Qualification Results Summary of ADGM1004 Revision

Qualification data supports the PCN of ADGM1304 and ADGM1004 generics

QUALIFICATION RESULTS			
TEST	**SPECIFICATION**	**SAMPLE SIZE**	**RESULTS**
Electrostatic Discharge *Field-Induced Charged Device Model*	JEDEC *JS-002*	**3/voltage**	**Pass**
Electrostatic Discharge *Human Body Model*	JEDEC *JS-001-2010*	**3/voltage**	**Pass**
Latch-up	JEDEC *JESD78*	**1 x 15**	**Pass**
Solder Heat Resistance (SHR)*	JEDEC/IPC *J-STD-020*	**3 x 11**	**Pass**
High Temperature Storage Life (HTSL)	JEDEC *JESD22-A103*	**3 x 77**	**Pass**
Temperature Cycle (TC)*	JEDEC *JESD22-A104*	**3 x 77**	**Pass**
High Temperature Operating Life (HTOL) – Toggle Mode	JEDEC *JESD22-A108*	**3 x 77**	**Pass**
High Temperature Operating Life (HTOL) – Hold Down Mode	JEDEC *JESD22-A108*	**3 x 77**	**Pass**
Highly Accelerated Stress Test (HAST)*	JEDEC *JESD22-A110*	**3 x 77**	**Pass**

*These samples were subjected to preconditioning (per J-STD-020 Level 3) prior to the start of the stress test. Level 3 preconditioning consists of the following: 1. Bake – 24 hours at 125ºC; 2. Soak – unbiased soak for 192 hours at 30ºC, 60%RH; 3. Reflow – three passes through a reflow oven with a peak temperature of 260ºC.

PCN 19_0094

ADGM1004 Data Sheet Changes

Rev.C to Rev.D

This document highlights the changes from the Rev. C to the Rev. D data sheet for the ADGM1004 SP4T MEMS switch with integrated driver.

In brief following changes are made from Rev. C to the Rev. D data sheet.

- *Wider operating voltage range*
- *Improved internal oscillator feedthrough noise*
- *Added SPI functionality*

For full product information and changes to pin configuration of the part please refer to the ADGM1004 Rev. D data sheet.

1. Specification changes from datasheet Rev. C to Rev. D

Table 1 outlines the datasheet specifications which are changed in Rev. D material as compared to Rev. C material. The updated specifications are highlighted in red font.
Table 2 outlines the datasheet specifications which are added to Rev. D material.
Table 3 outlines the datasheet specifications which are removed from Rev. C material.

2. Absolute Maximum Rating updates from datasheet Rev. C to Rev. D

Table 4 outlines the Absolute Maximum Rating comparison of the Rev. D to Rev. E material. The updated specifications are highlighted in red font.

3. Pin Configuration updates from datasheet Rev. C to Rev. D

Table 5 outlines the pin configuration comparison of the Rev. C to Rev. D material and Table 6 highlights pin function descriptions. All the updated pins configuration are highlighted in red font.

4. Typical Operating Circuit changes from datasheet Rev. C to Rev. D

Figure 3 and Figure 4 outlines the typical operating circuit comparison of the Rev. C to Rev. D material. There are no changes to typical operating circuit in parallel mode for both Rev C and Rev D material.

5. ON Resistance (RON) Properties

Table 7 outlines the ON Resistance specification. This section explains about Ron performance and Ron stability of the ADGM1004. The RON performance of the MEMS switch is affected by part to part variation, channel to channel variation, cycle actuations, settling time post turn on, bias voltage and Temperature changes.

1. SPECIFICATION CHANGES FROM DATASHEET REV. C TO REV. D

SPECIFICATIONS UPDATED

Supply voltage (V_{DD}) = 3.0 V to 3.6 V, GND = 0 V, all specifications at T_A = 25°C, unless otherwise noted. Typical specifications tested at T_A = 25°C with V_{DD} = 3.3 V.

Table 1.

