



# 0.35 $\Omega$ CMOS 1.65 V to 3.6 V Single SPDT Switch/2:1 MUX

## ADG839

### FEATURES

1.65 V to 3.6 V operation

Ultralow on resistance:

0.35  $\Omega$  typical

0.5  $\Omega$  max at 2.7 V supply

Excellent audio performance, ultralow distortion:

0.055  $\Omega$  typical

0.09  $\Omega$  max  $R_{ON}$  flatness

High current carrying capability:

300 mA continuous

500 mA peak current at 3.3 V

Automotive temperature range:  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$

Rail-to-rail switching operation

Typical power consumption ( $<0.1 \mu\text{W}$ )

### APPLICATIONS

Cellular phones

PDA's

MP3 players

Power routing

Battery-powered systems

PCMCIA cards

Modems

Audio and video signal routing

Communication systems

### FUNCTIONAL BLOCK DIAGRAM

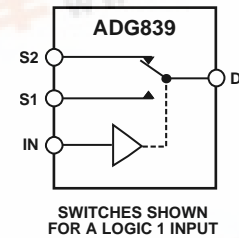


Figure 1.

### PRODUCT HIGHLIGHTS

1. 0.6  $\Omega$  over full temperature range of  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ .
2. Compatible with 1.8 V CMOS logic.
3. High current handling capability (300 mA continuous current at 3.3 V).
4. Low THD + N (0.01% typ).
5. Tiny SC70 package.

### GENERAL DESCRIPTION

The ADG839 is a low voltage CMOS device containing a single-pole, double-throw (SPDT) switch. This device offers ultralow on resistance of less than 0.6  $\Omega$  over the full temperature range. The ADG839 is fully specified for 1.8 V, 2.5 V, and 3.3 V supply operation.

Each switch conducts equally well in both directions when on and has an input signal range that extends to the supplies. The ADG839 exhibits break-before-make switching action.

The ADG839 is available in a 6-lead SC70 package.

Table 1. ADG839 Truth Table

Logic	Switch 2 (S2)	Switch 1 (S1)
0	Off	On
1	On	Off

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**REVISION HISTORY**

10/04—Initial Version: Revision 0

## SPECIFICATIONS<sup>1</sup>—2.7 V TO 3.6 V

$V_{DD}$  = 2.7 V to 3.6 V, GND = 0 V, unless otherwise noted.

Table 2.

Parameter	+25°C	–40°C to +85°C	–40°C to +125°C	Unit	Test Conditions/Comments
<b>ANALOG SWITCH</b>					
Analog Signal Range			0 V to $V_{DD}$	V	$V_{DD}$ = 2.7 V
On Resistance ( $R_{ON}$ )	0.35			$\Omega$ typ	$V_{DD}$ = 2.7 V, $V_S$ = 0 V to $V_{DD}$ , $I_S$ = 100 mA;
	0.5	0.56	0.61	$\Omega$ max	Figure 19
On Resistance Match between Channels ( $\Delta R_{ON}$ )	0.04			$\Omega$ typ	$V_{DD}$ = 2.7 V, $V_S$ = 0.9 V, $I_S$ = 100 mA
	0.075	0.085	0.095	$\Omega$ max	
On Resistance Flatness ( $R_{FLAT(ON)}$ )	0.055			$\Omega$ typ	$V_{DD}$ = 2.7 V, $V_S$ = 0 V to $V_{DD}$ ,
	0.07	0.082	0.09	$\Omega$ max	$I_S$ = 100 mA
<b>LEAKAGE CURRENTS</b>					
Source Off Leakage $I_S$ (OFF)	±0.2			nA typ	$V_{DD}$ = 3.6 V
Channel On Leakage $I_D$ , $I_S$ (ON)	±0.2			nA typ	$V_S$ = 0.6 V/3.3 V, $V_D$ = 3.3 V/0.6 V; Figure 20
<b>DIGITAL INPUTS</b>					
Input High Voltage, $V_{INH}$			2	V min	$V_{IN}$ = $V_{INL}$ or $V_{INH}$
Input Low Voltage, $V_{INL}$			0.8	V max	
Input Current					
$I_{INL}$ or $I_{INH}$	0.005			$\mu$ A typ	
			±0.1	$\mu$ A max	
$C_{IN}$ , Digital Input Capacitance	3.2			pF typ	
<b>DYNAMIC CHARACTERISTICS<sup>2</sup></b>					
$t_{ON}$	12			ns typ	$R_L$ = 50 $\Omega$ , $C_L$ = 35 pF
	16	18	19	ns max	$V_S$ = 1.5 V/0 V; Figure 22
$t_{OFF}$	6.5			ns typ	$R_L$ = 50 $\Omega$ , $C_L$ = 35 pF
	8.5	9	9.5	ns max	$V_S$ = 1.5 V; Figure 22
Break-Before-Make Time Delay ( $t_{BBM}$ )	5		1	ns typ	$R_L$ = 50 $\Omega$ , $C_L$ = 35 pF; Figure 23
				ns min	$V_{S1}$ = $V_{S2}$ = 1.5 V;
Charge Injection	70			pC typ	$V_S$ = 1.5 V, $R_S$ = 0 $\Omega$ , $C_L$ = 1 nF; Figure 24
Off Isolation	–57			dB typ	$R_L$ = 50 $\Omega$ , $C_L$ = 5 pF, $f$ = 100 kHz; Figure 25
Channel-to-Channel Crosstalk	–57			dB typ	S1 –S2;
					$R_L$ = 50 $\Omega$ , $C_L$ = 5 pF, $f$ = 100 kHz; Figure 26
Total Harmonic Distortion (THD + N)	0.013			%	$R_L$ = 32 $\Omega$ , $f$ = 20 Hz to 20 kHz, $V_S$ = 3 V p-p
Insertion Loss	–0.01			dB typ	$R_L$ = 50 $\Omega$ , $C_L$ = 5 pF; Figure 27
–3 dB Bandwidth	25			MHz typ	$R_L$ = 50 $\Omega$ , $C_L$ = 5 pF; Figure 27
$C_S$ (OFF)	74			pF typ	
$C_D$ , $C_S$ (ON)	120			pF typ	$V_{DD}$ = 3.6 V
<b>POWER REQUIREMENTS</b>					
$I_{DD}$	0.003			$\mu$ A typ	Digital inputs = 0 V or 3.6 V
		1	4	$\mu$ A max	

