

# AS1746

## 0.5/0.6Ω, Low-Voltage, Dual SPDT Analog Switch

### 1 General Description

The AS1746 is a low on-resistance ( $R_{ON}$ ), low-voltage, dual-single-pole/double-throw (SPDT) analog switch designed to operate from a single +1.8 to +5.5V supply.

The device features a 0.5Ω (max)  $R_{ON}$  for normally closed (NC) switches and a 0.6Ω (max)  $R_{ON}$  for normally open (NO) switches using a +2.7V supply.

The AS1746 features break-before-make switching (2ns) with  $t_{ON} = 50ns$  and  $t_{OFF} = 30ns$  (using a +2.7V supply).

The digital logic inputs are 1.8V logic-compatible with +2.7 to +3.3V supplies.

The AS1746 is available in a TDFN-10 (3x3mm) package and a WL-CSP-10 package.

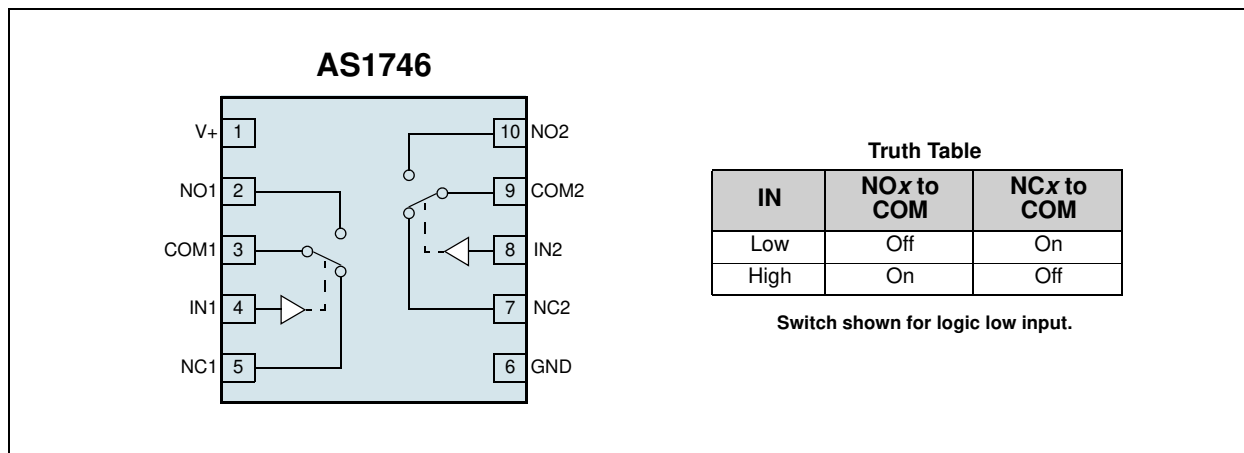
### 2 Key Features

- Single Supply Operation: +1.8V to +5.5V
- Normally Closed Switch  $R_{ON}$ : 0.45Ω (+2.7V Supply)
- Normally Open Switch  $R_{ON}$ : 0.55Ω (+2.7V Supply)
- $R_{ON}$  Matching Between Channels: 0.06Ω
- $R_{ON}$  Flatness Over Signal Range: 0.15Ω
- Supply Current: 50nA
- Rail-to-Rail Signal Handling
- 1.8V Logic Compatibility
- Low Crosstalk: -60dB (100kHz)
- High Off-Isolation: -64dB (100kHz)
- Total Harmonic Distortion: 0.025%
- Ultra-Low Leakage Currents: 1nA (@  $T_{AMB} = +25^{\circ}C$ )
- Package Types:
  - TDFN-10 (3x3mm)
  - WL-CSP-10

### 3 Applications

The device is ideal for audio headsets, MP3 players, power routing switches, relay replacements, audio and video signal routing, communications circuits, PCMCIA cards, mobile phones, MODEMs, and any battery-operated equipment.

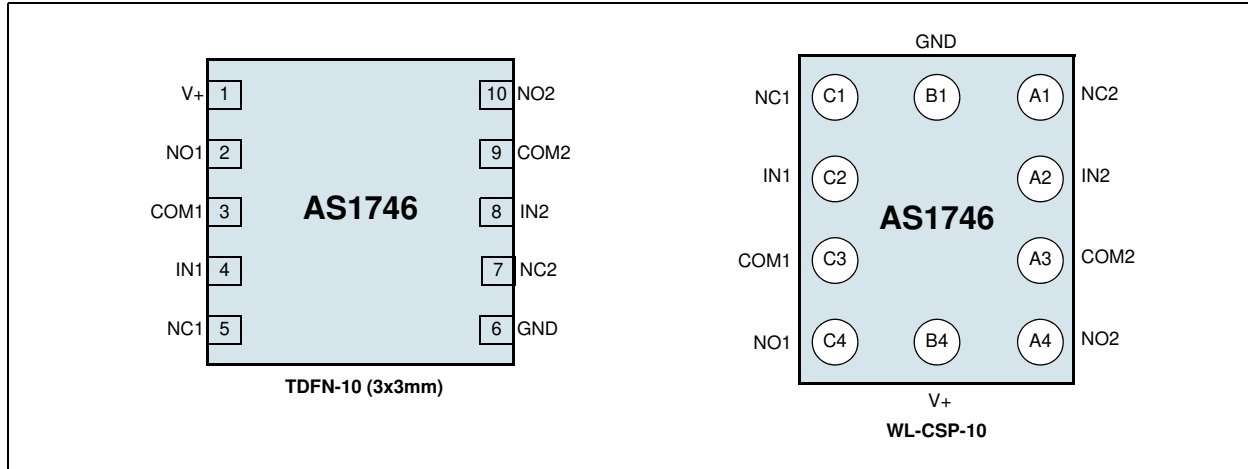
Figure 1. AS1746 - Block Diagram



## 4 Pinout

### Pin Assignments

Figure 2. Pin Assignments (Top View)



### Pin Descriptions

Table 1. Pin Descriptions

Pin Number	Pin Name	Description
See <a href="#">Figure 2</a>	V+	Positive Input Supply Voltage
	NO1	Normally Open Analog Switch 1
	COM1	Analog Switch 1 Common
	IN1	Switch 1 Digital Input
	NC1	Normally Closed Analog Switch 1
	GND	Ground
	NC2	Normally Closed Analog Switch 2
	IN2	Switch 2 Digital Input
	COM2	Analog Switch 2 Common
	NO2	Normally Open Analog Switch 2

