# Wideband, 40 dB Isolation at 1 GHz, CMOS 1.65 V to 2.75 V, SPST Switches

# ADG901/ADG902

## FEATURES

**Wideband switch: −3 dB @ 4.5 GHz**
**ADG901—absorptive switch**
**ADG902—reflective switch**
**High off isolation: 40 dB @ 1 GHz**
**Low insertion loss: 0.8 dB @1 GHz**
**Single 1.65 V to 2.75 V power supply**
**CMOS/LVTTL control logic**
**8-lead MSOP and tiny 3 mm × 3 mm LFCSP packages**
**Low power consumption (<1 µA)**

## APPLICATIONS

**Wireless communications**
**General purpose RF switching**
**Dual-band applications**
**High speed filter selection**
**Digital transceiver front end switch**
**IF switching**
**Tuner modules**
**Antenna diversity switching list**

## FUNCTIONAL BLOCK DIAGRAM

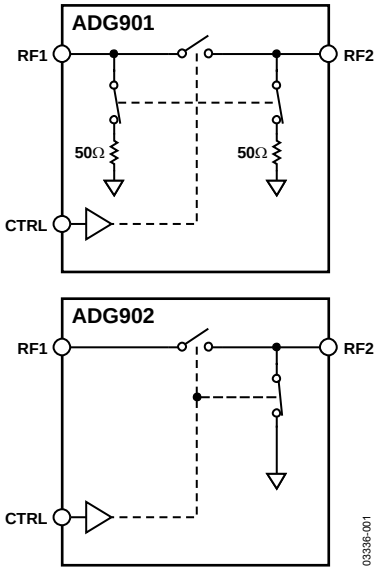



*Figure 1.*

## GENERAL DESCRIPTION

The ADG901/ADG902 are wideband switches that use a CMOS process to provide high isolation and low insertion loss to 1 GHz. The ADG901 is an absorptive (matched) switch with 50 Ω terminated shunt legs, while the ADG902 is a reflective switch. These devices are designed such that the isolation is high over the dc to 1 GHz frequency range. They have on-board CMOS control logic, thus eliminating the need for external controlling circuitry. The control inputs are both CMOS and LVTTL compatible. The low power consumption of these CMOS devices makes them ideally suited to wireless applications and general-purpose high frequency switching.

## PRODUCT HIGHLIGHTS

1. −40 dB Off Isolation @ 1 GHz
2. 0.8 dB Insertion Loss @ 1 GHz
3. Tiny 8-Lead MSOP/LFCSP Packages

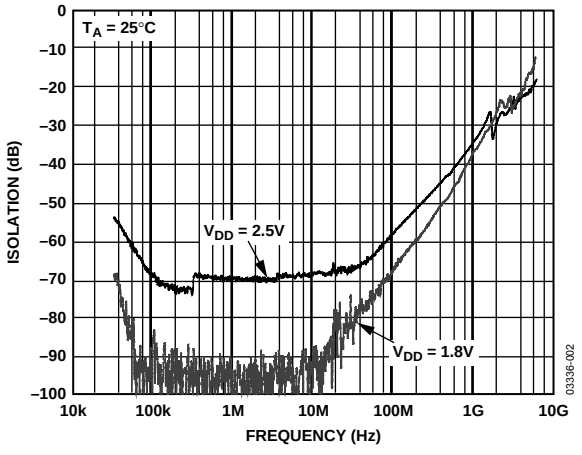



*Figure 2. Off Isolation vs. Frequency*

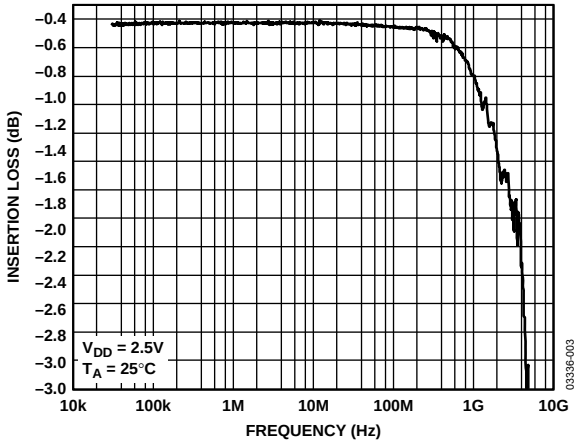



*Figure 3. Insertion Loss vs. Frequency*

**Rev. B**
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# TABLE OF CONTENTS

Features ..... 1
Applications ..... 1
Functional Block Diagram ..... 1
General Description ..... 1
Product Highlights ..... 1
Revision History ..... 2
Specifications ..... 3
Absolute Maximum Ratings ..... 4
ESD Caution ..... 4
Pin Configuration and Function Descriptions ..... 5
Typical Performance Characteristics ..... 6
Terminology ..... 8
Test Circuits ..... 9
Applications ..... 10
Absorptive vs. Reflective Switches ..... 10
ADG90x Evaluation Board ..... 11
Outline Dimensions ..... 12
Ordering Guide ..... 13

