19-3797; Rev 2; 1/07

MAXIM

High-/Full-Speed USB 2.0 Switches

General Description

The MAX4906/MAX4906F/MAX4907/MAX4907F analog switches combine the low on-capacitance (C_{ON}) and low on-resistance (R_{ON}) necessary for high-performance switching applications. These devices are designed for USB 2.0 high-speed applications at 480Mbps. These switches will also handle all the requirements for USB low- and full-speed signaling.

The MAX4906/MAX4906F feature two single-pole/double-throw (SPDT) switches, and the MAX4907/MAX4907F feature two single-pole/single-throw switches (SPST). The MAX4907/MAX4907F have a low 7Ω (max) on-resistance and 7pF (max) on-capacitance. These devices are fully specified to operate from a single +3.0V to +3.6V power supply and are protected against a +5.5V short to COM1 and COM2. This feature makes them fully compliant with the USB 2.0 specification of +5.5V fault protection. These devices feature a low threshold voltage and a +1.4V V_{IH}, permitting them to be used with low-voltage logic. The MAX4906/MAX4906F/MAX4907/MAX4907F operate at 300µA (max) quiescent current and feature a shutdown input to reduce the quiescent current to less than 2µA (max).

The MAX4906/MAX4906F/MAX4907/MAX4907F are available in space-saving, 2mm x 2mm µDFN packages and operate over a -40°C to +85°C temperature range.

Applications

Cell Phones
PDAs
Digital Still Cameras
GPS
Notebook Computers
Relay Replacements
USB Switching
Ethernet Switching
Video Switching
Bus Switches
T3/E3 Switches for Redundancy Protection

Features

- **Fully Specified for a Single +3.0V to +3.6V Power-Supply Voltage**
- **Low 4Ω (typ), 7Ω (max) On-Resistance (R_{ON})**
- **MAX4907/MAX4907F Ultra-Low 4pF (typ), 7pF (max) On-Capacitance (C_{ON})**
- **-3dB Bandwidth: 1GHz (typ)**
- **Low Bit-to-Bit Skew ≤ 100ps**
- **Shutdown Input Reduces Power Consumption to 2µA (max)**
- **3.3V, 1.8V, and 1.4V Logic Compatible**
- **COM_ Analog Inputs Fault Protected Against Shorts to USB Supply Rail Up to +5.5V**
- **Space-Saving Packages**
  8-Pin and 10-Pin, 2mm x 2mm µDFN Packages

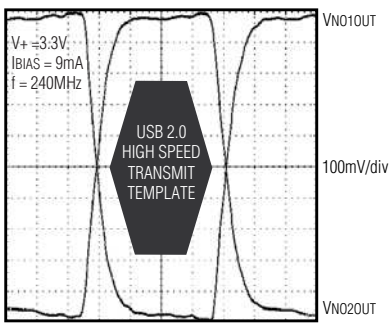
Ordering Information

PART	PIN-PACKAGE	PKG CODE
MAX4906ELB	10 µDFN	L1022-1
MAX4906FELB	10 µDFN	L1022-1
MAX4907ELA	8 µDFN	L822-1
MAX4907FELA	8 µDFN	L822-1

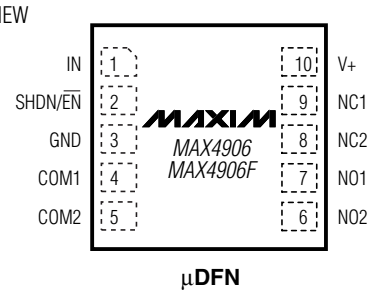
Note: *All devices operate over the -40°C to +85°C operating temperature range.*

Selector Guide appears at end of data sheet.

Typical Operating Characteristics



Pin Configurations



µDFN

Pin Configurations continued at end of data sheet.

For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at 1-888-629-4642, or visit Maxim's website at www.maxim-ic.com.

ABSOLUTE MAXIMUM RATINGS

Voltages Referenced to GND
V+ .....-0.3V to +4V
IN, SHDN, SHDN/$\overline{EN}$ (Note 1) .....-0.3V to (V+ + 0.3V)
COM_, NO_, NC_ .....-0.5V to +5.5V
Continuous Current (COM_ to NO_/NC_) .....±120mA
Peak Current, (COM_ to NO_/NC_)
(pulsed at 1ms 10% duty cycle).....±240mA

Continuous Power Dissipation (T_A = +70°C)
8-Pin µDFN (derate 5.0mW/°C above +70°C) 400mW
10-Pin µDFN (derate 5.3mW/°C above +70°C) 423.7mW
Operating Temperature Range .....-40°C to +85°C
Junction Temperature .....+150°C
Storage Temperature Range .....-65°C to +150°C
Lead Temperature (soldering, 10s) .....+300°C

Note 1: Signals on IN, SHDN or SHDN/$\overline{EN}$ exceeding V+ or GND are clamped by internal diodes. Limit forward-diode current to maximum current rating.

Stresses beyond those listed under "Absolute Maximum Ratings" 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 the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

(V+ = +3V to +3.6V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at V+= 3.3V, T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
ANALOG SWITCH							
Analog Signal Range	$V_{COM_}$, $V_{NO_}$, $V_{NC_}$	SHDN or SHDN/$\overline{EN}$ = 0 (Note 3)		0		V+	V
Fault-Protection Trip Threshold	V_{FP}			3.6		4.0	V
On-Resistance	R_{ON}	$I_{COM_}$ = -40mA, 0V ≤ $V_{COM_}$ ≤ V+, SHDN or SHDN/$\overline{EN}$ = 0	T_A = +25°C		4	7	Ω
			T_A = T_{MIN} to T_{MAX}			8	
On-Resistance During Shutdown	R_{ONSH}	$I_{COM_}$ = -40mA, 0V ≤ $V_{COM_}$ ≤ 1.5V, SHDN = V+ (MAX4907/MAX4907F)	T_A = +25°C		4	10	Ω
			T_A = T_{MIN} to T_{MAX}			13	
On-Resistance Match Between Channels	ΔR_{ON}	V+ = 3.0V, $I_{COM_}$= -40mA, $V_{COM_}$ = 1.5V (Note 4)	T_A = +25°C		0.7	1.2	Ω
			T_A = T_{MIN} to T_{MAX}			1.5	
On-Resistance Flatness	$R_{FLAT (ON)}$	V+ = 3.0V, $I_{COM_}$ = -40mA, $V_{COM_}$ = 1.5V, 3.0V (Note 5)			1.0		Ω
Off-Leakage Current	$I_{COM_(OFF)}$	V+ = 3.6V, $V_{COM_}$ = 0.3V, 3.3V; $V_{NO_}$ or $V_{NC_}$ = 3.3V, 0.3V		-1		+1	µA
On-Leakage Current	$I_{COM_(ON)}$	V+ = 3.6V, V_{COM} = 0.3V, 3.3V; $V_{NO_}$ or $V_{NC_}$ = 0.3V, 3.3V, or floating		-1		+1	µA
SWITCH AC PERFORMANCE							
On-Channel -3dB Bandwidth	BW	R_L = R_S = 50Ω, signal = 0dBm, Figure 1			1000		MHz
Off-Isolation	V_{ISO}	f = 10MHz; $V_{NO_}$, $V_{NC_}$ = $1V_{P-P}$; R_L = R_S = 50Ω, Figure 1			-60		dB
		f = 250MHz; $V_{NO_}$, $V_{NC_}$ = $1V_{P-P}$; R_L = R_S = 50Ω, Figure 1			-32		
		f = 500MHz; $V_{NO_}$, $V_{NC_}$ = $1V_{P-P}$; R_L = R_S = 50Ω, Figure 1			-26		