## 5 Absolute Maximum Ratings

Stresses beyond those listed in [Table 2](#) may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in [Electrical Characteristics on page 4](#) is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Table 2. Absolute Maximum Ratings

Parameter	Min	Max	Units	Comments
V+, INx to GND	-0.3	+7	V	
COMx, NOx, NCx, to GND	-0.3	V+ + 0.3	V	COMx, NOx, NCx signals exceeding V+ or GND are internally clamped by diodes and forward-diode current must be limited to the maximum current rating.
COMx, NOx, NCx Continuous Current	-300	+300	mA	
COMx, NOx, NCx Peak Current	-400	+400	mA	Pulsed at 50% duty cycle
COMx, NOx, NCx Peak Current	-500	+500	mA	Pulsed at 10% duty cycle
Continuous Power Dissipation		444	mW	TAMB = +70°C
Electro-Static Discharge		2.5	kV	HBM Mil-Std883E 3015.7 methods
Latchup Immunity		250	mA	Class II, Level A
Operating Ambient Temperature Range	-40	+85	°C	
Storage Temperature Range	-65	+150	°C	
Package Body Temperature		+260	°C	The reflow peak soldering temperature (body temperature) specified is in accordance with IPC/JEDEC J-STD-020D "Moisture/Reflow Sensitivity Classification for Non-Hermetic Solid State Surface Mount Devices". The lead finish for Pb-free leaded packages is matte tin (100% Sn).

## 6 Electrical Characteristics

( $V_+ = +2.7V$  to  $+3.3V$ ,  $V_{IH} = +1.4V$ ,  $V_{IL} = +0.5V$ ,  $T_{AMB} = -40^\circ C$  to  $+85^\circ C$  (unless otherwise specified). Typical values are at  $+3V$  and  $+25^\circ C$ .)

Table 3. Electrical Characteristics

Symbol	Parameter <sup>1</sup>	Condition	Min	Typ	Max	Unit
<b>Analog Switch</b>						
$V_{NOx}, V_{NCx}, V_{COMx}$	Analog Signal Range		0		$V_+$	V
$R_{ON(NC)}$	NCx On-Resistance	$V_+ = 2.7V, I_{COMx} = 100mA, V_{NCx} = 0$ to $V_+, T_{AMB} = 25^\circ C$		0.3	0.45	$\Omega$
		$V_+ = 2.7V, I_{COMx} = 100mA, V_{NCx} = 0$ to $V_+$			0.5	
$R_{ON(NO)}$	NOx On-Resistance	$V_+ = 2.7V, I_{COMx} = 100mA, V_{NOx} = 0$ to $V_+, T_{AMB} = 25^\circ C$		0.35	0.55	$\Omega$
		$V_+ = 2.7V, I_{COMx} = 100mA, V_{NOx} = 0$ to $V_+$			0.6	
$\Delta R_{ON}$	On-Resistance Match Between Channels <sup>2</sup>	$V_+ = 2.7V, I_{COMx} = 100mA, V_{NCx}/V_{NOx} = 1.5V$		0.02	0.06	$\Omega$
$R_{FLAT(NC)}$	NCx On-Resistance Flatness <sup>3</sup>	$V_+ = 2.7V, I_{COMx} = 100mA, V_{NCx} = 0$ to $V_+$		0.06	0.15	$\Omega$
$R_{FLAT(NO)}$	NOx On-Resistance Flatness <sup>3</sup>	$V_+ = 2.7V, I_{COMx} = 100mA, V_{NOx} = 0$ to $V_+$		0.1	0.35	$\Omega$
$I_{NOxOFF}/I_{NCxOFF}$	NCx or NOx Off-Leakage Current <sup>4</sup>	$V_+ = 3.3V, V_{NOx}/V_{NCx} = 3V, 0.3V, V_{COMx} = 0.3V, 3V, T_{AMB} = 25^\circ C$	-1		1	nA
		$V_+ = 3.3V, V_{NOx}/V_{NCx} = 3V, 0.3V, V_{COMx} = 0.3V, 3V$	-10		10	nA
$I_{COMxON}$	COMx On-Leakage Current <sup>4</sup>	$V_+ = 3.3V, V_{NOx}/V_{NCx} = 3V, 0.3V$ or float, $V_{COMx} = 3V, 0.3V$ , or float, $T_{AMB} = 25^\circ C$	-2		2	nA
		$V_+ = 3.3V, V_{NOx}/V_{NCx} = 3V, 0.3V$ or float, $V_{COMx} = 3V, 0.3V$ , or float	-30		30	nA
<b>Dynamic Characteristics</b>						
$t_{ON}$	Turn On Time <sup>5</sup>	$V_+ = 2.7V, V_{NOx}/V_{NCx} = 1.5V, R_{LOAD} = 50\Omega, C_{LOAD} = 35pF, T_{AMB} = 25^\circ C$		30	50	ns
		$V_+ = 2.7V, V_{NOx}/V_{NCx} = 1.5V, R_{LOAD} = 50\Omega, C_{LOAD} = 35pF$ (see Figure 17 on page 10)			60	
$t_{OFF}$	Turn Off Time <sup>5</sup>	$V_+ = 2.7V, V_{NOx}/V_{NCx} = 1.5V, R_{LOAD} = 50\Omega, C_{LOAD} = 35pF, T_{AMB} = 25^\circ C$		20	30	ns
		$V_+ = 2.7V, V_{NOx}/V_{NCx} = 1.5V, R_{LOAD} = 50\Omega, C_{LOAD} = 35pF$ (see Figure 17 on page 10)			35	
$t_{BBM}$	Break-Before-Make Delay <sup>5</sup>	$V_+ = 2.7V, V_{NOx}/V_{NCx} = 1.5V, R_{LOAD} = 50\Omega, C_{LOAD} = 35pF$ (see Figure 18 on page 10)	2	15		ns
Q	Charge Injection	COMx = 0, $R_S = 0, C_{LOAD} = 1nF$ (see Figure 19 on page 10)		200		pC

Table 3. Electrical Characteristics (Continued)

