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.

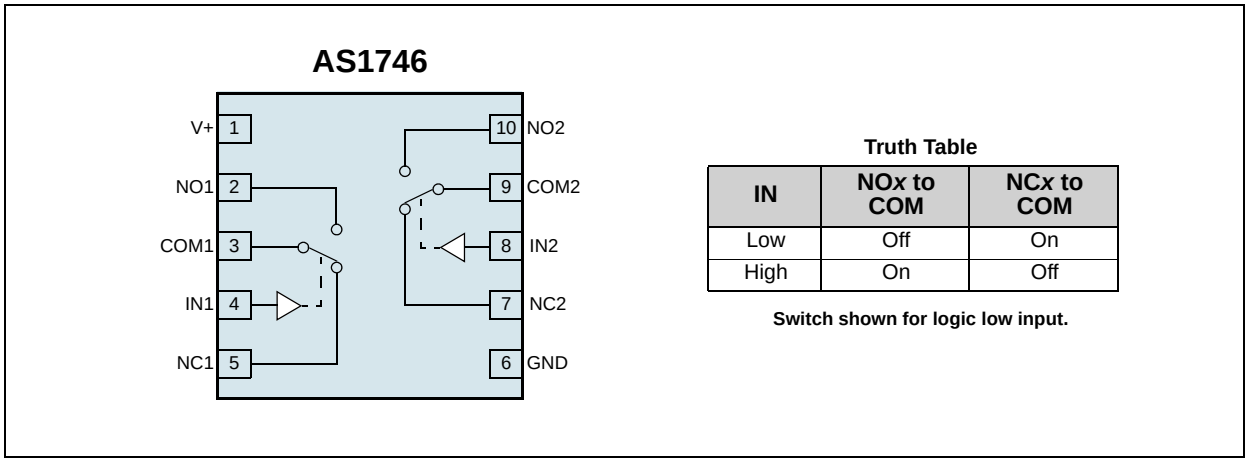
2 Key Features

- 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} = +25ºC)
- 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



Truth Table

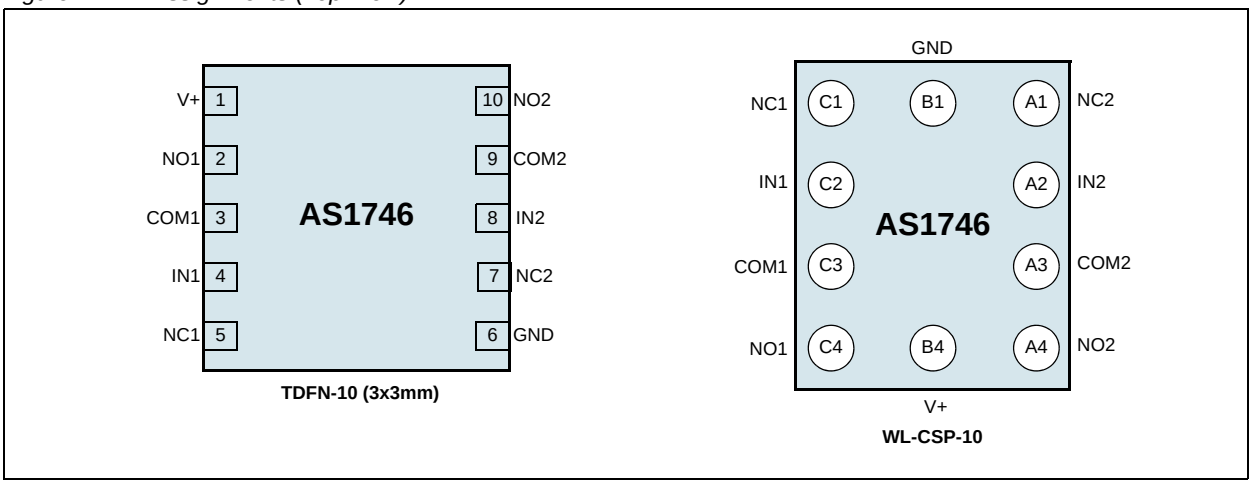
IN	NO*x* to COM	NC*x* to COM
Low	Off	On
High	On	Off

Switch shown for logic low input.

4 Pinout

Pin Assignments

Figure 2. Pin Assignments (Top View)



Pin Descriptions

Table 1. Pin Descriptions

Pin Number	Pin Name	Description
See Figure 2	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+, IN*x* to GND	-0.3	+7	V	
COM*x*, NO*x*, NC*x*, to GND	-0.3	V+ + 0.3	V	COM*x*, NO*x*, NC*x* signals exceeding V+ or GND are internally clamped by diodes and forward-diode current must be limited to the maximum current rating.
COM*x*, NO*x*, NC*x* Continuous Current	-300	+300	mA	
COM*x*, NO*x*, NC*x* Peak Current	-400	+400	mA	Pulsed at 50% duty cycle
COM*x*, NO*x*, NC*x* Peak Current	-500	+500	mA	Pulsed at 10% duty cycle
Continuous Power Dissipation		444	mW	T_{AMB} = +70ºC
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	ºC	
Storage Temperature Range	-65	+150	ºC	
Package Body Temperature		+260	ºC	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°C to +85°C (unless otherwise specified). Typical values are at +3V and +25°C.

