19-1515; Rev 0; 7/99

MAXIM

Fault-Protected, High-Voltage, Dual Analog Switches

General Description

The MAX4631/MAX4632/MAX4633 high-voltage, dual analog switches are pin compatible with the industry-standard DG401/DG403/DG405. They upgrade the existing devices with fault-protected inputs and Rail-to-Rail® signal handling capabilities. The MAX4631/MAX4632/MAX4633's normally open (NO) and normally closed (NC) terminals are protected from overvoltage faults up to 36V during power-up or power-down. During a fault condition, these terminals become open circuit and only nanoamperes of leakage current flow from the source, yet the switch output (COM_) continues to furnish up to 18mA of the appropriate polarity supply voltage to the load. This ensures unambiguous rail-to-rail outputs when a fault begins and ends. On-resistance is 85Ω (max) at +25°C and is matched between switches to 6Ω (max). Off-leakage current is only 0.5nA at +25°C and 5nA at +85°C.

The MAX4631 has two NO single-pole/single-throw (SPST) switches. The MAX4632 has two NO/NC single-pole/double-throw (SPDT) switches. The MAX4633 has two NO double-pole/single-throw (DPST) switches.

These CMOS switches operate with dual power supplies ranging from ±4.5V to ±18V or a single supply between +9V and +36V. All digital inputs have +0.8V and +2.4V logic thresholds, ensuring both TTL- and CMOS-logic compatibility when using ±15V or a single +12V supply.

Applications

ATE Equipment

Data Acquisition

Industrial and Process Control Systems

Avionics

Redundant/Backup Systems

Pin Configurations appear at end of data sheet.

Features

- **Fault Protection**
  ±40V with Power Off
  ±36V with ±15V Supplies (MAX4631/MAX4633)
  ±25V with ±15V Supplies (MAX4632)
- **Rail-to-Rail Signal Handling**
- **No Power-Supply Sequencing Required**
- **All Switches Off with Power Off**
- **Output Clamped to Appropriate Supply Voltage During Fault Condition; No Transition Glitch**
- **85Ω (max) Signal Paths with ±15V Supplies**
- **±4.5V to ±18V Dual Supplies**
  +9V to +36V Single Supply
- **Low Power Consumption: <6mW**
- **Pin Compatible with Industry-Standard DG401/DG403/DG405**
- **TTL- and CMOS-Logic Compatible Inputs with Single +9V to +15V, or ±15V Supplies**

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX4631CSE	0°C to +70°C	16 Narrow SO
MAX4631CPE	0°C to +70°C	16 Plastic DIP
MAX4631ESE	-40°C to +85°C	16 Narrow SO
MAX4631EPE	-40°C to +85°C	16 Plastic DIP
MAX4631MJE	-55°C to +125°C	16 CERDIP
MAX4632CSE	0°C to +70°C	16 Narrow SO
MAX4632CPE	0°C to +70°C	16 Plastic DIP
MAX4632ESE	-40°C to +85°C	16 Narrow SO
MAX4632EPE	-40°C to +85°C	16 Plastic DIP
MAX4632MJE	-55°C to +125°C	16 CERDIP
MAX4633CSE	0°C to +70°C	16 Narrow SO
MAX4633CPE	0°C to +70°C	16 Plastic DIP
MAX4633ESE	-40°C to +85°C	16 Narrow SO
MAX4633EPE	-40°C to +85°C	16 Plastic DIP
MAX4633MJE	-55°C to +125°C	16 CERDIP

Rail-to-Rail is a registered trademark of Nippon Motorola, Ltd.

Fault-Protected, High-Voltage, Dual Analog Switches

ABSOLUTE MAXIMUM RATINGS

(Voltages referenced to GND)
V+ .....-0.3V to +44V
V- .....-44V to +0.3V
V+ to V-.....-0.3V to +44V
COM_, IN_ (Note 1) .....(V- - 0.3V) to (V+ + 0.3V)
NC_, NO_ (Note 2)
MAX4631_ _E .....(V+ - 36V) to (V- + 36V)
MAX4632_ _E .....(V+ - 25V) to (V- + 25V)
MAX4633_ _E .....(V+ - 36V) to (V- + 36V)
NC_, NO_ to COM_
MAX4631_ _E .....-36V to +36V
MAX4632_ _E .....-25V to +25V
MAX4633_ _E .....-36V to +36V

Continuous Current into Any Terminal.....±30mA
Peak Current into Any Terminal (pulsed at 1ms, 10% duty cycle).....±50mA
Continuous Power Dissipation (T_A = +70°C) (Note 2)
Plastic DIP (derate 10.53mW/°C above +70°C) 842mW
Narrow SO (derate 8.70mW/°C above +70°C) 696mW
CERDIP (derate 10.00mW/°C above +70°C).....842mW
Operating Temperature Ranges
MAX463_C_E .....0°C to +70°C
MAX463_E_E .....-40°C to +85°C
MAX463_M_E .....-55°C to +125°C
Storage Temperature Range .....-65°C to +150°C
Lead Temperature (soldering, 10sec) .....+300°C

Note 1: COM_ and IN_ pins are not fault protected. Signals on COM_ to IN_ exceeding V+ or V- are clamped by internal diodes. Limit forward diode current to maximum current rating.

Note 2: NC_ and NO_ pins are fault protected (see *Electrical Characteristics*). With power applied to V+ or V-, signals on NC_ or NO_ exceeding ±25V (MAX4632) or ±36V (MAX4631/MAX4633) may damage the device. With V+ = V- = 0, signals on NC_ or NO_ exceeding ±40V may damage the device.

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—Dual Supplies

(V+ = +15V, V- = -15V, $V_{INL\_}$ = 0.8V, $V_{INH\_}$ = 2.4V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 3)

PARAMETER	SYMBOL	CONDITIONS		T_A	MIN	TYP	MAX	UNITS
ANALOG SWITCH								
Fault-Free Analog Signal Range (Note 2)	$V_{NO\_}$, $V_{NC\_}$			C, E, M	V-		V+	V
COM_ to NO_ or NC_ On-Resistance	R_{ON}	$V_{COM\_}$ = ±10V, $I_{COM\_}$ = 1mA		+25°C		62	85	Ω
				C, E			100	
				M			200	
COM_ to NO_ or NC_ On-Resistance Match Between Channels (Note 4)	ΔR_{ON}	$V_{COM\_}$ = ±10V, $I_{COM\_}$ = 1mA		+25°C		3	6	Ω
				C, E			10	
				M			15	
NO_, NC_, COM_ Off-Leakage Current (Note 5)	$I_{NO\_ (OFF)}$, $I_{NC\_ (OFF)}$, $I_{COM\_(OFF)}$	$V_{COM\_}$ = ±14V, $V_{NO\_}$ or $V_{NC\_}$ = ∓14V		+25°C	-0.5	0.01	0.5	nA
				C, E	-5		5	
				M	-100		100	
COM_ On-Leakage Current (Note 5)	$I_{COM\_(ON)}$	$V_{COM\_}$ = ±14V, $V_{NO\_}$ or $V_{NC\_}$ = ±14V or floating		+25°C	-0.5	0.01	0.5	nA
				C, E	-20		20	
				M	-100		100	
FAULT PROTECTION								
Fault-Protected Analog Signal Range (Note 2)	$V_{NO\_}$, $V_{NC\_}$	Applies with power on	MAX4631/ MAX4633	C, E, M	-36		36	V
			MAX4632	C, E, M	-25		25	
		Applies with power off		C, E, M	-40		40	

ELECTRICAL CHARACTERISTICS—Dual Supplies (continued)

(V+ = +15V, V- = -15V, $V_{INL\_}$ = 0.8V, $V_{INH\_}$ = 2.4V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 3)