<sup>1</sup> Temperature range for the Y version is –40°C to +125°C.

<sup>2</sup> Guaranteed by design; not subject to production test.

# ADG839

## SPECIFICATIONS<sup>1</sup>—2.3 V TO 2.7 V

$V_{DD} = 2.5 \text{ V} \pm 0.2 \text{ V}$ ,  $GND = 0 \text{ V}$ , unless otherwise noted.

Table 3.

Parameter	+25°C	–40°C to +85°C	–40°C to +125°C	Unit	Test Conditions/Comments
<b>ANALOG SWITCH</b>					
Analog Signal Range			0 V to $V_{DD}$	V	
On Resistance ( $R_{ON}$ )	0.35			$\Omega$ typ	$V_{DD} = 2.3 \text{ V}$ , $V_S = 0 \text{ V}$ to $V_{DD}$ , $I_S = 100 \text{ mA}$ ; Figure 19
	0.5	0.55	0.6	$\Omega$ max	
On Resistance Match between Channels ( $\Delta R_{ON}$ )	0.04			$\Omega$ typ	$V_{DD} = 2.3 \text{ V}$ , $V_S = 0.95 \text{ V}$ , $I_S = 100 \text{ mA}$
	0.075	0.085	0.095	$\Omega$ max	
On Resistance Flatness ( $R_{FLAT(ON)}$ )	0.045			$\Omega$ typ	$V_{DD} = 2.3 \text{ V}$ , $V_S = 0 \text{ V}$ to $V_{DD}$ , $I_S = 100 \text{ mA}$
		0.13	0.13	$\Omega$ max	
<b>LEAKAGE CURRENTS</b>					
Source Off Leakage $I_S$ (OFF)	$\pm 0.2$			nA typ	$V_{DD} = 2.7 \text{ V}$ $V_S = 0.6 \text{ V}/2.4 \text{ V}$ , $V_D = 2.4 \text{ V}/0.6 \text{ V}$ ; Figure 20
Channel On Leakage $I_D$ , $I_S$ (ON)	$\pm 0.2$			nA typ	$V_S = V_D = 0.6 \text{ V}$ or $2.4 \text{ V}$ ; Figure 21
<b>DIGITAL INPUTS</b>					
Input High Voltage, $V_{INH}$			1.7	V min	
Input Low Voltage, $V_{INL}$			0.7	V max	
Input Current $I_{INL}$ or $I_{INH}$	0.005			$\mu\text{A}$ typ	$V_{IN} = V_{INL}$ or $V_{INH}$
			$\pm 0.1$	$\mu\text{A}$ max	
$C_{IN}$ , Digital Input Capacitance	3.2			pF typ	
<b>DYNAMIC CHARACTERISTICS<sup>2</sup></b>					
$t_{ON}$	14.5			ns typ	$R_L = 50 \Omega$ , $C_L = 35 \text{ pF}$
	18	20	21	ns max	$V_S = 1.5 \text{ V}/0 \text{ V}$ ; Figure 22
$t_{OFF}$	7.5			ns typ	$R_L = 50 \Omega$ , $C_L = 35 \text{ pF}$
	9.2	9.5	9.8	ns max	$V_S = 1.5 \text{ V}$ ; Figure 22
Break-before-Make Time Delay ( $t_{BBM}$ )	7			ns typ	$R_L = 50 \Omega$ , $C_L = 35 \text{ pF}$ ; Figure 23
			1	ns min	$V_{S1} = V_{S2} = 1.5 \text{ V}$ ;
Charge Injection	60			pC typ	$V_S = 1.25 \text{ V}$ , $R_S = 0 \Omega$ , $C_L = 1 \text{ nF}$ ; Figure 24
Off Isolation	–57			dB typ	$R_L = 50 \Omega$ , $C_L = 5 \text{ pF}$ , $f = 100 \text{ kHz}$ ; Figure 25
Channel-to-Channel Crosstalk	–57			dB typ	$S1-S2$ ; $R_L = 50 \Omega$ , $C_L = 5 \text{ pF}$ , $f = 100 \text{ kHz}$ ; Figure 26
Total Harmonic Distortion (THD + N)	0.021			%	$R_L = 32 \Omega$ , $f = 20 \text{ Hz}$ to $20 \text{ kHz}$ , $V_S = 2 \text{ V}$ p-p
Insertion Loss	–0.01			dB typ	$R_L = 50 \Omega$ , $C_L = 5 \text{ pF}$ ; Figure 27
–3 dB Bandwidth	25			MHz typ	$R_L = 50 \Omega$ , $C_L = 5 \text{ pF}$ ; Figure 27
$C_S$ (OFF)	78			pF typ	
$C_D$ , $C_S$ (ON)	127			pF typ	$V_{DD} = 2.7 \text{ V}$
<b>POWER REQUIREMENTS</b>					
$I_{DD}$	0.003			$\mu\text{A}$ typ	Digital inputs = 0 V or 2.7 V
		1	4	$\mu\text{A}$ max	

<sup>1</sup> Temperature range for the Y version is –40°C to +125°C.