ELECTRICAL CHARACTERISTICS (continued)

(V+ = +3V to +3.6V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at V+ = 3.3V, T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Crosstalk (Note 6)	V_{CT}	f = 10MHz; $V_{NO_}$, $V_{NC_}$ = $1V_{P-P}$; R_L = R_S = 50Ω, Figure 1			-59		dB
		f = 250MHz; $V_{NO_}$, $V_{NC_}$ = $1V_{P-P}$; R_L = R_S = 50Ω, Figure 1			-31		
		f = 500MHz; $V_{NO_}$, $V_{NC_}$ = $1V_{P-P}$; R_L = R_S = 50Ω, Figure 1			-25		
SWITCH DYNAMICS							
NO_, NC_ Off-Capacitance	$C_{(OFF)}$	f = 1MHz, Figure 2 (Note 7)			2	4	pF
Switch On-Capacitance	$C_{(ON)}$	f = 1MHz, Figure 2 (Note 7)	MAX4906ELB, MAX4906FELB		6	9	pF
			MAX4907ELA, MAX4907FELA		4	7	
Switch On-Capacitance Matching	C_{ONM}	f = 1MHz (Note 7)	MAX4906ELB, MAX4906FELB		0.4		pF
			MAX4907ELA, MAX4907FELA		0.3		
Turn-On Time	t_{ON}	$V_{NO_}$, $V_{NC_}$ = 1.5V; R_L = 300Ω, C_L = 35pF, V_{IH} = V+, V_{IL} = 0V, SHDN or SHDN/$\overline{EN}$ = 0V, Figure 3				60	ns
Turn-Off Time	t_{OFF}	$V_{NO_}$, $V_{NC_}$ = 1.5V; R_L = 300Ω, C_L = 35pF, V_{IH} = V+, V_{IL} = 0V, SHDN or SHDN/$\overline{EN}$ = 0V, Figure 3; T_A = +25°C				30	ns
Propagation Delay	$t_{PLH_}$,t_{PHL}	R_L = R_S = 50Ω, Figure 4			0.25		ns
Fault-Protection Response Time	t_{FP}	$V_{COM_}$ = 0 to 5V step, R_L = R_S = 50Ω, Figure 5				3.0	µs
Fault-Protection Recovery Time	t_{FPR}	$V_{COM_}$ = 5V to 3V step, R_L = R_S = 50Ω, Figure 5				2	µs
Output Skew Between Switches	$t_{SK(o)}$	Skew between switch 1 and switch 2, R_L = R_S = 50Ω, Figure 4 (Note 7)			50	100	ps
Output Skew Same Switch	$t_{SK(p)}$	Skew between opposite transitions in same switch, R_L = R_S = 50Ω, Figure 4 (Note 7)			50	100	ps

ELECTRICAL CHARACTERISTICS (continued)

(V+ = +3V to +3.6V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at V+ = 3.3V, T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Total Harmonic Distortion Plus Noise	THD+N	$V_{COM_}$ = $2V_{P-P}$, R_L = 600Ω, f = 20Hz to 20kHz		0.03		%
Charge Injection	Q	V_{GEN} = 1.5V, R_{GEN} = 0Ω, C_L = 100pF, Figure 6		5		pC
SWITCH LOGIC						
Logic-Input-Voltage Low	V_{IL}				0.4	V
Logic-Input-Voltage High	V_{IH}		1.1			V
Input-Logic Hysteresis	V_{HYST}			100		mV
Input Leakage Current	I_{IN}	V+ = 3.6V, V_{IN} = 0 or V+	-1		+1	µA
Operating Supply-Voltage Range	V+		3.0		3.6	V
Quiescent Supply Current	I+	V+ = 3.6V, V_{IN} = 0 or V+, SHDN or SHDN/$\overline{EN}$ = 0		120	300	µA
Quiescent Supply Current During Shutdown	I+	V+ = 3.6V, V_{IN} = 0 or V+, SHDN or SHDN/$\overline{EN}$ = V+			2	µA

Note 2: All units are 100% production tested at T_A = +25°C. Limits over the operating temperature range are guaranteed by design and not production tested.

Note 3: The switch will turn off for voltages above (V_{FP}); therefore, protecting downstream circuits in case of a fault condition (MAX4906F/MAX4907F).

Note 4: $\Delta R_{ON(MAX)} = | R_{ON(CH1)} - R_{ON(CH2)} |$

Note 5: Flatness is defined as the difference between the maximum and minimum value of on-resistance, as measured over specified analog signal ranges.

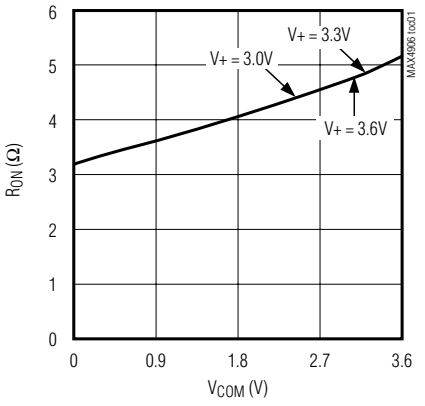
Note 6: Between any two switches.

Note 7: Switch off-capacitance, switch on-capacitance, output skew between switches, and output skew same-switch limits are not production tested; design guaranteed by bench characterization.

