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Fault Protection and Detection, 10 Ω R_{ON}, Quad SPST Switches

Data Sheet

ADG5412F/ADG5413F

FEATURES

- Overvoltage protection up to −55 V and +55 V
- Power-off protection up to −55 V and +55 V
- Overvoltage detection on source pins
- Low on resistance: 10 Ω
  - On-resistance flatness of 0.5 Ω
- 5.5 kV human body model (HBM) ESD rating
- Latch-up immune under any circumstance
- Known state without digital inputs present
- V_{SS} to V_{DD} analog signal range
  - ±5 V to ±22 V dual supply operation
  - 8 V to 44 V single-supply operation
  - Fully specified at ±15 V, ±20 V, +12 V, and +36 V

APPLICATIONS

- Analog input/output modules
- Process control/distributed control systems
- Data acquisition
- Instrumentation
- Avionics
- Automatic test equipment
- Communication systems
- Relay replacement

FUNCTIONAL BLOCK DIAGRAMS

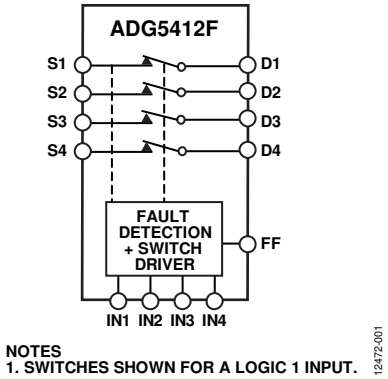

Figure 1. ADG5412F

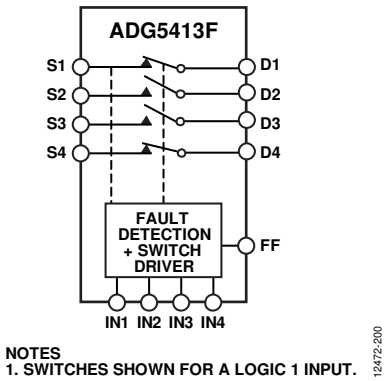

Figure 2. ADG5413F

GENERAL DESCRIPTION

The ADG5412F and ADG5413F contain four independently controlled single-pole/single-throw (SPST) switches. The ADG5412F has four switches that turn on with Logic 1 inputs. The ADG5413F has two switches that turn on and two switches that turn off with Logic 1 inputs. Each switch conducts equally well in both directions when on, and each switch has an input signal range that extends to the supplies. The digital inputs are compatible with 3 V logic inputs over the full operating supply range.

When no power supplies are present, the switch remains in the off condition, and the switch inputs are high impedance. Under normal operating conditions, if the analog input signal levels on any Sx pin exceed V_{DD} or V_{SS} by a threshold voltage, V_T, the switch turns off. Input signal levels up to +55 V or −55 V relative to ground are blocked, in both the powered and unpowered condition.

The low on resistance of these switches, combined with on-resistance flatness over a significant portion of the signal range make them an ideal solution for data acquisition and gain switching applications where excellent linearity and low distortion are critical.

PRODUCT HIGHLIGHTS

1. Source pins are protected against voltages greater than the supply rails, up to −55 V and +55 V.
2. Source pins are protected against voltages between −55 V and +55 V in an unpowered state.
3. Overvoltage detection with digital output indicates operating state of switches.
4. Trench isolation guards against latch-up.
5. Optimized for low on resistance and on-resistance flatness.
6. The ADG5412F/ADG5413F can be operated from a dual supply of ±5 V up to ±22 V or a single power supply of 8 V up to 44 V.

Rev. B

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SPECIFICATIONS

±15 V DUAL SUPPLY

V_{DD} = 15 V ± 10%, V_{SS} = −15 V ± 10%, GND = 0 V, $C_{DECOUPLING}$ = 0.1 µF, unless otherwise noted.

Table 1.

Parameter	+25°C	−40°C to +85°C	−40°C to +125°C	Unit	Test Conditions/Comments
ANALOG SWITCH					V_{DD} = 13.5 V, V_{SS} = −13.5 V, see Figure 32
Analog Signal Range			V_{DD} to V_{SS}	V	
On Resistance, R_{ON}	10			Ω typ	V_S = ±10 V, I_S = −10 mA
	11.2	14	16.5	Ω max	
	9.5			Ω typ	V_S = ±9 V, I_S = −10 mA
	10.7	13.5	16	Ω max	
On-Resistance Match Between Channels, ΔR_{ON}	0.05			Ω typ	V_S = ±10 V, I_S = −10 mA
	0.5	0.6	0.7	Ω max	
	0.05			Ω typ	V_S = ±9 V, I_S = −10 mA
	0.35	0.5	0.5	Ω max	
On-Resistance Flatness, $R_{FLAT(ON)}$	0.6			Ω typ	V_S = ±10 V, I_S = −10 mA
	0.9	1.1	1.1	Ω max	
	0.1			Ω typ	V_S = ±9 V, I_S = −10 mA
	0.4	0.5	0.5	Ω max	
Threshold Voltage, V_T	0.7			V typ	See Figure 28
LEAKAGE CURRENTS					V_{DD} = 16.5 V, V_{SS} = −16.5 V
Source Off Leakage, I_S (Off)	±0.1			nA typ	V_S = ±10 V, V_D = ∓10 V, see Figure 33
	±1.5	±5.0	±21	nA max	
Drain Off Leakage, I_D (Off)	±0.1			nA typ	V_S = ±10 V, V_D = ∓10 V, see Figure 33
	±1.5	±5.0	±18	nA max	
Channel On Leakage, I_D (On), I_S (On)	±0.3			nA typ	V_S = V_D = ±10 V, see Figure 34
	±1.5	±2.0	±4.5	nA max	
FAULT					
Source Leakage Current, I_S					
With Overvoltage			±78	µA typ	V_{DD} = 16.5 V, V_{SS} = 16.5 V, GND = 0 V, V_S = ±55 V, see Figure 37
Power Supplies Grounded or Floating			±40	µA typ	V_{DD} = 0 V or floating, V_{SS} = 0 V or floating, GND = 0 V, INx = 0 V or floating, V_S = ±55 V, see Figure 38
Drain Leakage Current, I_D					
With Overvoltage	±2.0			nA typ	V_{DD} = 16.5 V, V_{SS} = 16.5 V, GND = 0 V, V_S = ±55 V, see Figure 37
	±8.0	±15	±49	nA max	
Power Supplies Grounded	±10			nA typ	V_{DD} = 0 V, V_{SS} = 0 V, GND = 0 V, V_S = ±55 V, INx = 0 V, see Figure 38
	±30	±50	±100	nA max	
Power Supplies Floating	±10	±10	±10	µA typ	V_{DD} = floating, V_{SS} = floating, GND = 0 V, V_S = ±55 V, INx = 0 V, see Figure 38
DIGITAL INPUTS/OUTPUTS					
Input Voltage High, V_{INH}			2.0	V min	
Input Voltage Low, V_{INL}			0.8	V max	
Input Current, I_{INL} or I_{INH}	±0.7			µA typ	V_{IN} = V_{GND} or V_{DD}
			±1.2	µA max	
Digital Input Capacitance, C_{IN}	5.0			pF typ	
Output Voltage High, V_{OH}	2.0			V min	
Output Voltage Low, V_{OL}	0.8			V max	

Parameter	+25°C	−40°C to +85°C	−40°C to +125°C	Unit	Test Conditions/Comments
DYNAMIC CHARACTERISTICS[1]					
t_{ON}	400			ns typ	R_L = 300 Ω, C_L = 35 pF
	495	525	550	ns max	V_S = 10 V, see Figure 47
t_{OFF}	410			ns typ	R_L = 300 Ω, C_L = 35 pF
	510	545	555	ns max	V_S = 10 V, see Figure 47
Break-Before-Make Time Delay, t_D (ADG5413F Only)	285			ns typ	R_L = 300 Ω, C_L = 35 pF
			185	ns min	V_{S1} = V_{S2} = 10 V, see Figure 46
Overvoltage Response Time, $t_{RESPONSE}$	460			ns typ	R_L = 1 kΩ, C_L = 2 pF, see Figure 41
	585	615	630	ns max	
Overvoltage Recovery Time, $t_{RECOVERY}$	720			ns typ	R_L = 1 kΩ, C_L = 2 pF, see Figure 42
	930	1050	1100	ns max	
Interrupt Flag Response Time, $t_{DIGRESP}$	85		115	ns typ	C_L = 10 pF, see Figure 43
Interrupt Flag Recovery Time, t_{DIGREC}	60		85	µs typ	C_L = 10 pF, see Figure 44
	600			ns typ	C_L = 10 pF, R_{PULLUP} = 1 kΩ, see Figure 45
Charge Injection, Q_{INJ}	−680			pC typ	V_S = 0 V, R_S = 0 Ω, C_L = 1 nF, see Figure 48
Off Isolation	−70			dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz, see Figure 35
Channel-to-Channel Crosstalk	−90			dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz, see Figure 36
Total Harmonic Distortion Plus Noise, THD + N	0.0015			% typ	R_L = 10 kΩ, V_S = 15 V p-p, f = 20 Hz to 20 kHz, see Figure 40
−3 dB Bandwidth	270			MHz typ	R_L = 50 Ω, C_L = 5 pF, see Figure 39
Insertion Loss	−0.72			dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz, see Figure 39
C_S (Off)	13			pF typ	V_S = 0 V, f = 1 MHz
C_D (Off)	12			pF typ	V_S = 0 V, f = 1 MHz
C_D (On), C_S (On)	24			pF typ	V_S = 0 V, f = 1 MHz
POWER REQUIREMENTS					V_{DD} = 16.5 V, V_{SS} = −16.5 V, GND = 0 V, digital inputs = 0 V, 5 V, or V_{DD}
Normal Mode					
I_{DD}	0.9			mA typ	
	1.2		1.3	mA max	
I_{GND}	0.4			mA typ	
	0.55		0.6	mA max	
I_{SS}	0.5			mA typ	
	0.65		0.7	mA max	
Fault Mode					V_S = ±55 V
I_{DD}	1.2			mA typ	
	1.6		1.8	mA max	
I_{GND}	0.8			mA typ	
	1.0		1.1	mA max	
I_{SS}	0.5			mA typ	
	1.0		1.8	mA max	
V_{DD}/V_{SS}			±5	V min	GND = 0 V
			±22	V max	GND = 0 V

[1] Guaranteed by design; not subject to production test.

±20 V DUAL SUPPLY

V_{DD} = 20 V ± 10%, V_{SS} = −20 V ± 10%, GND = 0 V, $C_{DECOUPLING}$ = 0.1 µF, unless otherwise noted.

Table 2.