## REVISION HISTORY

**10/05—Rev. A to Rev. B**

Changes to Figure 1 ..... 1
Changes to Table 1 ..... 3
Changes to Ordering Guide ..... 12

**10/04—Rev. 0 to Rev. A.**

Changes to Features ..... 1
Changes to Product Highlights ..... 1
Changes to Specifications ..... 2
Changes to Ordering Guide ..... 3
Change to ADG9xx Evaluation Board Section ..... 9
Changes to Ordering Guide ..... 10

**8/03—Revision 0: Initial Version**

# SPECIFICATIONS

$V_{DD}$ = 1.65 V to 2.75 V, GND = 0 V, input power = 0 dBm, all specifications $T_{MIN}$ to $T_{MAX}$, unless otherwise specified.[1]

**Table 1.**

| | | | B Version | | | |
|---|---|---|---|---|---|---|
| **Parameter** | **Symbol** | **Conditions** | **Min** | **Typ**[2] | **Max** | **Unit** |
| AC ELECTRICAL CHARACTERISTICS | | | | | | |
| Operating Frequency[3] | | | DC | | 2.5 | GHz |
| −3 dB Frequency[4] | | | | | 4.5 | GHz |
| Input Power[4] | | 0 V dc bias | | | 7 | dBm |
| | | 0.5 V dc bias | | | 16 | dBm |
| Insertion Loss | $S_{21}$, $S_{12}$ | DC to 100 MHz; $V_{DD}$ = 2.5 V ± 10% | | 0.4 | 0.7 | dB |
| | | 500 MHz; $V_{DD}$ = 2.5 V ± 10% | | 0.5 | 0.8 | dB |
| | | 1000 MHz; $V_{DD}$ = 2.5 V ± 10% | | 0.8 | 1.25 | dB |
| Isolation—RF1 to RF2 | $S_{21}$, $S_{12}$ | 100 MHz | 60 | 61 | | dB |
| CP Package | | 500 MHz | 43 | 45 | | dB |
| | | 1000 MHz | 34 | 40 | | dB |
| Isolation—RF1 to RF2 | $S_{21}$, $S_{12}$ | 100 MHz | 51 | 60 | | dB |
| RM Package | | 500 MHz | 37.5 | 47 | | dB |
| | | 1000 MHz | 31 | 37 | | dB |
| Return Loss (On Channel)[4] | $S_{11}$, $S_{22}$ | DC to 100 MHz | 20 | 28 | | dB |
| | | 500 MHz | 23 | 29 | | dB |
| | | 1000 MHz | 25 | 28 | | dB |
| Return Loss (Off Channel)[4] | $S_{11}$, $S_{22}$ | DC to 100 MHz | 18 | 23 | | dB |
| | | 500 MHz | 17 | 21 | | dB |
| | | 1000 MHz | 15 | 19 | | dB |
| On Switching Time[4] | $t_{ON}$ | 50% CTRL to 90% RF | | 3.6 | 6 | ns |
| Off Switching Time[4] | $t_{OFF}$ | 50% CTRL to 10% RF | | 5.8 | 9.5 | ns |
| Rise Time[4] | $t_{RISE}$ | 10% to 90% RF | | 3.1 | 5.5 | ns |
| Fall Time[4] | $t_{FALL}$ | 90% to 10% RF | | 6.0 | 8.5 | ns |
| 1 dB Compression[4] | $P_{-1\ dB}$ | 1000 MHz | | 17 | | dBm |
| Third-Order Intermodulation Intercept | IP3 | 900 MHz/901 MHz, 4 dBm | 28.5 | 36 | | dBm |
| Video Feedthrough[5] | | | | 2.5 | | mV p-p |
| DC ELECTRICAL CHARACTERISTICS | | | | | | |
| Input High Voltage | $V_{INH}$ | $V_{DD}$ = 2.25 V to 2.75 V | 1.7 | | | V |
| | $V_{INH}$ | $V_{DD}$ = 1.65 V to 1.95 V | 0.65 $V_{DD}$ | | | V |
| Input Low Voltage | $V_{INL}$ | $V_{DD}$ = 2.25 V to 2.75 V | | | 0.7 | V |
| | $V_{INL}$ | $V_{DD}$ = 1.65 V to 1.95 V | | | 0.35 $V_{DD}$ | V |
| Input Leakage Current | $I_I$ | 0 ≤ $V_{IN}$ ≤ 2.75 V | | ±0.1 | ±1 | µA |
| CAPACITANCE[4] | | | | | | |
| RF1/RF2, RF Port On Capacitance | $C_{RF}$ on | f = 1 MHz | | 1.2 | | pF |
| CTRL Input Capacitance | $C_{CTRL}$ | f = 1 MHz | | 2.1 | | pF |
| POWER REQUIREMENTS | | | | | | |
| $V_{DD}$ | | | 1.65 | | 2.75 | V |
| Quiescent Power Supply Current | $I_{DD}$ | Digital inputs = 0 V or $V_{DD}$ | | 0.1 | 1 | µA |

[1] Temperature range for B version: −40°C to +85°C.
[2] Typical values are at $V_{DD}$ = 2.5 V and 25°C, unless otherwise specified.
[3] Point at which insertion loss degrades by 1 dB.
[4] Guaranteed by design, not subject to production test.
[5] The dc transience at the output of any port of the switch when the control voltage is switched from high to low or low to high in a 50 Ω test setup, measured with 1 ns rise time pulses and 500 MHz bandwidth.