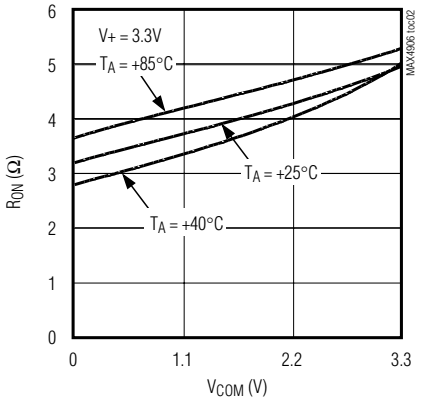
Typical Operating Characteristics

(T_A = +25°C, unless otherwise noted.)

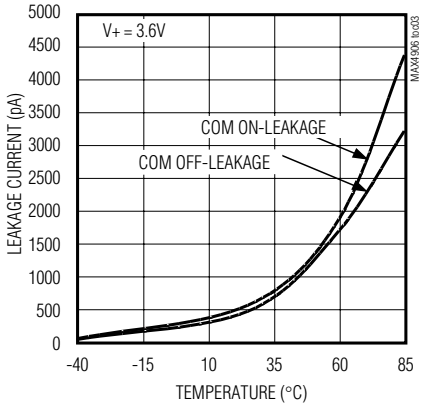
ON-RESISTANCE vs. V_{COM}



ON-RESISTANCE vs. V_{COM}



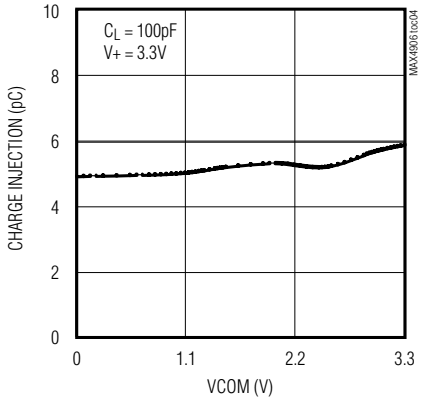
LEAKAGE CURRENT vs. TEMPERATURE



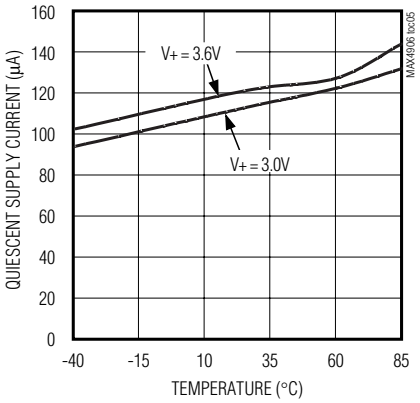
Typical Operating Characteristics (continued)

(T_A = +25°C, unless otherwise noted.)

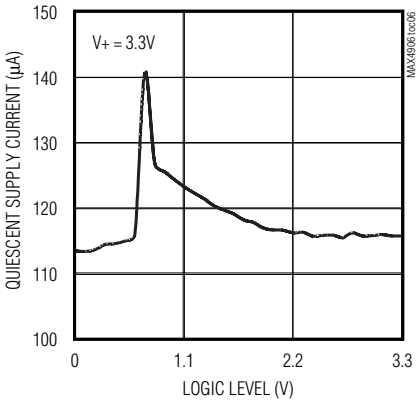
CHARGE INJECTION vs. V_{COM}



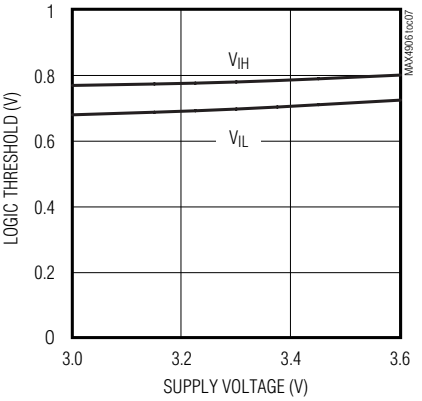
QUIESCENT SUPPLY CURRENT vs. TEMPERATURE



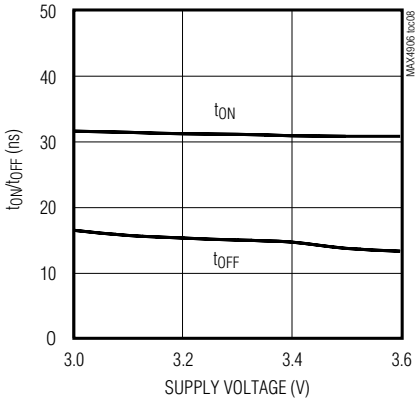
QUIESCENT SUPPLY CURRENT vs. LOGIC LEVEL



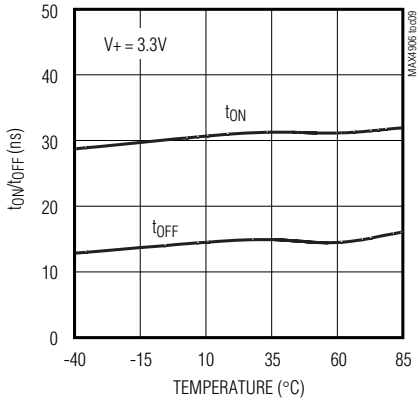
LOGIC THRESHOLD vs. SUPPLY VOLTAGE



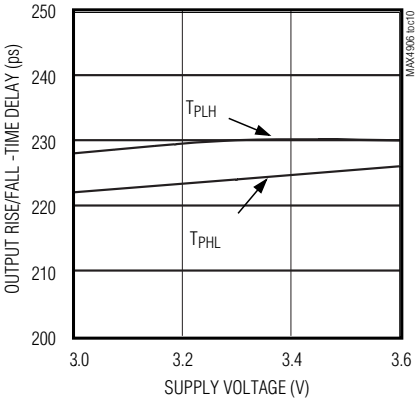
TURN-ON/OFF TIME vs. SUPPLY VOLTAGE



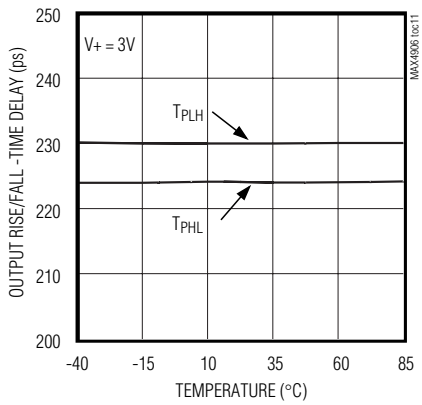
TURN-ON/OFF TIME vs. TEMPERATURE



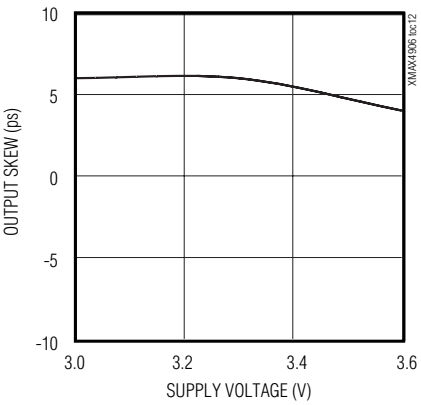
RISE/FALL-TIME PROPAGATION DELAY vs. SUPPLY VOLTAGE