PARAMETER	SYMBOL	CONDITIONS	T_A	MIN	TYP	MAX	UNITS
COM_ Output Leakage Current, Supplies On	$I_{COM\_}$	$V_{NO\_}$ or $V_{NC\_}$ = ±25V, no connection to "on" channel (MAX4632 only)	+25°C	-10		10	nA
			C, E	-200		200	
			M	-1		1	µA
NO_ or NC_ Input Leakage Current, Supplies On	$I_{NO\_}$, $I_{NC\_}$	$V_{NO\_}$ or $V_{NC\_}$ = ±25V, $V_{COM\_}$ = ±10V	+25°C	-20		20	nA
			C, E	-200		200	
			M	-10		10	µA
NO_ or NC_ Input Leakage Current, Supplies Off	$I_{NO\_}$, $I_{NC\_}$	$V_{NO\_}$ or $V_{NC\_}$ = ±40V,	+25°C	-20		20	nA
			C, E	-200		200	
			M	-10		10	µA
COM_ Output Clamp Current, Supplies On	$I_{COM\_}$	$V_{NO\_}$ or $V_{NC\_}$ = +25V	+25°C	13	18	24	mA
		$V_{NO\_}$ or $V_{NC\_}$ = -25V	+25°C	-24	-18	13	
COM_ Output Clamp Resistance, Supplies On	$R_{COM\_}$	$V_{NO\_}$ or $V_{NC\_}$ = ±25V	+25°C		0.5	1	kΩ
LOGIC INPUT							
IN_ Input Logic Voltage High	$V_{INH\_}$		C, E, M	2.4			V
IN_ Input Logic Voltage Low	$V_{INL\_}$		C, E, M			0.8	V
IN_ Input Current Logic High or Low	$I_{INH\_}$, $I_{INL\_}$	$V_{IN\_}$ = 0.8V or 2.4V	+25°C	-1	0.03	1	µA
			C, E, M	-5		5	
SWITCH DYNAMIC CHARACTERISTICS							
Turn-On Time	t_{ON}	$V_{COM\_}$ = ±10V, R_L = 1kΩ, Figure 2	+25°C		100	150	ns
			C, E,			500	
			M			600	
Turn-Off Time	t_{OFF}	$V_{COM\_}$ = ±10V, R_L = 1kΩ, Figure 2	+25°C		50	100	ns
			C, E,			400	
			M			500	
Break-Before-Make Time Delay (MAX4632 only)	t_{BBM}	$V_{COM\_}$ = ±10V, R_L = 1kΩ, Figure 3	+25°C	10	40		ns
Charge Injection (Note 6)	Q	C_L = 100pF, Figure 4, NO_ = NC_ = GND, R_S = 0	+25°C		5	10	pC
NO_, NC_ Off- Capacitance	$C_{NC\_(OFF)}$, $C_{NO\_(OFF)}$	NO_ = NC_ = GND, f = 1MHz, Figure 5	C, E, M		18		pF
COM_ Off-Capacitance	$C_{COM\_(OFF)}$	COM_ = GND, f = 1MHz, Figure 5	C, E, M		18		pF
COM_ On-Capacitance	$C_{COM\_(ON)}$	COM_ = NO_ = NC_ = GND, f = 1MHz, Figure 5	C, E, M		22		pF

Fault-Protected, High-Voltage, Dual Analog Switches

ELECTRICAL CHARACTERISTICS—Dual Supplies (continued)

(V+ = +15V, V- = -15V, $V_{INL\_}$ = 0.8V, $V_{INH\_}$ = 2.4V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 3)

PARAMETER	SYMBOL	CONDITIONS	T_A	MIN	TYP	MAX	UNITS
Off-Isolation (Note 7)	V_{ISO}	R_L = 50Ω, C_L = 15pF, $V_{NO\_}$ = $V_{NC\_}$ = $1V_{RMS}$, f = 1MHz, Figure 6	C, E, M		-62		dB
Channel-to-Channel Crosstalk (Note 8)	V_{CT}	R_L = 50Ω, C_L = 15pF, $V_{NO\_}$ = $V_{NC\_}$ = $1V_{RMS}$, f = 1MHz, Figure 7	C, E, M		-66		dB
POWER SUPPLY							
Power-Supply Range	V+, V-		C, E, M	±4.5		±18	V
V+ Supply Current	I+	All $V_{IN\_}$ = 0 or 5V, $V_{NO\_}$ or $V_{NC\_}$ = 0	+25°C		230	325	µA
			C, E, M			550	
V- Supply Current	I-	All $V_{IN\_}$ = 0 or 5V, $V_{NO\_}$ or $V_{NC\_}$ = 0	+25°C		130	200	µA
			C, E, M			300	
GND Supply Current	I_{GND}	All $V_{IN\_}$ = 0 or 15V, $V_{NO\_}$ or $V_{NC\_}$ = 0	+25°C	-1	0.01	1	µA
			C, E, M			10	
		All $V_{IN\_}$ = 5V, $V_{NO\_}$ or $V_{NC\_}$ = 0	+25°C		125	175	
			C, E, M			300	

ELECTRICAL CHARACTERISTICS—Single Supply

(V+ = +15V, V- = -15V, $V_{INL\_}$ = 0.8V, $V_{INH\_}$ = 2.4V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 3)

PARAMETER	SYMBOL	CONDITIONS	T_A	MIN	TYP	MAX	UNITS
ANALOG SWITCH							
Fault-Free Analog Signal Range (Note 2)	$V_{NO\_}$, $V_{NC\_}$		C, E, M	0		V+	V
COM_ to NO_ or NC_ On-Resistance	R_{ON}	$V_{COM\_}$ = 10V, $I_{COM\_}$ = 1mA	+25°C		125	200	Ω
			C, E			250	
			M			300	
COM_ to NO_ or NC_ On-Resistance Match Between Channels (Note 4)	ΔR_{ON}	$V_{COM\_}$ = 10V, $I_{COM\_}$ = 1mA	+25°C		4	10	Ω
			C, E			20	
			M			30	
NO_, NC_, COM_ Off-Leakage Current (Notes 5, 9)	$I_{NO\_ (OFF)}$, $I_{NC\_ (OFF)}$	$V_{COM\_}$ = 10V, $V_{NO\_}$ or $V_{NC\_}$ = 12V	+25°C	-0.5	0.01	0.5	nA
			C, E	-10		10	
			M	-200		200	
COM_ On-Leakage Current (Notes 5, 9)	$I_{COM\_(ON)}$	$V_{COM\_}$ = 10V, $V_{NO\_}$ or $V_{NC\_}$ = 1V or 12V	+25°C	-0.5	0.01	0.5	nA
			C, E	-20		20	
			M	-400		400	
FAULT PROTECTION							
Fault-Protected Analog Signal Range (Note 2)	$V_{NO\_}$, $V_{NC\_}$	Applies with power on, MAX4631/MAX4633	C, E, M	-36		36	V
		Applies with power on, MAX4632	C, E, M	-25		25	
		Applies with power off	C, E, M	-40		40	

ELECTRICAL CHARACTERISTICS—Single Supply (continued)

(V+ = +15V, V- = -15V, $V_{INL\_}$ = 0.8V, $V_{INH\_}$ = 2.4V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 3)