# ABSOLUTE MAXIMUM RATINGS

$T_A$ = 25°C, unless otherwise specified.

**Table 2.**

| Parameter | Rating |
|---|---|
| $V_{DD}$ to GND | −0.5 V to +4 V |
| Inputs to GND | −0.5 V to $V_{DD}$ + 0.3 V[1] |
| Continuous Current | 30 mA |
| Input Power | 18 dBm |
| Operating Temperature Range | |
| Industrial (B Version) | −40°C to +85°C |
| Storage Temperature Range | −65°C to +150°C |
| Junction Temperature | 150°C |
| MSOP Package | |
| $\theta_{JA}$ Thermal Impedance | 206°C/W |
| LFCSP Package | |
| $\theta_{JA}$ Thermal Impedance (2-Layer board) | 84°C/W |
| $\theta_{JA}$ Thermal Impedance (4-Layer board) | 48°C/W |
| Lead Temperature, Soldering (10 sec) | 300°C |
| IR Reflow, Peak Temperature (<20 sec) | 235°C |
| ESD | 1 kV |

[1] RF1/RF2 off port inputs to ground: −0.5 V to $V_{DD}$ − 0.5 V

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

## ESD CAUTION

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although this product features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.



# PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

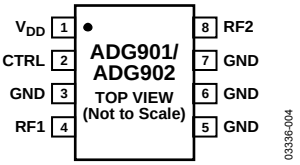



*Figure 4. 8-Lead MSOP (RM-8) and*
*8-Lead 3 mm × 3 mm LFCSP (CP-8 – Exposed pad tied to substrate, GND*

**Table 3. Pin Function Descriptions**

| Pin No. | Mnemonic | Description |
|---|---|---|
| 1 | $V_{DD}$ | Power Supply Input. These parts can be operated from 1.65 V to 2.75 V; $V_{DD}$ should be decoupled to GND. |
| 2 | CTRL | CMOS or LVTTL Logic Level. CTRL input should not exceed $V_{DD}$. |
| | | 0 → RF1 Isolated from RF2. |
| | | 1 → RF1 to RF2. |
| 3, 5, 6, 7 | GND | Ground Reference Point for All Circuitry on the Part. |
| 4 | RF1 | RF1 Port. |
| 8 | RF2 | RF2 Port. |

**Table 4. Truth Table**

| CTRL | Signal Path |
|---|---|
| 0 | RF1 isolated from RF2 |
| 1 | RF1 to RF2 |

# TYPICAL PERFORMANCE CHARACTERISTICS

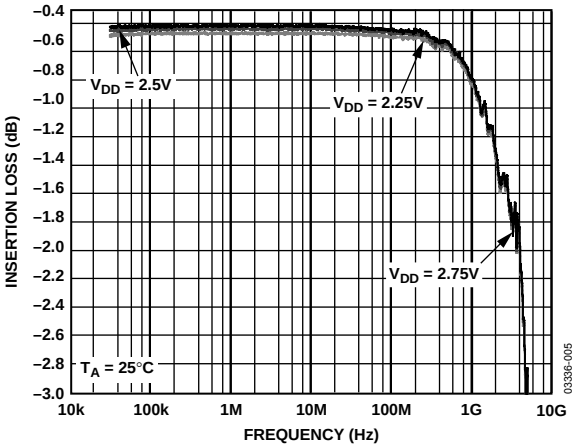



Figure 5. Insertion Loss vs. Frequency over Supplies (S12 and S21)

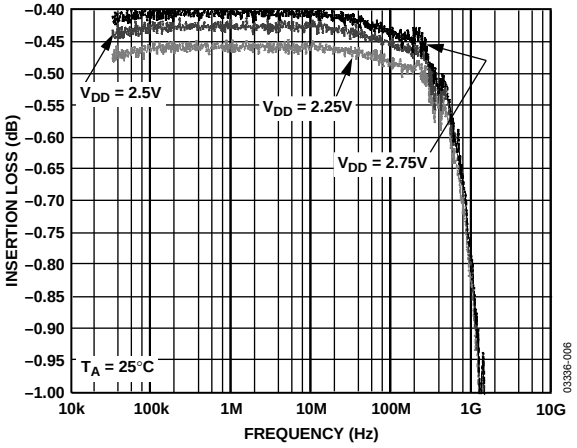



Figure 6. Insertion Loss vs. Frequency over Supplies (S12 and S21) (Zoomed Figure 5 Plot)