Parameter	+25°C	−40°C to +85°C	−40°C to +125°C	Unit	Test Conditions/Comments
ANALOG SWITCH					V_{DD} = 18 V, V_{SS} = −18 V, see Figure 32
Analog Signal Range			V_{DD} to V_{SS}	V	
On Resistance, R_{ON}	10			Ω typ	V_S = ±15 V, I_S = −10 mA
	11.5	14.5	16.5	Ω max	
	9.5			Ω typ	V_S = ±13.5 V, I_S = −10 mA
	11	14	16.5	Ω max	
On-Resistance Match Between Channels, ΔR_{ON}	0.05			Ω typ	V_S = ±15 V, I_S = −10 mA
	0.35	0.5	0.5	Ω max	
	0.05			Ω typ	V_S = ±13.5 V, I_S = −10 mA
	0.35	0.5	0.5	Ω max	
On-Resistance Flatness, $R_{FLAT(ON)}$	1.0			Ω typ	V_S = ±15 V, I_S = −10 mA
	1.4	1.5	1.5	Ω max	
	0.1			Ω typ	V_S = ±13.5 V, I_S = −10 mA
	0.4	0.5	0.5	Ω max	
Threshold Voltage, V_T	0.7			V typ	See Figure 28
LEAKAGE CURRENTS					V_{DD} = 22 V, V_{SS} = −22 V
Source Off Leakage, I_S (Off)	±0.1			nA typ	V_S = ±15 V, V_D = ∓15 V, see Figure 33
	±1.5	±5.0	±21	nA max	
Drain Off Leakage, I_D (Off)	±0.1			nA typ	V_S = ±15 V, V_D = ∓15 V, see Figure 33
	±1.5	±5.0	±18	nA max	
Channel On Leakage, I_D (On), I_S (On)	±0.3			nA typ	V_S = V_D = ±15 V, see Figure 34
	±1.5	±2.0	±4.5	nA max	
FAULT					
Source Leakage Current, I_S					
With Overvoltage			±78	µA typ	V_{DD} = 22 V, V_{SS} = −22 V, GND = 0 V, V_S = ±55 V, see Figure 37
Power Supplies Grounded or Floating			±40	µA typ	V_{DD} = 0 V or floating, V_{SS} = 0 V or floating, GND = 0 V, INx = 0 V or floating, V_S = ±55 V, see Figure 38
Drain Leakage Current, I_D					
With Overvoltage	±5.0			nA typ	V_{DD} = +22 V, V_{SS} = −22 V, GND = 0 V, V_S = ±55 V, see Figure 37
	±1.0	±1.0	±1.0	µA max	
Power Supplies Grounded	±10			nA typ	V_{DD} = 0 V, V_{SS} = 0 V, GND = 0 V, V_S = ±55 V, INx = 0 V, see Figure 38
	±30	±50	±100	nA max	
Power Supplies Floating	±10	±10	±10	µA typ	V_{DD} = floating, V_{SS} = floating, GND = 0 V, V_S = ±55 V, INx = 0 V, see Figure 38
DIGITAL INPUTS					
Input Voltage High, V_{INH}			2.0	V min	
Input Voltage Low, V_{INL}			0.8	V max	
Input Current, I_{INL} or I_{INH}	0.7			µA typ	V_{IN} = V_{GND} or V_{DD}
			1.2	µA max	
Digital Input Capacitance, C_{IN}	5.0			pF typ	
Output Voltage High, V_{OH}	2.0			V min	
Output Voltage Low, V_{OL}	0.8			V max	

Parameter	+25°C	−40°C to +85°C	−40°C to +125°C	Unit	Test Conditions/Comments
DYNAMIC CHARACTERISTICS[1]					
t_{ON}	400			ns typ	R_L = 300 Ω, C_L = 35 pF
	500	530	555	ns max	V_S = 10 V, see Figure 47
t_{OFF}	415			ns typ	R_L = 300 Ω, C_L = 35 pF
	515	550	565	ns max	V_S = 10 V, see Figure 47
Break-Before-Make Time Delay, t_D (ADG5413F Only)	295			ns typ	R_L = 300 Ω, C_L = 35 pF
			200	ns min	V_{S1} = V_{S2} = 10 V, see Figure 46
Overvoltage Response Time, $t_{RESPONSE}$	370			ns typ	R_L = 1 kΩ, C_L = 2 pF, see Figure 41
	480	500	515	ns max	
Overvoltage Recovery Time, $t_{RECOVERY}$	840			ns typ	R_L = 1 kΩ, C_L = 2 pF, see Figure 42
	1200	1400	1700	ns max	
Interrupt Flag Response Time, $t_{DIGRESP}$	85		115	ns typ	C_L = 10 pF, see Figure 43
Interrupt Flag Recovery Time, t_{DIGREC}	60		85	µs typ	C_L = 10 pF, see Figure 44
	600			ns typ	C_L = 10 pF, R_{PULLUP} = 1 kΩ, see Figure 45
Charge Injection, Q_{INJ}	−640			pC typ	V_S = 0 V, R_S = 0 Ω, C_L = 1 nF, see Figure 48
Off Isolation	−70			dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz, see Figure 35
Channel-to-Channel Crosstalk	−90			dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz, see Figure 36
Total Harmonic Distortion Plus Noise, THD + N	0.001			% typ	R_L = 10 kΩ, V_S = 20 V p-p, f = 20 Hz to 20 kHz, see Figure 40
−3 dB Bandwidth	270			MHz typ	R_L = 50 Ω, C_L = 5 pF, see Figure 39
Insertion Loss	−0.73			dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz, see Figure 39
C_S (Off)	12			pF typ	V_S = 0 V, f = 1 MHz
C_D (Off)	11			pF typ	V_S = 0 V, f = 1 MHz
C_D (On), C_S (On)	23			pF typ	V_S = 0 V, f = 1 MHz
POWER REQUIREMENTS					V_{DD} = 22 V, V_{SS} = −22 V, digital inputs = 0 V, 5 V, or V_{DD}
Normal Mode					
I_{DD}	0.9			mA typ	
	1.2		1.3	mA max	
I_{GND}	0.4			mA typ	
	0.55		0.6	mA max	
I_{SS}	0.5			mA typ	
	0.65		0.7	mA max	
Fault Mode					V_S = ±55 V
I_{DD}	1.2			mA typ	
	1.6		1.8	mA max	
I_{GND}	0.8			mA typ	
	1.0		1.1	mA max	
I_{SS}	0.5			mA typ	
	1.0		1.8	mA max	
V_{DD}/V_{SS}			±5	V min	GND = 0 V
			±22	V max	GND = 0 V

[1] Guaranteed by design; not subject to production test.

12 V SINGLE SUPPLY

V_{DD} = 12 V ± 10%, V_{SS} = 0 V, GND = 0 V, $C_{DECOUPLING}$ = 0.1 µF, unless otherwise noted.

Table 3.

Parameter	+25°C	−40°C to +85°C	−40°C to +125°C	Unit	Test Conditions/Comments
ANALOG SWITCH					V_{DD} = 10.8 V, V_{SS} = 0 V, see Figure 32
Analog Signal Range			0 V to V_{DD}	V	
On Resistance, R_{ON}	22			Ω typ	V_S = 0 V to 10 V, I_S = −10 mA
	24.5	31	37	Ω max	
	10			Ω typ	V_S = 3.5 V to 8.5 V, I_S = −10 mA
	11.2	14	16.5	Ω max	
On-Resistance Match Between Channels, ΔR_{ON}	0.05			Ω typ	V_S = 0 V to 10 V, I_S = −10 mA
	0.5	0.6	0.7	Ω max	
	0.05			Ω typ	V_S = 3.5 V to 8.5 V, I_S = −10 mA
	0.5	0.6	0.7	Ω max	
On-Resistance Flatness, $R_{FLAT(ON)}$	12.5			Ω typ	V_S = 0 V to 10 V, I_S = −10 mA
	14.5	19	23	Ω max	
	0.6			Ω typ	V_S = 3.5 V to 8.5 V, I_S = −10 mA
	0.9	1.1	1.3	Ω max	
Threshold Voltage, V_T	0.7			V typ	See Figure 28
LEAKAGE CURRENTS					V_{DD} = 13.2 V, V_{SS} = 0 V
Source Off Leakage, I_S (Off)	±0.1			nA typ	V_S = 1 V/10 V, V_D = 10 V/1 V, see Figure 33
	±1.5	±5.0	±21	nA max	
Drain Off Leakage, I_D (Off)	±0.1			nA typ	V_S = 1 V/10 V, V_D = 10 V/1 V, see Figure 33
	±1.5	±5.0	±18	nA max	
Channel On Leakage, I_D (On), I_S (On)	±0.3			nA typ	V_S = V_D = 1 V/10 V, see Figure 34
	±1.5	±2.0	±4.5	nA max	
FAULT					
Source Leakage Current, I_S					
With Overvoltage			±78	µA typ	V_{DD} = 13.2 V, V_{SS} = 0 V, GND = 0 V, V_S = ±55 V, see Figure 37
Power Supplies Grounded or Floating			±40	µA typ	V_{DD} = 0 V or floating, V_{SS} = 0 V or floating, GND = 0 V, INx = 0 V or floating, V_S = ±55 V, see Figure 38
Drain Leakage Current, I_D					
With Overvoltage	±2.0			nA typ	V_{DD} = 13.2 V, V_{SS} = 0 V, GND = 0 V, V_S = ±55 V, see Figure 37
	±8.0	±15	±49	nA max	
Power Supplies Grounded	±10			nA typ	V_{DD} = 0 V, V_{SS} = 0 V, GND = 0 V, V_S = ±55 V, INx = 0 V, see Figure 38
	±30	±50	±100	nA max	
Power Supplies Floating	±10	±10	±10	µA typ	V_{DD} = floating, V_{SS} = floating, GND = 0 V, V_S = ±55 V, INx = 0 V, see Figure 38
DIGITAL INPUTS					
Input Voltage High, V_{INH}			2.0	V min	
Input Voltage Low, V_{INL}			0.8	V max	
Input Current, I_{INL} or I_{INH}	0.7			µA typ	V_{IN} = V_{GND} or V_{DD}
			1.2	µA max	
Digital Input Capacitance, C_{IN}	5.0			pF typ	
Output Voltage High, V_{OH}	2.0			V min	
Output Voltage Low, V_{OL}	0.8			V max	