		Rev C			Rev D				
Parameter	**Symbol**	**Min**	**Typ[1]**	**Max**	**Min**	**Typ[1]**	**Max**	**Unit**	**Test Conditions/Comments**
DYNAMIC CHARACTERISTICS									
Radio Frequency (RF) Power Rating[2]				32			32	dBm	Switch in the on state and terminated into 50 Ω; 25°C
On Switching Time[3]	t_{ON}		30	75	0		75	µs	50% INx to 90% (0.05dB final IL value) RFx, 50 Ω termination
Off Switching Time[3]	t_{OFF}		5	30	0		75	µs	50% INx to 10% (0.05dB final IL value) RFx, 50 Ω termination
Power-Up Time			0.55			0.75		ms	C_{CP} = 47 pF; 95% V_{DD} to 90% RFx, 0°C to 85°C
Internal Oscillator Frequency		6		16	8	10	12	MHz	0°C to 85°C
Internal Oscillator Feedthrough[4]			-115			-123		dBm	Spectrum analyzer resolution bandwidth (RBW) = 200 Hz; one switch in on state, all other switches off with 50 Ω terminations[5]
			-138			-146		dBm/Hz	
SWITCH PROPERTIES									See the ON Resistance (RON) Properties section for details
On Resistance	R_{ON}		1.8	3.5			2.9	Ω	Drain source current (I_{DS})= 50 mA, 0 V input bias, at 1 ms after actuation
On Resistance Variation									
Over Time	ΔRON_{TIME}		-0.11	-0.32			-0.25		RON change from 1 ms to 100 ms after actuation, maximum value tested from 0°C to 85°C
Over Actuations	ΔRON		1.4				5	Ω	10^9 actuations, 1 kHz cycling frequency, 220 mA load between toggles
POWER REQUIREMENTS									
Supply Voltage	V_{DD}	3.1		3.3	3.0		3.6	V	
Supply Current	I_{DD}		3	4			2.5	mA	Digital inputs = 0 V or V_{DD}, serial data out (SDO) is floating in serial peripheral interface (SPI) mode

[1] Typical specifications tested at 25°C with V_{DD}= 3.3 V.
[2] The 1 dB compression point (P1dB) is not reached up to the maximum power rating of the switch.
[3] Switch is settled after 75 µs. Do not apply RF power between 0 µs to 75 µs.

[4] Disable the internal oscillator to eliminate feedthrough. When the internal oscillator and charge pump circuitry is disabled, the V_{CP} pin (Pin 24) must be driven with 80V dc (VCP_{EXT}) from an external voltage supply required for MEMS switch actuation.
[5] The spectrum analyzer setup is as follows: RBW = 200 Hz, video bandwidth (VBW) = 2 Hz, span = 100 kHz, input attenuator = 0 dB, the detector type is peak, and the maximum hold is off. The fundamental feedthrough noise or harmonic thereof (whichever is higher) is tested.

NEW SPECIFICATIONS ADDED

Supply voltage (V_{DD}) = 3.0 V to 3.6 V, GND = 0 V, all specifications at T_A = 25°C, unless otherwise noted. Typical specifications tested at T_A = 25°C with V_{DD} = 3.3 V.

Table 2

		Rev C			Rev D				
Parameter	**Symbol**	**Min**	**Typ[1]**	**Max**	**Min**	**Typ[1]**	**Max**	**Unit**	**Test Conditions/Comments**
ON RESISTANCE PROPERTIES[2]									See the ON Resistance (RON) Properties section for details
RELIABILITY PROPERTIES									
Hot Switched									RF power = Continuous Wave (CW), Terminated into 50 Ω.
10dBm							5.16×10^9	Actuations	50 percent of test population failure point (T50)
15dBm							3.21×10^9	Actuations	50 percent of test population failure point (T50)
20dBm							390×10^3	Actuations	50 percent of test population failure point (T50)
DIGITAL OUTPUTS									
Output High Voltage	V_{OH}				V_{DD} – 0.4 V			V	Source current (I_{SOURCE}) = 1 mA
Output Low Voltage	V_{OL}						0.4	V	Sink current (I_{SINK}) = 1 mA
POWER REQUIREMENTS									
External Drive Current	$I_{CP\ EXT\ VCP}$						20	µA	

[1]Typical specifications tested at 25°C with V_{DD}= 3.3 V.
[2] This section is intentionally left blank, for details see the ON Resistance (RON) Properties section for details

SPECIFICATIONS REMOVED

Supply voltage (V_{DD}) = 3.0 V to 3.6 V, GND = 0 V, all specifications at T_A = 25°C, unless otherwise noted. Typical specifications tested at T_A = 25°C with V_{DD} = 3.3 V.