PARAMETER	SYMBOL	CONDITIONS	T_A	MIN	TYP	MAX	UNITS
COM_ Output Leakage Current, Supplies On	$I_{COM\_}$	$V_{NO\_}$ or $V_{NC\_}$ = ±25V, no connection to "on" channel (MAX4632 only)	C, E	-10		10	nA
			M	-1		1	µA
NO_ or NC_ Input Leakage Current, Supplies On	$I_{NO\_}$, $I_{NC\_}$	$V_{NO\_}$ or $V_{NC\_}$ = ±25V, $V_{COM\_}$ = ±10V	C, E	-100		100	nA
			M	-10		10	µA
NO_ or NC_ Input Leakage Current, Supplies Off	$I_{NO\_}$, $I_{NC\_}$	$V_{NO\_}$ or $V_{NC\_}$ = ±40V	C, E	-100	1	100	nA
			M	-10		10	µA
COM_ Output Clamp Current, Supplies On	$I_{COM\_}$	$V_{NO\_}$ or $V_{NC\_}$ = 25V	+25°C	4	5.5	10	mA
COM_ Output Clamp Resistance, Supplies On	$R_{COM\_}$	$V_{NO\_}$ or $V_{NC\_}$ = 25V	+25°C		1	2.5	kΩ
LOGIC INPUT							
IN_ Input Logic Voltage High	$V_{INH\_}$		C, E, M	2.4			V
IN_ Input Logic Voltage Low	$V_{INL\_}$		C, E, M			0.8	V
IN_ Input Current Logic High or Low	$I_{INH\_}$, $I_{INL\_}$	$V_{IN\_}$ = 0.8V or 2.4V	+25°C	-1	0.03	1	µA
			C, E, M	-5		5	µA
SWITCH DYNAMIC CHARACTERISTICS							
Turn-On Time	t_{ON}	$V_{COM\_}$ = ±10V, R_L = 2kΩ, Figure 2	+25°C		140	250	ns
			C, E,			300	
			M			500	
Turn-Off Time	t_{OFF}	$V_{COM\_}$ = ±10V, R_L = 2kΩ, Figure 2	+25°C		100	200	ns
			C, E,			250	
			M			400	
Break-Before-Make Time Delay (MAX4632 only)	t_{BBM}	$V_{COM\_}$ = ±10V, R_L = 2kΩ, Figure 3	+25°C	5	40		ns
Charge Injection (Note 6)	Q	C_L = 100pF, Figure 4, NO_ = NC_ = GND, R_S = 0	+25°C		5		pC
NO_, NC_ Off-Capacitance	$C_{NC\_(OFF)}$, $C_{NO\_(OFF)}$	NO_ = NC_ = GND, f = 1MHz, Figure 5	C, E, M		20		pF
COM_ Off-Capacitance	$C_{COM\_(OFF)}$	COM_ = GND, f = 1MHz, Figure 5	C, E, M		20		pF
COM_ On-Capacitance	$C_{COM\_(ON)}$	COM_ = NO_ = NC_ = GND, f = 1MHz, Figure 5	C, E, M		25		pF
Off-Isolation (Note 7)	V_{ISO}	R_L = 50Ω, C_L = 15pF, $V_{NO\_}$ = $V_{NC\_}$ = $1V_{RMS}$, f = 1MHz, Figure 6	C, E, M		-62		dB
Channel-to-Channel Crosstalk (Note 8)	V_{CT}	R_L = 50Ω, C_L = 15pF, $V_{NO\_}$ = $V_{NC\_}$ = $1V_{RMS}$, f = 1MHz, Figure 7	C, E, M		-65		dB

Fault-Protected, High-Voltage, Dual Analog Switches

ELECTRICAL CHARACTERISTICS—Single Supply (continued)

(V+ = +15V, V- = -15V, $V_{INL\_}$ = 0.8V, $V_{INH\_}$ = 2.4V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 3)

PARAMETER	SYMBOL	CONDITIONS	T_A	MIN	TYP	MAX	UNITS
POWER SUPPLY							
Power-Supply Range	V+, V-		C, E, M	0		36	V
V+ Supply Current	I+	All $V_{IN\_}$ = 0 or 5V, $V_{NO\_}$ or $V_{NC\_}$ = 0	+25°C		165	250	µA
			C, E, M			400	
GND Supply Current	I_{GND}	All $V_{IN\_}$ = 0 or 5V, $V_{NO\_}$ or $V_{NC\_}$ = 0	+25°C		165	250	µA
			C, E, M			400	

Note 2: NC_ and NO_ pins are fault protected (see *Electrical Characteristics*). With power applied to V+ or V-, signals on NC_ or NO_ exceeding ±25V (MAX4632) or ±36V (MAX4631/MAX4633) may damage the device. With V+ = V- = 0, signals on NC_ or NO_ exceeding ±40V may damage the device.

Note 3: The algebraic convention is used in this data sheet; the most negative value is shown in the minimum column.

Note 4: $\Delta R_{ON} = R_{ON(MAX)} - R_{ON(MIN)}$.

Note 5: Leakage parameters are 100% tested at maximum rated hot temperature and guaranteed by correlation at +25°C.

Note 6: Guaranteed by design.

Note 7: Off-isolation = $20\log_{10}[V_{COM\_} / (V_{NC\_}$ or $V_{NO\_})]$, $V_{COM\_}$ = output, $V_{NC\_}$ or $V_{NO\_}$ = input to off switch.

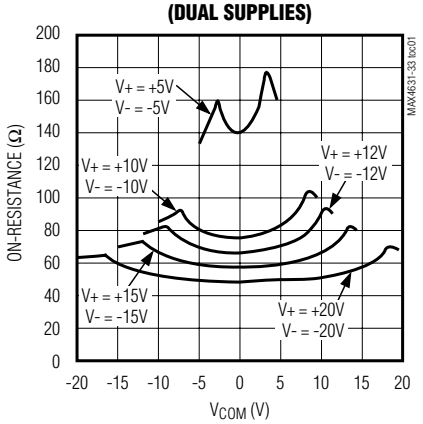
Note 8: Between any two switches.

Note 9: Leakage testing for single-supply operation is guaranteed by testing with dual supplies.

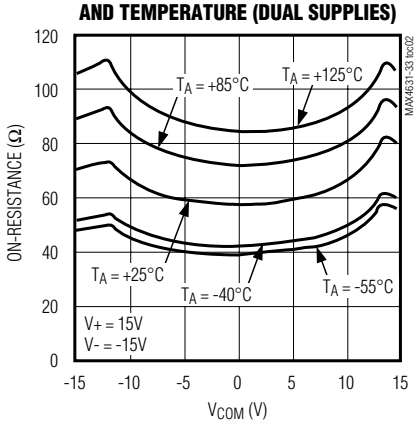
Typical Operating Characteristics

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

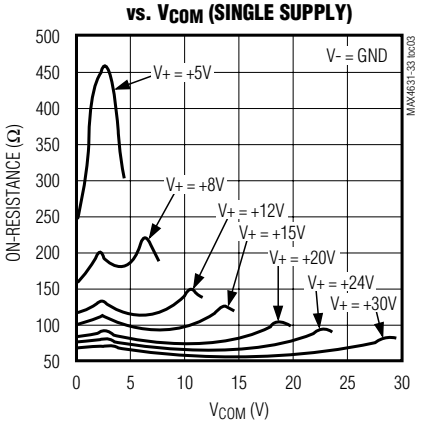
SWITCH ON-RESISTANCE vs. V_{COM} (DUAL SUPPLIES)



ON-RESISTANCE vs. V_{COM} AND TEMPERATURE (DUAL SUPPLIES)



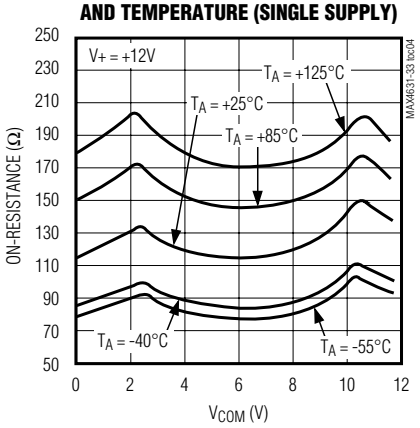
SWITCH ON-RESISTANCE vs. V_{COM} (SINGLE SUPPLY)



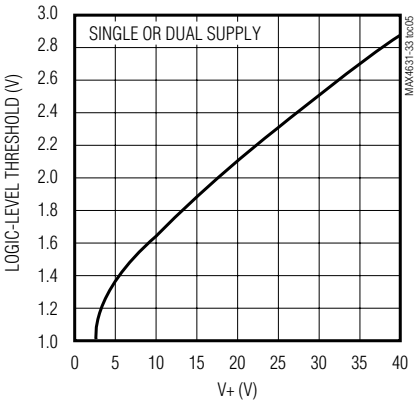
Typical Operating Characteristics (continued)