RISE/FALL-TIME PROPAGATION DELAY vs. TEMPERATURE



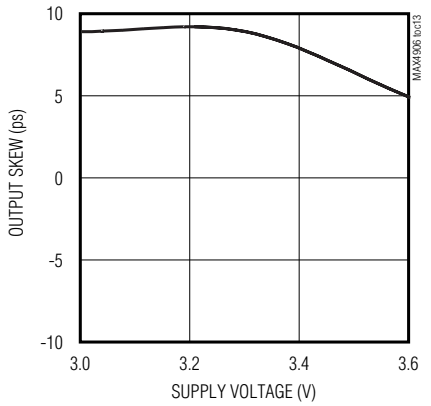
SAME SWITCH OUTPUT SKEW vs. SUPPLY VOLTAGE



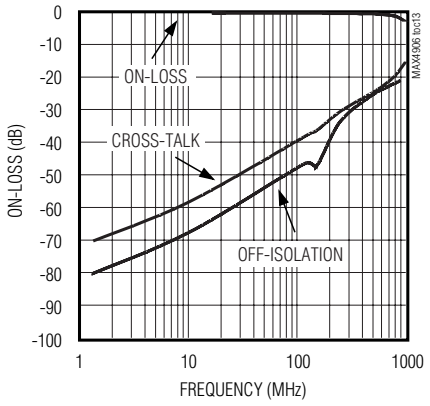
Typical Operating Characteristics (continued)

(T_A = +25°C, unless otherwise noted.)

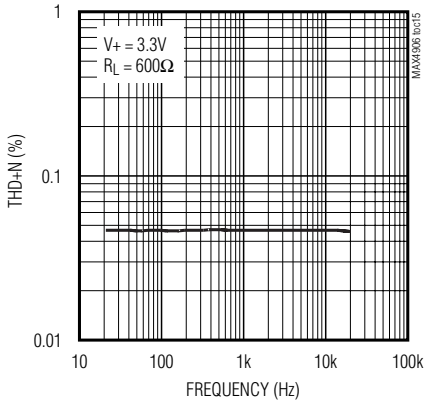
OUTPUT SKEW BETWEEN SWITCHES vs. SUPPLY VOLTAGE



FREQUENCY RESPONSE



TOTAL HARMONIC DISTORTION PLUS NOISE vs. FREQUENCY



Pin Description

PIN		NAME	FUNCTION
MAX4906/ MAX4906F	MAX4907/ MAX4907F		
1	8	IN	Digital Control Input. IN controls switch 1 and switch 2.
2	—	SHDN/$\overline{EN}$	Shutdown and Enable Input. Drive SHDN/$\overline{EN}$ high to consume minimum current and to put the device in high-impedance mode. Drive the SHDN/$\overline{EN}$ low for normal operation.
3	2	GND	Ground
4	3	COM1	Analog Switch 1—Common Terminal
5	4	COM2	Analog Switch 2—Common Terminal
6	5	NO2	Analog Switch 2—Normally Open Terminal
7	6	NO1	Analog Switch 1—Normally Open Terminal
8	—	NC2	Analog Switch 2—Normally Closed Terminal
9	—	NC1	Analog Switch 1—Normally Closed Terminal
10	7	V+	Positive-Supply Voltage Input. Connect V+ to a 3.0V to 3.6V supply voltage. Bypass V+ to GND with a 0.1µF capacitor.
—	1	SHDN	Shutdown Input. Drive SHDN high to put the device into shutdown mode. For normal operation, drive SHDN low.

Test Circuits/Timing Diagrams

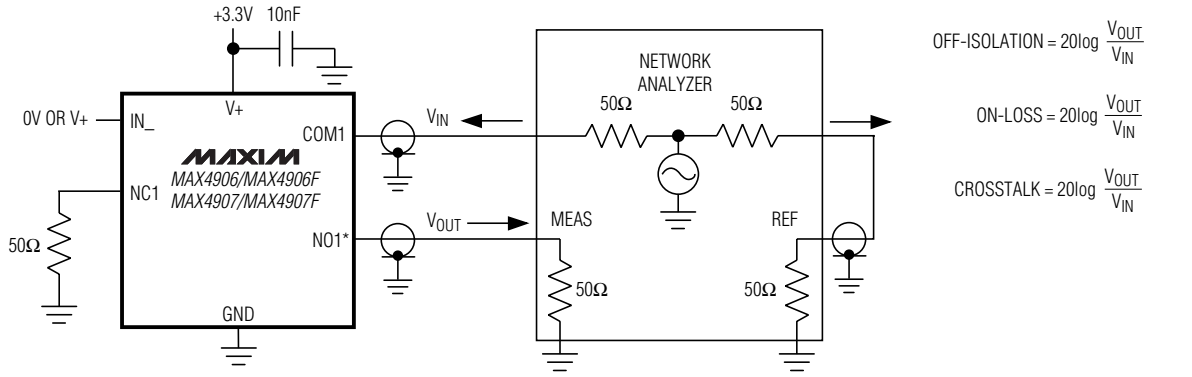


Figure 1. On-Loss, Off-Isolation, and Crosstalk

Test Circuits/Timing Diagrams (continued)