Table 3. Electrical Characteristics

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

Table 3. Electrical Characteristics (Continued)

Symbol	Parameter [1]	Condition	Min	Typ	Max	Unit
V_{ISO}	Off-Isolation [6]	V_{COMx} = 1V_{RMS}, R_{LOAD} = 50Ω, C_{LOAD} = 5pF, f = 100kHz (see Figure 20 on page 11)		-64		dB
V_{XT}	Crosstalk	V_{COMx} = 1V_{RMS}, R_{LOAD} = 50Ω, C_{LOAD} = 5pF, f = 100kHz (see Figure 20 on page 11)		-60		dB
THD	Total Harmonic Distortion	R_{LOAD} = 600Ω, IN*x* = *2V_{P-P}*, f = 20Hz to 20kHz		0.025		%
C_{NCXOFF}	NC*x* Off-Capacitance	f = 1MHz (see Figure 21 on page 11)		84		pF
C_{NOXOFF}	NO*x* Off-Capacitance	f = 1MHz (see Figure 21 on page 11)		37		pF
C_{NCXON}	NC*x* On-Capacitance	f = 1MHz (see Figure 21 on page 11)		190		pF
C_{NOXON}	NO*x* On-Capacitance	f = 1MHz (see Figure 21 on page 11)		150		pF
Digital I/O						
V_{IH}	Input Logic High		1.4			V
V_{IL}	Input Logic Low				0.5	V
I_{INx}	IN*x* Input Leakage Current	V_{INx} = 0 or V+	-1		1	µA
Power Supply						
V+	Power Supply Range		1.8		5.5	V
I+	Supply Current	V+ = 5.5V; V_{INX} = 0 or V+, *T_{AMB} = 25℃*	-50		50	nA
		V+ = 5.5V; V_{INX} = 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. ΔR_{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_{ON} as measured over the specified analog signal ranges.
4. 100% tested.
5. Guaranteed by design.
6. Off-isolation = 20_{LOG10} (V_{COM}/V_{NO}), V_{COM} = output, V_{NO} = input to off switch.

7 Typical Operating Characteristics

TAMB = +25ºC. Values measured in TDFN-10 (3x3mm) package.