<sup>2</sup> Guaranteed by design; not subject to production test.

## SPECIFICATIONS<sup>1</sup>—1.65 V TO 1.95 V

$V_{DD} = 1.65\text{ V} \pm 1.95\text{ V}$ , GND = 0 V, unless otherwise noted.

Table 4.

Parameter	+25°C	–40°C to +85°C	–40°C to +125°C	Unit	Test Conditions/Comments
<b>ANALOG SWITCH</b>					
Analog Signal Range			0 V to $V_{DD}$	V	
On Resistance ( $R_{ON}$ )	0.5			$\Omega$ typ	$V_{DD} = 1.8\text{ V}$ , $V_S = 0\text{ V}$ to $V_{DD}$ , $I_S = 100\text{ mA}$ ; Figure 19
	0.8	1.2	1.2	$\Omega$ max	
	1.3	2.5	2.5	$\Omega$ max	$V_{DD} = 1.65\text{ V}$ , $V_S = 0\text{ V}$ to $V_{DD}$ , $I_S = 100\text{ mA}$
On Resistance Match between Channels ( $\Delta R_{ON}$ )	0.04			$\Omega$ typ	$V_{DD} = 1.65\text{ V}$ , $V_S = \text{TBD}$ , $I_S = 100\text{ mA}$
	0.075	0.08	0.08	$\Omega$ max	$I_S = 100\text{ mA}$
On Resistance Flatness ( $R_{\text{FLAT}}(\text{ON})$ )	0.3			$\Omega$ typ	$V_{DD} = 1.65\text{ V}$ , $V_S = 0\text{ V}$ to $V_{DD}$ , $I_S = 100\text{ mA}$
<b>LEAKAGE CURRENTS</b>					
Source Off Leakage $I_S$ (OFF)	$\pm 0.2$			nA typ	$V_{DD} = 1.95\text{ V}$ $V_S = 0.6\text{ V}/1.65\text{ V}$ , $V_D = 1.65\text{ V}/0.6\text{ V}$ ; Figure 20
Channel On Leakage $I_D$ , $I_S$ (ON)	$\pm 0.2$			nA typ	$V_S = V_D = 0.6\text{ V}$ or $1.65\text{ V}$ ; Figure 21
<b>DIGITAL INPUTS</b>					
Input High Voltage, $V_{\text{INH}}$			$0.65 V_{DD}$	V min	
Input Low Voltage, $V_{\text{INL}}$			$0.35 V_{DD}$	V max	
Input Current $I_{\text{INL}}$ or $I_{\text{INH}}$	0.005			$\mu\text{A}$ typ	$V_{\text{IN}} = V_{\text{INL}}$ or $V_{\text{INH}}$
			$\pm 0.1$	$\mu\text{A}$ max	
$C_{\text{IN}}$ , Digital Input Capacitance	3.2			pF typ	
<b>DYNAMIC CHARACTERISTICS<sup>2</sup></b>					
$t_{\text{ON}}$	20			ns typ	$R_L = 50\ \Omega$ , $C_L = 35\text{ pF}$
	28	30	31	ns max	$V_S = 1.5\ \Omega/0\text{ V}$ ; Figure 22
$t_{\text{OFF}}$	8			ns typ	$R_L = 50\ \Omega$ , $C_L = 35\text{ pF}$
	10.1	10.5	10.7	ns max	$V_S = 1.5\text{ V}$ ; Figure 22
Break-before-Make Time Delay ( $t_{\text{BBM}}$ )	12			ns typ	$R_L = 50\ \Omega$ , $C_L = 35\text{ pF}$
			1	ns min	$V_{S1} = V_{S2} = 1\text{ V}$ ; Figure 23
Charge Injection	50			pC typ	$V_S = 1\text{ V}$ , $R_S = 0\text{ V}$ , $C_L = 1\text{ nF}$ ; Figure 24
Off Isolation	–57			dB typ	$R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $f = 100\text{ kHz}$ ; Figure 25
Channel-to-Channel Crosstalk	–57			dB typ	$S1 - S2$ ; $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $f = 100\text{ kHz}$ ; Figure 26
Total Harmonic Distortion (THD + N)	0.033			%	$R_L = 32\ \Omega$ , $f = 20\text{ Hz}$ to $20\text{ kHz}$ , $V_S = 1\text{ V p-p}$
Insertion Loss	–0.01			dB typ	$R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ ; Figure 27
–3 dB Bandwidth	25			MHz typ	$R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ ; Figure 27
$C_S$ (OFF)	83			pF typ	$V_{DD} = 1.95\text{ V}$
$C_D$ , $C_S$ (ON)	132			pF typ	Digital inputs = 0 V or 1.95 V
<b>POWER REQUIREMENTS</b>					
$I_{DD}$	0.003			$\mu\text{A}$ typ	Digital inputs = 0 V or 1.95 V
		1	4	$\mu\text{A}$ max	

<sup>1</sup> Temperature range for the Y version is –40°C to +125°C.

<sup>2</sup> Guaranteed by design; not subject to production test.

## ADG839

### ABSOLUTE MAXIMUM RATINGS

$T_A = 25^\circ\text{C}$ , unless otherwise noted.

Table 5.

