# CMOS QUAD BILATERAL SWITCH

**Check for Samples: CD4066B-Q1**

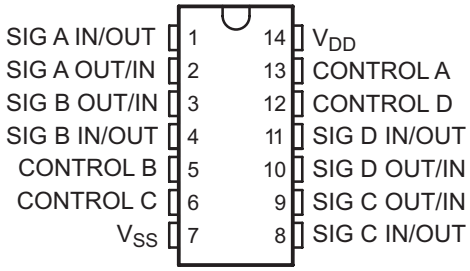
## FEATURES

- **Qualified for Automotive Applications**
- **15-V Digital or ±7.5-V Peak-to-Peak Switching**
- **125-Ω Typical On-State Resistance for 15-V Operation**
- **Switch On-State Resistance Matched to Within 5 Ω Over 15-V Signal-Input Range**
- **On-State Resistance Flat Over Full Peak-to-Peak Signal Range**
- **High On/Off Output-Voltage Ratio: 80 dB Typical at $f_{is}$ = 10 kHz, $R_L$ = 1 kΩ**
- **High Degree of Linearity: <0.5% Distortion Typical at $f_{is}$ = 1 kHz, $V_{is}$ = 5 V p-p, $V_{DD} - V_{SS} \geq 10$ V, $R_L$ = 10 kΩ**
- **Extremely Low Off-State Switch Leakage, Resulting in Very Low Offset Current and High Effective Off-State Resistance: 10 pA Typical at $V_{DD} - V_{SS}$ = 10 V, $T_A$ = 25°C**
- **Extremely High Control Input Impedance (Control Circuit Isolated From Signal Circuit): $10^{12}$ Ω Typical**
- **Low Crosstalk Between Switches: –50 dB Typical at $f_{is}$ = 8 MHz, $R_L$ = 1 kΩ**
- **Matched Control-Input to Signal-Output Capacitance: Reduces Output Signal Transients**
- **Frequency Response, Switch On = 40 MHz Typical**
- **100% Tested for Quiescent Current at 20 V**
- **5-V, 10-V, and 15-V Parametric Ratings**
- **Latch-Up Exceeds 100mA per JESD78 - Class I**
- **Meets All Requirements of JEDEC Tentative Standard No. 13-B, *Standard Specifications for Description of "B" Series CMOS Devices***

## APPLICATIONS

- **Analog Signal Switching/Multiplexing: Signal Gating, Modulator, Squelch Control, Demodulator, Chopper, Commutating Switch**
- **Digital Signal Switching/Multiplexing**
- **Transmission-Gate Logic Implementation**
- **Analog-to-Digital and Digital-to-Analog Conversion**
- **Digital Control of Frequency, Impedance, Phase, and Analog-Signal Gain**

**E, F, M, NS, OR PW PACKAGE**
**(TOP VIEW)**




## DESCRIPTION/ORDERING INFORMATION

The CD4066B-Q1 is a quad bilateral switch intended for the transmission or multiplexing of analog or digital signals. It is pin-for-pin compatible with the CD4016B, but exhibits a much lower on-state resistance. In addition, the on-state resistance is relatively constant over the full signal-input range.

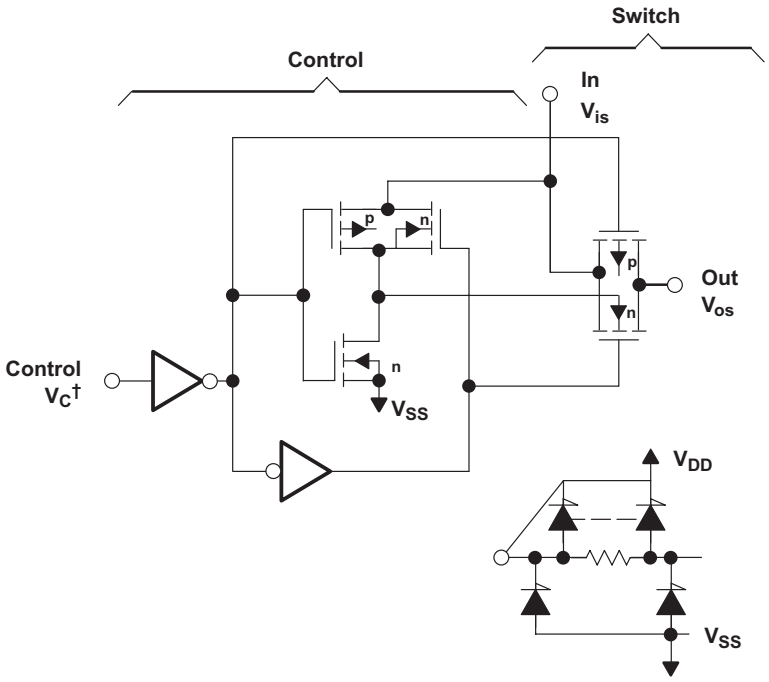
The CD4066B-Q1 consists of four bilateral switches, each with independent controls. Both the p and the n devices in a given switch are biased on or off simultaneously by the control signal. As shown in Figure 1, the well of the n-channel device on each switch is tied to either the input (when the switch is on) or to VSS (when the switch is off). This configuration eliminates the variation of the switch-transistor threshold voltage with input signal and, thus, keeps the on-state resistance low over the full operating-signal range.