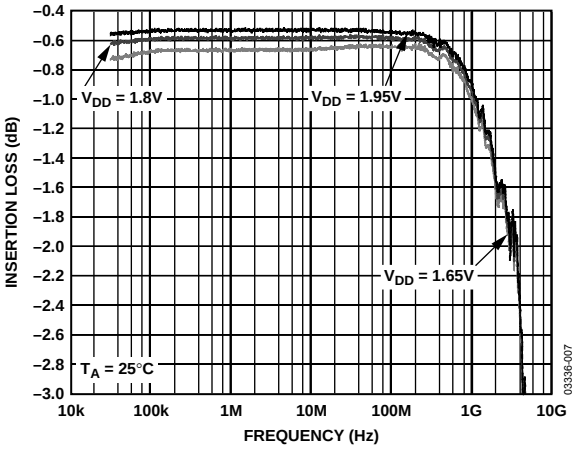



Figure 7. Insertion Loss vs. Frequency over Supplies (S12 and S21)

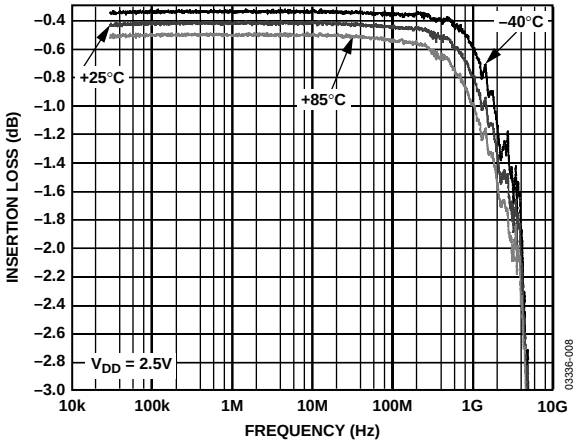



Figure 8. Insertion Loss vs. Frequency over Temperature (S12 and S21)

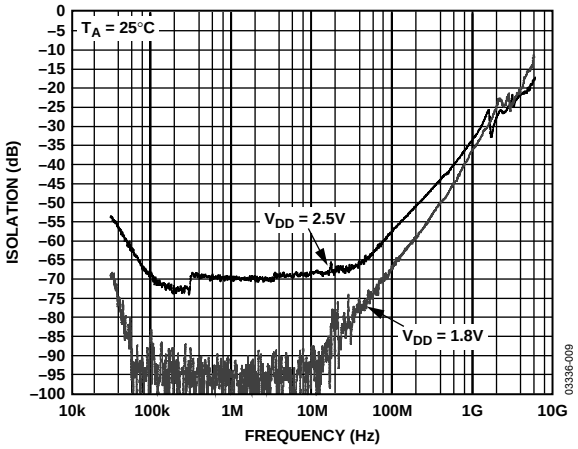



Figure 9. OFF Isolation vs. Frequency over Supplies (S12 and S21)

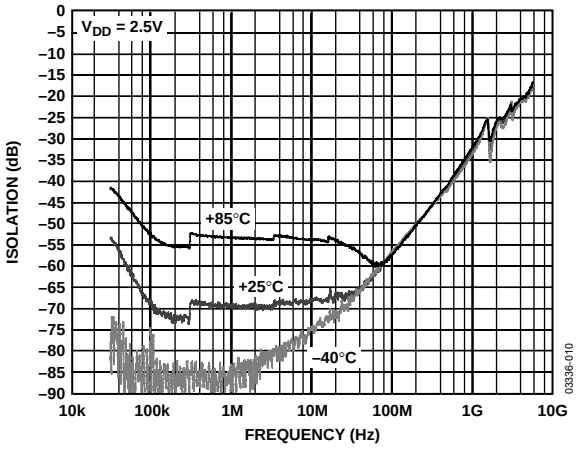



Figure 10. Off Isolation vs. Frequency over Temperature (S12 and S21)

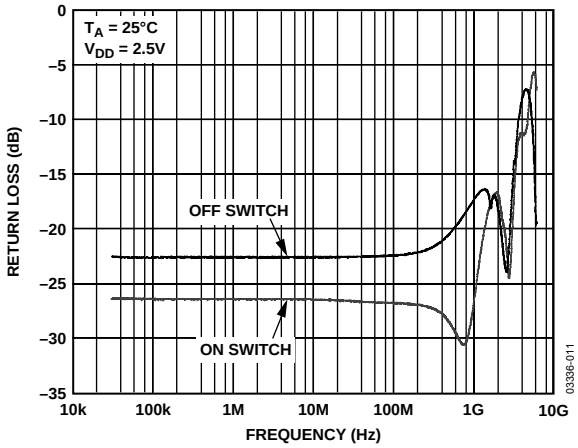



Figure 11. Return Loss vs. Frequency (S11)