Table 3

		Rev C			Rev D				
Parameter	**Symbol**	**Min**	**Typ[1]**	**Max**	**Min**	**Typ[1]**	**Max**	**Unit**	**Test Conditions/Comments**
DYNAMIC CHARACTERISTICS									
Settling									
Rising Edge			40					µs	50% INx pin to 0.05 dB final IL value, 50 Ω termination
Falling Edge			8					µs	50% INx pin to 0.05 dB final IL value, 50 Ω termination
ON RESISTANCE PROPERTIES									
On Resistance Repeatability	$\Delta R_{ON\ REP}$		0.01					Ω	One on to off to on actuation cycle
On Resistance Input Voltage Bias	$\Delta R_{ON\ VBIAS}$		0.17					Ω	I_{DS} = 50 mA, from −6 V to +6 V input bias

[1]Typical specifications tested at 25°C with V_{DD} = 3.3 V.

2. ABSOLUTE MAXIMUM RATINGS UPDATES FROM REV.C TO REV.D

T_A = 25°C, unless otherwise noted.

Table 4.

Parameter	Rating	Rating
	Rev. C	**Rev. D**
V_{DD} to GND	−0.3 V to +6 V	−0.3 V to +6 V
Digital Inputs[1]	−0.3 V to V_{DD} + 0.3 V or 30 mA (whichever occurs first)	−0.3 V to V_{DD} + 0.3 V or 30 mA (whichever occurs first)
DC Voltage Rating[2]	±10 V	±7 V
Standoff Voltage[3]	20 V	20 V
RF_X to AGND		±10 V
RFC to AGND		±10 V
RF_X to RFC		20 V
Current Rating[2]	250 mA	250 mA
RF Power Rating[4]	33 dBm	33 dBm
Operating Temperature Range	0°C to +85°C	0°C to +85°C
Storage Temperature Range	−65°C to +150°C	−65°C to +150°C
Reflow Soldering (Pb-Free)		
Peak Temperature	260 (+0/−5)°C	260 (+0/−5)°C
Time at Peak Temperature	10 sec to 30 sec	10 sec to 30 sec
Electrostatic Discharge (ESD)		
Human Body Model (HBM)		
RF1, RF2, RF3, RF4 and RFC Pins	5 kV	5 kV
All Other Pins	2.5 kV	2.5 kV
Field Induced Charged Device Model[5]		
All Pins	1.25 kV	1.25 kV
Group D		
Mechanical Shock (with 0.5 ms Pulse)[6]	1500 *g*	1500 *g*
Vibration (Acceleration at 50 *g)*	20 Hz to 2000 Hz	20 Hz to 2000 Hz
Constant Acceleration	30,000 *g*	30,000 *g*

[1] Clamp overvoltages at INx by internal diodes. Limit the current to the maximum ratings given.
[2] This rating is with respect to the switch in the on position with no radio frequency signal applied.
[3] This rating is with respect to the switch in the off position.
[4] This rating is with respect to the switch in the on position and terminated into 50 Ω. The rating is 27 dBm when the switch is unterminated.
[5] A safe automated handling and assembly process is achieved at this rating level by implementing industry standard ESD controls.
[6] If the device is dropped during handling, do not use the device.