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

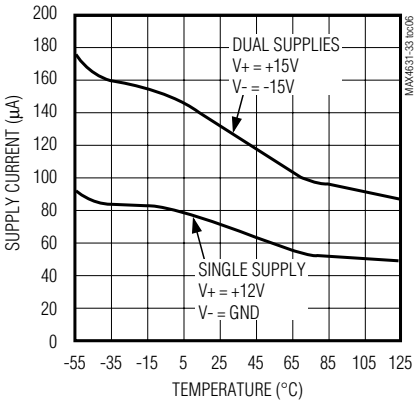
ON-RESISTANCE vs. V_{COM} AND TEMPERATURE (SINGLE SUPPLY)



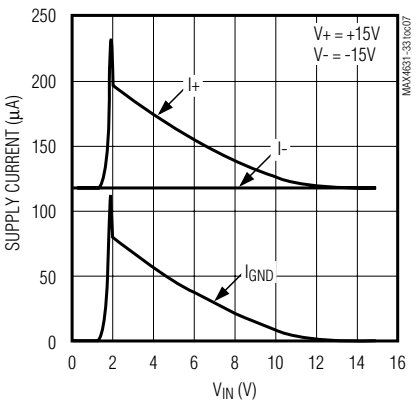
LOGIC-LEVEL THRESHOLD vs. V+



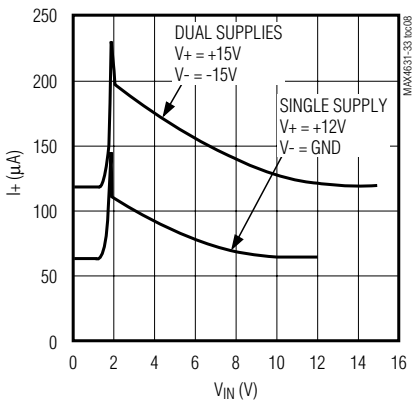
SUPPLY CURRENT vs. TEMPERATURE



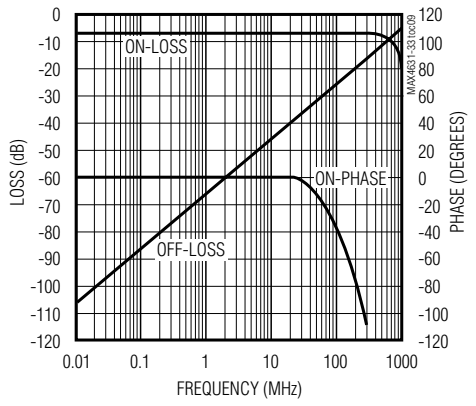
SUPPLY CURRENT vs. V_{IN}



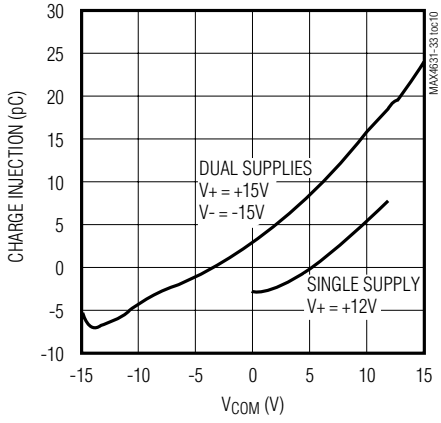
I+ vs. V_{IN}



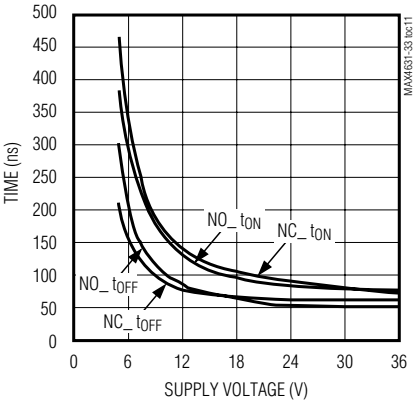
FREQUENCY RESPONSE



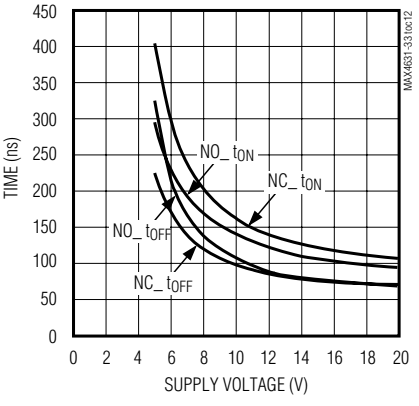
CHARGE INJECTION vs. V_{COM}



ON/OFF TIME vs. SINGLE-SUPPLY VOLTAGE



ON/OFF TIME vs. DUAL-SUPPLY VOLTAGE

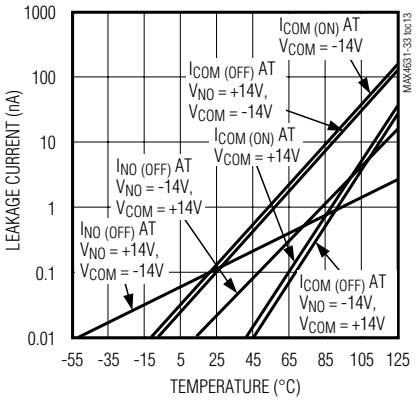


Fault-Protected, High-Voltage, Dual Analog Switches

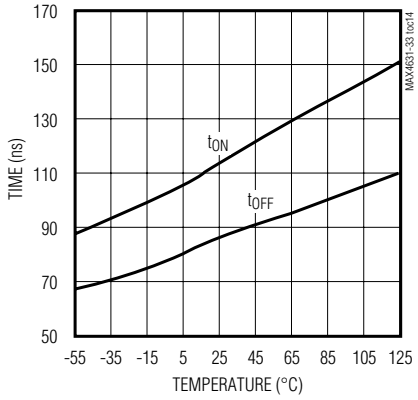
Typical Operating Characteristics (continued)

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

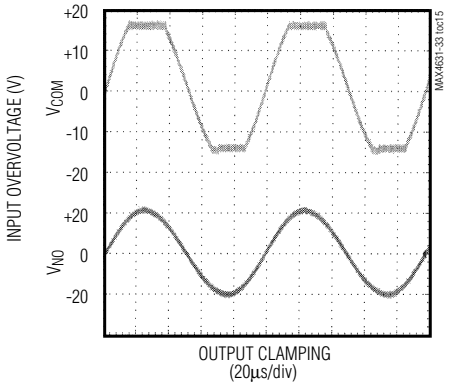
LEAKAGE CURRENT vs. TEMPERATURE



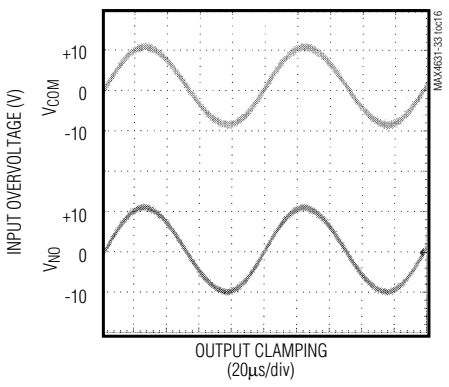
ON/OFF TIME vs. TEMPERATURE



INPUT OVERVOLTAGE vs. OUTPUT CLAMPING (±15V SUPPLIES)



FAULT-FREE SIGNAL (±15V SUPPLIES)



Pin Description

PIN			NAME	FUNCTION
MAX4631	MAX4632	MAX4633		
1, 8	1, 8	1, 8	COM1, COM2	Analog Switch Common Terminals
16, 9	16, 9	16, 9	NO1, NO2	Analog Switch Normally Open Terminals
15, 10	15, 10	15, 10	IN1, IN2	Logic-Control Digital Inputs
2–7, 12	2, 7, 12	2, 7, 12	N.C.	No Connection. Not internally connected.
—	3, 6	3, 6	COM3, COM4	Analog Switch Common Terminals
—	4, 5	—	NC3, NC4	Analog Switch Normally Closed Terminals
—	—	4, 5	NO3, NO4	Analog Switch Normally Open Terminals
11	11	11	V+	Positive Supply Input
13	13	13	GND	Ground
14	14	14	V-	Negative Supply Input