Figure 3. NC ON-Resistance vs. VCOM

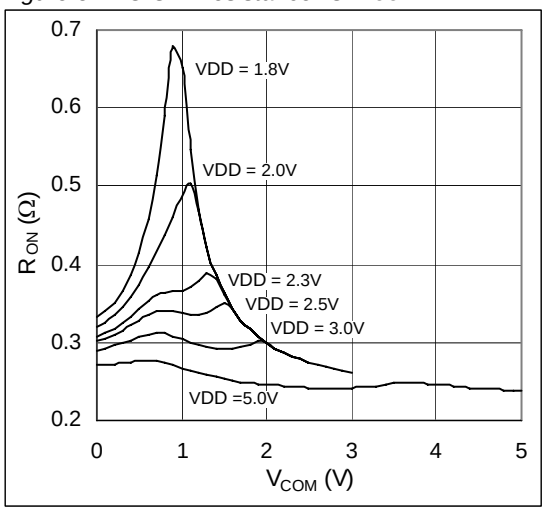


Figure 4. NO ON-Resistance vs. VCOM

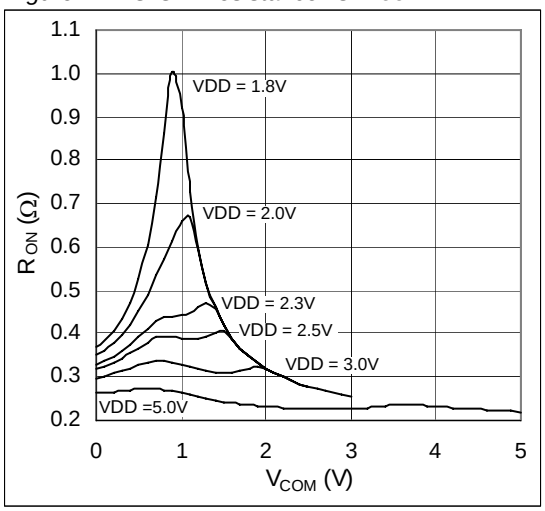


Figure 5. NC ON-Resistance vs. VCOM, 5V

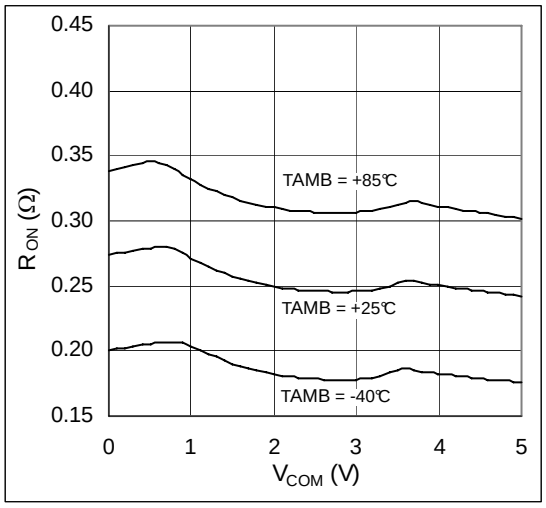


Figure 6. NO ON-Resistance vs. VCOM, 5V

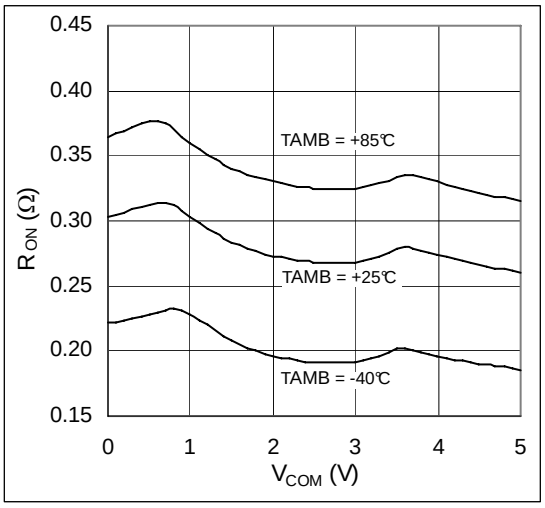


Figure 7. NC ON-Resistance vs. VCOM, 3V

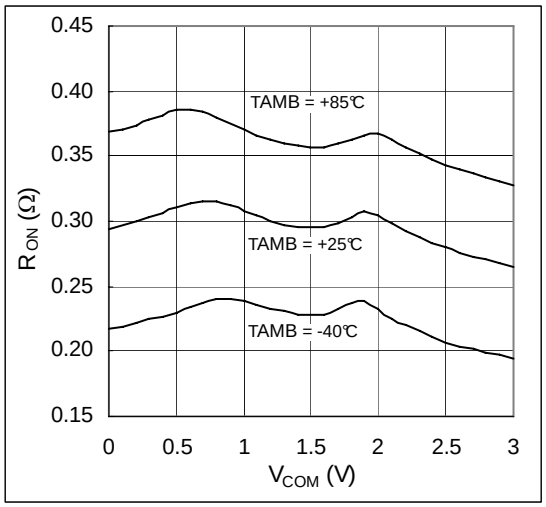


Figure 8. NO ON-Resistance vs. VCOM, 3V

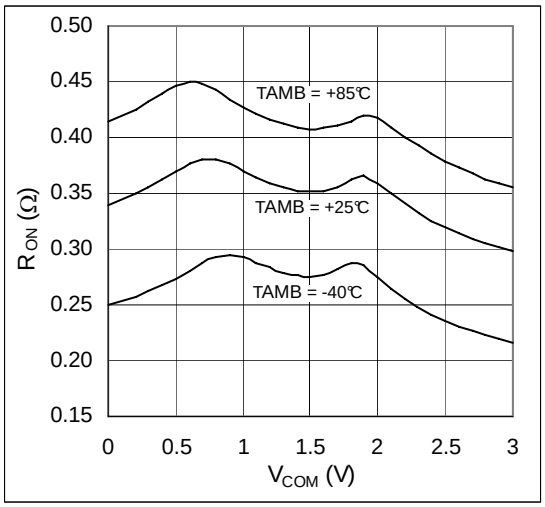