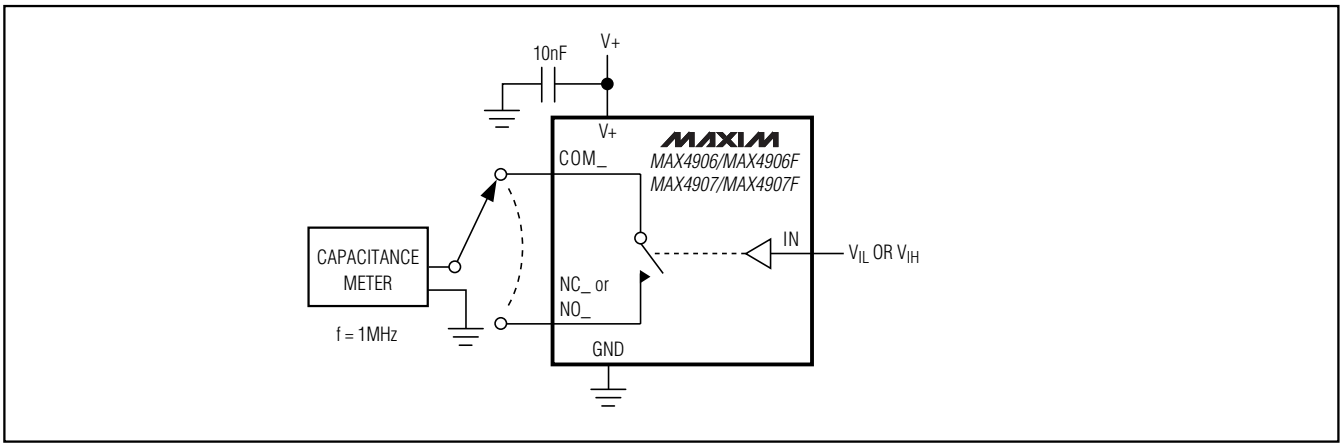


Figure 2. Channel Off/On-Capacitance

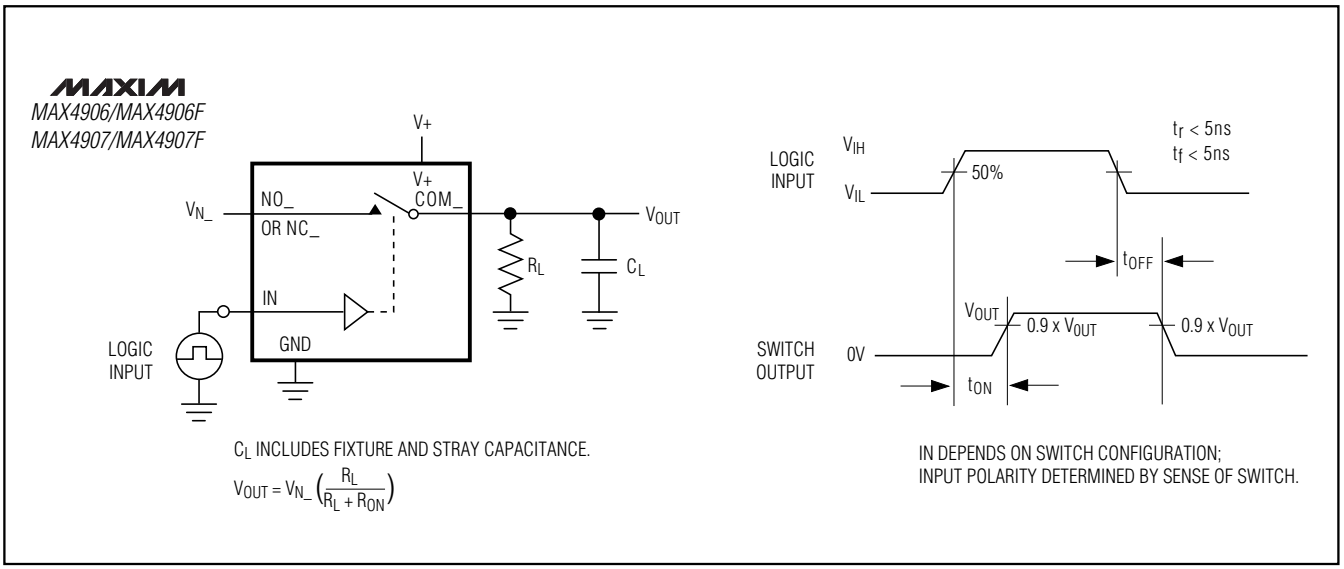


Figure 3. Switching Time

Test Circuits/Timing Diagrams (continued)