Parameter	Rating
$V_{DD}$ to GND	–0.3 V to +4.6 V
Analog Inputs <sup>1</sup>	–0.3 V to $V_{DD} + 0.3$ V
Digital Inputs	–0.3 V to 4.6 V or 10 mA, whichever occurs first
Peak Current, S or D	
3.3 V Operation	500 mA
2.5 V Operation	460 mA
1.8 V Operation	420 mA (pulsed at 1 ms, 10% duty cycle max)
Continuous Current, S or D	
3.3 V Operation	300 mA
2.5 V Operation	275 mA
1.8 V Operation	250 mA
Operating Temperature Range	
Automotive (Y Version)	–40°C to +125°C
Storage Temperature Range	–65°C to +150°C
Junction Temperature	150°C
SC70 Package	332°C/W
$\theta_{JA}$ Thermal Impedance	120°C/W
Lead Temperature, Soldering (10 seconds)	300°C
IR Reflow, Peak Temperature	220°C

<sup>1</sup> Overvoltages at S or D are clamped by internal diodes. Current should be limited to the maximum ratings given.

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those listed in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Only one absolute maximum rating may be applied at any one time.

### ESD CAUTION

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although this product features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.



PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

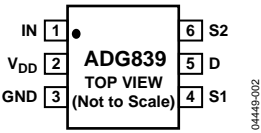


Figure 2. Pin Configuration

Table 6. Pin Function Descriptions

Pin No.	Mnemonic	Description
1	IN	Logic control input.
2	V <sub>DD</sub>	Most positive power supply potential.
3	GND	Ground (0 V) reference.
4, 6	S1, S2	Source terminal. Can be an input or output.
5	D	Drain terminal. Can be an input or output.

For more information, refer to the Terminology section.

## TYPICAL PERFORMANCE CHARACTERISTICS

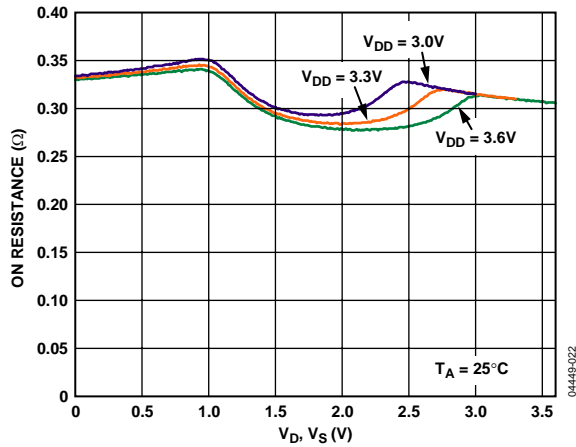


Figure 3. On Resistance vs.  $V_D$  ( $V_S$ )  $V_{DD} = 3V$  to  $3.6V$

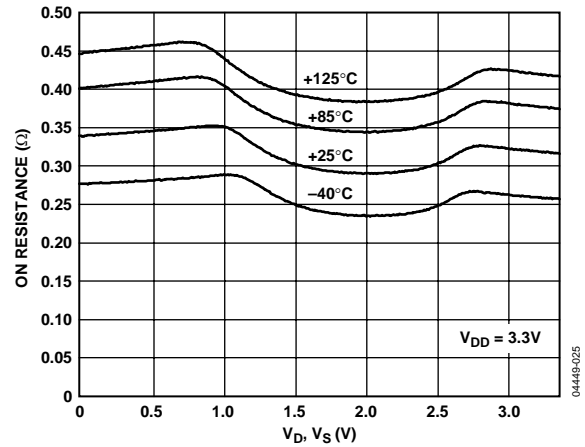


Figure 6. On Resistance vs.  $V_D$  ( $V_S$ ) for Different Temperature,  $V_{DD} = 3.3V$

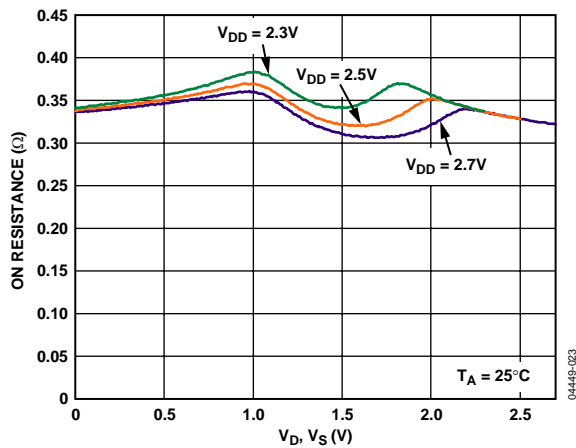


Figure 4. On Resistance vs.  $V_D$  ( $V_S$ )  $V_{DD} = 2.5V \pm 0.2V$

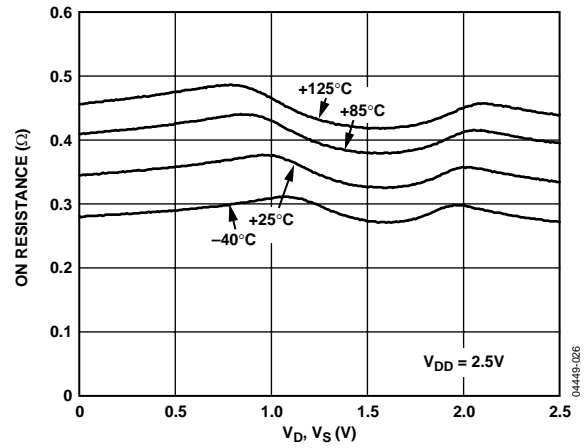


Figure 7. On Resistance vs.  $V_D$  ( $V_S$ ) for Different Temperature,  $V_{DD} = 2.5V$