3. PIN CONFIGURATION UPDATES FROM REV.C TO REV.D

Table 5 Pin Configuration Changes

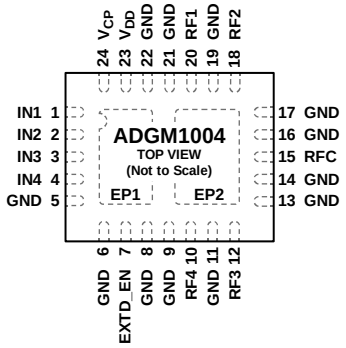
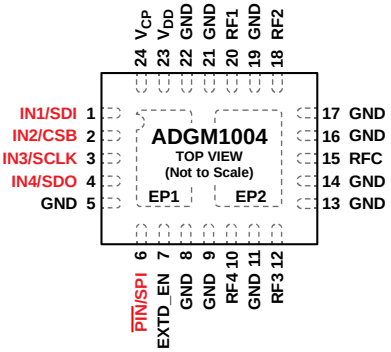
Rev.C	Rev.D
 NOTES 1. EXPOSED PAD 1. EP1 IS INTERNALLY CONNECTED TO EP2 AND MUST BE CONNECTED TO GND. 2. EXPOSED PAD 2. EP2 IS INTERNALLY CONNECTED TO EP1 AND MUST BE CONNECTED TO GND. *Figure 1 Pin Configuration of ADGM1004 Rev C*	 NOTES 1. EXPOSED PAD 1. EP1 IS INTERNALLY CONNECTED TO EP2 AND MUST BE CONNECTED TO GND. 2. EXPOSED PAD 2. EP2 IS INTERNALLY CONNECTED TO EP1 AND MUST BE CONNECTED TO GND. *Figure 2 Pin Configuration of ADGM1004 Rev D*

Table 6 Pin Function Descriptions

	Rev C	Rev D	
Pin No.	**Mnemonic**	**Mnemonic**	**Description**
1	IN1	IN1/SDI	Parallel Logic Digital Control Input 1/Serial Data Input. The voltage applied to this pin controls the gate of the MEMS switch from RF1 to RFC. In SPI mode, this is the serial data input pin. In parallel mode, if IN1 is low, RF1 to RFC is open (off). If IN1 is high, RF1 to RFC is closed (on).
2	IN2	IN2/CSB	Parallel Logic Digital Control Input 2/Chip Select. The voltage applied to this pin controls the gate of the MEMS switch from RF2 to RFC. In SPI mode, this is the chip select pin. In parallel mode, if IN2 is low, RF2 to RFC is open (off). If IN2 is high, RF2 to RFC is closed (on).
3	IN3	IN3/SCLK	Parallel Logic Digital Control Input 3/Serial Clock. The voltage applied to this pin controls the gate of the MEMS switch from RF3 to RFC. In SPI mode, this is the serial clock pin. In parallel mode, if IN3 is low, RF3 to RFC is open (off). If IN3 is high, RF3 to RFC is closed (on).
4	IN4	IN4/SDO	Parallel Logic Digital Control Input 4/Serial Data Output. The voltage applied to this pin controls the gate of the MEMS switch from RF4 to RFC. In SPI mode, this is the serial data output pin. In parallel mode, if IN4 is low, RF4 to RFC is open (off). If IN4 is high, RF4 to RFC is closed (on).
5, 8, 9, 11, 13, 14, 16, 17, 19, 21, 22	GND	Ground Connection.	5, 6, 8, 9, 11, 13, 14, 16, 17, 19, 21, 22
6	GND	PIN/SPI	Parallel Mode Enable/SPI Mode Enable. The SPI interface is enabled when this pin is high, and the parallel interface (IN1, IN2, IN3, IN4) is enabled when this pin is low.
7	EXTD_EN	EXTD_EN	External Voltage Drive Enable. In normal operation, set EXTD_EN low to enable the built in 10 MHz oscillator, which enables the internal charge pump circuitry. Setting EXTD_EN high disables the internal 10 MHz oscillator and the charge pump. With the oscillator disabled, the switch can still be controlled via the logic interface pins (IN1 to IN4) but the VCP pin must to be driven with 80 V dc from an external voltage supply. Disabling the internal oscillator eliminates the associated 10 MHz noise feedthrough into the switch.
10	RF4	RF4	RF4 Port. This pin can be an input or an output. If unused, the pin must be connected to GND.