Figure 9. Turn-ON/OFF vs. Temperature, V_{DD} = 3V

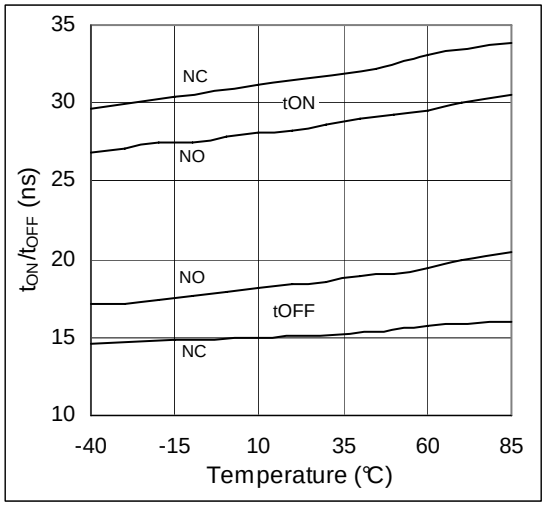


Figure 10. Turn-ON/OFF Times vs. V_{Supply}

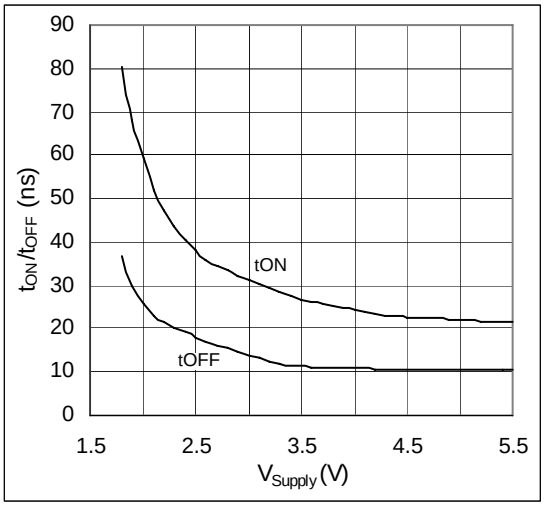


Figure 11. Logic Threshold Voltage vs. Supply Voltage

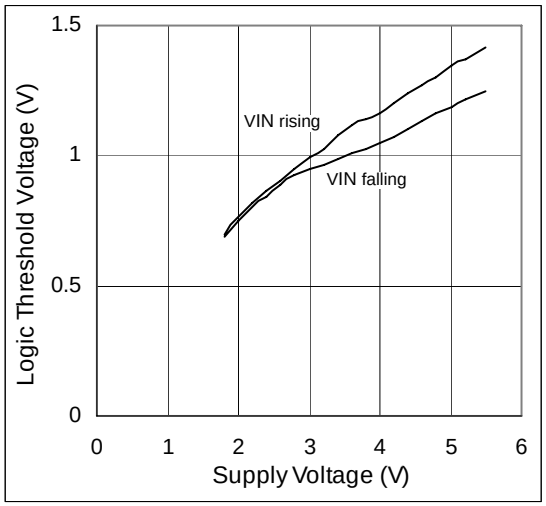


Figure 12. Charge Injection vs. COM Voltage

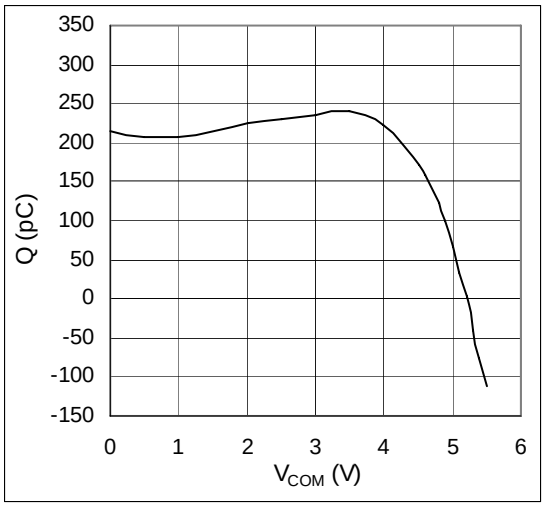


Figure 13. Frequency Response

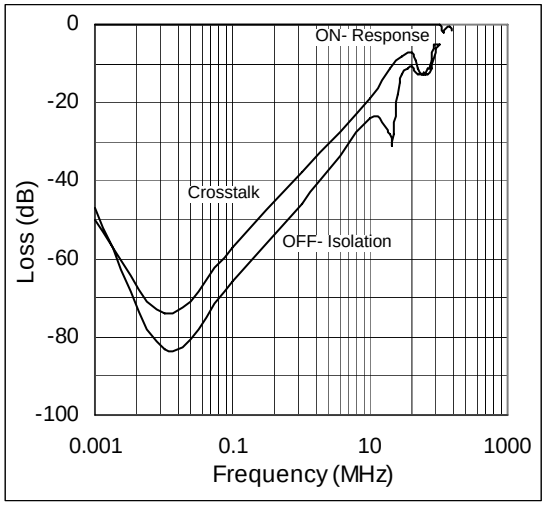
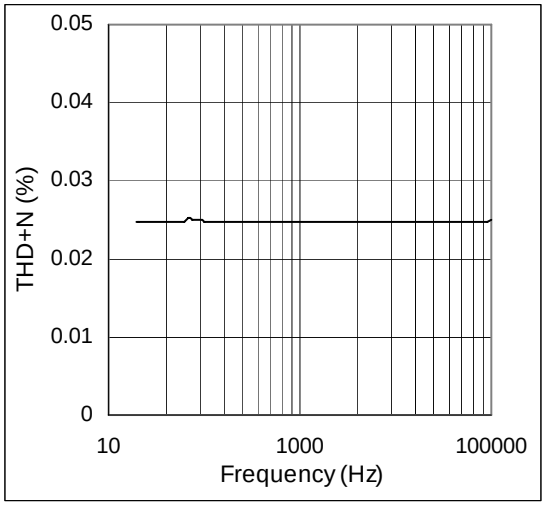