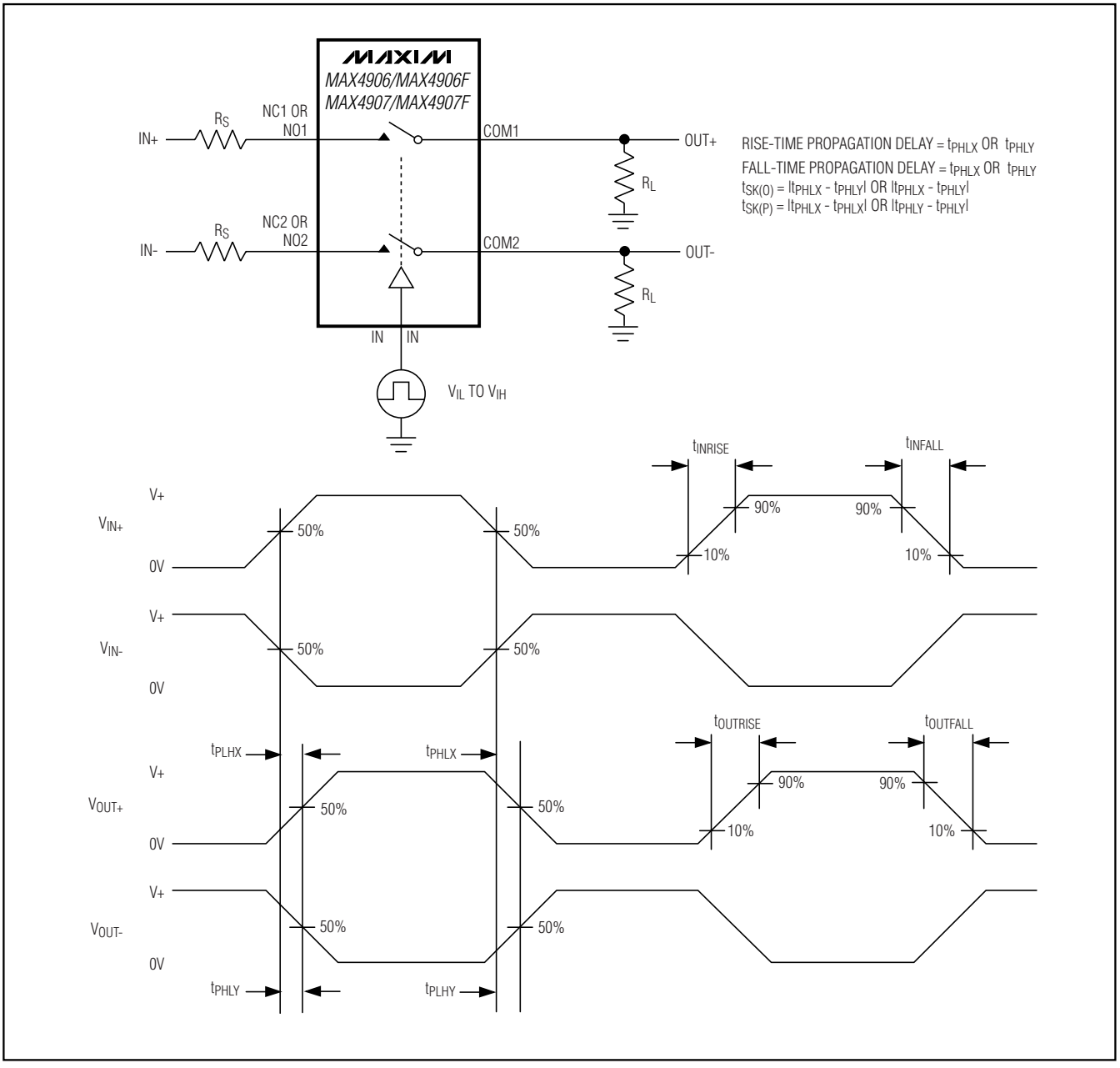


Figure 4. Output Signal Skew, Rise/Fall Time, Propagation Delay

Test Circuits/Timing Diagrams (continued)