	Rev C	Rev D	
Pin No.	**Mnemonic**	**Mnemonic**	**Description**
12	RF3	RF3	RF3 Port. This pin can be an input or an output. If unused, the pin must be connected to GND.
15	RFC	RFC	Common RF Port. This pin can be an input or an output.
18	RF2	RF2	RF2 Port. This pin can be an input or an output. If unused, the pin must be connected to GND.
20	RF1	RF1	RF1 Port. This pin can be an input or an output. If unused, the pin must be connected to GND.
23	V_{DD}	V_{DD}	Positive Power Supply Input. The recommended decoupling capacitor to ground value is 0.1uF. For the recommended input voltage for this chip, see the Specifications section.
24	V_{CP}	V_{CP}	Charge Pump Capacitor Terminal. The recommended shunt capacitor to ground value is 47 pF (100V rated). If Pin 7 is high, an 80 V dc drive voltage must be input into VCP to drive the switches.
	EP1	EP1	Exposed Pad 1. EP1 is internally connected to EP2 and must be connected to GND.
	EP2	EP2	Exposed Pad 2. EP2 is internally connected to EP1 and must be connected to GND.

4. TYPICAL OPERATING CIRCUIT UPDATES FROM REV.C TO REV.D

ADGM1004 REV C TYPICAL OPERATING CIRCUIT

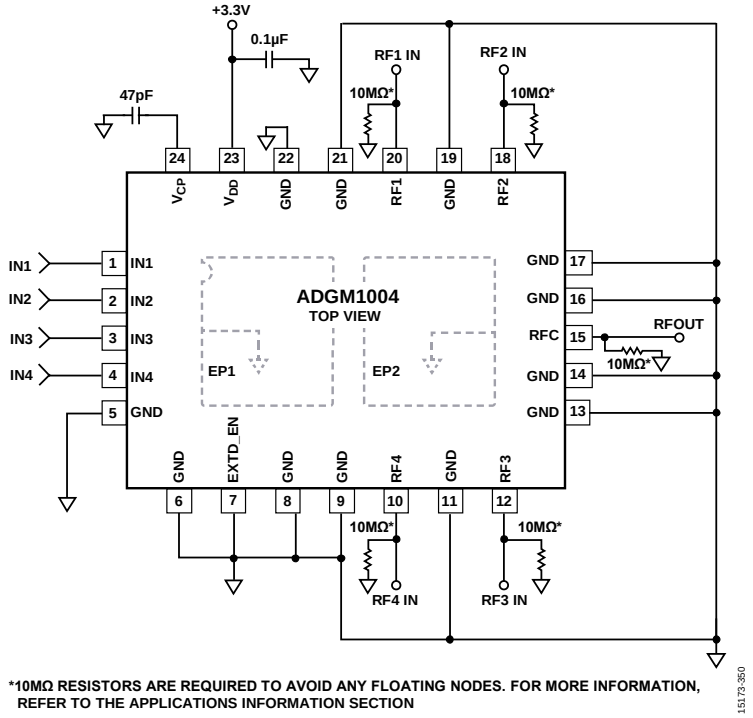


Figure 3 Typical Operating Circuit for ADGM1004 Rev C

ADGM1004 REV D TYPICAL OPERATING CIRCUIT IN PARALLEL MODE

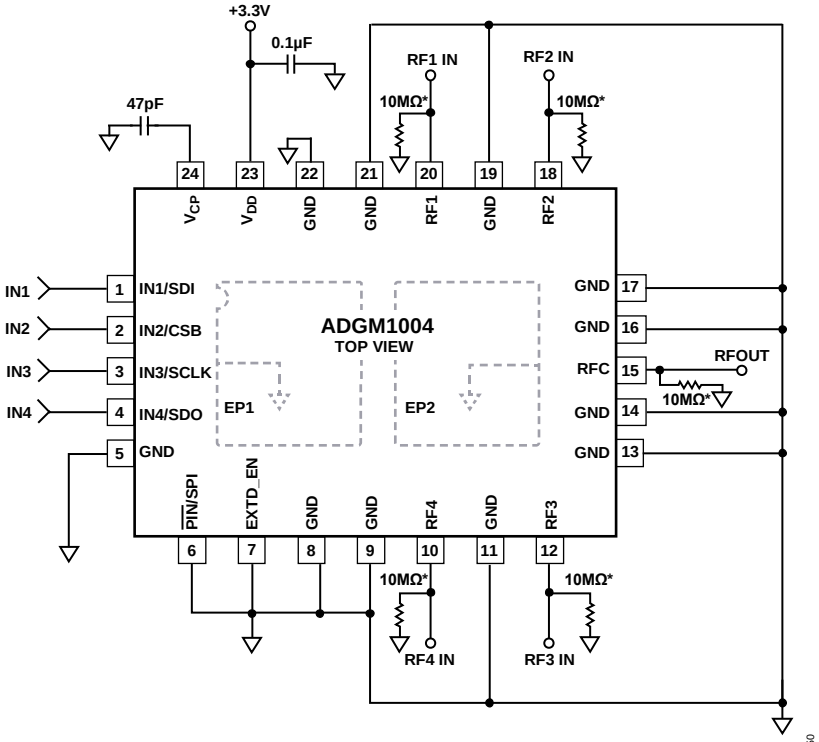


Figure 4 Typical Operating Circuit in Parallel Mode for ADGM1004 Rev D

5. ON RESISTANCE (RON) PROPERTIES

The ADGM1004 MEMS switch is fully operational at DC(0Hz). It is recommended to refer to **Table 7** which details the DC resistance (RON) performance and RON drift of the switch. Further discussion follows below with important typical performance plots shown. The RON performance of the MEMS switch is affected by part to part variation, channel to channel variation, cycle actuations, settling time post turn on, bias voltage and Temperature changes.