Parameter	+25°C	−40°C to +85°C	−40°C to +125°C	Unit	Test Conditions/Comments
DYNAMIC CHARACTERISTICS[1]					
t_{ON}	400			ns typ	R_L = 300 Ω, C_L = 35 pF
	485	515	540	ns max	V_S = 8 V, see Figure 47
t_{OFF}	375			ns typ	R_L = 300 Ω, C_L = 35 pF
	460	495	520	ns max	V_S = 8 V, see Figure 47
Break-Before-Make Time Delay, t_D (ADG5413F Only)	260			ns typ	R_L = 300 Ω, C_L = 35 pF
			170	ns min	$V_{S1} = V_{S2}$ = 8 V, see Figure 46
Overvoltage Response Time, $t_{RESPONSE}$	560			ns typ	R_L = 1 kΩ, C_L = 2 pF, see Figure 41
	660	700	720	ns max	
Overvoltage Recovery Time, $t_{RECOVERY}$	640			ns typ	R_L = 1 kΩ, C_L = 2 pF, see Figure 42
	800	865	960	ns max	
Interrupt Flag Response Time, $t_{DIGRESP}$	85		115	ns typ	C_L = 10 pF, see Figure 43
Interrupt Flag Recovery Time, t_{DIGREC}	60		85	µs typ	C_L = 10 pF, see Figure 44
	600			ns typ	C_L = 10 pF, R_{PULLUP} = 1 kΩ, see Figure 45
Charge Injection, Q_{INJ}	−340			pC typ	V_S = 6 V, R_S = 0 Ω, C_L = 1 nF, see Figure 48
Off Isolation	−65			dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz, see Figure 35
Channel-to-Channel Crosstalk	−90			dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz, see Figure 36
Total Harmonic Distortion Plus Noise, THD + N	0.007			% typ	R_L = 10 kΩ, V_S = 6 V p-p, f = 20 Hz to 20 kHz, see Figure 40
−3 dB Bandwidth	270			MHz typ	R_L = 50 Ω, C_L = 5 pF, see Figure 39
Insertion Loss	−0.74			dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz, see Figure 39
C_S (Off)	16			pF typ	V_S = 6 V, f = 1 MHz
C_D (Off)	15			pF typ	V_S = 6 V, f = 1 MHz
C_D (On), C_S (On)	25			pF typ	V_S = 6 V, f = 1 MHz
POWER REQUIREMENTS					V_{DD} = 13.2 V, V_{SS} = 0 V, digital inputs = 0 V, 5 V, or V_{DD}
Normal Mode					
I_{DD}	0.9			mA typ	
	1.2		1.3	mA max	
I_{GND}	0.4			mA typ	
	0.55		0.6	mA max	
I_{SS}	0.5			mA typ	
	0.65		0.7	mA max	
Fault Mode					V_S = ±55 V
I_{DD}	1.2			mA typ	
	1.6		1.8	mA max	
I_{GND}	0.8			mA typ	
	1.0		1.1	mA max	
I_{SS}	0.5			mA typ	Digital inputs = 5 V
	1.0		1.8	mA max	V_S = ±55 V, V_D = 0 V
V_{DD}			8	V min	GND = 0 V
			44	V max	GND = 0 V

[1] Guaranteed by design; not subject to production test.

36 V SINGLE SUPPLY

V_{DD} = 36 V ± 10%, V_{SS} = 0 V, GND = 0 V, $C_{DECOUPLING}$ = 0.1 µF, unless otherwise noted.

Table 4.

Parameter	+25°C	−40°C to +85°C	−40°C to +125°C	Unit	Test Conditions/Comments
ANALOG SWITCH					V_{DD} = 32.4 V, V_{SS} = 0 V, see Figure 32
Analog Signal Range			0 V to V_{DD}	V	
On Resistance, R_{ON}	22			Ω typ	V_S = 0 V to 30 V, I_S = −10 mA
	24.5	31	37	Ω max	
	10			Ω typ	V_S = 4.5 V to 28 V, I_S = −10 mA
	11	14	16.5	Ω max	
On-Resistance Match Between Channels, ΔR_{ON}	0.05			Ω typ	V_S = 0 V to 30 V, I_S = −10 mA
	0.5	0.6	0.7	Ω max	
	0.05			Ω typ	V_S = 4.5 V to 28 V, I_S = −10 mA
	0.35	0.5	0.5	Ω max	
On-Resistance Flatness, $R_{FLAT(ON)}$	12.5			Ω typ	V_S = 0 V to 30 V, I_S = −10 mA
	14.5	19	23	Ω max	
	0.1			Ω typ	V_S = 4.5 V to 28 V, I_S = −10 mA
	0.4	0.5	0.5	Ω max	
Threshold Voltage, V_T	0.7			V typ	See Figure 28
LEAKAGE CURRENTS					V_{DD} =39.6 V, V_{SS} = 0 V
Source Off Leakage, I_S (Off)	±0.1			nA typ	V_S = 1 V/30 V, V_D = 30 V/1 V, see Figure 33
	±1.5	±5.0	±21	nA max	
Drain Off Leakage, I_D (Off)	±0.1			nA typ	V_S = 1 V/30 V, V_D = 30 V/1 V, see Figure 33
	±1.5	±5.0	±18	nA max	
Channel On Leakage, I_D (On), I_S (On)	±0.3			nA typ	V_S = V_D = 1 V/30 V, see Figure 34
	±1.5	±2.0	±4.5	nA max	
FAULT					
Source Leakage Current, I_S					
With Overvoltage			±78	µA typ	V_{DD} = 39.6 V, V_{SS} = 0 V, GND = 0 V, V_S = +55 V, −40 V, see Figure 37
Power Supplies Grounded or Floating			±40	µA typ	V_{DD} = 0 V or floating, V_{SS} = 0 V or floating, GND = 0 V, INx = 0 V or floating, V_S = +55 V, −40 V, see Figure 38
Drain Leakage Current, I_D					
With Overvoltage	±2.0			nA typ	V_{DD} = 39.6 V, V_{SS} = 0 V, GND = 0 V, V_S = +55 V, −40 V, see Figure 37
	±8.0	±15	±49	nA max	
Power Supplies Grounded	±10			nA typ	V_{DD} = 0 V, V_{SS} = 0 V, GND = 0 V, V_S = +55 V, −40 V, INx = 0 V, see Figure 38
	±30	±50	±100	nA max	
Power Supplies Floating	±10	±10	±10	µA typ	V_{DD} = floating, V_{SS} = floating, GND = 0 V, V_S = +55 V, −40 V, INx = 0 V, see Figure 38
DIGITAL INPUTS					
Input Voltage High, V_{INH}			2.0	V min	
Input Voltage Low, V_{INL}			0.8	V max	
Input Current, I_{INL} or I_{INH}	0.7			µA typ	V_{IN} = V_{GND} or V_{DD}
			1.2	µA max	
Digital Input Capacitance, C_{IN}	5.0			pF typ	
Output Voltage High, V_{OH}	2.0			V min	
Output Voltage Low, V_{OL}	0.8			V max	

Parameter	+25°C	−40°C to +85°C	−40°C to +125°C	Unit	Test Conditions/Comments
DYNAMIC CHARACTERISTICS[1]					
t_{ON}	400			ns typ	R_L = 300 Ω, C_L = 35 pF
	490	520	545	ns max	V_S = 18 V, see Figure 47
t_{OFF}	375			ns typ	R_L = 300 Ω, C_L = 35 pF
	460	485	510	ns max	V_S = 18 V, see Figure 47
Break-Before-Make Time Delay, t_D (ADG5413F Only)	285			ns typ	R_L = 300 Ω, C_L = 35 pF
			195	ns min	V_{S1} = V_{S2} = 18 V, see Figure 46
Overvoltage Response Time, $t_{RESPONSE}$	250			ns typ	R_L = 1 kΩ, C_L = 2 pF, see Figure 41
	350	360	375	ns max	
Overvoltage Recovery Time, $t_{RECOVERY}$	1500			ns typ	R_L = 1 kΩ, C_L = 2 pF, see Figure 42
	2000	2300	2700	ns max	
Interrupt Flag Response Time, $t_{DIGRESP}$	85		115	ns typ	C_L = 10 pF, see Figure 43
Interrupt Flag Recovery Time, t_{DIGREC}	60		85	µs typ	C_L = 10 pF, see Figure 44
	600			ns typ	C_L = 10 pF, R_{PULLUP} = 1 kΩ, see Figure 45
Charge Injection, Q_{INJ}	−610			pC typ	V_S = 18 V, R_S = 0 Ω, C_L = 1 nF, see Figure 48
Off Isolation	−70			dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz, see Figure 35
Channel-to-Channel Crosstalk	−90			dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz, see Figure 36
Total Harmonic Distortion Plus Noise, THD + N	0.001			% typ	R_L = 10 kΩ, V_S = 18 V p-p, f = 20 Hz to 20 kHz, see Figure 40
−3 dB Bandwidth	270			MHz typ	R_L = 50 Ω, C_L = 5 pF, see Figure 39
Insertion Loss	−0.75			dB typ	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz, see Figure 39
C_S (Off)	12			pF typ	V_S = 18 V, f = 1 MHz
C_D (Off)	11			pF typ	V_S = 18 V, f = 1 MHz
C_D (On), C_S (On)	23			pF typ	V_S = 18 V, f = 1 MHz
POWER REQUIREMENTS					V_{DD} = 39.6 V, V_{SS} = 0 V, digital inputs = 0 V, 5 V, or V_{DD}
Normal Mode					
I_{DD}	0.9			mA typ	
	1.2		1.3	mA max	
I_{GND}	0.4			mA typ	
	0.55		0.6	mA max	
I_{SS}	0.5			mA typ	
	0.65		0.7	mA max	
Fault Mode					V_S = +55 V, −40 V
I_{DD}	1.2			mA typ	
	1.6		1.8	mA max	
I_{GND}	0.8			mA typ	
	1.0		1.1	mA max	
I_{SS}	0.5			mA typ	
	1.0		1.8	mA max	
V_{DD}			8	V min	GND = 0 V
			44	V max	GND = 0 V

[1] Guaranteed by design; not subject to production test.

CONTINUOUS CURRENT PER CHANNEL, Sx OR Dx

Table 5.

Parameter	25°C	85°C	125°C	Unit	Test Conditions/Comments
16-LEAD TSSOP					
θ_{JA} = 112.6°C/W	83	59	39	mA max	$V_S = V_{SS} + 4.5$ V to $V_{DD} - 4.5$ V
	64	48	29	mA max	$V_S = V_{SS}$ to V_{DD}
16-LEAD LFCSP					
θ_{JA} = 30.4°C/W	152	99	61	mA max	$V_S = V_{SS} + 4.5$ V to $V_{DD} - 4.5$ V
	118	80	52	mA max	$V_S = V_{SS}$ to V_{DD}

ABSOLUTE MAXIMUM RATINGS

T_A = 25°C, unless otherwise noted.

Table 6.