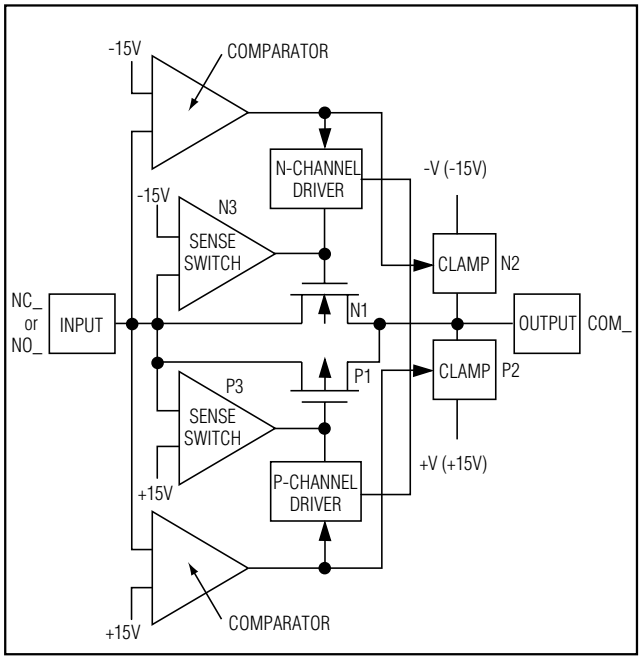


Figure 1. Simplified Internal Structure

Detailed Description

The MAX4631/MAX4632/MAX4633 are fault-protected analog switches with special operation and construction. Traditional fault-protected switches are constructed using three series CMOS devices. This combination produces good fault-protection but fairly high on-resistance when the signals are within 3V of each supply rail. These series devices are not capable of handling signals up to the power-supply rails.

These devices differ considerably from traditional fault-protection switches, with three advantages. First, they are constructed with two parallel FETs, allowing very low on-resistance when the switch is on. Second, they allow signals on the NC_ or NO_ pins that are within or slightly beyond the supply rails to be passed through the switch to the COM_ terminal, allowing rail-to-rail signal operation. Third, when a signal on NC_ or NO_ exceeds the supply rails by about 50mV (a fault condition), the voltage on COM_ is limited to the appropriate polarity supply voltage. Operation is identical for both fault polarities. The fault-protection extends to ±25V (MAX4632) or ±36V (MAX4631/MAX4633) with power on and ±40V with power off.

The MAX4631/MAX4632/MAX4633 have a parallel N-channel and P-channel MOSFET switch configuration with input voltage sensors. The simplified structure is shown in Figure 1. The parallel N1 and P1 MOSFETs form the switch element. N3 and P3 are sensor elements to sample the input voltage and compare it against the power-supply rails.

During normal operation of a conducting channel, N1 and P1 remain on with a typical 62Ω on-resistance between NO_ (or NC_) and COM_. If the input voltage exceeds either supply rail by about 50mV, the parallel combination switches (N1, P1) are forced off through the driver and sensing circuitry. At the same time, the output (COM_) is clamped to the appropriate supply rail by the clamp circuitry (N2, P2). Two clamp circuits limit the output voltage to the supply voltages.

Pin Compatibility

These switches have identical pinouts to common non-fault-protected CMOS switches (DG401, DG403, DG405). Exercise care in considering them as direct replacements in existing printed circuit boards, since only the NO_ and NC_ pins of each switch are fault protected.

Normal Operation

Two comparators continuously compare the voltage on the NO_ (or NC_) pin with V+ and V- supply voltages (Figure 1). When the signal on NO_ (or NC_) is between V+ and V-, the switch behaves normally, with FETs N1 and P1 turning on and off in response to NO_ (or NC_) signals.

For any voltage between the supply rails, the switch is bidirectional; therefore, COM_ and NO_ (or NC_) are interchangeable. Only NO_ and NC_ can be exposed to overvoltages beyond the supply range and within the specified breakdown limits of the device.

Fault Condition

The MAX4631/MAX4632/MAX4633 protect devices connected to their outputs (COM_) through their unique fault-protection circuitry. When the input voltage is raised 50mV above either supply rail, the internal sense and comparator circuitry (N3 and N-channel driver or P3 and P-channel driver) disconnect the output (COM_) from the input (Figure 1).

If the switch driven above the supply rail has an on state, the clamp circuitry (N2 or P2) connects the output to the appropriate supply rail. Table 1 summarizes the switches' operation under normal and fault conditions.

Fault-Protected, High-Voltage, Dual Analog Switches

Table 1. Switch States in Normal and Fault Conditions

POWER SUPPLIES (V+, V-)	INPUT RANGE	NC_	NO_	OUTPUT
On	Between Rails	On	Off	NC_
On	Between Rails	Off	On	NO_
On	Between V+ and (+40V - V+)	On	Off	V+
On	Between V+ and (+40V - V+)	Off	On	V+
On	Between V- and (-40V - V-)	On	Off	V-
On	Between V+ and (-40V - V-)	Off	On	V-
Off	Between Rails	Off	Off	Follows the load terminal voltage

Transient Fault Response and Recovery

When a fast rising and falling transient on NO_ (or NC_) exceeds V+ or V-, the output (COM_) follows the input (IN_) to the supply rail with only a few nanoseconds of delay. This delay is due to the switch on-resistance and circuit capacitance to ground. However, when the input transient returns to within the supply rails, there is a longer output recovery time delay. For positive and negative faults, the recovery time is typically 2.5µs. These values depend on the COM_ output resistance and capacitance, and are not production tested or guaranteed. The delays are not dependent on the fault amplitude. Higher COM_ output resistance and capacitance increase recovery times.

Fault-Protection Voltage and Power Off

The maximum fault voltage on the NO_ (or NC_) pins is ±40V when the power is off. For the MAX4631/MAX4633, with ±15V supplies, the highest voltage on NO_ (or NC_) can be +36V, and the lowest voltage on NO (or NC_) can be -36V. For the MAX4632, with ±15V supplies, the highest voltage on NO_ (or NC_) can be +25V, and the lowest voltage on NO_ (or NC_) can be -25V. Exceeding these limits can damage the device.

IN_ Logic-Level Thresholds

The logic-level thresholds are TTL/CMOS compatible when V+ is +15V. Raising V+ increases the threshold slightly; when V+ reaches +25V, the level threshold is about 2.8V—higher than the TTL output high-level minimum of 2.4V, but still compatible with CMOS outputs (see *Typical Operating Characteristics*).

Increasing V- has no effect on the logic-level thresholds, but it does increase the gate-drive voltage to the signal FETs, reducing their on-resistance.

Failure Modes

The MAX4631/MAX4632/MAX4633 are not lightning arrestors or surge protectors. Exceeding the fault-protection voltage limits on NO_ or NC_, even for very short periods, can cause the device to fail. The failure modes may not be obvious, and failure in one switch may or may not affect other switches in the same package.

Applications Information

Ground

There is no connection between the analog signal paths and GND. The analog signal paths consist of an N-channel and a P-channel MOSFET with their sources and drains paralleled and their gates driven out of phase to V+ and V- by the logic-level translators.

V+ and GND power the internal logic and logic-level translators and set the input logic thresholds. The logic-level translators convert the logic levels to switched V+ and V- signals to drive the analog switch gates. This drive signal is the only connection between the power supplies and the analog signals. GND, IN_, and COM_ have ESD-protection diodes to V+ and V-.

Supply-Current Reduction

When the logic signals are driven rail-to-rail from 0 to +12V or -15V to +15V, the supply current reduces to approximately half of the supply current when the logic input levels are at 0 to +5V.

Power Supplies

The MAX4631/MAX4632/MAX4633 operate with bipolar supplies between ±4.5V and ±18V. The V+ and V- supplies need not be symmetrical, but their difference can not exceed the absolute maximum rating of +44V. These devices operate from a single supply between +9V and +36V when V- is connected to GND.