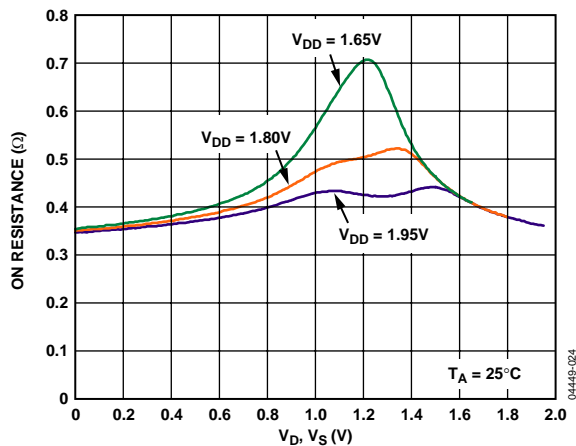


Figure 5. On Resistance vs.  $V_D$  ( $V_S$ )  $V_{DD} = 1.8V \pm 0.15V$

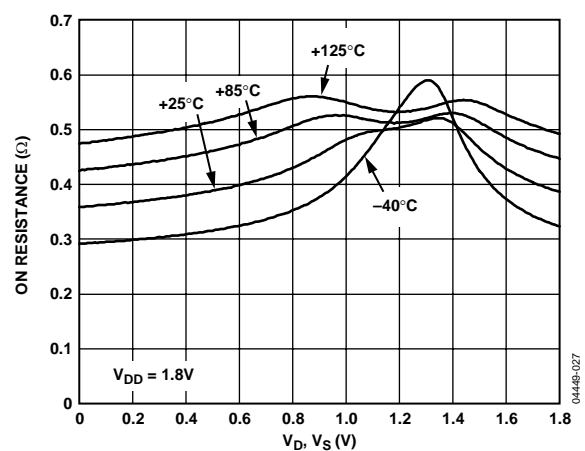


Figure 8. On Resistance vs.  $V_D$  ( $V_S$ ) for Different Temperature,  $V_{DD} = 1.8V$