Figure 14. THD+N vs. Frequency

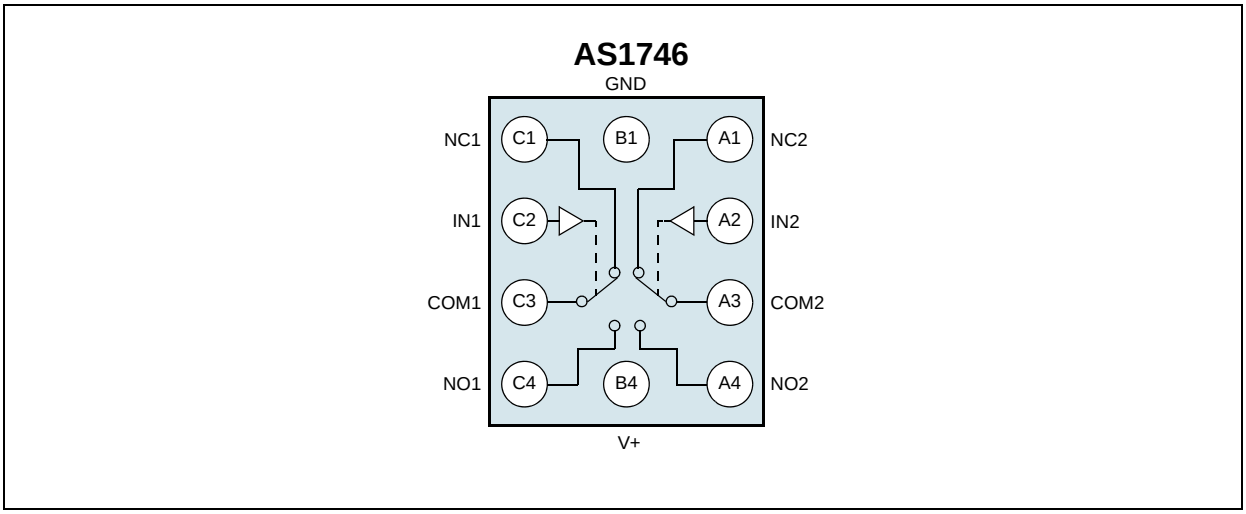


8 Detailed Description

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} = 60ns max, t_{OFF} = 35ns max).

The device provides 0.5Ω (max) R_{ON} for its NC switch, and 0.6Ω (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*x* may be driven low to GND and high to 5.5V. Driving IN*x* rail-to-rail minimizes power consumption.

Analog Signal Levels

Analog signals that range over the entire supply voltage (V+ to GND) are passed with very little change in RON (see Typical Operating Characteristics on page 6). The switches are bi-directional, so the NO*x*, NC*x*, and COM*x* 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+
2. NO*x,* NC*x,* COM*x*

Always apply V+ 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.

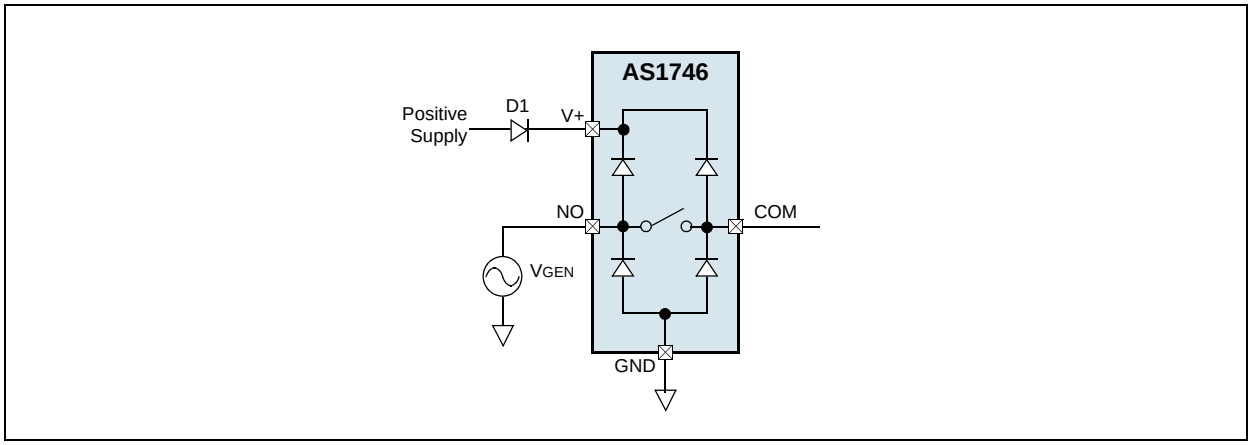
Overvoltage Protection

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

Caution: The maximum supply voltage (V+) 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*x,* NC*x,* or COM*x*).