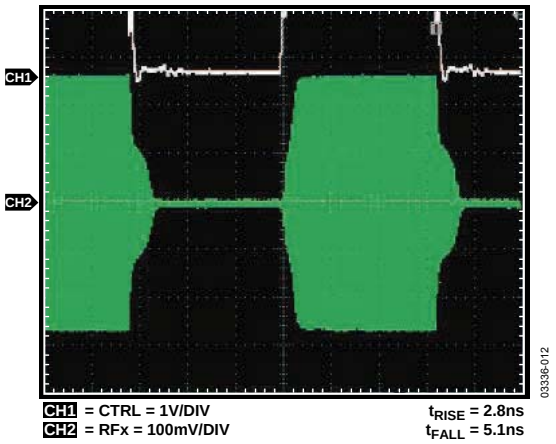



Figure 12. Switch Timing

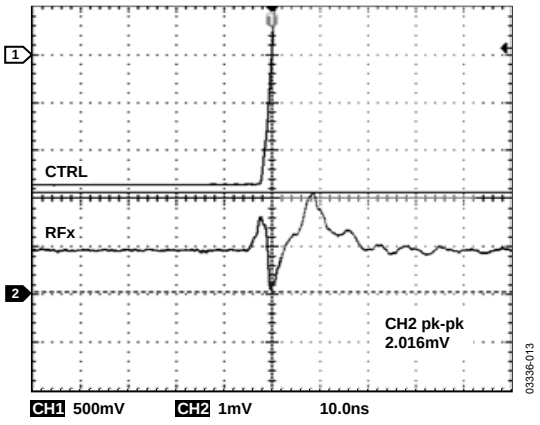



Figure 13. Video Feedthrough

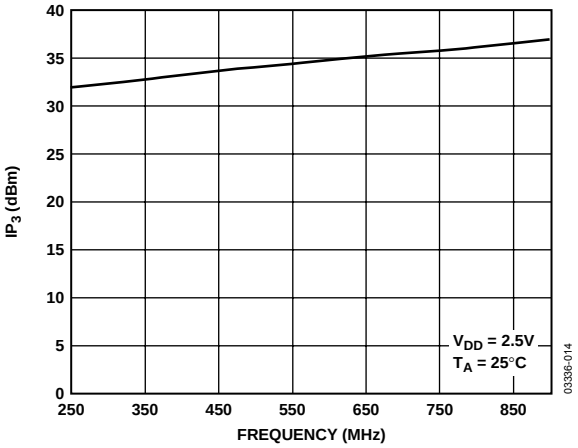



Figure 14. $IP_3$ vs. Frequency

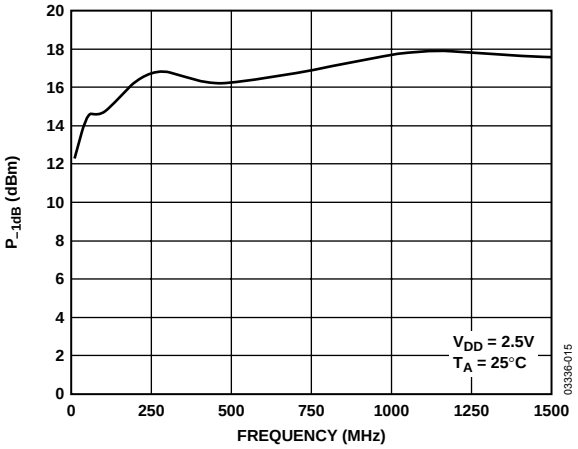



Figure 15. $P_{-1dB}$ vs. Frequency

# TERMINOLOGY

**$V_{DD}$**
Most positive power supply potential.

**$I_{DD}$**
Positive supply current.

**GND**
Ground (0 V) reference.

**CTRL**
Logic control input.

**$V_{INL}$**
Maximum input voltage for Logic 0.

**$V_{INH}$**
Minimum input voltage for Logic 1.

**$I_{INL}$ ($I_{INH}$)**
Input current of the digital input.

**$C_{IN}$**
Digital input capacitance.

**$t_{ON}$**
Delay between applying the digital control input and the output switching on.

**$t_{OFF}$**
Delay between applying the digital control input and the output switching off.

**$t_{RISE}$**
Rise time. Time for the RF signal to rise from 10% to 90% of the on level.

**$t_{FALL}$**
Fall time. Time for the RF signal to fall from 90% to 10% of the on level.

**Off Isolation**
The attenuation between input and output ports of the switch when the switch control voltage is in the off condition.

**Insertion Loss**
The attenuation between input and output ports of the switch when the switch control voltage is in the on condition.

**$P_{-1\ dB}$**
1 dB compression point. The RF input power level at which the switch insertion loss increases by 1 dB over its low level value. It is a measure of how much power the on switch can handle before the insertion loss increases by 1 dB.

**$IP_3$**
Third-order intermodulation intercept. This is a measure of the power in false tones that occur when closely spaced tones are passed through a switch, whereby the nonlinearity of the switch causes these false tones to be generated.