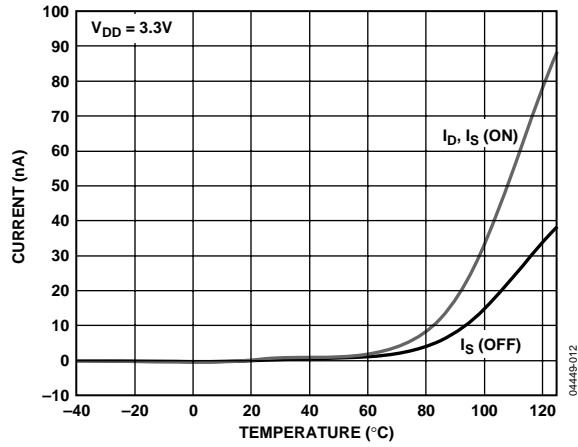


Figure 9. Leakage Current vs. Temperature,  $V_{DD} = 3.3\text{ V}$

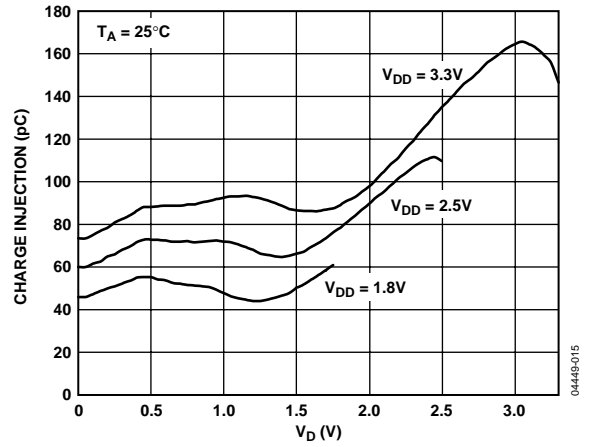


Figure 12. Charge Injection vs. Source Voltage

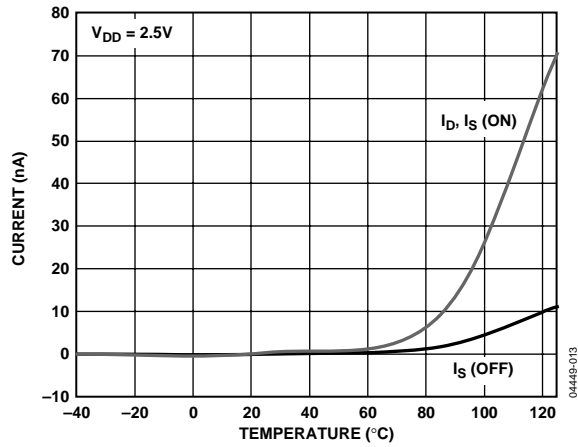


Figure 10. Leakage Current vs. Temperature,  $V_{DD} = 2.5\text{ V}$

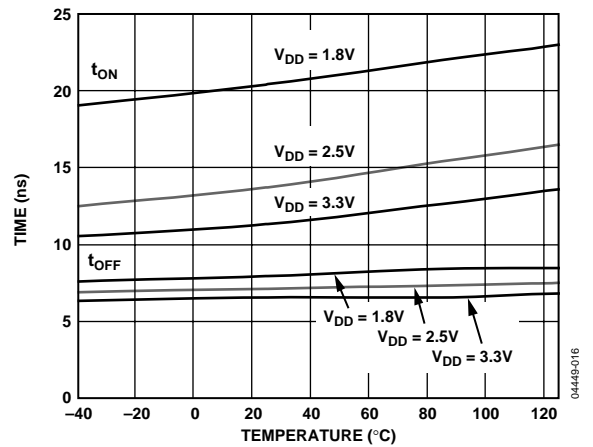


Figure 13.  $t_{ON}/t_{OFF}$  Times vs. Temperature

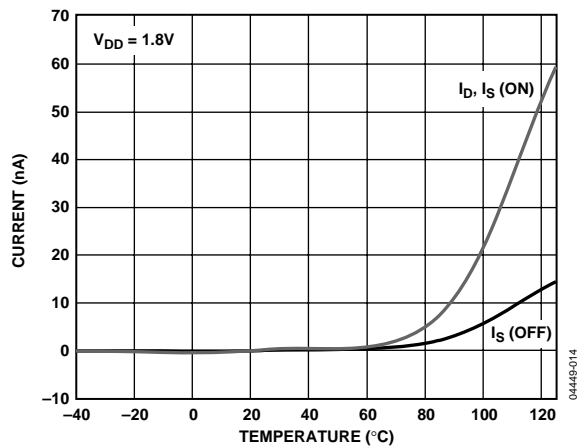


Figure 11. Leakage Current vs. Temperature,  $V_{DD} = 1.8\text{ V}$

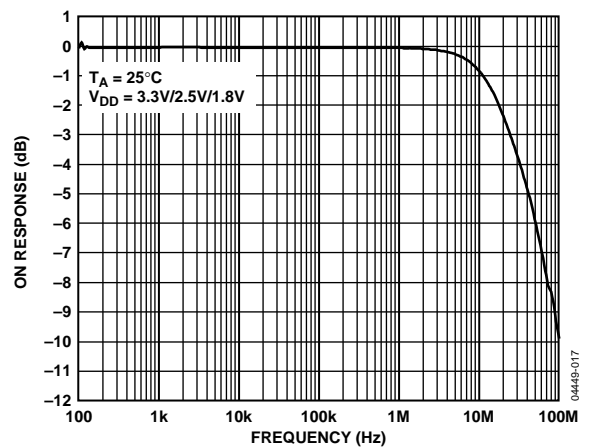


Figure 14. Bandwidth

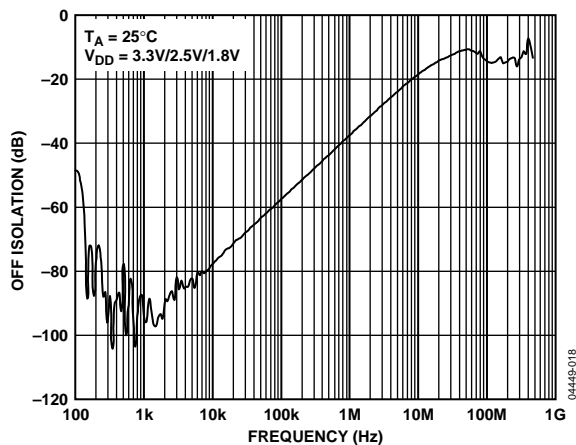


Figure 15. Off Isolation vs. Frequency

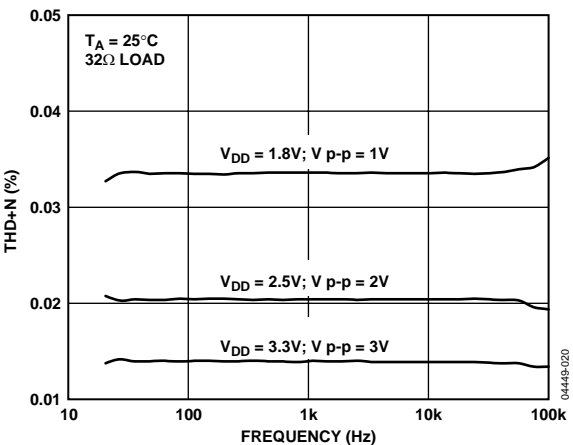


Figure 17. Total Harmonic Distortion + Noise

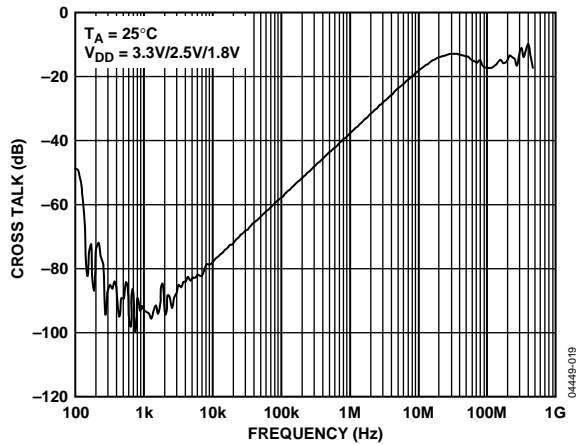


Figure 16. Crosstalk vs. Frequency

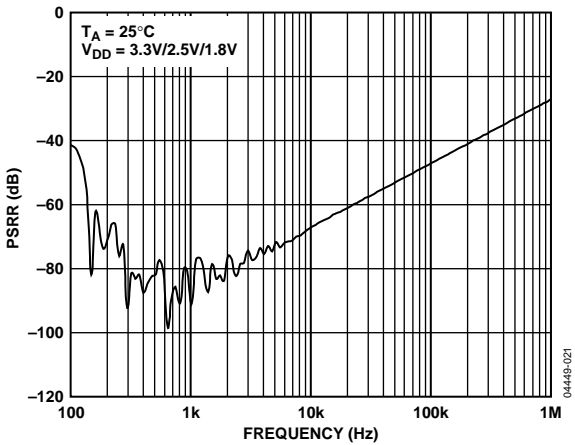


Figure 18. AC PSRR

## TERMINOLOGY

### **I<sub>DD</sub>**

Positive supply current.