Test Circuits and Timing Diagrams

Figure 17. Switching Time

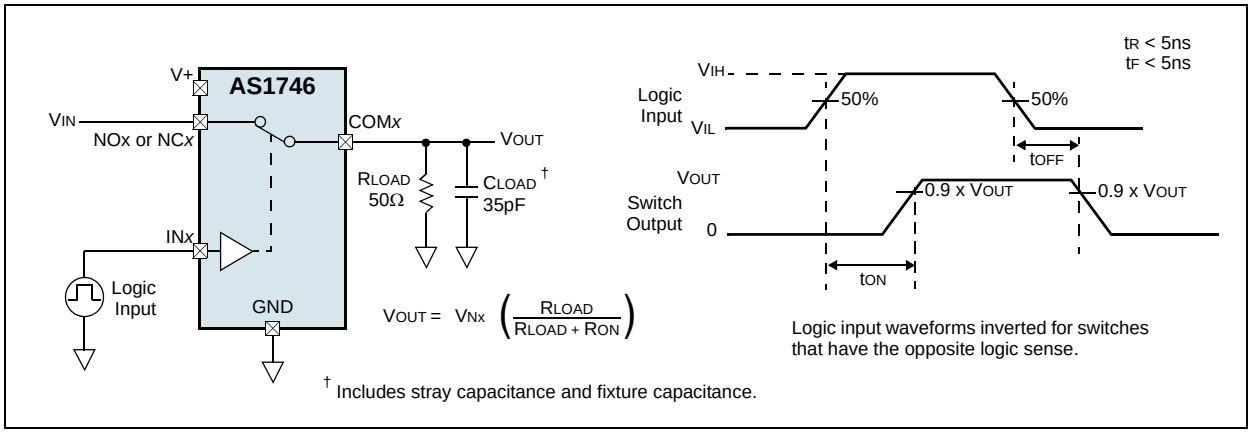


Figure 18. Break-Before-Make Interval

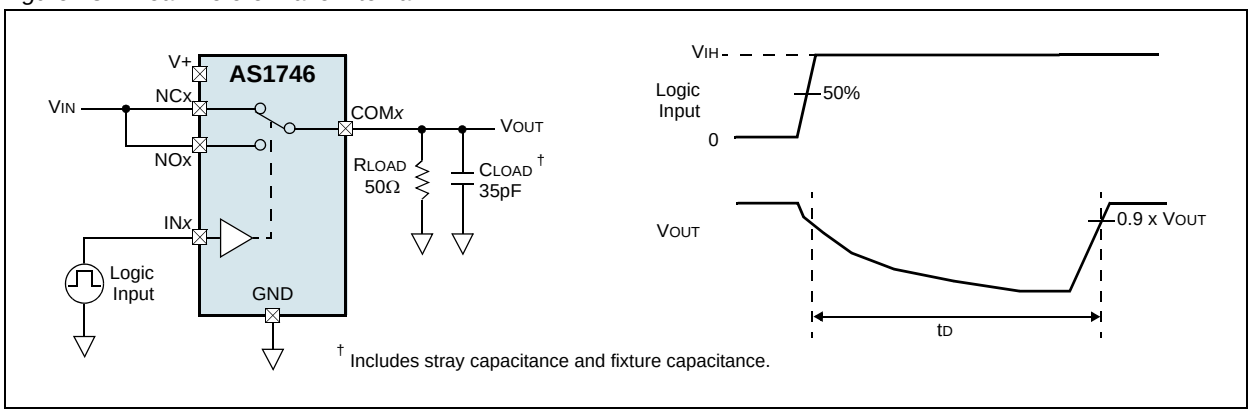


Figure 19. Charge Injection

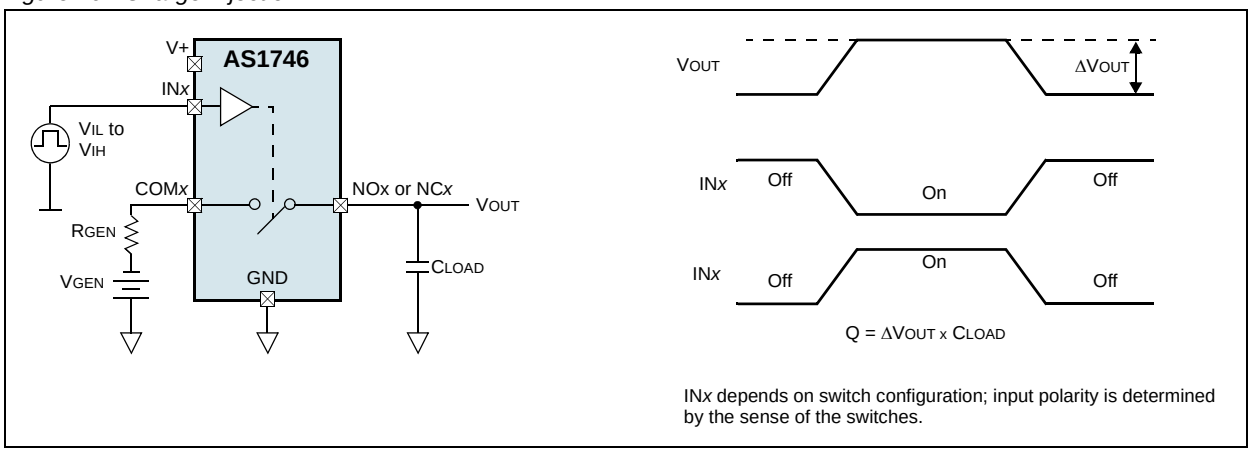
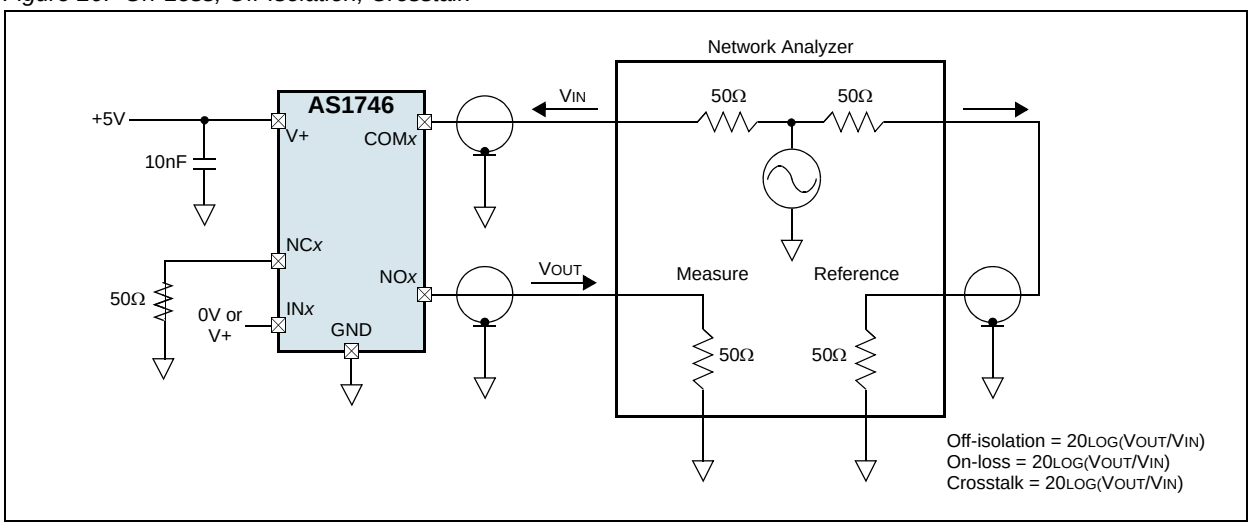


