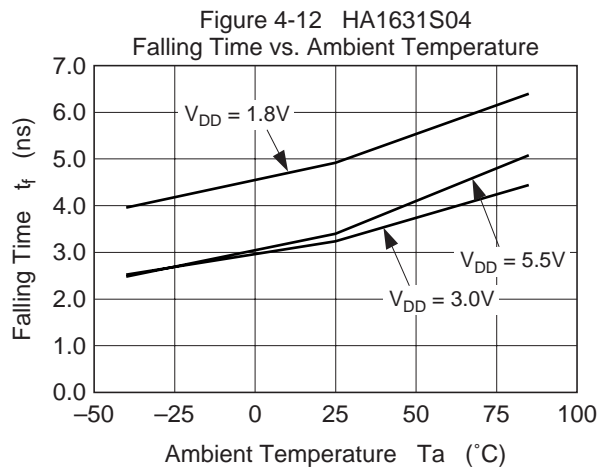
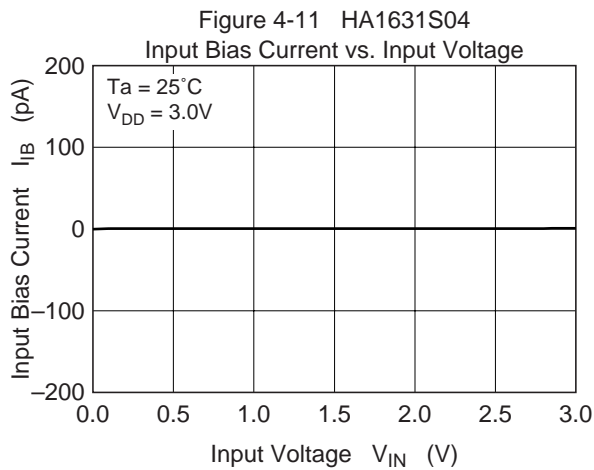
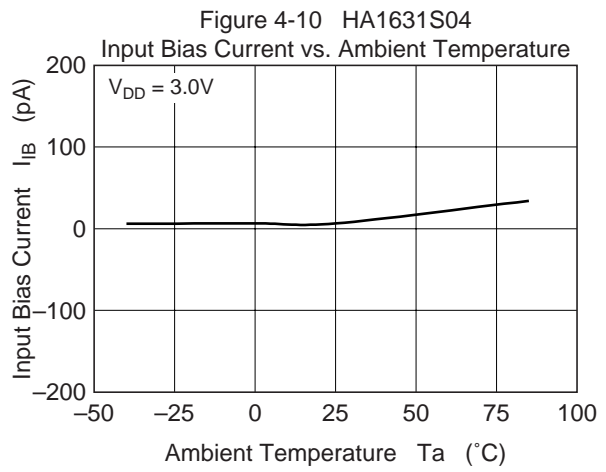
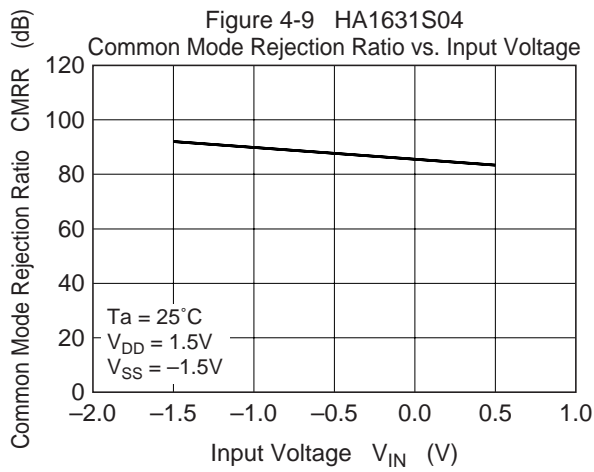
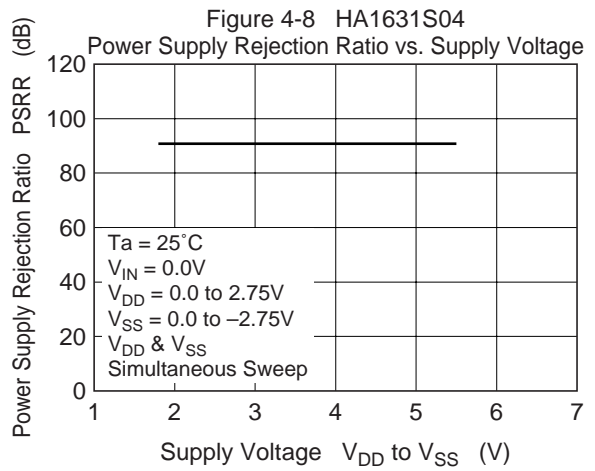
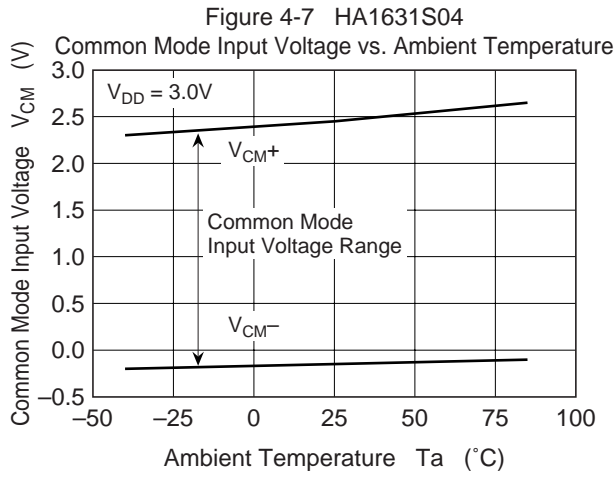