Symbol	Parameter <sup>1</sup>	Condition	Min	Typ	Max	Unit
V <sub>ISO</sub>	Off-Isolation <sup>6</sup>	V <sub>COMx</sub> = 1V <sub>RMS</sub> , R <sub>LOAD</sub> = 50Ω, C <sub>LOAD</sub> = 5pF, f = 100kHz (see Figure 20 on page 11)		-64		dB
V <sub>XT</sub>	Crosstalk	V <sub>COMx</sub> = 1V <sub>RMS</sub> , R <sub>LOAD</sub> = 50Ω, C <sub>LOAD</sub> = 5pF, f = 100kHz (see Figure 20 on page 11)		-60		dB
THD	Total Harmonic Distortion	R <sub>LOAD</sub> = 600Ω, I <sub>Nx</sub> = 2VP-P, f = 20Hz to 20kHz		0.025		%
CNCXOFF	NCx Off-Capacitance	f = 1MHz (see Figure 21 on page 11)		84		pF
CNOXOFF	NOx Off-Capacitance	f = 1MHz (see Figure 21 on page 11)		37		pF
CNCXON	NCx On-Capacitance	f = 1MHz (see Figure 21 on page 11)		190		pF
CNOXON	NOx On-Capacitance	f = 1MHz (see Figure 21 on page 11)		150		pF
<b>Digital I/O</b>						
V <sub>IH</sub>	Input Logic High		1.4			V
V <sub>IL</sub>	Input Logic Low				0.5	V
I <sub>INx</sub>	I <sub>Nx</sub> Input Leakage Current	V <sub>INx</sub> = 0 or V+	-1		1	μA
<b>Power Supply</b>						
V+	Power Supply Range		1.8		5.5	V
I+	Supply Current	V+ = 5.5V; V <sub>INx</sub> = 0 or V+, T <sub>AMB</sub> = 25°C	-50		50	nA
		V+ = 5.5V; V <sub>INx</sub> = 0 or V+	-350		350	

1. The algebraic convention used in this data sheet is such that the most negative value is the minimum and the most positive value is the maximum.
2.  $\Delta R_{ON} = R_{ON(MAX)} - R_{ON(MIN)}$  between pins NC1 and NC2 or between pins NO1 and NO2.
3. Flatness is defined as the difference between the maximum and minimum value of R<sub>ON</sub> as measured over the specified analog signal ranges.
4. 100% tested.
5. Guaranteed by design.
6. Off-isolation = 20LOG<sub>10</sub> (V<sub>COM</sub>/V<sub>NO</sub>), V<sub>COM</sub> = output, V<sub>NO</sub> = input to off switch.

## 7 Typical Operating Characteristics

$T_{AMB} = +25^{\circ}\text{C}$ . Values measured in TDFN-10 (3x3mm) package.