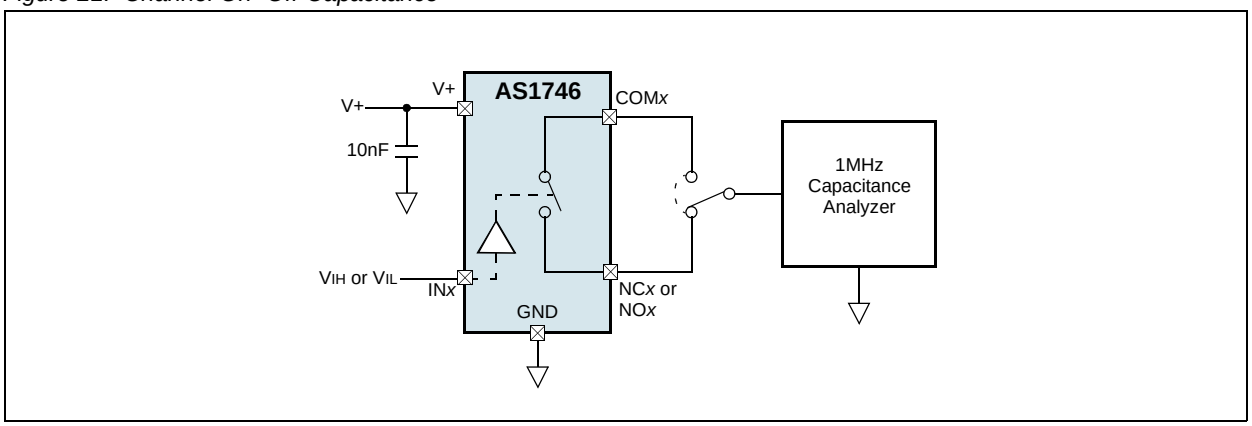
Figure 20. On-Loss, Off-Isolation, Crosstalk



Notes:

1. Measurements are standardized against short-circuit at all terminals.
2. Off-isolation is measured between COM*x* and the off NC*x*/NO*x* 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.