**Return Loss**
The amount of reflected power relative to the incident power at a port. Large return loss indicates good matching. By measuring return loss the VSWR can be calculated from conversion charts. voltage standing wave ratio (VSWR) indicates the degree of matching present at a switch RF port.

**Video Feedthrough**
The spurious signals present at the RF ports of the switch when the control voltage is switched from high to low or low to high without an RF signal present.

# TEST CIRCUITS

Similar setups for ADG902.

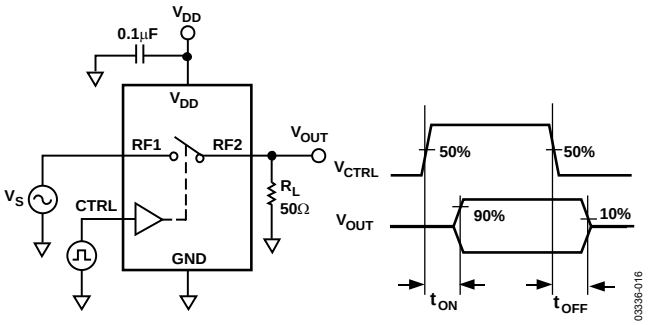



*Figure 16. Switching Timing: $t_{ON}$, $t_{OFF}$*

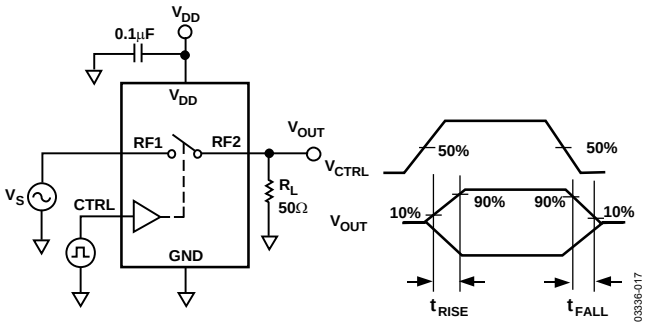



*Figure 17. Switch Timing: $t_{RISE}$, $t_{FALL}$*

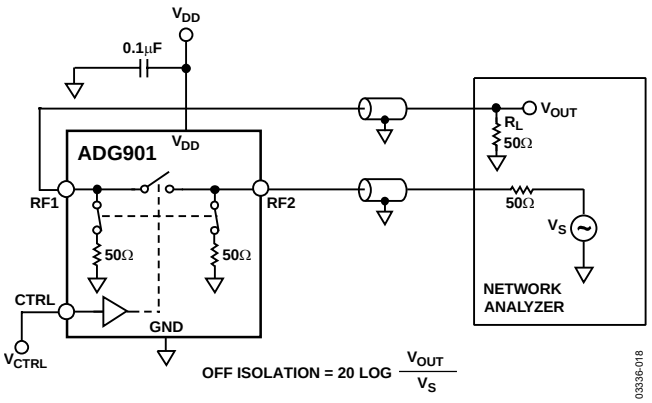



*Figure 18. Off Isolation*

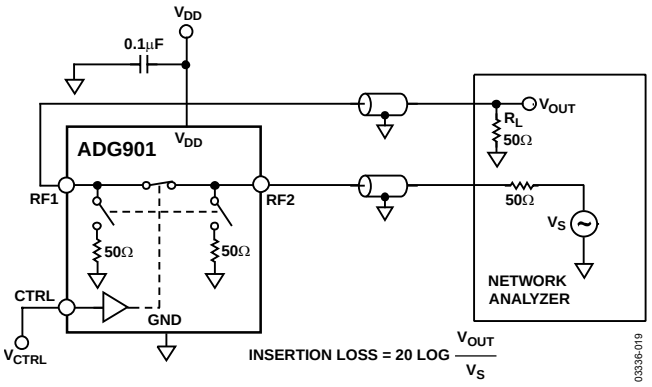



*Figure 19. Insertion Loss*

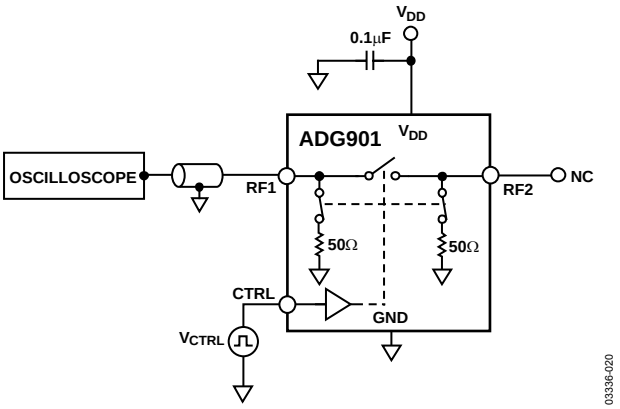



*Figure 20. Video Feedthrough*

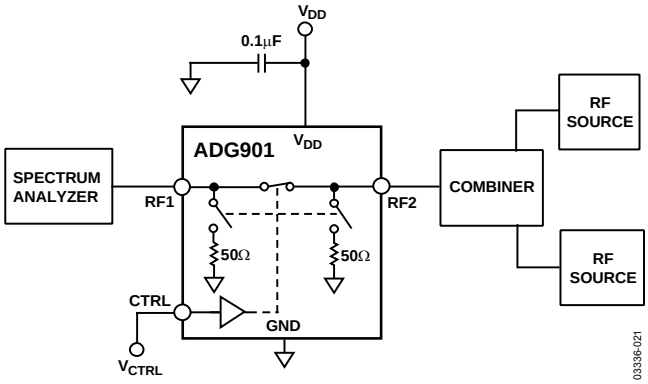



*Figure 21. $IP_3$*

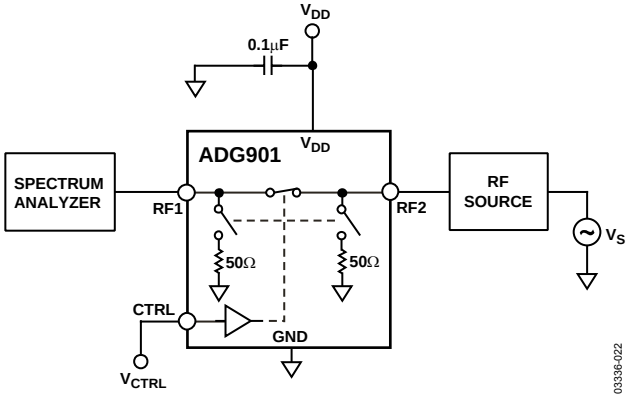



*Figure 22. $P_{-1\,dB}$*

# APPLICATIONS

The ADG901/ADG902 are ideal solutions for low power, high frequency applications. The low insertion loss, high isolation between ports, low distortion, and low current consumption of these parts make them excellent solutions for many high frequency switching applications.

Applications include switching between high frequency filters, ASK generators, and FSK generators.

## ABSORPTIVE vs. REFLECTIVE SWITCHES

The ADG901 is an absorptive (matched) switch with 50 Ω terminated shunt legs and the ADG902 is a reflective switch with 0 Ω terminated shunts to ground. The ADG901 absorptive switch has a good VSWR on each port, regardless of the switch mode. An absorptive switch should be used when there is a need for a good VSWR that is looking into the port but not passing the through signal to the common port. The ADG901 is therefore ideal for applications that require minimum reflections back to the RF source. It also ensures that the maximum power is transferred to the load.