Parameter	Rating
V_{DD} to V_{SS}	48 V
V_{DD} to GND	−0.3 V to +48 V
V_{SS} to GND	−48 V to +0.3 V
Sx Pins	−55 V to +55 V
Sx to V_{DD} or V_{SS}	80 V
V_S to V_D	80 V
Dx Pins[1]	V_{SS} − 0.7 V to V_{DD} + 0.7 V or 30 mA, whichever occurs first
Digital Inputs	GND − 0.7 V to +48 V or 30 mA, whichever occurs first
Peak Current, Sx or Dx Pins	288 mA (pulsed at 1 ms, 10% duty cycle maximum)
Continuous Current, Sx or Dx Pins	Data[2] + 15%
Digital Output	GND − 0.7 V to 6 V or 30 mA, whichever occurs first
Operating Temperature Range	−40°C to +125°C
Storage Temperature Range	−65°C to +150°C
Junction Temperature	150°C
Thermal Impedance, θ_{JA}	
16-Lead TSSOP (4-Layer Board)	112.6°C/W
16-Lead LFCSP (4-Layer Board)	30.4°C/W
Reflow Soldering Peak Temperature, Pb-Free	As per JEDEC J-STD-020
ESD (HBM: ANSI/ESD STM5.1-2007)	
I/O Port to Supplies	5.5 kV
I/O Port to I/O Port	5.5 kV
All Other Pins	5.5 kV

[1] Overvoltages at the Dx pins are clamped by internal diodes. Limit current to the maximum ratings given.
[2] See Table 5.

Stresses at or above those listed under Absolute Maximum Ratings may cause permanent damage to the product. This is a stress rating only; functional operation of the product at these or any other conditions above those indicated in the operational section of this specification is not implied. Operation beyond the maximum operating conditions for extended periods may affect product reliability.

Only one absolute maximum rating can be applied at any one time.

ESD CAUTION

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

PIN CONFIGURATIONS AND FUNCTION DESCRIPTIONS

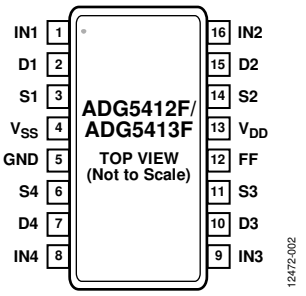
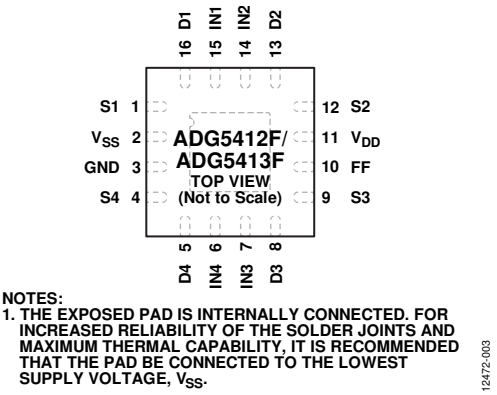


Figure 3. TSSOP Pin Configuration



NOTES:
1. THE EXPOSED PAD IS INTERNALLY CONNECTED. FOR INCREASED RELIABILITY OF THE SOLDER JOINTS AND MAXIMUM THERMAL CAPABILITY, IT IS RECOMMENDED THAT THE PAD BE CONNECTED TO THE LOWEST SUPPLY VOLTAGE, V_{SS}.

Figure 4. LFCSP Pin Configuration

Table 7. Pin Function Descriptions

Pin No.			
TSSOP	**LFCSP**	**Mnemonic**	**Description**
1	15	IN1	Logic Control Input.
2	16	D1	Drain Terminal. This pin can be an input or an output.
3	1	S1	Overvoltage Protected Source Terminal. This pin can be an input or an output.
4	2	V_{SS}	Most Negative Power Supply Potential.
5	3	GND	Ground (0 V) Reference.
6	4	S4	Overvoltage Protected Source Terminal. This pin can be an input or an output.
7	5	D4	Drain Terminal. This pin can be an input or an output.
8	6	IN4	Logic Control Input.
9	7	IN3	Logic Control Input.
10	8	D3	Drain Terminal. This pin can be an input or an output.
11	9	S3	Overvoltage Protected Source Terminal. This pin can be an input or an output.
12	10	FF	Fault Flag Digital Output. This pin has a high output when the device is in normal operation or a low when a fault condition occurs on any of the Sx inputs.
13	11	V_{DD}	Most Positive Power Supply Potential.
14	12	S2	Overvoltage Protected Source Terminal. This pin can be an input or an output.
15	13	D2	Drain Terminal. This pin can be an input or an output.
16	14	IN2	Logic Control Input.
	EP	Exposed Pad	The exposed pad is internally connected. For increased reliability of the solder joints and maximum thermal capability, it is recommended that the pad be connected to the lowest supply voltage, V_{SS}.

Table 8. ADG5412F Truth Table

INx	Switch Condition (S1 to S4)
1	On
0	Off

Table 9. ADG5413F Truth Table

	Switch Condition	
INx	**S1, S4**	**S2, S3**
0	Off	On
1	On	Off

TYPICAL PERFORMANCE CHARACTERISTICS

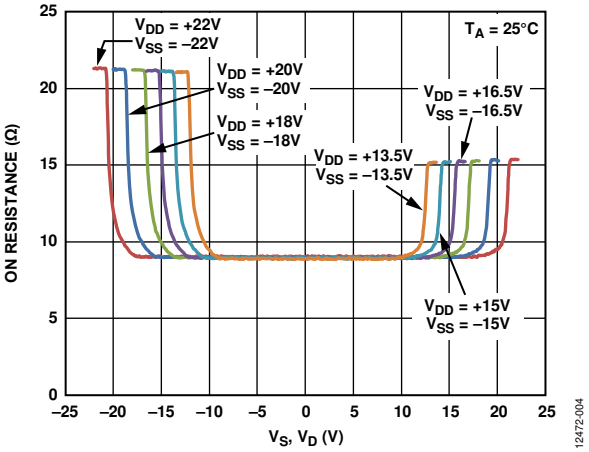


Figure 5. R_{ON} as a Function of V_S,V_D (Dual Supply)

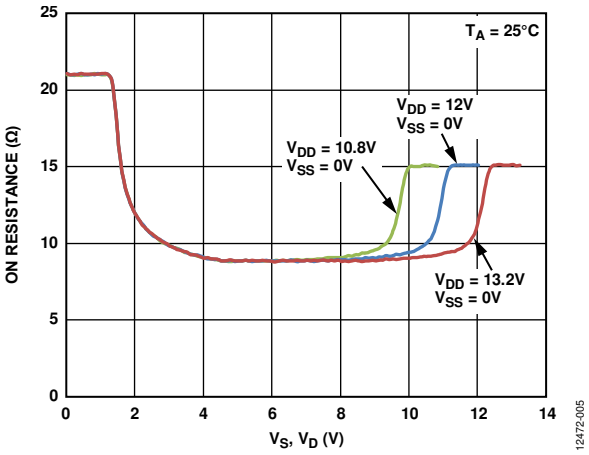


Figure 6. R_{ON} as a Function of V_S,V_D (12 V Single Supply)

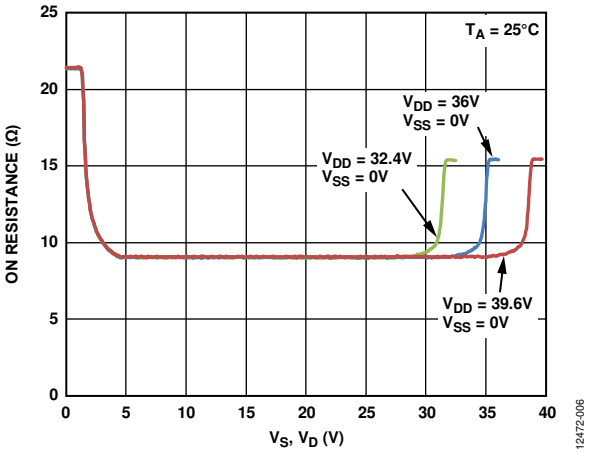


Figure 7. R_{ON} as a Function of V_S,V_D (36 V Single Supply)

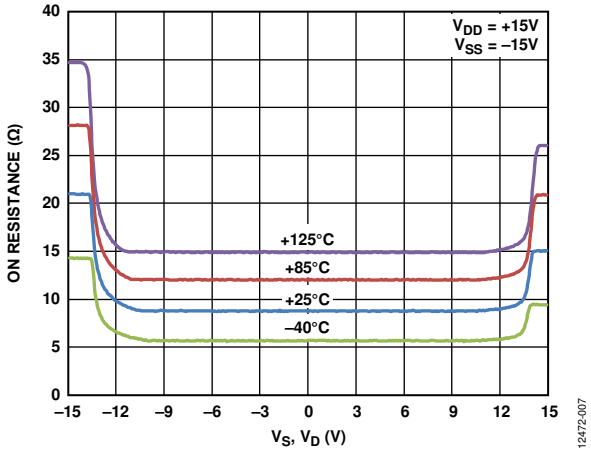


Figure 8. R_{ON} as a Function of V_S,V_D for Different Temperatures, ±15 V Dual Supply

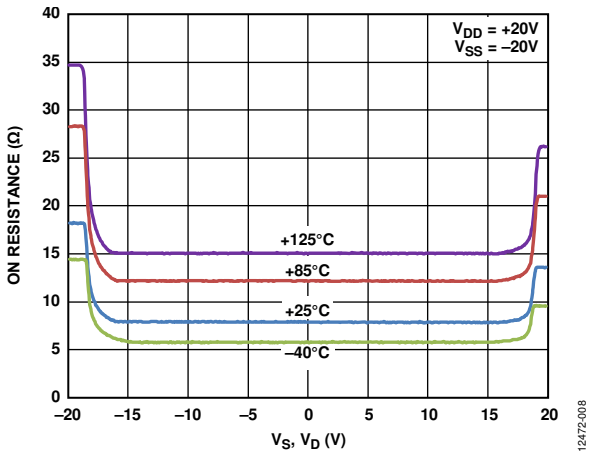


Figure 9. R_{ON} as a Function of V_S,V_D for Different Temperatures, ±20 V Dual Supply

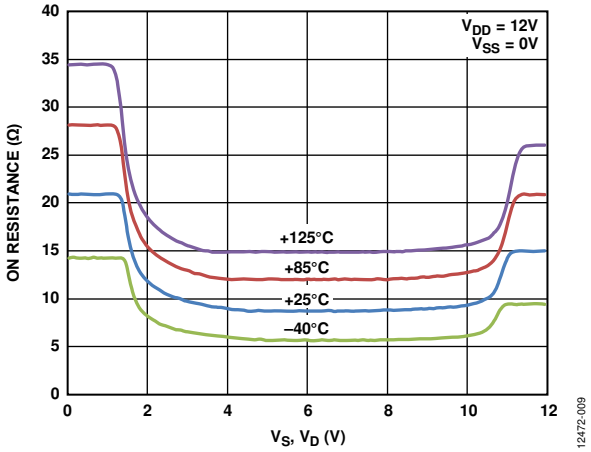


Figure 10. R_{ON} as a Function of V_S,V_D for Different Temperatures, 12 V Single Supply