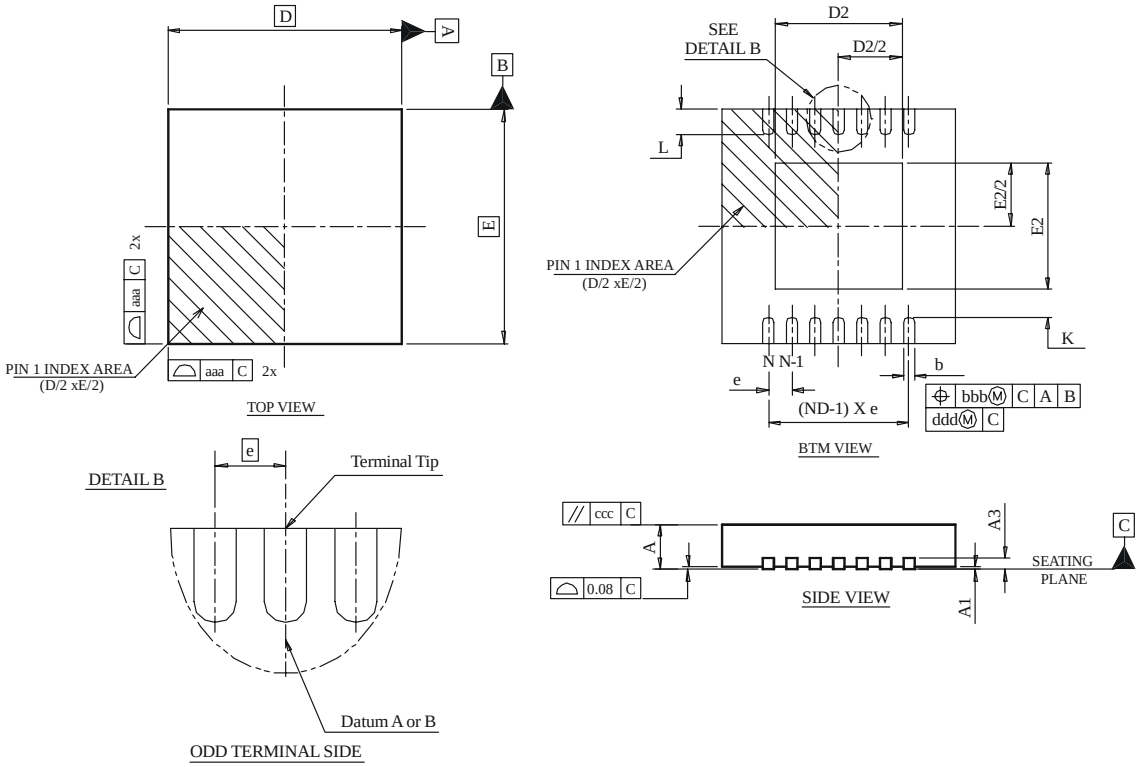
Figure 21. Channel On- Off-Capacitance



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) Packagee



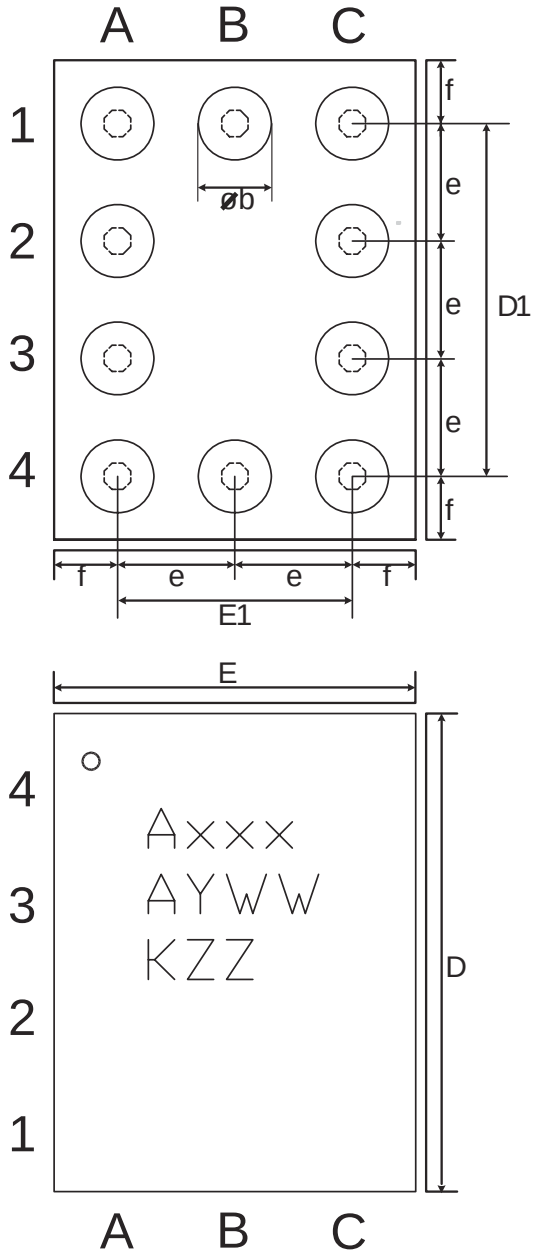
Symbol	Min	Typ	Max	Notes
A	0.70	0.75	0.80	1, 2
A1	0.00	0.02	0.05	1, 2
A3		0.20 REF		1, 2
L	0.30	0.40	0.50	1, 2
aaa		0.15		1, 2
bbb		0.10		1, 2
ccc		0.10		1, 2
ddd		0.05		1, 2
eee		0.08		1, 2
ggg		0.10		1, 2

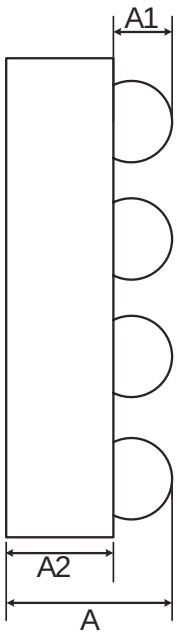
Symbol	Min	Typ	Max	Notes
D BSC		3.00		1, 2
E BSC		3.00		1, 2
D2	2.20		2.70	1, 2
E2	1.40		1.75	1, 2
θ	0º		14º	1, 2
K	0.20			1, 2
b	0.18	0.25	0.30	1, 2, 5
e		0.50		
N		10		1, 2
ND		5		1, 2, 5

Notes:

1. Figure 22 is shown for illustration only.
2. All dimensions are in millimeters; angles in degrees.
3. Dimensioning and tolerancing conform to *ASME Y14.5 M-1994*.
4. N is the total number of terminals.
5. 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.
6. Dimension b applies to metallized terminal and is measured between 0.15mm and 0.30mm from the terminal tip.
7. ND refers to the maximum number of terminals on side D.
8. Unilateral coplanarity zone applies to the exposed heat sink slug as well as the terminals

Figure 23. WL-CSP-10 Package





Dimensions			
Symbol	**Min**	**Typ**	**Max**
A	0.677	0.707	0.737
A1	0.230	0.250	0.270
A2	0.447	0.457	0.467
b	0.301	0.311	0.321
D		2.05	
D1		1.5	
E		1.55	
E1		1	
e		0.5	
f		0.275	

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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