The ADG902 reflective switch is suitable for applications where high off port VSWR does not matter and the switch has some other desired performance feature. It can be used in many applications, including high speed filter selection. In most cases, an absorptive switch can be used instead of a reflective switch, but not vice versa.

## ADG90x EVALUATION BOARD

The ADG90x evaluation board allows designers to evaluate the high performance wideband switches with a minimum of effort. To prove that these devices meet user requirements, the user requires only a power supply and a network analyzer along with the evaluation board. An application note is available with the evaluation board and provides complete information on operating the evaluation board.

The RF1 port (see Figure 23) is connected through a 50 Ω transmission line to the top left SMA Connector J1. RF2 is connected through a 50 Ω transmission line to the top SMA Connector J2. J3 is connected to GND. A through transmission line connects J4 and J5 and this transmission line is used to estimate the loss of the PCB over the environmental conditions being evaluated.

The board is constructed of a 4-layer, FR4 material with a dielectric constant of 4.3 and an overall thickness of 0.062 inches. Two ground layers with grounded planes provide ground for the RF transmission lines. The transmission lines were designed using a coplanar waveguide with ground plane model using a trace width of 0.052 inches, clearance to ground plane of 0.030 inches, dielectric thickness of 0.029 inches, and a metal thickness of 0.014 inches.

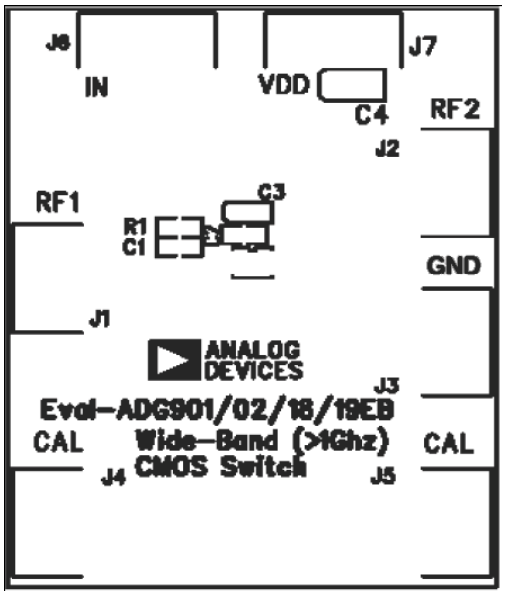
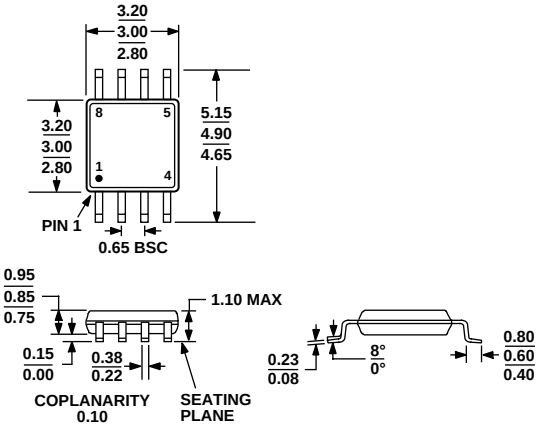