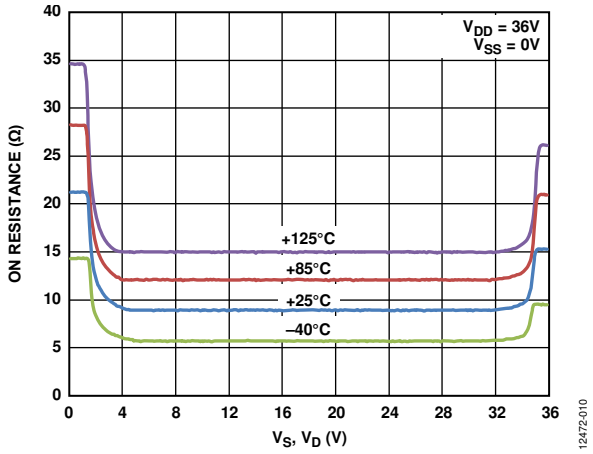


Figure 11. R_{ON} as a Function of V_S,V_D for Different Temperatures, 36 V Single Supply

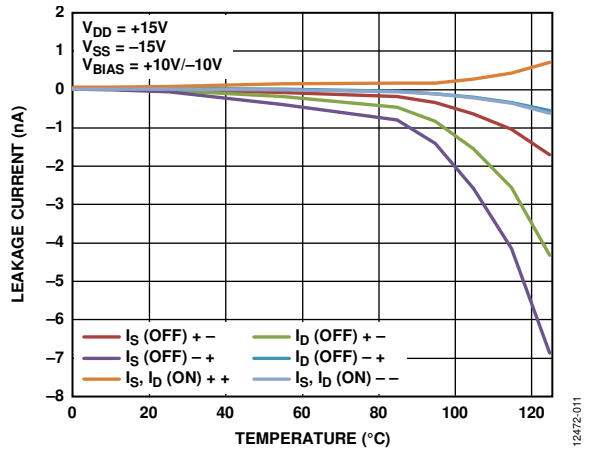


Figure 12. Leakage Current vs. Temperature, ±15 V Dual Supply

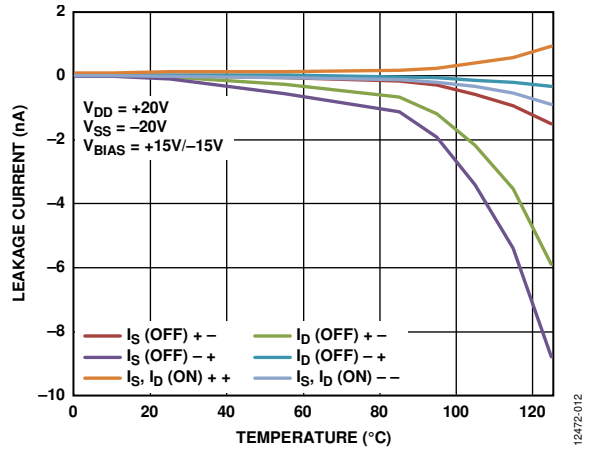


Figure 13. Leakage Current vs. Temperature, ±20 V Dual Supply

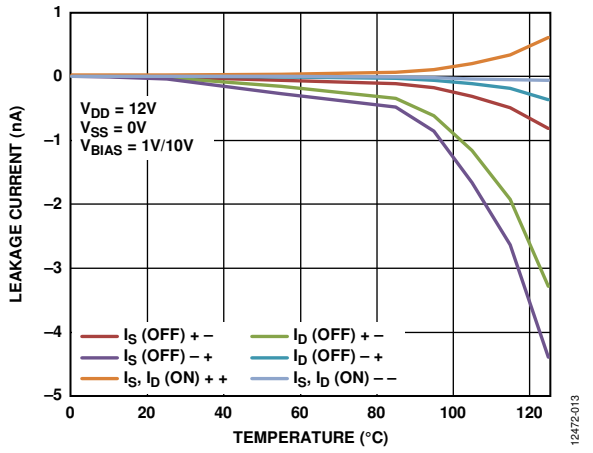


Figure 14. Leakage Current vs. Temperature, 12 V Single Supply

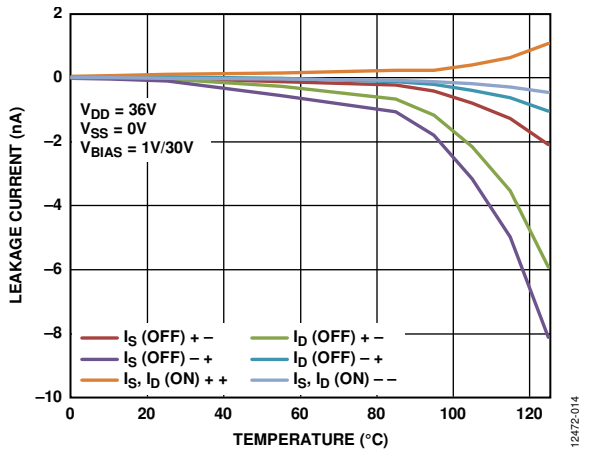


Figure 15. Leakage Current vs. Temperature, 36 V Single Supply

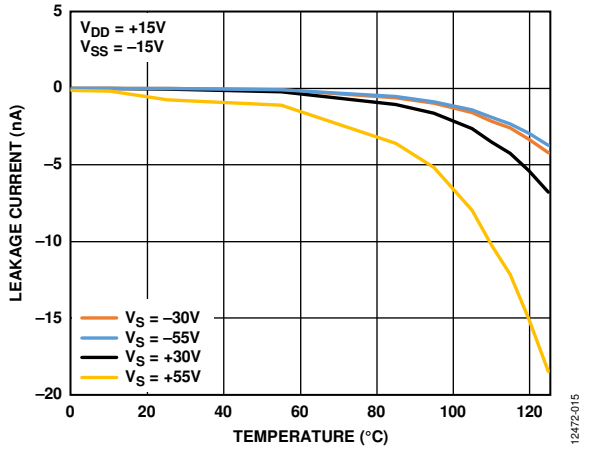


Figure 16. Overvoltage Leakage Current vs. Temperature, ±15 V Dual Supply

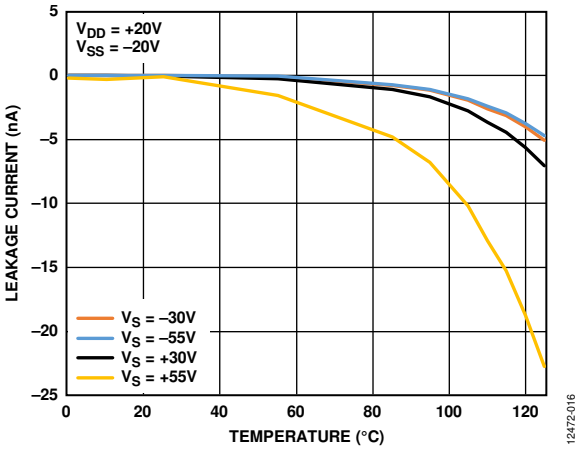


Figure 17. Overvoltage Leakage Current vs. Temperature, ±20 V Dual Supply

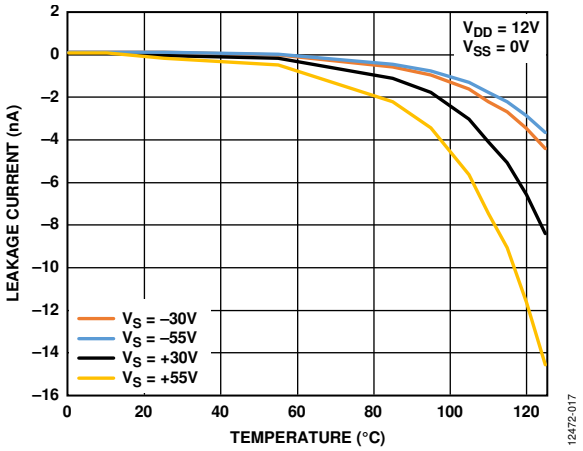


Figure 18. Overvoltage Leakage Current vs. Temperature, 12 V Single Supply

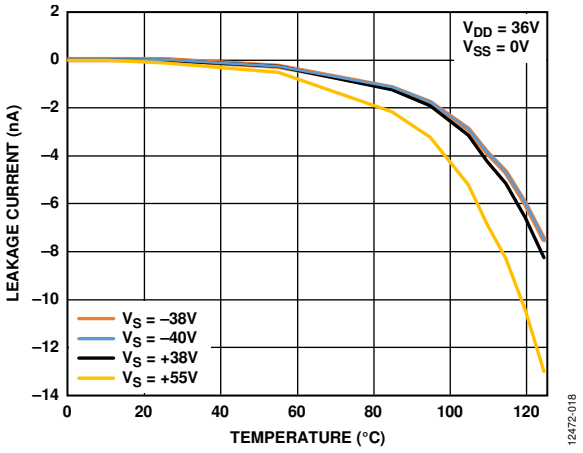


Figure 19. Overvoltage Leakage Current vs. Temperature, 36 V Single Supply

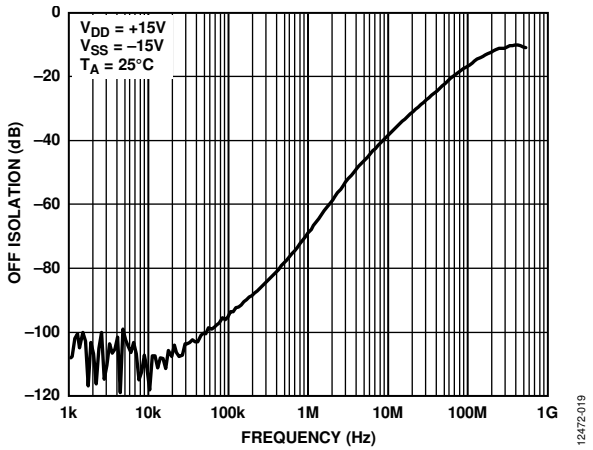


Figure 20. Off Isolation vs. Frequency, ±15 V Dual Supply