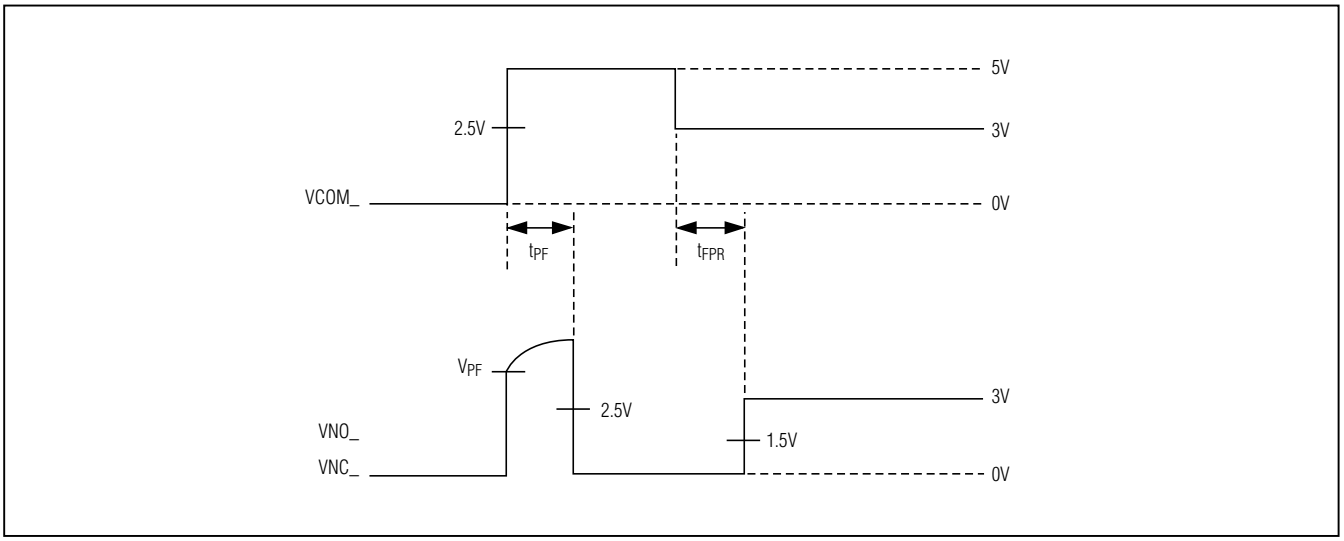


Figure 5. MAX4906F/MAX4907F Fault-Protection Response/Recovery Time

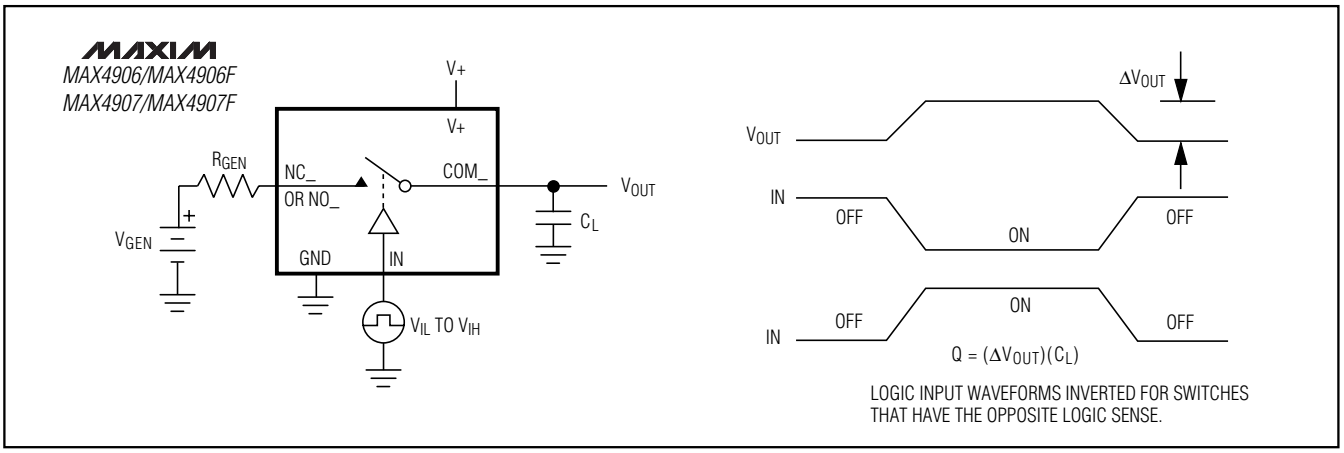


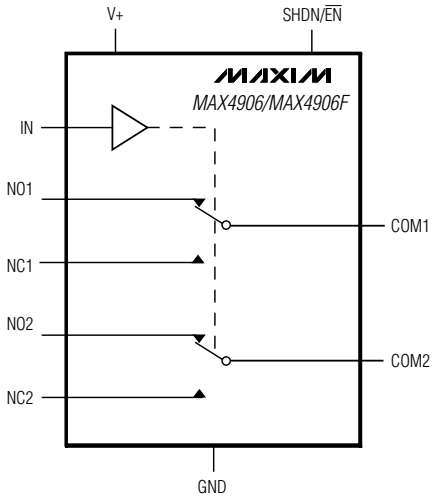
Figure 6. Charge Injection

Detailed Description

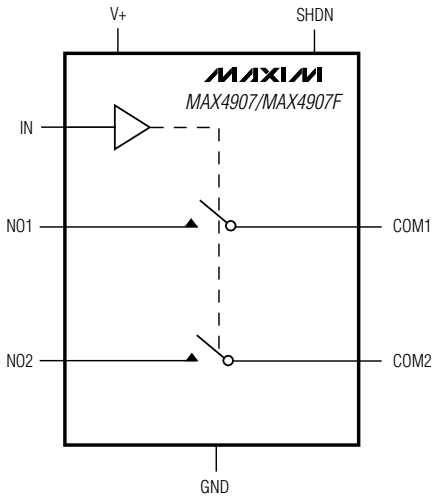
The MAX4906/MAX4906F/MAX4907/MAX4907F analog switches are targeted for USB 2.0 high-speed (480Mbps) switching applications. These devices still meet USB low- and full-speed requirements and are suitable for 10/100 Ethernet switching. The MAX4906/MAX4906F feature two SPDT switches, while the MAX4907/MAX4907F feature two SPST switches. The MAX4907/MAX4907F switch configurations have a low 7Ω (max) on-resistance and 7pF (max) on-capacitance.

The MAX4906/MAX4906F/MAX4907/MAX4907F are fully specified to operate from a single +3.0V to +3.6V supply and are available with +5.5V fault protection (MAX4906F/MAX4907F). When operating from a +3.0V to +3.6V supply, the low threshold of these devices permits them to be used with logic levels as low as 1.4V.The MAX4906/MAX4906F/MAX4907/MAX4907F are based on a charge-pump-assisted n-channel architecture and thus operate at 300µA (max) quiescent current. These devices all feature a shutdown input to reduce the quiescent current to less than 2µA (max).

Functional Diagram/Truth Table



MAX4906/MAX4906F			
SHDN/EN	IN	NO1 NO2	NC1 NC2
0	0	OFF	ON
0	1	ON	OFF
1	x	OFF	OFF



MAX4907/MAX4907F		
SHDN	IN	COM1- NO1 COM2- NO1
0	0	OFF
0	1	ON
1	0	OFF
1	1	ON

Digital Control Input

The MAX4906/MAX4906F/MAX4907/MAX4907F provide a single-digit control logic input, IN. IN controls the position of the switches as shown in the *Functional Diagram/Truth Table*. Driving IN rail-to-rail minimizes power consumption. With a +3.0V to +3.6V supply voltage range, these devices are +1.4V logic compatible.

Analog Signal Levels

The on-resistance of the MAX4906/MAX4906F/MAX4907/MAX4907F is very low and stable as the analog input signals are swept from ground to V+ (see the *Typical Operating Characteristics*). These switches are bidirectional, allowing NO_, NC_, and COM_ to be configured as either inputs or outputs.

Overvoltage Fault Protection

The MAX4906F and MAX4907F feature +5.5V fault protection to COM1 and COM2. Fault protection prevents these switches from being damaged due to shorts to the USB bus voltage rail.

Shutdown Mode

The MAX4906/MAX4906F feature a shutdown mode that reduces the quiescent current supply to less than 2µA. Drive SHDN/$\overline{EN}$ high to place the devices in high-impedance mode. When SHDN/$\overline{EN}$ is driven low, the devices are normal in operation.

The MAX4907/MAX4907F feature a SHDN input that reduces the quiescent current supply to less than 2µA. Drive SHDN high to place the devices in low current mode. The devices can be used in low current mode, but with a reduced analog voltage range of $0 < V_{ANALOG} < 1.5V$ and reduced performance. When SHDN is driven low, the MAX4907/MAX4907F are in normal operation.

Applications Information

USB Switching

The MAX4906/MAX4906F/MAX4907/MAX4907F analog switches are fully compliant with the USB 2.0 specification. The low on-resistance and low on-capacitance of these switches make them ideal for high-performance switching applications. The MAX4906/MAX4906F are

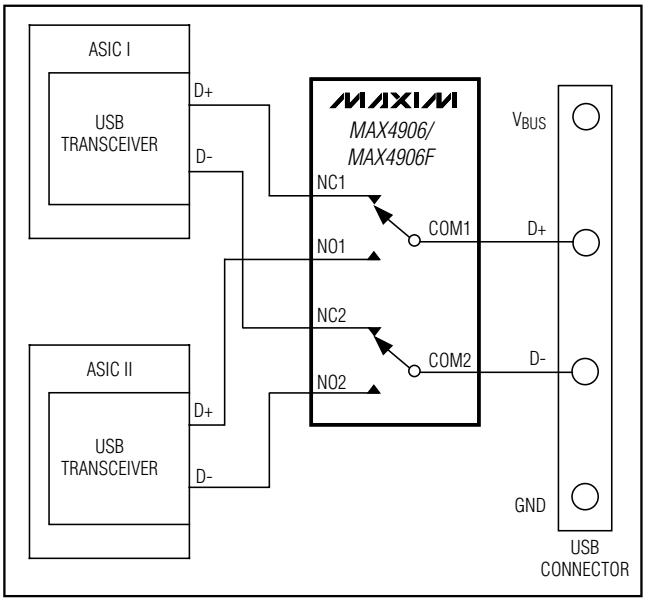


Figure 7. MAX4906/MAX4906F USB Data Routing

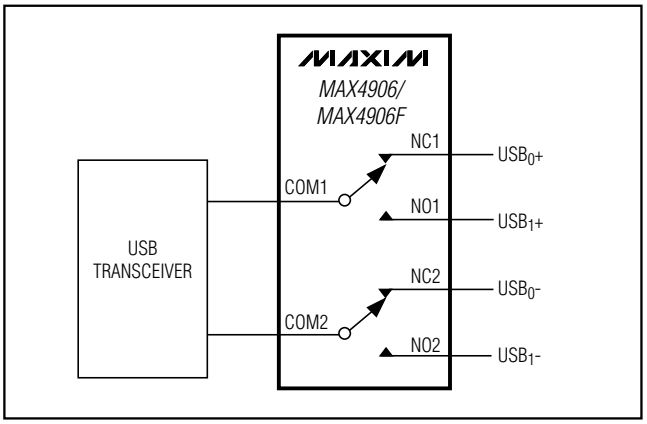


Figure 8. MAX4906/MAX4906F Switching Between Multiple USB Hosts

ideal for routing USB data lines (see Figure 7) and for applications that require switching between multiple USB hosts (see Figure 8). The MAX4907/MAX4907F can be used in applications that require different data types to share the same pins (see Figure 9); however, the shared device must be capable of going into the tri-state mode. The MAX4906F/MAX4907F also feature +5.5V fault protection to guard systems against shorts to the USB bus voltage. The fault-protected versions are recommended for all USB applications.