### **V<sub>D</sub> (V<sub>S</sub>)**

Analog voltage on Terminals D and S.

### **R<sub>ON</sub>**

Ohmic resistance between D and S.

### **R<sub>FLAT (ON)</sub>**

Flatness is defined as the difference between the maximum and minimum value of on resistance as measured.

### **ΔR<sub>ON</sub>**

On resistance match between any two channels.

### **I<sub>S</sub> (OFF)**

Source leakage current with the switch off.

### **I<sub>D</sub> (OFF)**

Drain leakage current with the switch off.

### **I<sub>D</sub>, I<sub>S</sub> (ON)**

Channel leakage current with the switch on.

### **V<sub>INL</sub>**

Maximum input voltage for Logic 0.

### **V<sub>INH</sub>**

Minimum input voltage for Logic 1.

### **I<sub>INL</sub> (I<sub>INH</sub>)**

Input current of the digital input.

### **C<sub>S</sub> (OFF)**

Off switch source capacitance. Measured with reference to ground.

### **C<sub>D</sub> (OFF)**

Off switch drain capacitance. Measured with reference to ground.

### **C<sub>D</sub>, C<sub>S</sub> (ON)**

On switch capacitance. Measured with reference to ground.

### **C<sub>IN</sub>**

Digital input capacitance.

### **t<sub>ON</sub>**

Delay time between the 50% and the 90% points of the digital input and switch on condition.

### **t<sub>OFF</sub>**

Delay time between the 50% and the 90% points of the digital input and switch off condition.

### **t<sub>B2M</sub>**

On or off time measured between the 80% points of both switches when switching from one to another.

### **Charge Injection**

A measure of the glitch impulse transferred from the digital input to the analog output during on-off switching.

### **Off Isolation**

A measure of unwanted signal coupling through an off switch.

### **Crosstalk**

A measure of unwanted signal which is coupled through from one channel to another as a result of parasitic capacitance.

### **–3 dB Bandwidth**

The frequency at which the output is attenuated by 3 dB.

### **On Response**

The frequency response of the on switch.

### **Insertion Loss**

The attenuation between the input and output ports of the switch when the switch is in the on condition, and is due to the on resistance of the switch.

### **THD + N**

The ratio of the harmonic amplitudes plus noise of a signal to the fundamental.

### **PSRR**

Power Supply Rejection Ratio. This is a measure of the coupling of unwanted ac signals on the power supply to the switch output when the supply is not decoupled.