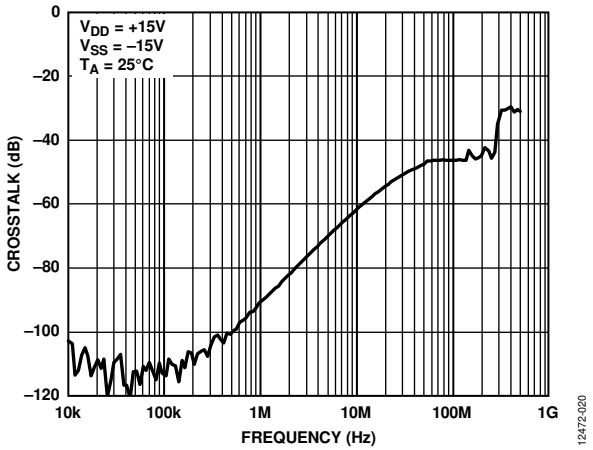


Figure 21. Crosstalk vs. Frequency, ±15 V Dual Supply

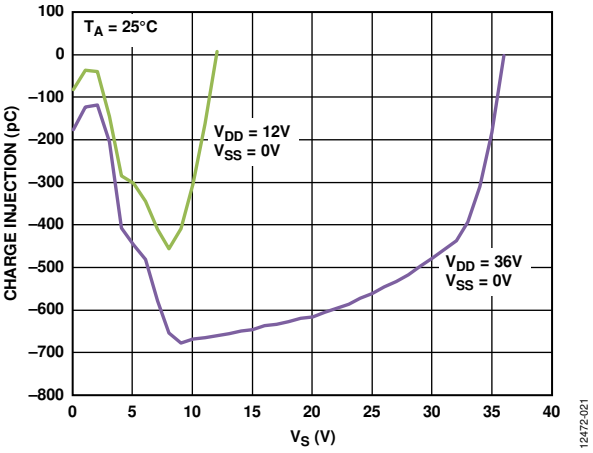


Figure 22. Charge Injection vs. Source Voltage (V_S), Single Supply

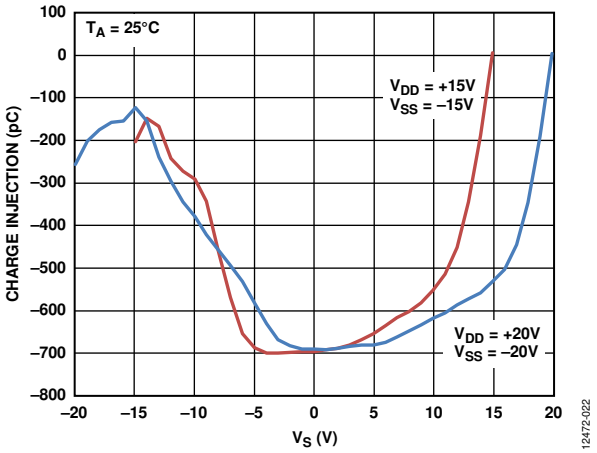


Figure 23. Charge Injection vs. Source Voltage (V_S), Dual Supply

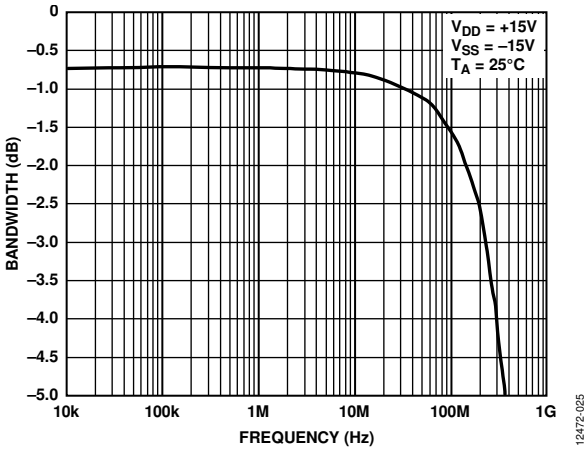


Figure 26. Bandwidth vs. Frequency

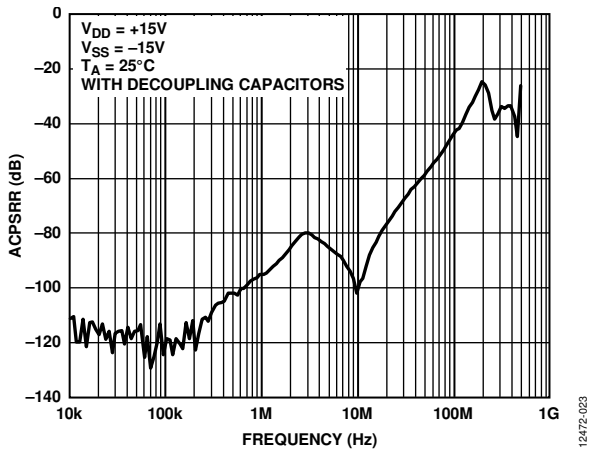


Figure 24. ACPSRR vs. Frequency, ±15 V Dual Supply

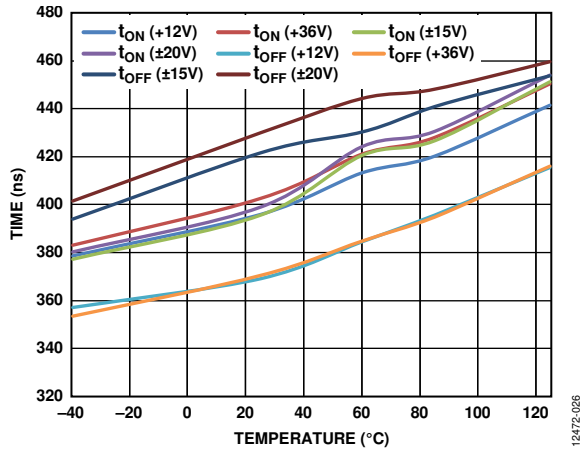


Figure 27. t_{ON}, t_{OFF} Times vs. Temperature

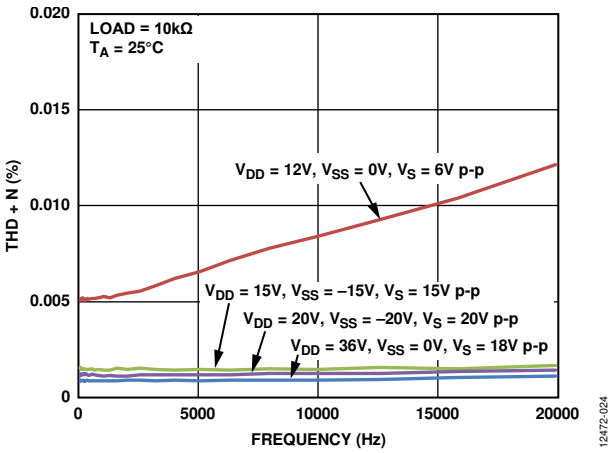


Figure 25. THD + N vs. Frequency, ±15 V Dual Supply

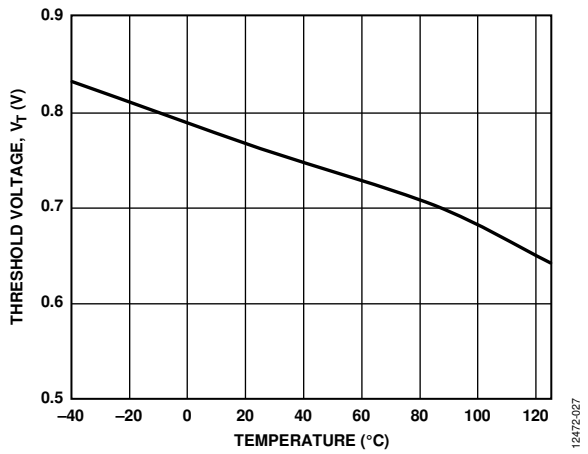


Figure 28. Threshold Voltage (V_T) vs. Temperature

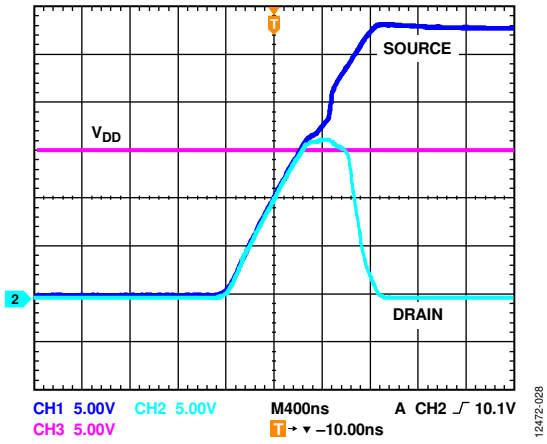


Figure 29. Drain Output Response to Positive Overvoltage

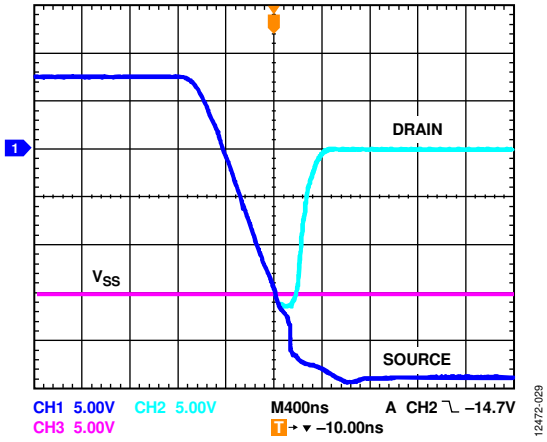


Figure 30. Drain Output Response to Negative Overvoltage

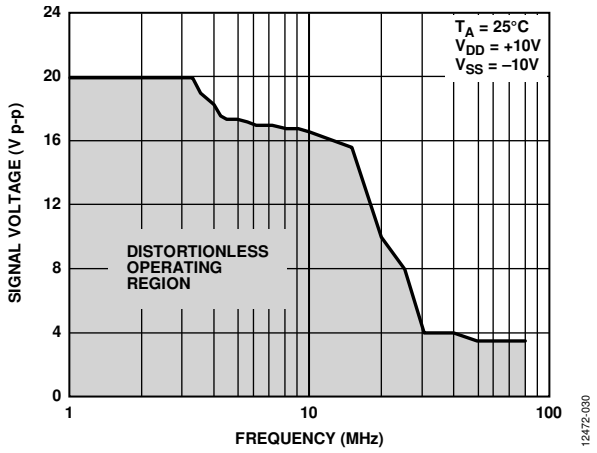


Figure 31. Large Voltage Signal Tracking vs. Frequency

TEST CIRCUITS

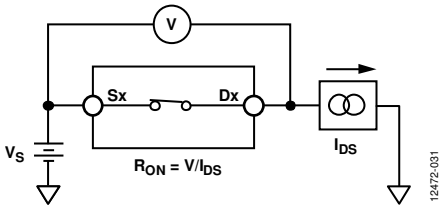