High-Frequency Performance

In 50Ω systems, signal response is reasonably flat up to 30MHz (see *Typical Operating Characteristics*). Above 30MHz, the on-response has several minor peaks that are highly layout dependent. The problem with high-frequency operation is not turning the switch on, but turning it off. The off-state switch acts like a capacitor and passes higher frequencies with less attenuation. At 10MHz, off-isolation is about -46dB in 50Ω systems, declining (approximately 20dB per decade) as frequency increases. Higher circuit impedance also diminishes off-isolation. Adjacent channel attenuation is about 3dB above that of a bare IC socket and is due entirely to capacitive coupling.

Test Circuits/Timing Diagrams

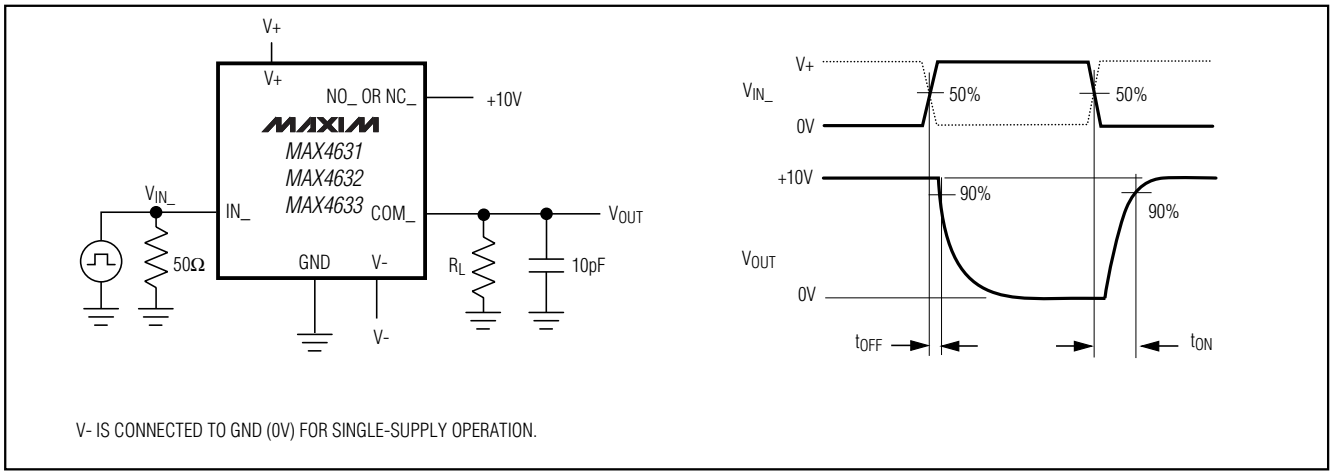


Figure 2. Switch Turn-On/Turn-Off Times

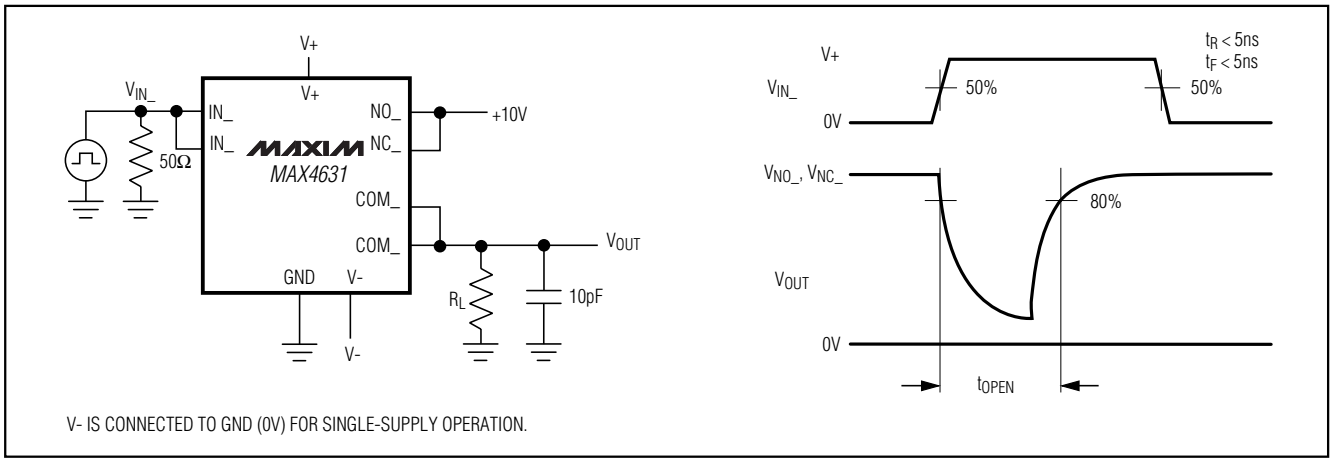


Figure 3. MAX4631 Break-Before-Make Interval

Fault-Protected, High-Voltage, Dual Analog Switches

Test Circuits/Timing Diagrams (continued)