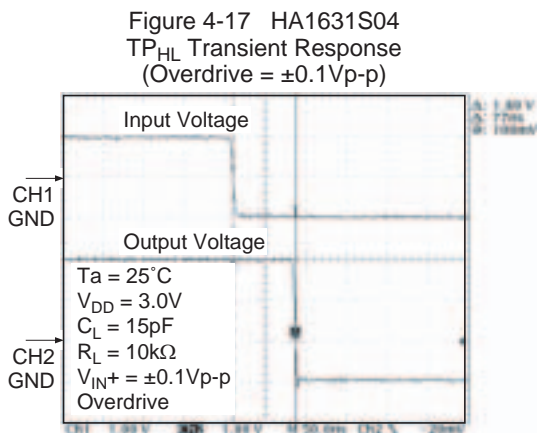
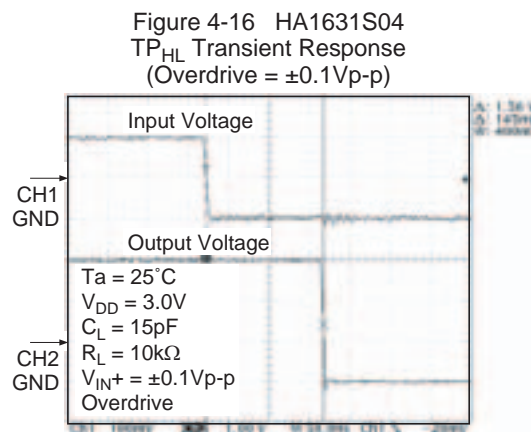
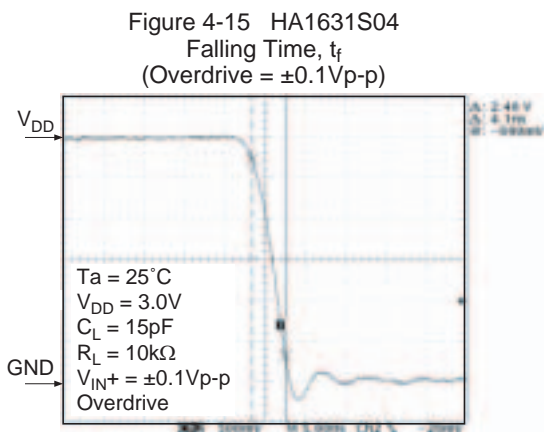
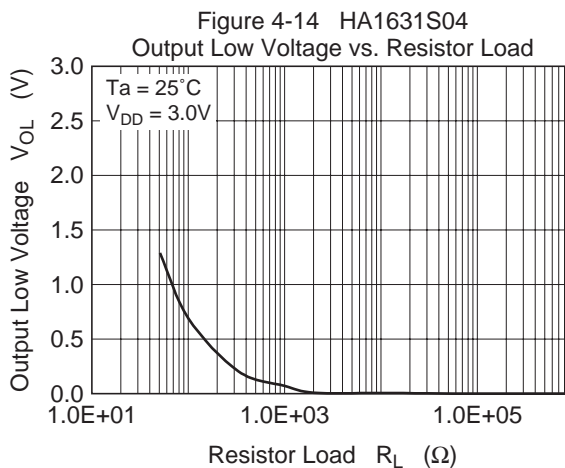
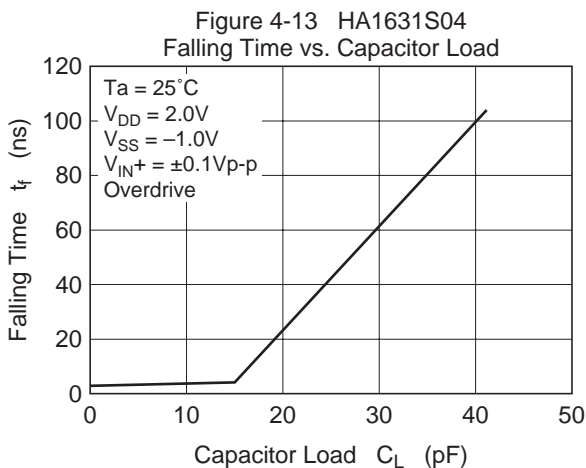