Figure 3. NC ON-Resistance vs.  $V_{COM}$

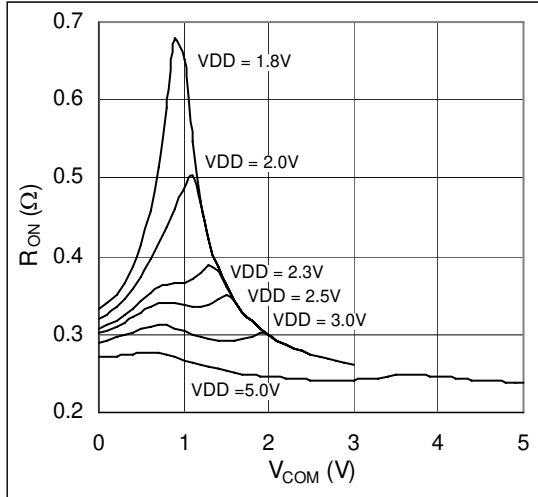


Figure 4. NO ON-Resistance vs.  $V_{COM}$

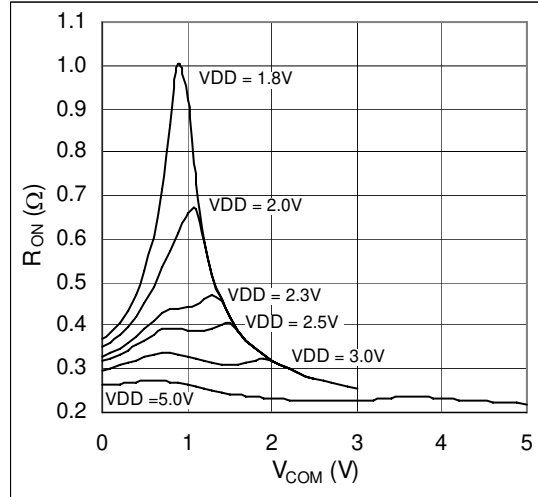


Figure 5. NC ON-Resistance vs.  $V_{COM}$ , 5V

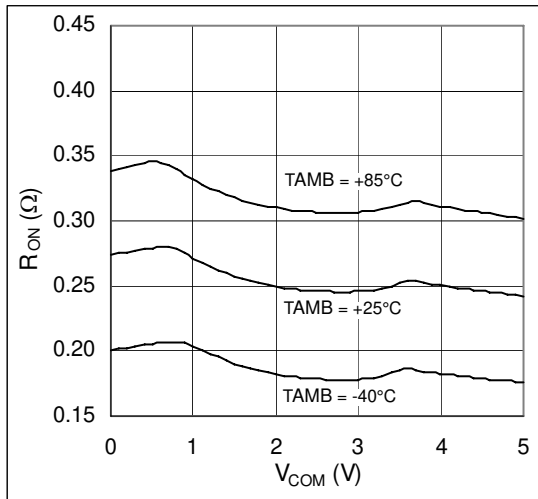


Figure 6. NO ON-Resistance vs.  $V_{COM}$ , 5V

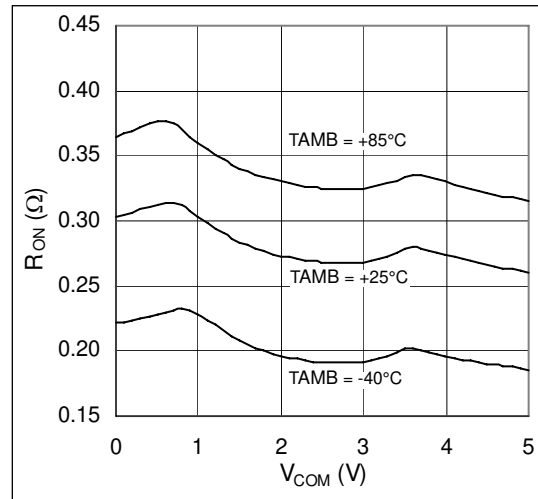


Figure 7. NC ON-Resistance vs.  $V_{COM}$ , 3V

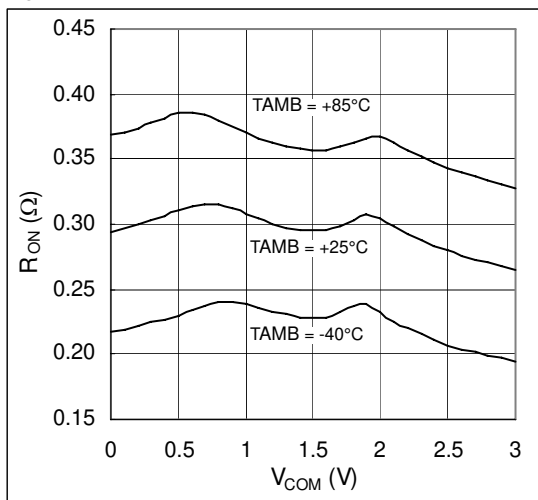


Figure 8. NO ON-Resistance vs.  $V_{COM}$ , 3V

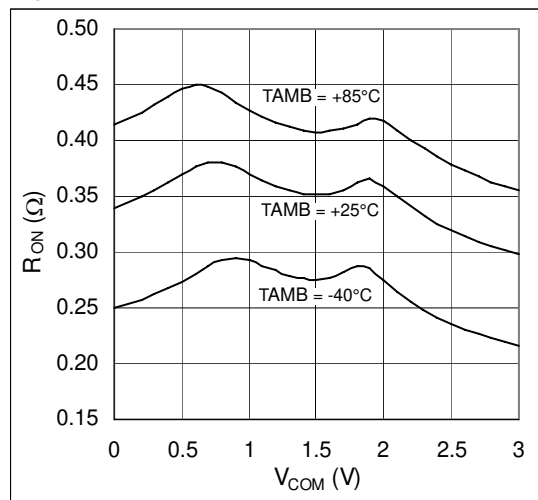


Figure 9. Turn-ON/OFF vs. Temperature,  $V_{DD} = 3V$

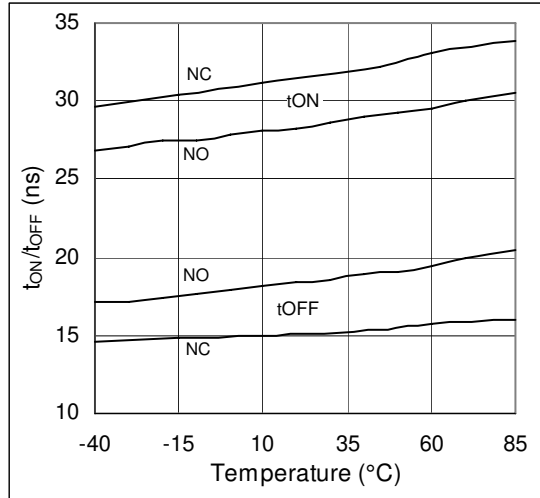


Figure 10. Turn-ON/OFF Times vs.  $V_{Supply}$

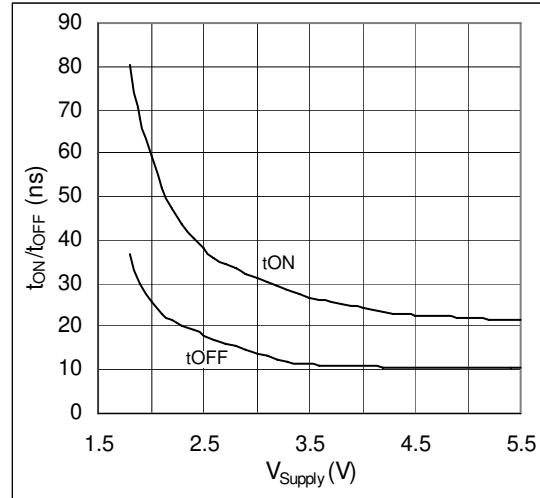


Figure 11. Logic Threshold Voltage vs. Supply Voltage

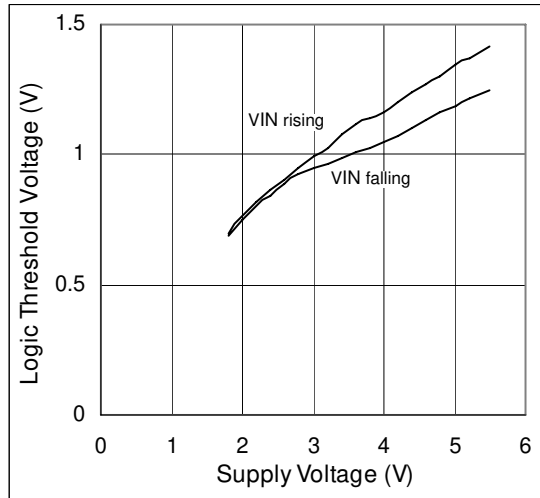


Figure 12. Charge Injection vs. COM Voltage

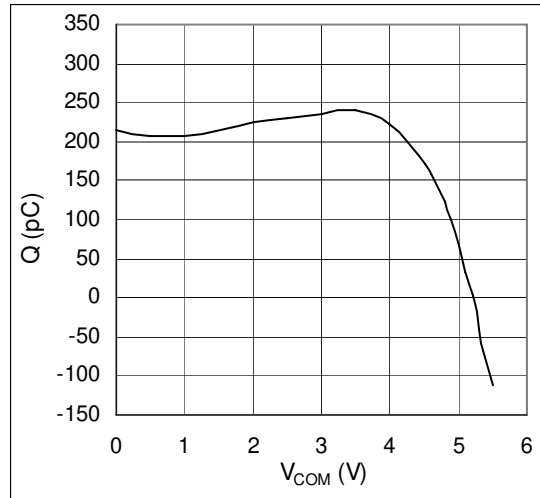


Figure 13. Frequency Response

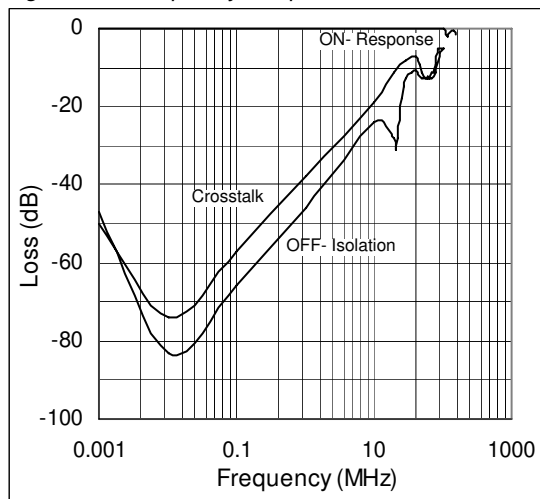
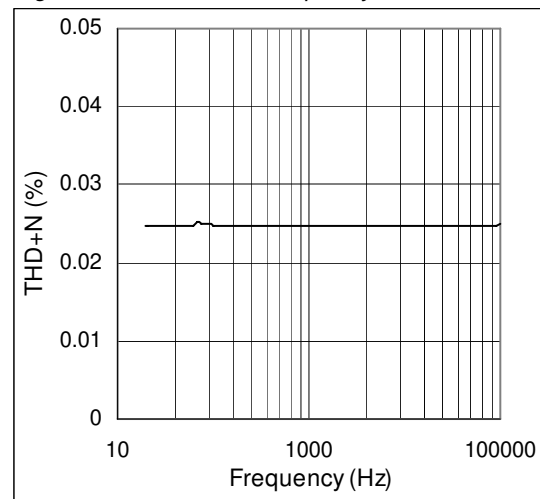