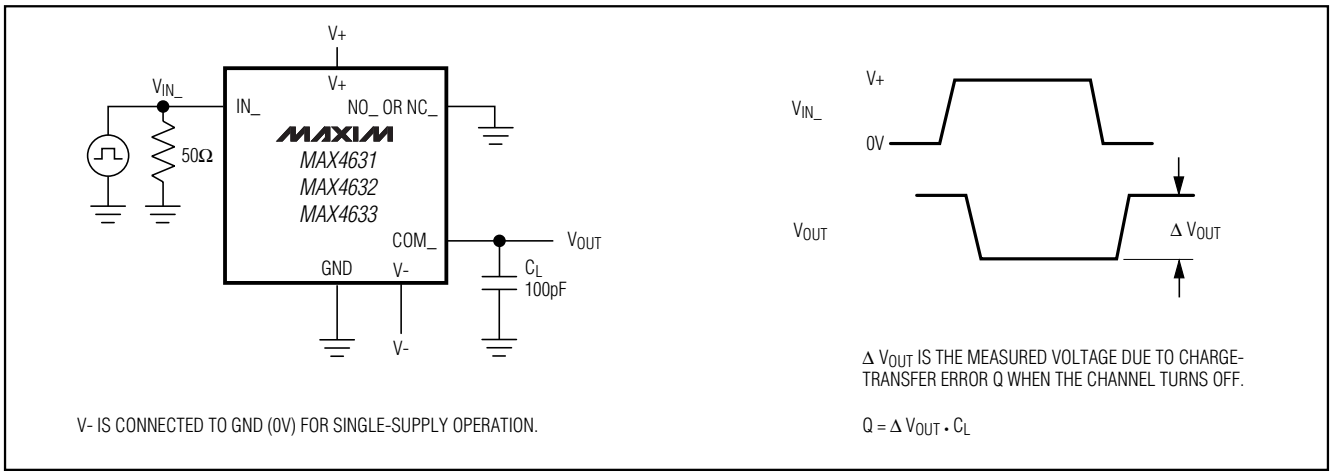


Figure 4. Charge Injection

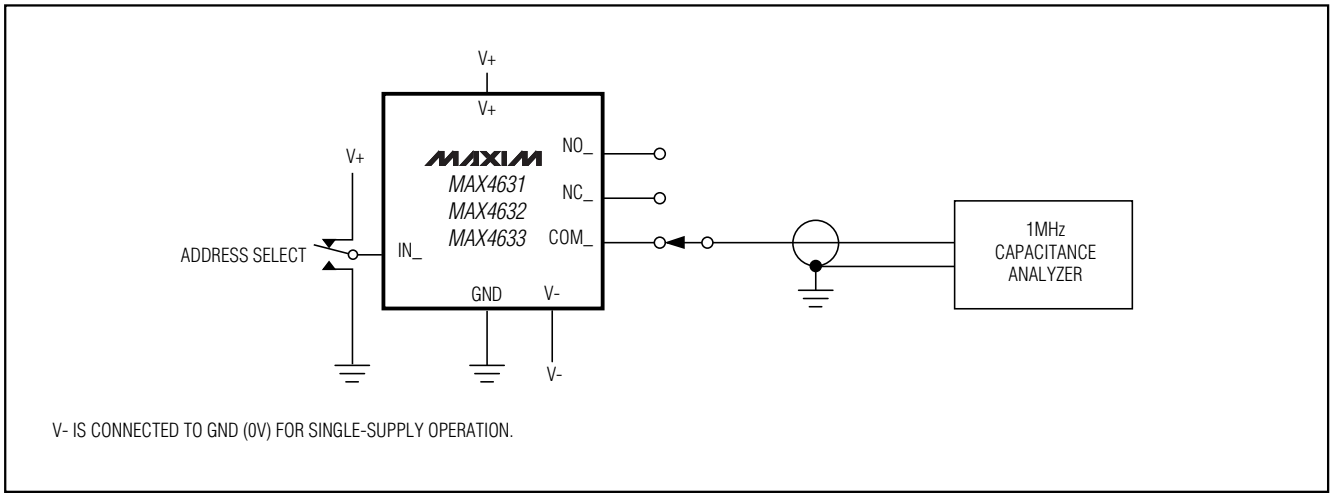


Figure 5. COM_, NO_, and NC_ Capacitance

Test Circuits/Timing Diagrams (continued)

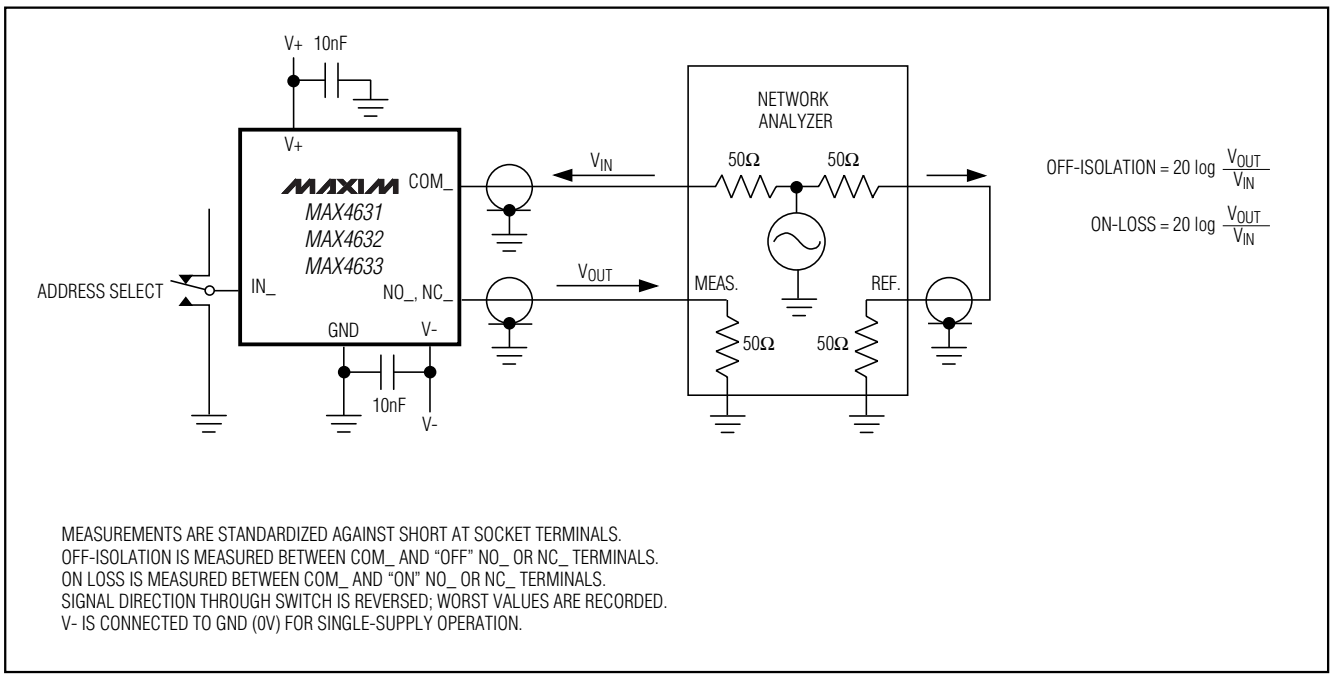


Figure 6. Frequency Response and Off-Isolation

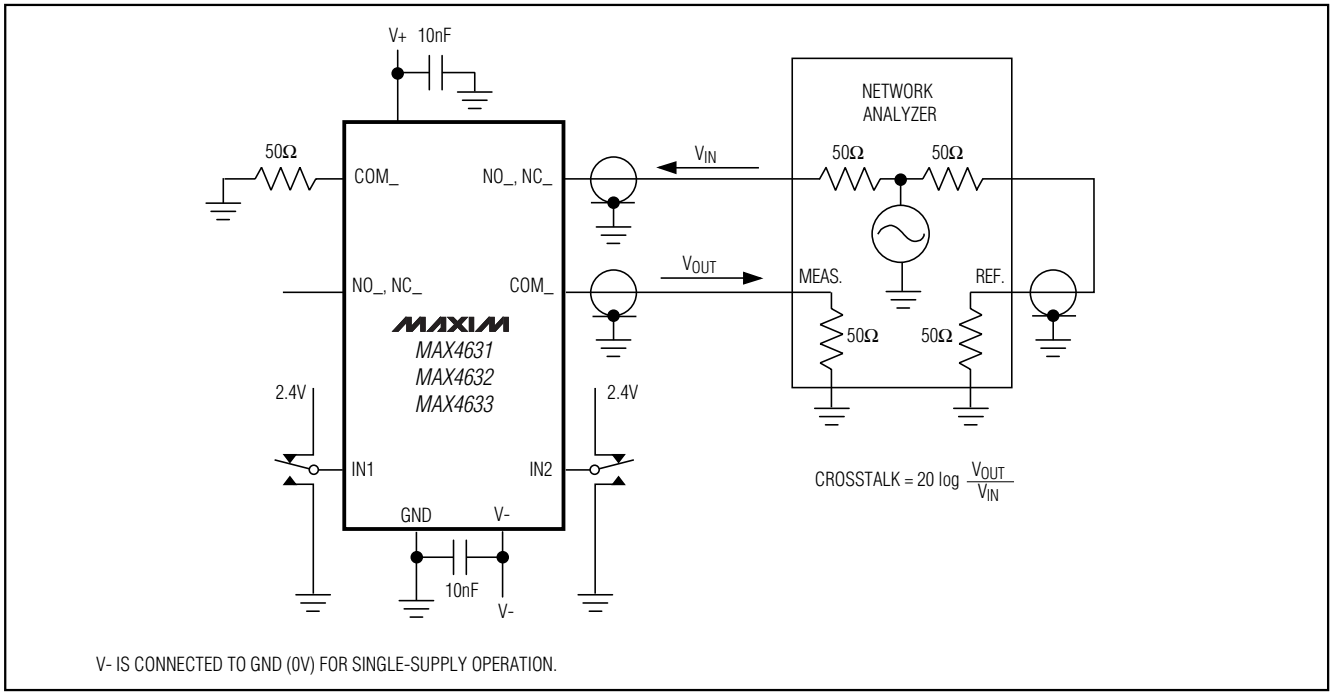
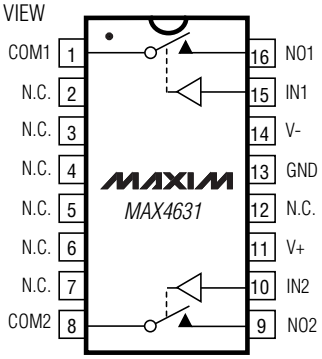