Figure 32. On Resistance

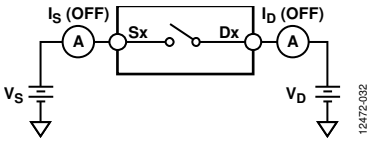


Figure 33. Off Leakage

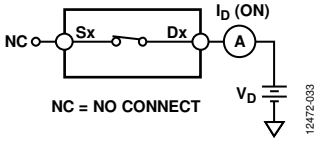


Figure 34. On Leakage

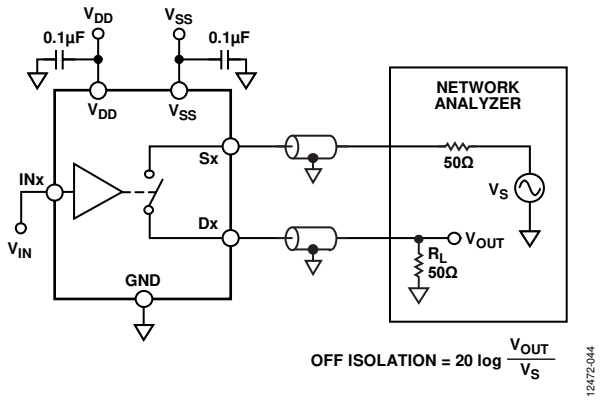


Figure 35. Off Isolation

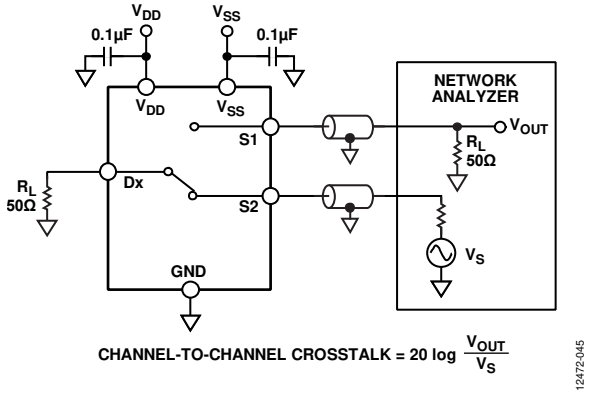


Figure 36. Channel-to-Channel Crosstalk

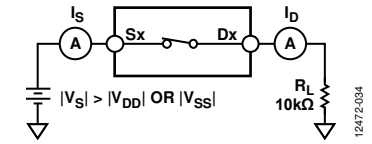


Figure 37. Switch Overvoltage Leakage

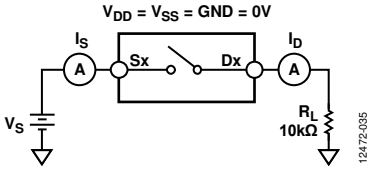


Figure 38. Switch Unpowered Leakage

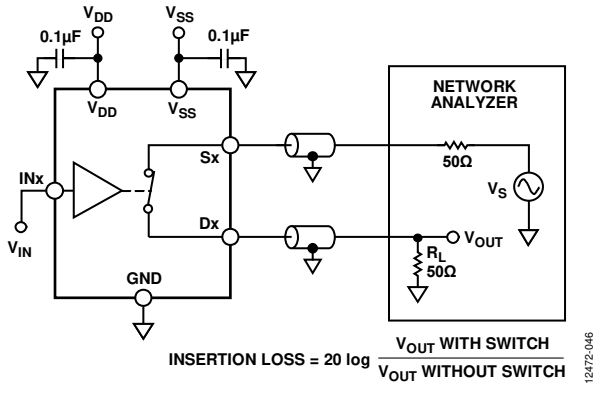


Figure 39. Bandwidth

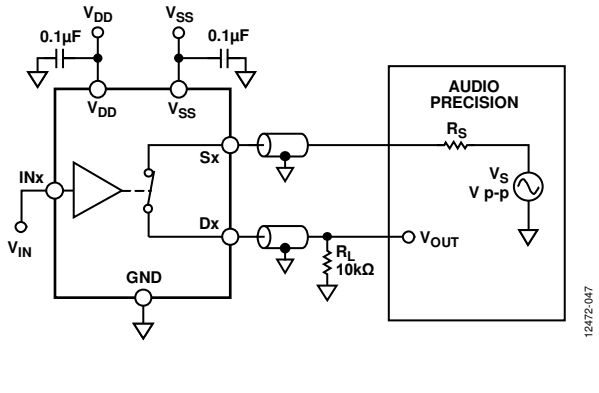


Figure 40. THD + N

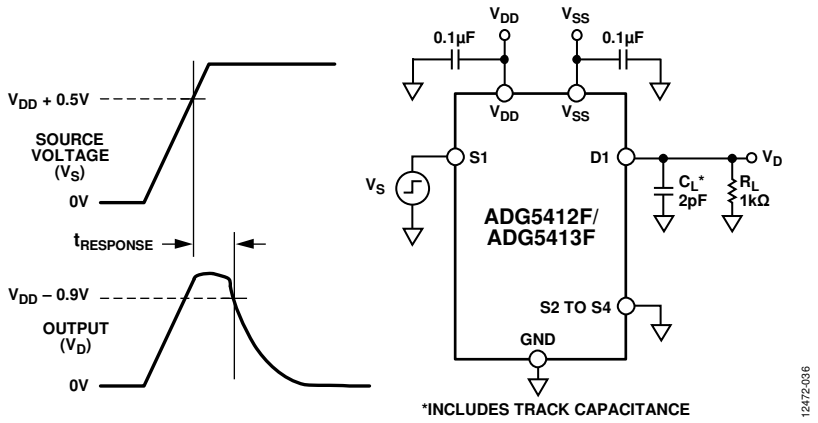


Figure 41. Overvoltage Response Time, $t_{RESPONSE}$

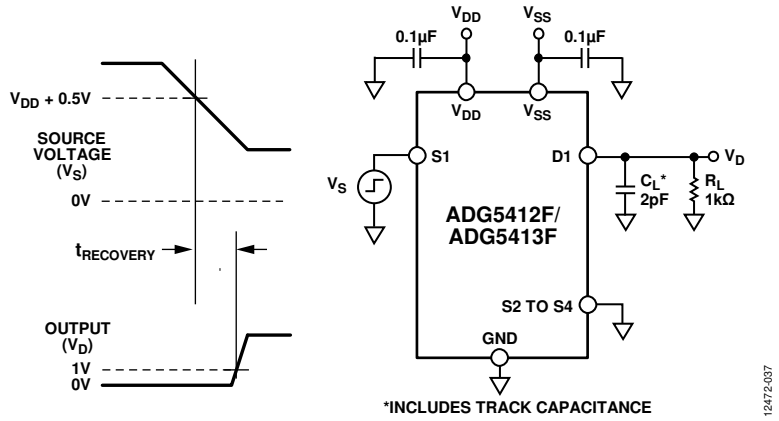


Figure 42. Overvoltage Recovery Time, $t_{RECOVERY}$

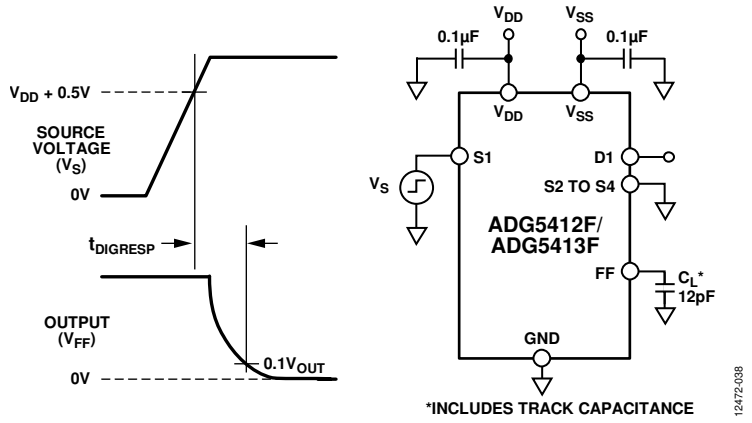


Figure 43. Interrupt Flag Response Time, $t_{DIGRESP}$

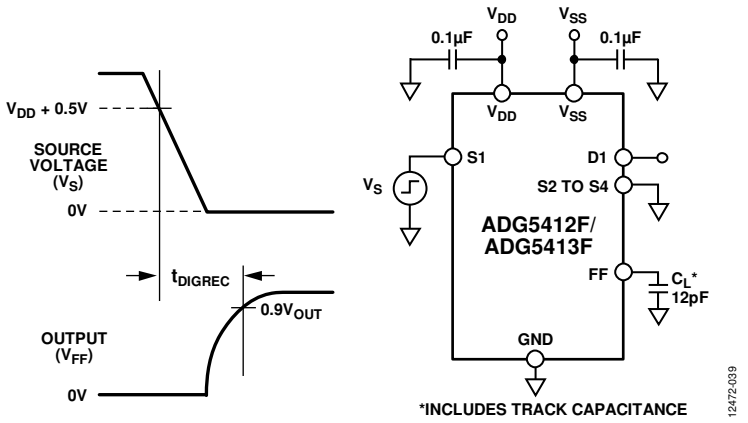


Figure 44. Interrupt Flag Recovery Time, t_{DIGREC}

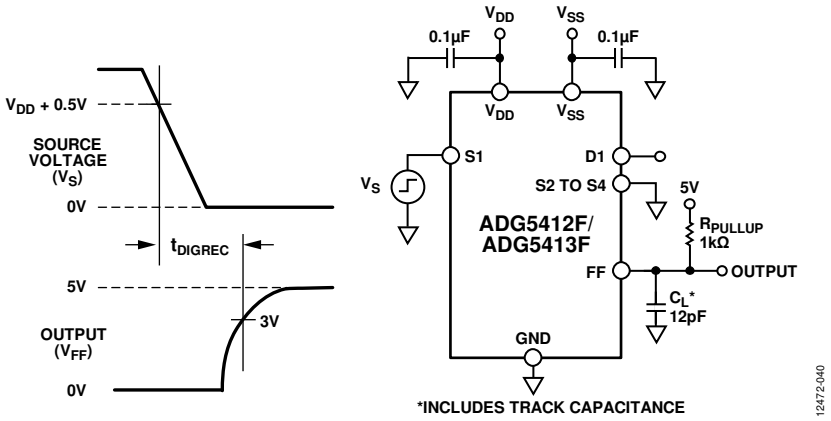


Figure 45. Interrupt Flag Recovery Time, t_{DIGREC}, with a 1 kΩ Pull-Up Resistor