Figure 14. THD+N vs. Frequency

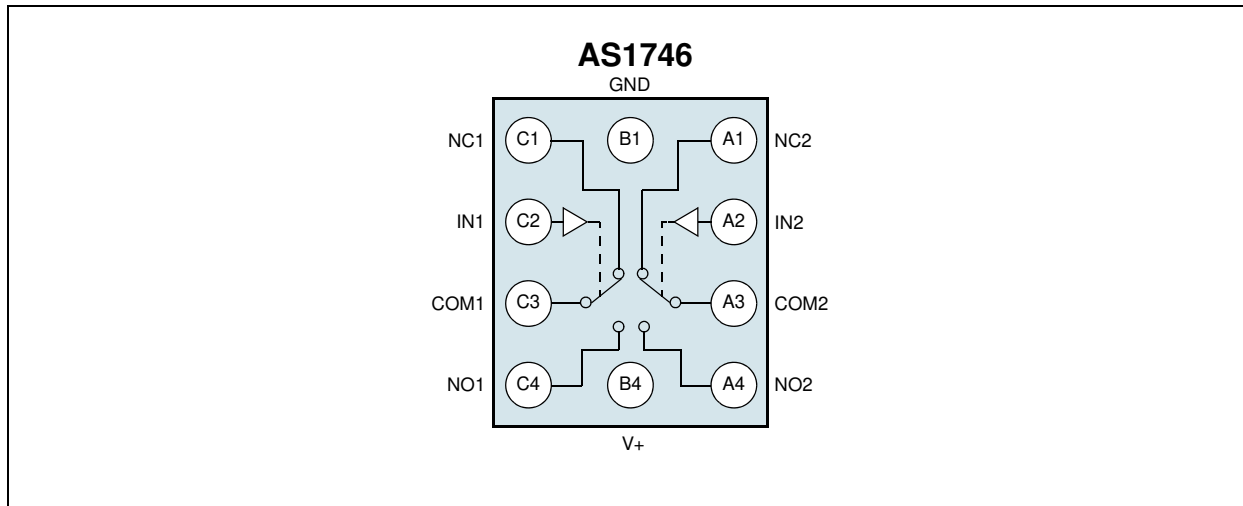


## 8 Detailed Description

The AS1746 is a low on-resistance, low-voltage, asymmetrical dual-SPDT analog switch designed to operate from a single +1.8 to +5.5V supply. The device is fully specified for nominal 3V applications and features break-before-make switching and fast switching speeds ( $t_{ON} = 60\text{ns}$  max,  $t_{OFF} = 35\text{ns}$  max).

The device provides  $0.5\Omega$  (max)  $R_{ON}$  for its NC switch, and  $0.6\Omega$  (max)  $R_{ON}$  for its NO switch for applications that require asymmetrical loads.

Figure 15. AS1746 - Block Diagram – WL-CSP-10





## 9 Application Information

### Digital Control Inputs

The AS1746 logic inputs can handle up to +5.5V regardless of the supply voltage. For example, with a +3.3V supply, IN<sub>x</sub> may be driven low to GND and high to 5.5V. Driving IN<sub>x</sub> rail-to-rail minimizes power consumption.

### Analog Signal Levels

Analog signals that range over the entire supply voltage (V<sub>+</sub> to GND) are passed with very little change in R<sub>ON</sub> (see [Typical Operating Characteristics on page 6](#)). The switches are bi-directional, so the NO<sub>x</sub>, NC<sub>x</sub>, and COM<sub>x</sub> pins can be used as inputs or outputs.

### Power Supply Sequencing

Proper power supply sequencing is recommended for all CMOS devices. The recommended sequence is as follows:

1. V<sub>+</sub>
2. NO<sub>x</sub>, NC<sub>x</sub>, COM<sub>x</sub>

Always apply V<sub>+</sub> before applying analog signals, especially if the analog signal is not current limited. If this sequencing is not possible, and if the analog inputs are not current limited to <20mA, add a small signal protection diode (D1) as shown in [Figure 16](#).

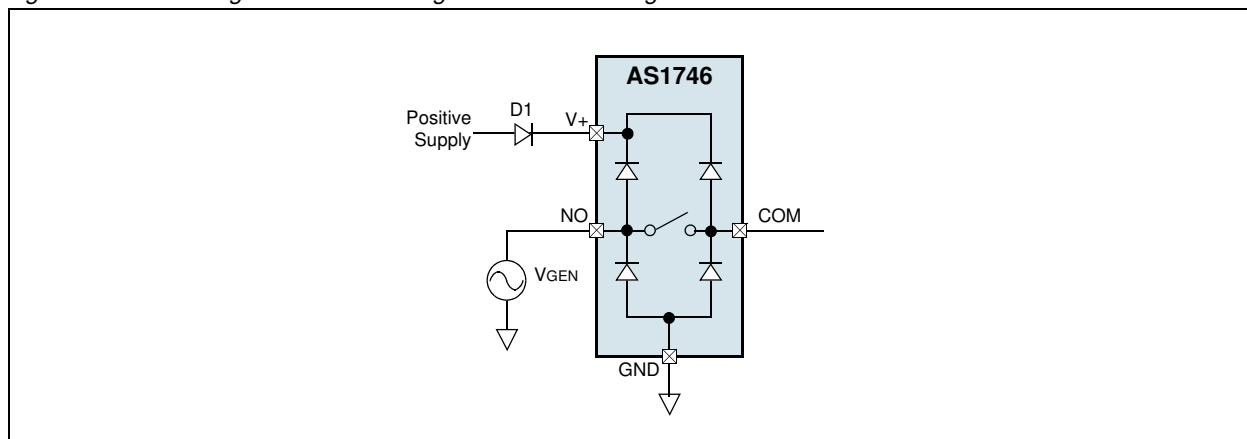
### Overvoltage Protection

Using a protection diode will reduce the analog range to a diode voltage drop (approximately 0.7V) below V<sub>+</sub> (for D1). R<sub>ON</sub> will increase slightly at low supply voltages.