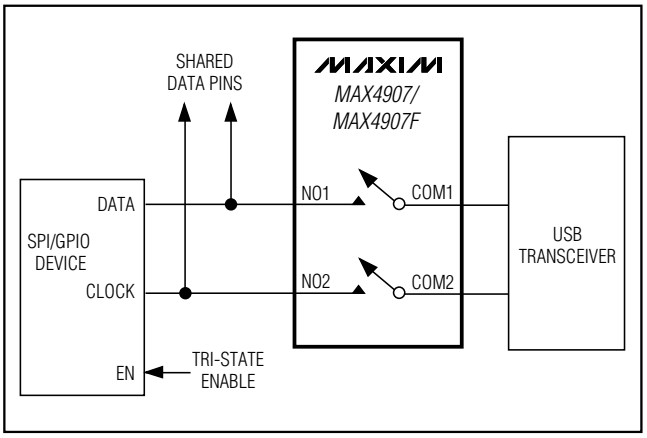


Figure 9. MAX4907/MAX4907F USB/SPI/GPIO Switch

Ethernet Switching

The wide bandwidth of the MAX4906/MAX4906F/MAX4907/MAX4907F meets the needs of 10/100 Ethernet switching. These devices switch the signals from two interface transformers and connect the signals to a single 10/100 Base-T Ethernet PHY, simplifying docking station design and reducing manufacturing costs.

Power-Supply Sequencing

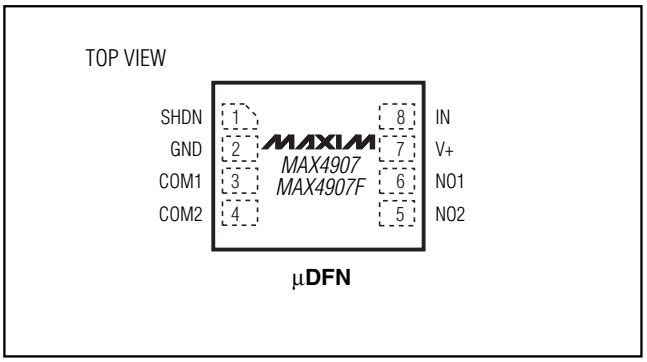
Caution: Do not exceed the absolute maximum ratings because stresses beyond the listed ratings may cause permanent damage to the device.

Proper power-supply sequencing is recommended for all CMOS devices. Always apply V+ before applying analog signals, especially if the analog signal is not current limited.

Layout

High-speed switches require proper layout and design procedures for optimum performance. Keep design-controlled-impedance PC board traces as short as possible. Ensure that bypass capacitors are as close to the device as possible. Use large ground planes where possible.

Pin Configurations (continued)



Selector Guide

PART	CONFIGURATION	FAULT PROTECTION	TOP MARK
MAX4906ELB	Dual SPDT	NO	AAB
MAX4906FELB	Dual SPDT	YES	AAA
MAX4907ELA	Dual SPST	NO	AAE
MAX4907FELA	Dual SPST	YES	AAD

Chip Information

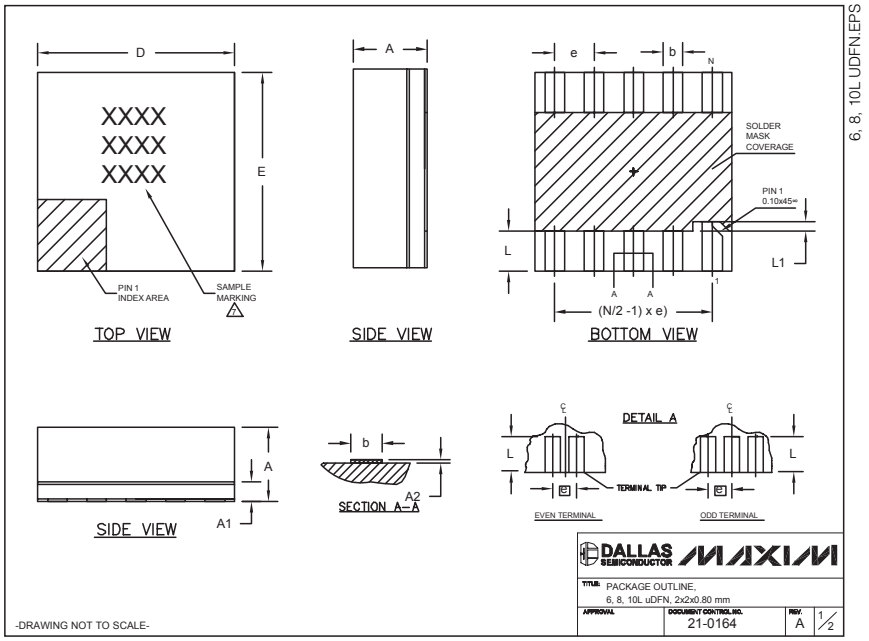
PROCESS: BiCMOS

Revision History

Pages changed at Rev 2: 1, 2, 3, 7, 11, 14

Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to **www.maxim-ic.com/packages**.)



COMMON DIMENSIONS			
SYMBOL	MIN.	NOM.	MAX.
A	0.70	0.75	0.80
A1	0.15	0.20	0.25
A2	0.020	0.025	0.035
D	1.95	2.00	2.05
E	1.95	2.00	2.05
L	0.30	0.40	0.50
L1	0.10 REF.		

PACKAGE VARIATIONS				
PKG. CODE	N	e	b	(N/2 -1) x e
L622-1	6	0.65 BSC	0.30±0.05	1.30 REF.
L822-1	8	0.50 BSC	0.25±0.05	1.50 REF.
L1022-1	10	0.40 BSC	0.20±0.03	1.60 REF.

NOTES:
1. ALL DIMENSIONS ARE IN mm. ANGLES IN DEGREES.
2. COPLANARITY SHALL NOT EXCEED 0.08mm.
3. WARPAGE SHALL NOT EXCEED 0.10mm.
4. PACKAGE LENGTH/PACKAGE WIDTH ARE CONSIDERED AS SPECIAL CHARACTERISTIC(S).
5. "N" IS THE TOTAL NUMBER OF LEADS.
6. NUMBER OF LEADS SHOWN ARE FOR REFERENCE ONLY.
7. MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY.

-DRAWING NOT TO SCALE-

DALLAS SEMICONDUCTOR MAXIM
TITLE: PACKAGE OUTLINE, 6, 8, 10L uDFN, 2x2x0.80 mm
APPROVAL
DOCUMENT CONTROL NO. 21-0164
REV. A
2/2

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