ON RESISTANCE SPECIFICATIONS

V_{DD} = 3.0 V to 3.6, GND = 0 V, all specifications minimum temperature (T_{MIN}) to maximum temperature (T_{MAX}) = 0°C to +85°C, after first actuation, unless otherwise noted.

Table 7.

Parameter	Symbol	Min	Typ	Max	Unit	Test Conditions/Comments
ON RESISTANCE PROPERTIES						
Initial On Resistance Properties						
On Resistance	RON			2.9	Ω	Drain source current (I_{DS}) = 50 mA, 0 V input bias, at 1 ms
On-Resistance Match Between Channels	ΔRON_{CH_CH}			1	Ω	
On Resistance Drift						
Over Time[1]	ΔRON_{TIME}			−0.25	Ω	RON change from 1 ms to 100 ms after actuation
Over Actuations[2]	ΔRON			5	Ω	10^9 actuations, 1 kHz cycling frequency, 220 mA load between toggles

[1] Max RON over time is RON (max)+ΔRON_{TIME} (max)= 2.65 Ω
[2] Max RON after 1Billion actuations is RON (max)+ΔRON (max)= 7.9 Ω

APPLICATION IMPACT EXAMPLE

System Error Considerations due to On Resistance Drift

ADGM1004 Ron varies over time and over actuations. In a 50 Ω system, the on-resistance drift over switch actuations can introduce system inaccuracy. Figure 5 shows ADGM1004 connected with the load in a 50 Ω system. The system error caused by ADGM1004 RON drift can be calculated by equation(1)

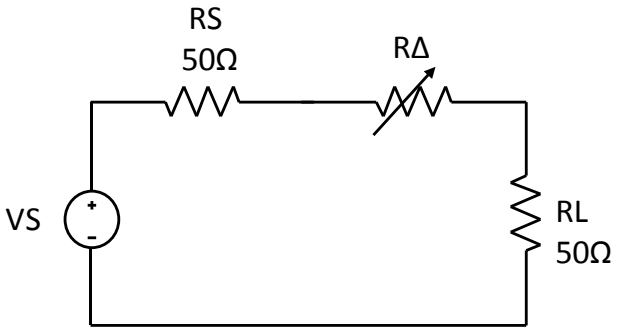


Figure 6 50 Ω system representation where the ADGM1004 is connected with the load

System Error (%) = RΔ / RL (1)

RΔ = ADGM1004 RON Drift

RL = Load Impedance

RS = Source Impedance

The ADGM1004 RON drift also effects insertion loss which need to be considered. The on-resistance impact on insertion loss can be calculated by the equation (2)

Insertion Loss [dB] = 10 log (1 +(RΔ / RL)) (2)

Table 8 shows the system error (%) and insertion loss error caused due to ADGM1004 RON drift

Ron Drift (Ω)	System Error (%)	Insertion Loss Error (dB)
4.75	9.5	0.39
5	10	0.41