**Caution:** The maximum supply voltage (V<sub>+</sub>) must not exceed +7V. Do not exceed the absolute maximum ratings because stresses beyond the ratings listed in [Absolute Maximum Ratings on page 3](#) may cause permanent damage to the device.

**Note:** Protection diode D1 can also protect the device from some overvoltage conditions.

Figure 16. Overvoltage Protections using 2 External Blocking Diodes



**Note:** No damage will result to the circuit shown in [Figure 16](#) if the supply voltage is below the absolute maximum rating applied to an analog signal pin (NO<sub>x</sub>, NC<sub>x</sub>, or COM<sub>x</sub>).

## Test Circuits and Timing Diagrams

Figure 17. Switching Time

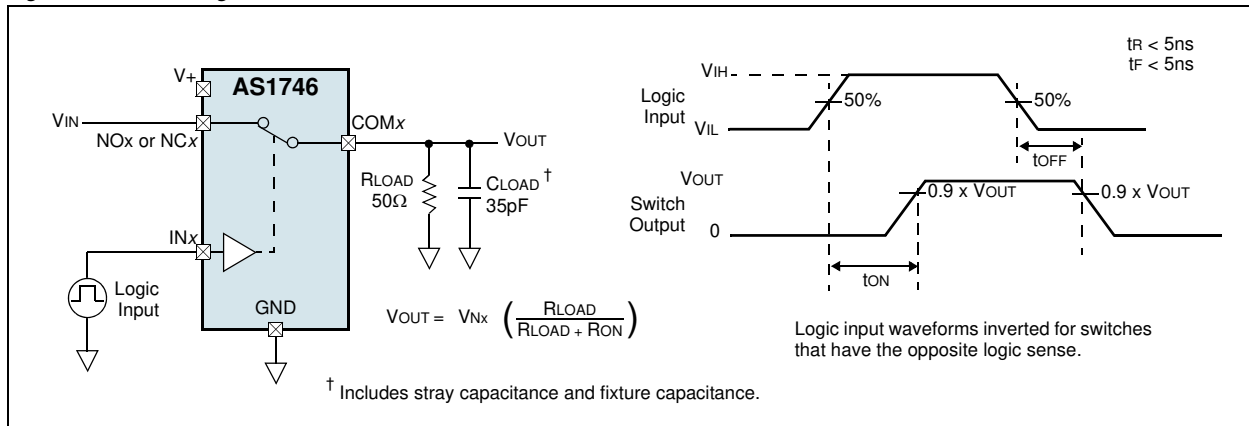


Figure 18. Break-Before-Make Interval

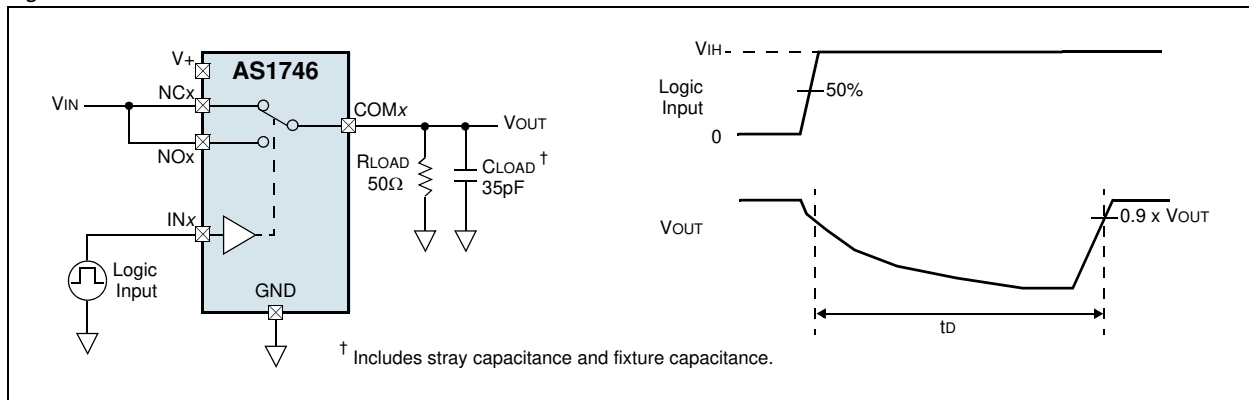


Figure 19. Charge Injection

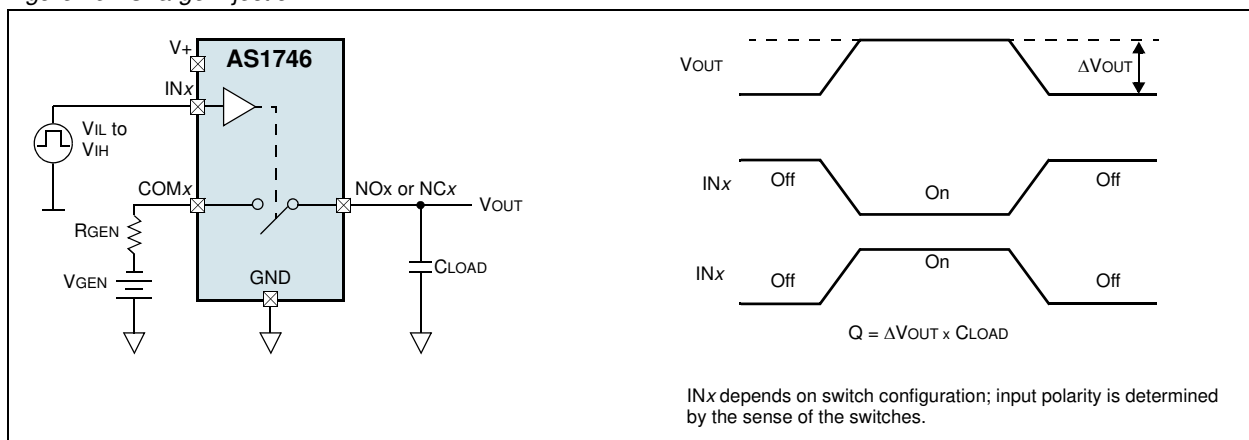
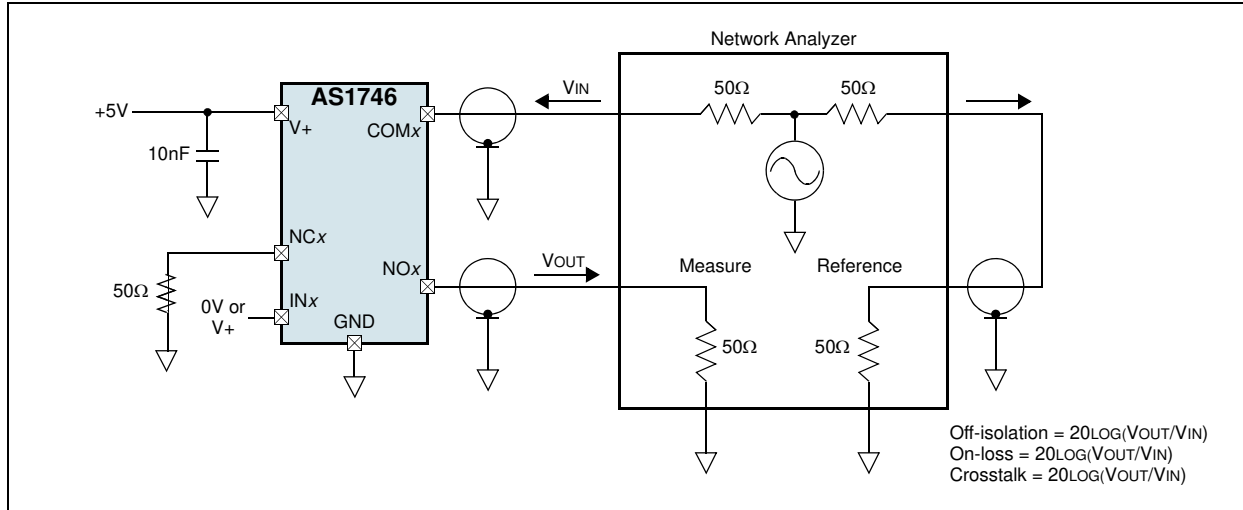