*Figure 23. ADG90x Evaluation Board Top View*

# OUTLINE DIMENSIONS




COMPLIANT TO JEDEC STANDARDS MO-187-AA

*Figure 24. 8-Lead Mini Small Outline Package [MSOP]*
*(RM-8)*
*Dimensions shown in millimeters*

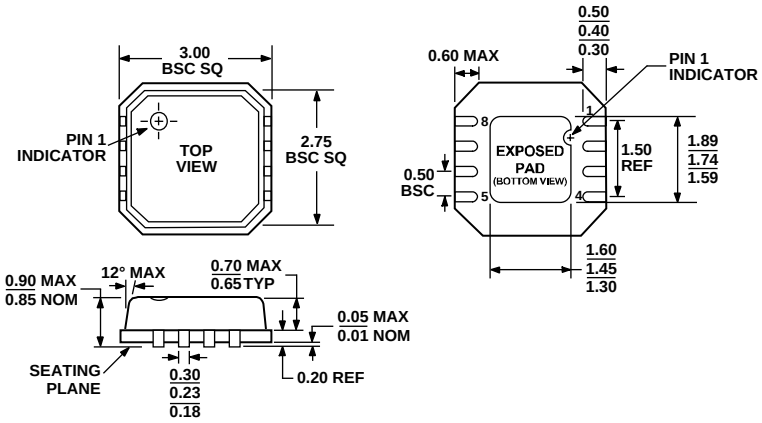



*Figure 25. 8-Lead Lead Frame Chip Scale Package [LFCSP]*
*3 mm × 3 mm Body*
*(CP-8-2)*
*Dimensions shown in millimeters*

## ORDERING GUIDE

| Model | Temperature Range | Package Description | Package Option | Branding |
|---|---|---|---|---|
| ADG901BRM | −40°C to +85°C | 8-Lead Mini Small Outline Package [MSOP] | RM-8 | W6B |
| ADG901BRM-500RL7 | −40°C to +85°C | 8-Lead Mini Small Outline Package [MSOP] | RM-8 | W6B |
| ADG901BRM-REEL7 | −40°C to +85°C | 8-Lead Mini Small Outline Package [MSOP] | RM-8 | W6B |
| ADG901BRMZ[1] | −40°C to +85°C | 8-Lead Mini Small Outline Package [MSOP] | RM-8 | S1T |
| ADG901BRMZ-REEL7[1] | −40°C to +85°C | 8-Lead Mini Small Outline Package [MSOP] | RM-8 | S1T |
| ADG901BCP-500RL7 | −40°C to +85°C | 8-Lead Lead Frame Chip Scale Package [LFCSP] | CP-8-2 | W6B |
| ADG901BCP-REEL7 | −40°C to +85°C | 8-Lead Lead Frame Chip Scale Package [LFCSP] | CP-8-2 | W6B |
| ADG901BCPZ-REEL7 | −40°C to +85°C | 8-Lead Lead Frame Chip Scale Package [LFCSP] | CP-8-2 | S1T |
| ADG902BRM | −40°C to +85°C | 8-Lead Mini Small Outline Package [MSOP] | RM-8 | W7B |
| ADG902BRM-500RL7 | −40°C to +85°C | 8-Lead Mini Small Outline Package [MSOP] | RM-8 | W7B |
| ADG902BRM-REEL7 | −40°C to +85°C | 8-Lead Lead Frame Chip Scale Package [LFCSP] | RM-8 | W7B |
| ADG902BRMZ[1] | −40°C to +85°C | 8-Lead Mini Small Outline Package [MSOP] | RM-8 | S1V |
| ADG902BCP-500RL7 | −40°C to +85°C | 8-Lead Lead Frame Chip Scale Package [LFCSP] | CP-8-2 | W7B |
| ADG902BCP-REEL7 | −40°C to +85°C | 8-Lead Lead Frame Chip Scale Package [LFCSP] | CP-8-2 | W7B |
| ADG902BCP-REEL7 | −40°C to +85°C | 8-Lead Lead Frame Chip Scale Package [LFCSP] | CP-8-2 | S1V |
| EVAL-ADG901EB | | Evaluation Board | | |
| EVAL-ADG902EB | | Evaluation Board | | |

[1] Z = Pb-free part.

## NOTES

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D03336–0–10/05(B)

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