## TEST CIRCUITS

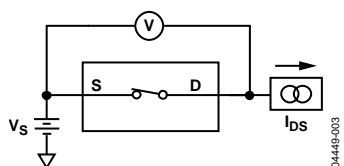


Figure 19. On Resistance

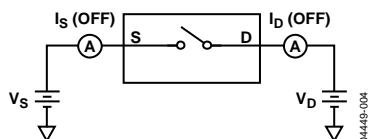


Figure 20. Off Leakage

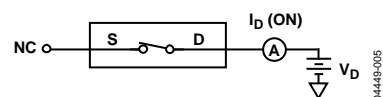


Figure 21. On Leakage

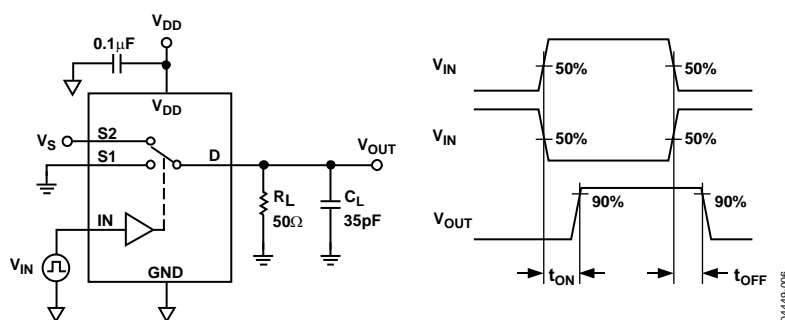


Figure 22. Switching Times,  $t_{ON}$ ,  $t_{OFF}$

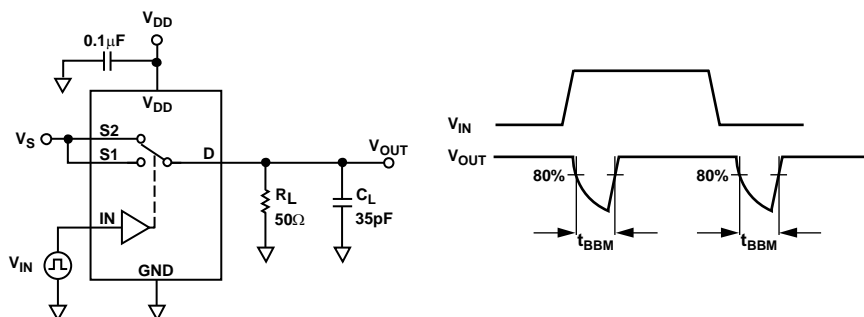


Figure 23. Break-before-Make Time Delay,  $t_{BBM}$

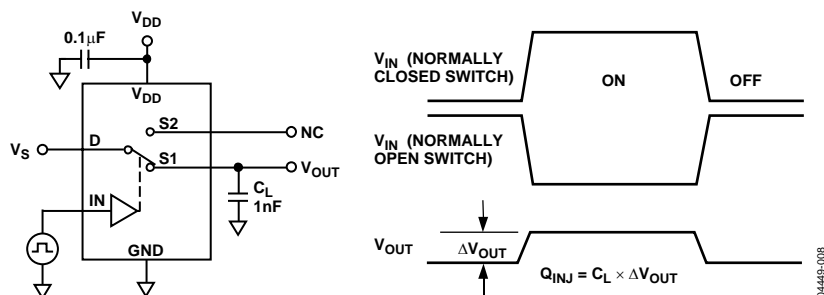


Figure 24. Charge Injection

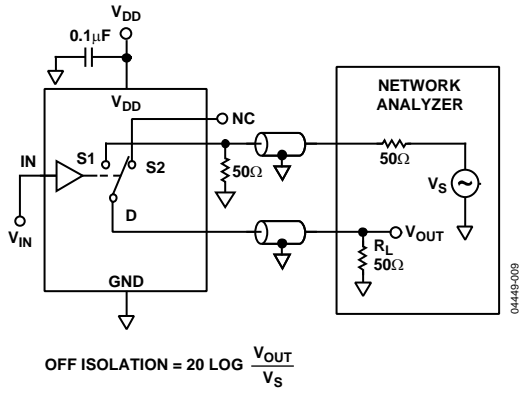


Figure 25. Off Isolation

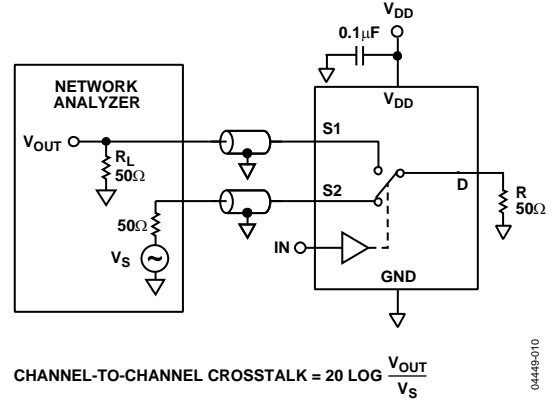


Figure 26. Channel-to-Channel Crosstalk

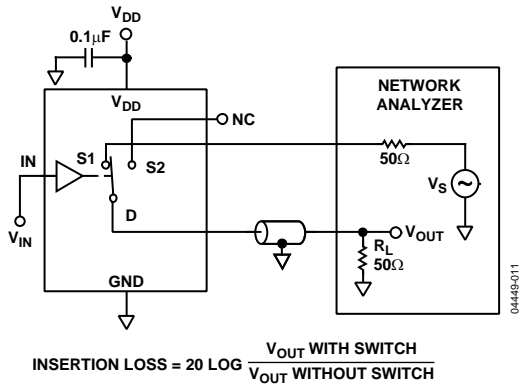


Figure 27. Bandwidth

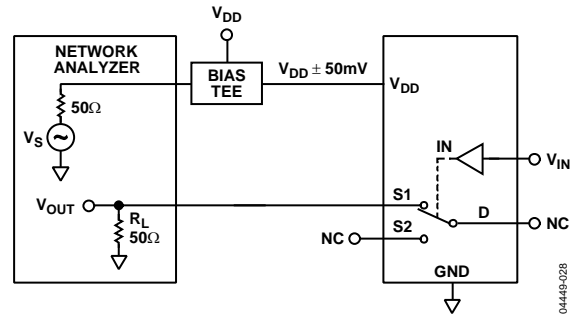


Figure 27. PSRR

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## OUTLINE DIMENSIONS

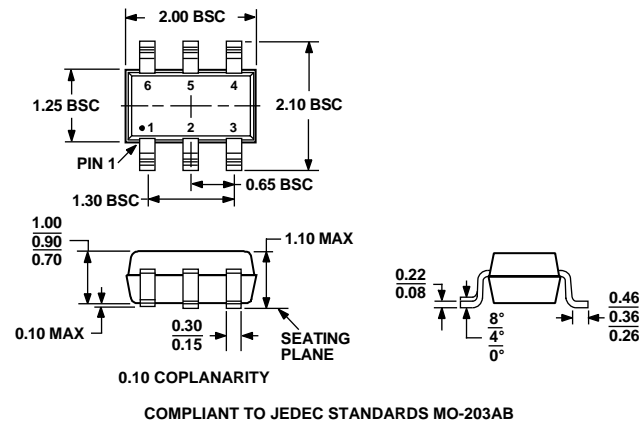


Figure 28. 6-Lead Thin Shrink Small Outline Transistor Package [SC70]  
(KS-6)  
Dimensions shown in millimeters

## ORDERING GUIDE

Model	Temperature Range	Package Description	Package Option	Branding <sup>1</sup>
ADG839YKSZ-500RL <sup>2</sup>	–40°C to +125°C	6-Lead Thin Shrink Small Outline Transistor Package	KS-6	SUA
ADG839YKSZ-REEL <sup>2</sup>	–40°C to +125°C	6-Lead Thin Shrink Small Outline Transistor Package	KS-6	SUA
ADG839YKSZ-REEL <sup>2</sup>	–40°C to +125°C	6-Lead Thin Shrink Small Outline Transistor Package	KS-6	SUA

<sup>1</sup> Branding on this package is limited to three characters due to space constraints.

<sup>2</sup> Z = Pb-free part.

**NOTES**

**ADG839**

**NOTES**