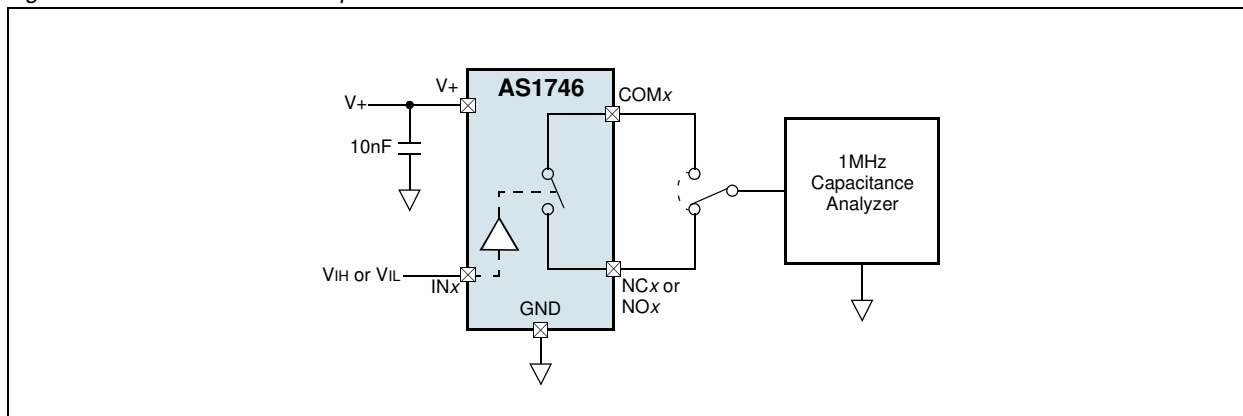
Figure 20. On-Loss, Off-Isolation, Crosstalk



**Notes:**

1. Measurements are standardized against short-circuit at all terminals.
2. Off-isolation is measured between COMx and the off NCx/NOx terminal of each switch.
3. Crosstalk is measured from one channel to all other channels.
4. Signal direction through the switch is reversed; worst values are recorded.

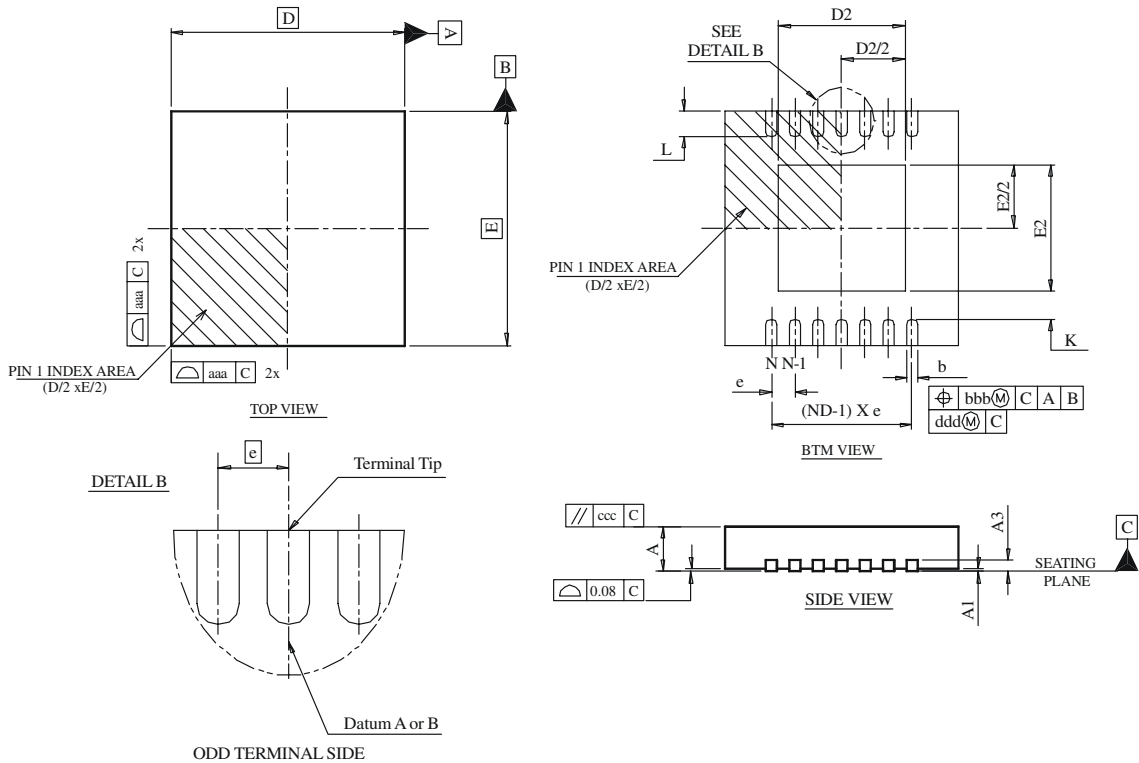
Figure 21. Channel On- Off-Capacitance



## 10 Package Drawings and Markings

The device is available in a TDFN-10 (3x3mm) package and a WL-CSP-10 package.