Figure 7. Crosstalk

Fault-Protected, High-Voltage, Dual Analog Switches

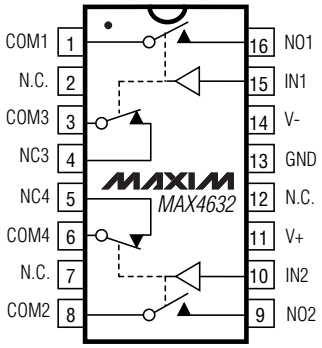
Pin Configurations/Functional Diagrams/Truth Tables

TOP VIEW



DIP/SO

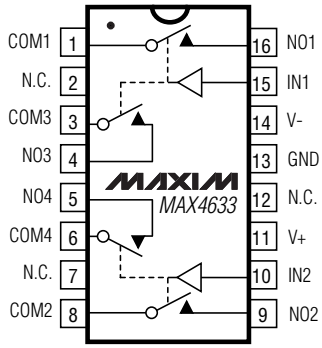
MAX4631	
LOGIC	SWITCH
0	OFF
1	ON



DIP/SO

MAX4632		
LOGIC	SWITCHES 1, 2	SWITCHES 3, 4
0	OFF	ON
1	ON	OFF

SWITCHES SHOWN FOR LOGIC "0" INPUT



DIP/SO

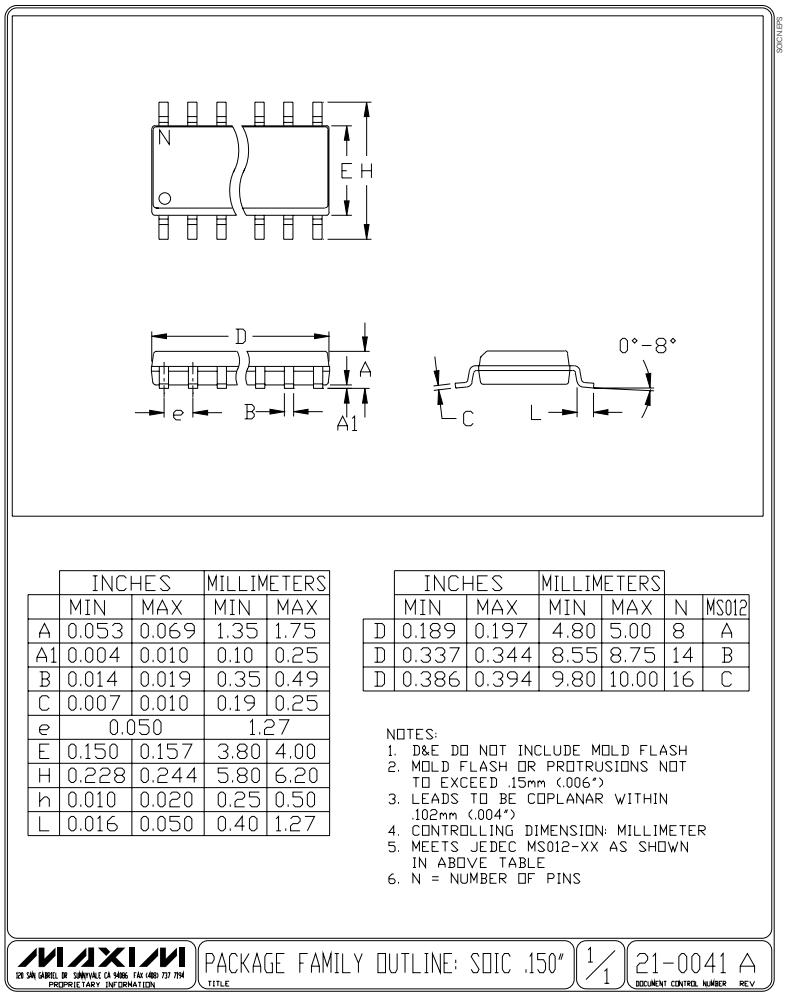
MAX4633	
LOGIC	SWITCH
0	OFF
1	ON

N.C. = NOT INTERNALLY CONNECTED

Chip Information

TRANSISTOR COUNT: 223

Package Information



	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.053	0.069	1.35	1.75
A1	0.004	0.010	0.10	0.25
B	0.014	0.019	0.35	0.49
C	0.007	0.010	0.19	0.25
e	0.050		1.27	
E	0.150	0.157	3.80	4.00
H	0.228	0.244	5.80	6.20
h	0.010	0.020	0.25	0.50
L	0.016	0.050	0.40	1.27

	INCHES		MILLIMETERS			
	MIN	MAX	MIN	MAX	N	MS012
D	0.189	0.197	4.80	5.00	8	A
D	0.337	0.344	8.55	8.75	14	B
D	0.386	0.394	9.80	10.00	16	C

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15mm (.006")
3. LEADS TO BE COPLANAR WITHIN .102mm (.004")
4. CONTROLLING DIMENSION: MILLIMETER
5. MEETS JEDEC MS012-XX AS SHOWN IN ABOVE TABLE
6. N = NUMBER OF PINS

MAXIM — 120 SAN GABRIEL DR SUNNYVALE CA 94086 FAX (408) 737 7194 — PROPRIETARY INFORMATION

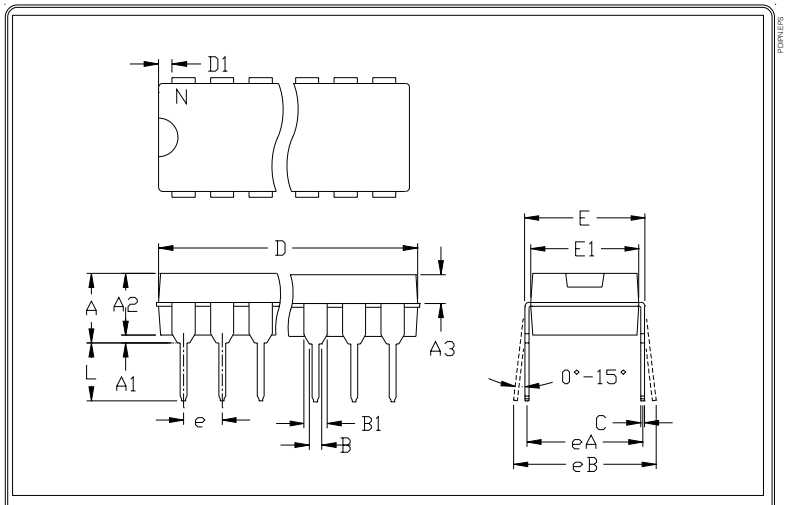
PACKAGE FAMILY OUTLINE: SOIC .150" — TITLE

1/1

21-0041 A — DOCUMENT CONTROL NUMBER — REV.

Fault-Protected, High-Voltage, Dual Analog Switches

Package Information (continued)



	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	---	0.200	---	5.08
A1	0.015	---	0.38	---
A2	0.125	0.175	3.18	4.45
A3	0.055	0.080	1.40	2.03
B	0.016	0.022	0.41	0.56
B1	0.045	0.065	1.14	1.65
C	0.008	0.012	0.20	0.30
D1	0.005	0.080	0.13	2.03
E	0.300	0.325	7.62	8.26
E1	0.240	0.310	6.10	7.87
e	0.100	---	2.54	---
eA	0.300	---	7.62	---
eB	---	0.400	---	10.16
L	0.115	0.150	2.92	3.81

	INCHES		MILLIMETERS			
	MIN	MAX	MIN	MAX	N	MS001
D	0.348	0.390	8.84	9.91	8	AB
D	0.735	0.765	18.67	19.43	14	AC
D	0.745	0.765	18.92	19.43	16	AA
D	0.885	0.915	22.48	23.24	18	AD
D	1.015	1.045	25.78	26.54	20	AE
D	1.14	1.265	28.96	32.13	24	AF
D	1.360	1.380	34.54	35.05	28	*5

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15mm (.006")
3. CONTROLLING DIMENSION: MILLIMETER
4. MEETS JEDEC MS001-XX AS SHOWN IN ABOVE TABLE
5. SIMILIAR TO JEDEC MO-058AB
6. N = NUMBER OF PINS

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