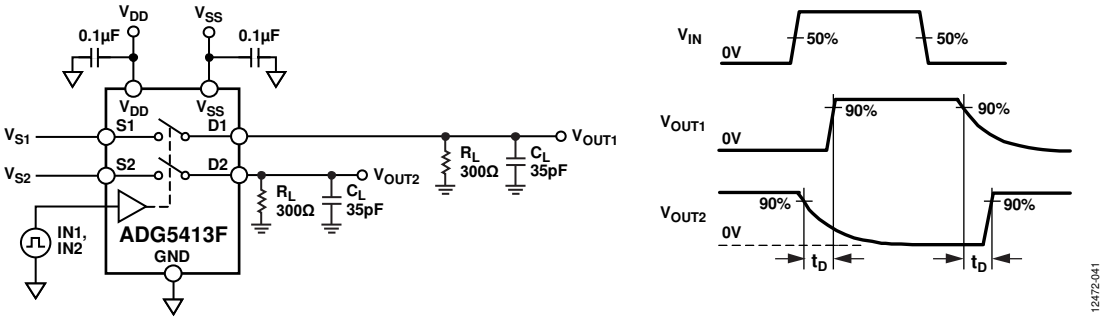


Figure 46. Break-Before-Make Time Delay, t_D

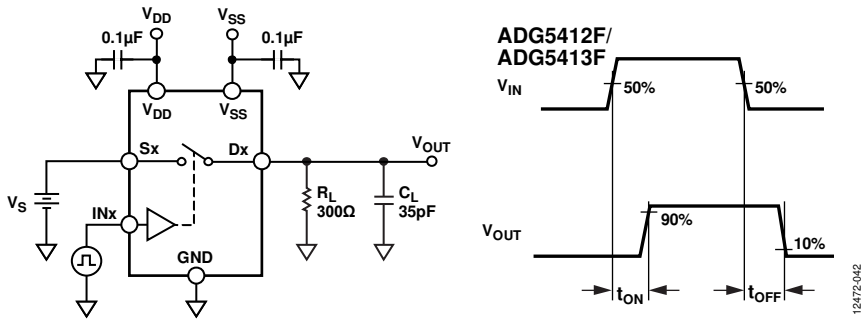


Figure 47. Switching Times, t_{ON} and t_{OFF}

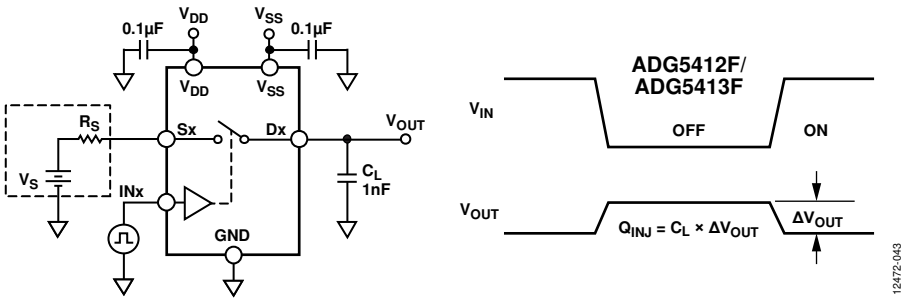


Figure 48. Charge Injection, Q_{INJ}

TERMINOLOGY

I_{DD}
I_{DD} represents the positive supply current.

I_{SS}
I_{SS} represents the negative supply current.

V_D, V_S
V_D and V_S represent the analog voltage on the Dx pins and the Sx pins, respectively.

R_{ON}
R_{ON} represents the ohmic resistance between the Dx pins and the Sx pins.

ΔR_{ON}
ΔR_{ON} represents the difference between the R_{ON} of any two channels.

$R_{FLAT(ON)}$
$R_{FLAT(ON)}$ is the flatness that is defined as the difference between the maximum and minimum value of on resistance measured over the specified analog signal range.

I_S (Off)
I_S (Off) is the source leakage current with the switch off.

I_D (Off)
I_D (Off) is the drain leakage current with the switch off.

I_D (On), I_S (On)
I_D (On) and I_S (On) represent the channel leakage currents with the switch on.

V_{INL}
V_{INL} is the maximum input voltage for Logic 0.

V_{INH}
V_{INH} is the minimum input voltage for Logic 1.

I_{INL}, I_{INH}
I_{INL} and I_{INH} represent the low and high input currents of the digital inputs.

C_D (Off)
C_D (Off) represents the off switch drain capacitance, which is measured with reference to ground.

C_S (Off)
C_S (Off) represents the off switch source capacitance, which is measured with reference to ground.

C_D (On), C_S (On)
C_D (On) and C_S (On) represent on switch capacitances, which are measured with reference to ground.

C_{IN}
C_{IN} is the digital input capacitance.

t_{ON}
t_{ON} represents the delay between applying the digital control input and the output switching on (see Figure 47).

t_{OFF}
t_{OFF} represents the delay between applying the digital control input and the output switching off (see Figure 47).

t_D
t_D represents the off time measured between the 90% point of both switches when switching from one address state to another.

$t_{DIGRESP}$
$t_{DIGRESP}$ is the time required for the FF pin to go low (0.3 V), measured with respect to voltage on the source pin exceeding the supply voltage by 0.5 V.

t_{DIGREC}
t_{DIGREC} is the time required for the FF pin to return high, measured with respect to voltage on the Sx pin falling below the supply voltage plus 0.5 V.

$t_{RESPONSE}$
$t_{RESPONSE}$ represents the delay between the source voltage exceeding the supply voltage by 0.5 V and the drain voltage falling to 90% of the supply voltage.

$t_{RECOVERY}$
$t_{RECOVERY}$ represents the delay between an overvoltage on the Sx pin falling below the supply voltage plus 0.5 V and the drain voltage rising from 0 V to 10% of the supply voltage.

Off Isolation
Off isolation is a measure of unwanted signal coupling through an off switch.

Charge Injection
Charge injection is a measure of the glitch impulse transferred from the digital input to the analog output during switching.

Channel-to-Channel Crosstalk
Crosstalk is a measure of unwanted signal that is coupled through from one channel to another as a result of parasitic capacitance.

−3 dB Bandwidth
Bandwidth is the frequency at which the output is attenuated by 3 dB.

On Response
On response is the frequency response of the on switch.

Insertion Loss
Insertion loss is the loss due to the on resistance of the switch.

Total Harmonic Distortion Plus Noise (THD + N)
THD + N is the ratio of the harmonic amplitude plus noise of the signal to the fundamental.

AC Power Supply Rejection Ratio (ACPSRR)
ACPSRR is the ratio of the amplitude of signal on the output to the amplitude of the modulation. ACPSRR is a measure of the ability of the device to avoid coupling noise and spurious signals that appear on the supply voltage pin to the output of the switch. The dc voltage on the device is modulated by a sine wave of 0.62 V p-p.

V_T
V_T is the voltage threshold at which the overvoltage protection circuitry engages. See Figure 28.

THEORY OF OPERATION

SWITCH ARCHITECTURE

Each channel of the ADG5412F/ADG5413F consists of a parallel pair of N-channel diffused metal-oxide semiconductor (NDMOS) and P-channel DMOS (PDMOS) transistors. This construction provides excellent performance across the signal range. The ADG5412F/ADG5413F channels operate as standard switches when input signals with a voltage between V_{SS} and V_{DD} are applied. For example, the on resistance is 10 Ω typically and the appropriate control pin, INx, controls the opening or closing of the switch.

Additional internal circuitry enables the switch to detect overvoltage inputs by comparing the voltage on the source pin with V_{DD} and V_{SS}. A signal is considered overvoltage if it exceeds the supply voltages by the voltage threshold, V_T. The threshold voltage is typically 0.7 V, but can range from 0.8 V at −40°C down to 0.6 V at +125°C. See Figure 28 to see the change in V_T with operating temperature.

The maximum voltage that can be applied to any source input is +55 V or −55 V. When the device is powered using the single supply of 25 V or greater, the maximum signal level reduces from −55 V to −40 V at V_{DD} = 40 V to remain within the 80 V maximum rating. Construction of the process allows the channel to withstand 80 V across the switch when it is opened. These overvoltage limits apply whether the power supplies are present or not.

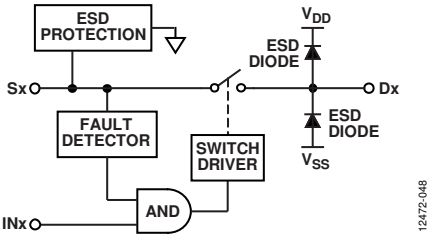


Figure 49. Switch Channel and Control Function

When an overvoltage condition is detected on a source pin, the switch is automatically opened regardless of the digital logic state, INx. The source and drain pins both become high impedance and ensure that no current flows through the switch. In Figure 29, the voltage on the drain pin can be seen to follow the voltage on the source pin until the switch has turned off completely and the drain voltage discharges through the load. The maximum voltage on the drain is limited by the internal ESD diodes and the rate at which the output voltage discharges is dependent on the load at the pin. The ADG5412BF/ADG5413BF are pin-compatible devices that are overvoltage protected on both the source and drain pins.

During overvoltage conditions, the leakage current into and out of the source pins is limited to tens of microamperes and only nanoamperes for the drain pins. This limit protects the switch and connected circuitry from overstresses as well as restricting the current drawn from the signal source. When an overvoltage event occurs, the channels undisturbed by the overvoltage input continue to operate normally without additional crosstalk.

ESD Performance

The ADG5412F/ADG5413F have an ESD rating of 5.5 kV for the human body model (HBM).

The drain pins have ESD protection diodes to the rails and the voltage at these pins must not exceed supply voltage. The source pins have specialized ESD protection that allow the signal voltage to reach ±55 V regardless of supply voltage level. See Figure 49 for switch channel overview.

Trench Isolation

In the ADG5412F and ADG5413F, an insulating oxide layer (trench) is placed between the NDMOS and the PDMOS transistors of each switch. Parasitic junctions, which occur between the transistors in junction-isolated switches, are eliminated, and the result is a switch that is latch-up immune under all circumstances. These devices pass a JESD78D latch-up test of ±500 mA for 1 sec, which is the harshest test in the specification.

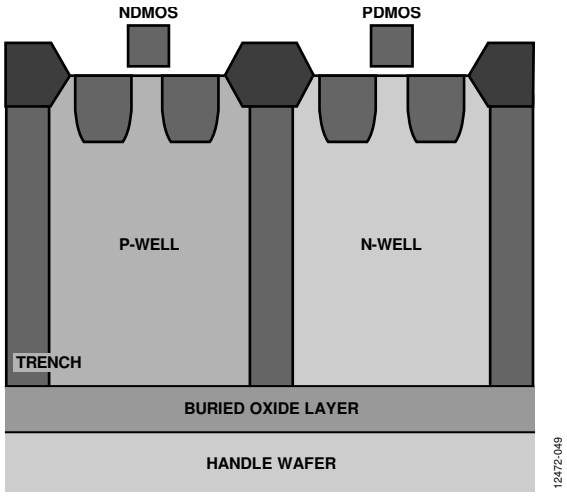


Figure 50. Trench Isolation