Figure 22. TDFN-10 (3x3mm) Package



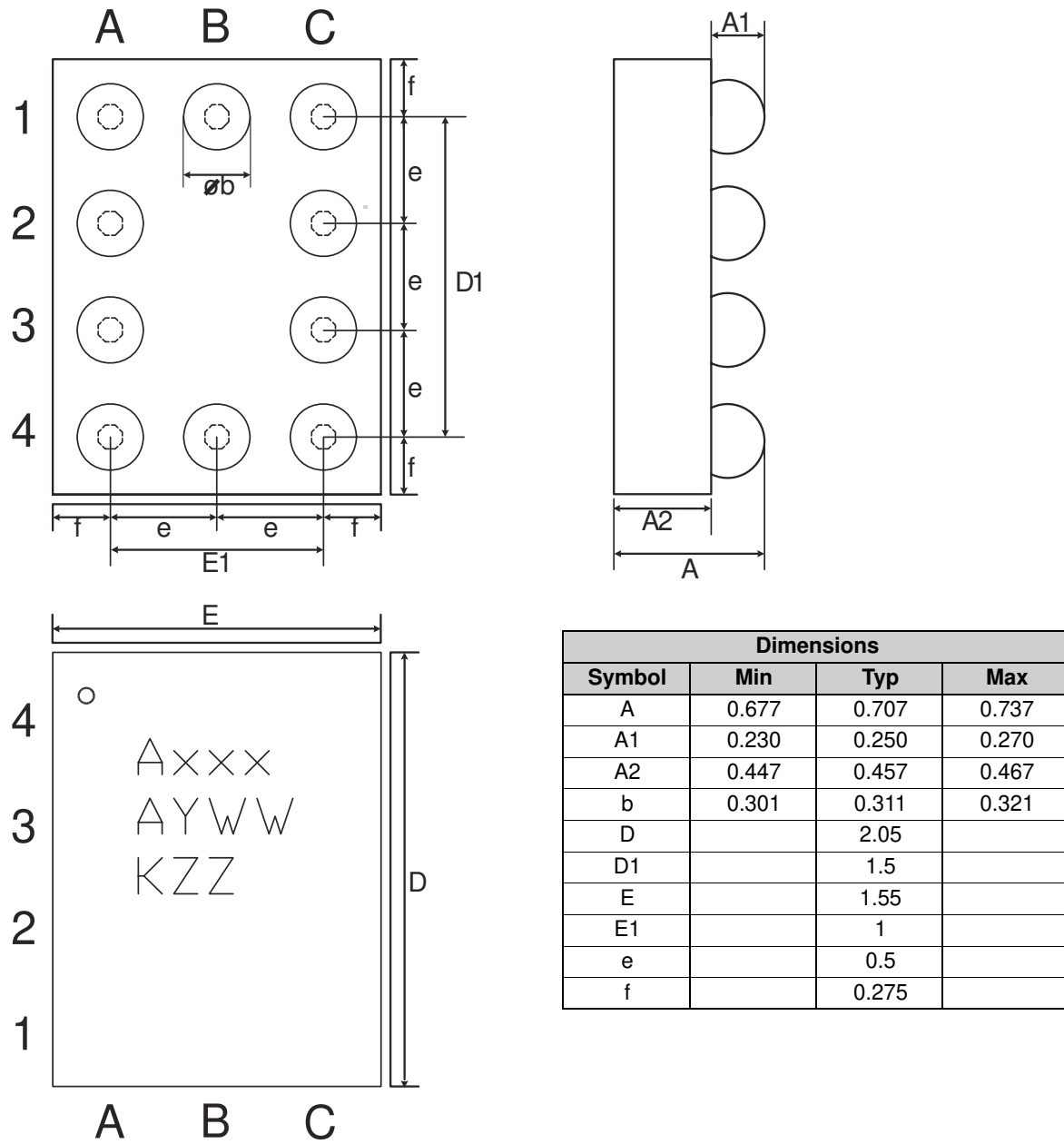
Symbol	Min	Typ	Max	Notes
A	0.70	0.75	0.80	1, 2
A1	0.00	0.02	0.05	1, 2
A3		0.20 REF		1, 2
L	0.30	0.40	0.50	1, 2
aaa		0.15		1, 2
bbb		0.10		1, 2
ccc		0.10		1, 2
ddd		0.05		1, 2
eee		0.08		1, 2
ggg		0.10		1, 2

Symbol	Min	Typ	Max	Notes
D BSC		3.00		1, 2
E BSC		3.00		1, 2
D2	2.20		2.70	1, 2
E2	1.40		1.75	1, 2
$\theta$	0°		14°	1, 2
K	0.20			1, 2
b	0.18	0.25	0.30	1, 2, 5
e		0.50		
N		10		1, 2
ND		5		1, 2, 5

### Notes:

- Figure 22 is shown for illustration only.
- All dimensions are in millimeters; angles in degrees.
- Dimensioning and tolerancing conform to ASME Y14.5 M-1994.
- N is the total number of terminals.
- The terminal #1 identifier and terminal numbering convention shall conform to JEDEC 95-1, SPP-012. Details of terminal #1 identifier are optional, but must be located within the zone indicated. The terminal #1 identifier may be either a mold or marked feature.
- Dimension b applies to metallized terminal and is measured between 0.15mm and 0.30mm from the terminal tip.
- ND refers to the maximum number of terminals on side D.
- Unilateral coplanarity zone applies to the exposed heat sink slug as well as the terminals

Figure 23. WL-CSP-10 Package



## 11 Ordering Information

The device is available as the standard products shown in [Table 4](#).

Table 4. Ordering Information

Ordering Code	Marking	Description	Delivery Form	Package
AS1746-BTDR	ASK8	0.5/0.6Ω, Low-Voltage, Dual SPDT Analog Switch	Tray	TDFN-10 (3x3mm)
AS1746-BTDT	ASK8	0.5/0.6Ω, Low-Voltage, Dual SPDT Analog Switch	Tape and Reel	TDFN-10 (3x3mm)
AS1746-BWLT*	ASK7	0.5/0.6Ω, Low-Voltage, Dual SPDT Analog Switch	Tape and Reel	WL-CSP-10

\* Available on request.

**Note:** All products are RoHS compliant and Pb-free.

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