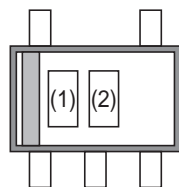
Figure 4-6 HA1631S04  
Input Offset Voltage vs. Ambient Temperature







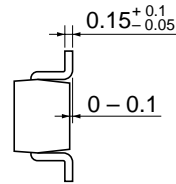
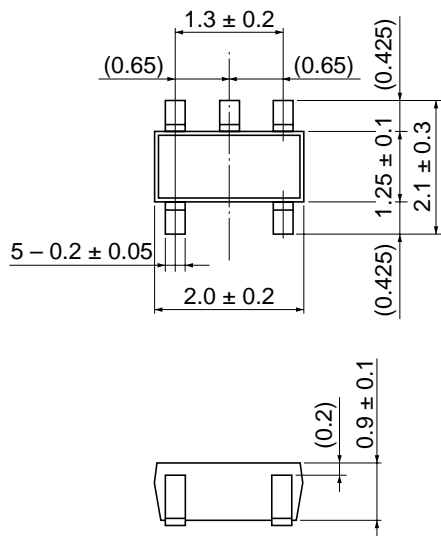
### Mark Indication



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

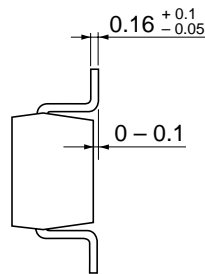
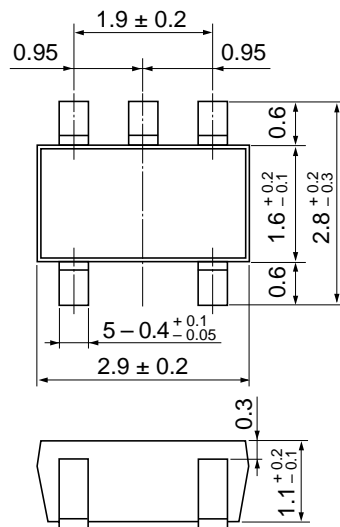
Package Information

Unit: mm



Package Code	CMPAK-5V
JEDEC	—
JEITA	Conforms
Mass (reference value)	0.006 g

Unit: mm



Package Code	MPAK-5
JEDEC	—
JEITA	—
Mass (reference value)	0.015 g

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