The advantages over single-channel switches include peak input-signal voltage swings equal to the full supply voltage and more constant on-state impedance over the input-signal range. However, for sample-and-hold applications, the CD4016B is recommended.

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

## ORDERING INFORMATION

| $T_A$ | PACKAGE | | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|---|---|---|---|---|
| –40°C to 125°C | SOIC – D | Reel of 2500 | CD4066BQDRQ1 | CD4066BQ |




† All control inputs are protected by the CMOS protection network.

NOTES: A.All p substrates are connected to $V_{DD}$.
B. Normal operation control-line biasing: switch on (logic 1), $V_C = V_{DD}$; switch off (logic 0), $V_C = V_{SS}$
C. Signal-level range: $V_{SS} \leq V_{is} \leq V_{DD}$

**Figure 1. Schematic Diagram of One-of-Four Identical Switches and Associated Control Circuitry**

## ABSOLUTE MAXIMUM RATINGS

over operating free-air temperature range (unless otherwise noted) (1)

| | | VALUE | UNIT |
|---|---|---|---|
| DC supply-voltage range, $V_{DD}$ (voltages referenced to $V_{SS}$ terminal) | | –0.5 to 20 | V |
| Input voltage range, $V_{is}$ (all inputs) | | –0.5 to $V_{DD}$ + 0.5 | V |
| DC input current, IIN (any one input) | | ±10 | mA |
| Package thermal impedance, $\theta_{JA}$ (2) | D package | 86 | °C/W |
| ESD Electrostatic discharge(3) | Human-Body Model (HBM) | 500 | V |
| | Machine Model (MM) | 150 | |
| | Field_Induced_Charged Device Model (CDM) | 1000 | |
| Lead temperature (during soldering): At distance 1/16 ± 1/32 inch (1,59 ± 0,79 mm) from case for 10 s max | | 265 | °C |
| Storage temperature range, $T_{stg}$ | | –65 to 150 | °C |

(1) 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 under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) The package thermal impedance is calculated in accordance with JESD 51-7.
(3) Tested in accordance with AEC-Q100.

## THERMAL INFORMATION

| THERMAL METRIC(1) | | CD4066B-Q1 D PACKAGE 14 PINS | UNITS |
|---|---|---|---|
| $\theta_{JA}$ | Junction-to-ambient thermal resistance | 92.4 | °C/W |
| $\theta_{JCtop}$ | Junction-to-case (top) thermal resistance | 52.5 | |
| $\theta_{JB}$ | Junction-to-board thermal resistance | 46.7 | |
| $\psi_{JT}$ | Junction-to-top characterization parameter | 46.4 | |
| $\psi_{JB}$ | Junction-to-board characterization parameter | 46.4 | |
| $\theta_{JCbot}$ | Junction-to-case (bottom) thermal resistance | N/A | |

(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, SPRA953.

## RECOMMENDED OPERATING CONDITIONS

| | | MIN | MAX | UNIT |
|---|---|---|---|---|
| $V_{DD}$ | Supply voltage | 3 | 18 | V |
| $T_A$ | Operating free-air temperature | –40 | 125 | °C |

## ELECTRICAL CHARACTERISTICS

over operating free-air temperature range (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | $V_{IN}$ (V) | $V_{DD}$ (V) | LIMITS AT INDICATED TEMPERATURES | | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | –40°C | 125°C | 25°C | | |
| | | | | | | | TYP | MAX | |
| $I_{DD}$ | Quiescent device current | | 0.5 | 5 | 0.25 | 7.5 | 0.01 | 0.25 | µA |
| | | | 0.10 | 10 | 0.5 | 15 | 0.01 | 0.5 | |
| | | | 0.15 | 15 | 1 | 30 | 0.01 | 1 | |
| | | | 0.20 | 20 | 5 | 150 | 0.02 | 5 | |
| **SIGNAL INPUTS ($V_{is}$) AND OUTPUTS ($V_{os}$)** | | | | | | | | | |
| $r_{on}$ | On-state resistance (max) | $V_C = V_{DD}$, $R_L$ = 10 kΩ returned to $\frac{V_{DD} \quad V_{SS}}{2}$, $V_{is} = V_{SS}$ to $V_{DD}$ | | 5 | 850 | 1300 | 470 | 1050 | Ω |
| | | | | 10 | 330 | 550 | 180 | 400 | |
| | | | | 15 | 210 | 320 | 125 | 240 | |
| $\Delta r_{on}$ | On-state resistance difference between any two switches | $R_L$ = 10 kΩ, $V_C = V_{DD}$ | | 5 | | | 15 | | Ω |
| | | | | 10 | | | 10 | | |
| | | | | 15 | | | 5 | | |
| THD | Total harmonic distortion | $V_C = V_{DD}$ = 5 V, $V_{SS}$ = –5 V, $V_{is(p-p)}$ = 5 V (sine wave centered on 0 V), $R_L$ = 10 kΩ, $f_{is}$ = 1-kHz sine wave | | | | | 0.4% | | |
| | 3-dB cutoff frequency (switch on) | $V_C = V_{DD}$ = 5 V, $V_{SS}$ = –5 V, $V_{is(p-p)}$ = 5 V (sine wave centered on 0 V), $R_L$ = 1 kΩ | | | | | 40 | | MHz |
| | –50-dB feedthrough frequency (switch off) | $V_C = V_{SS}$ = –5 V, $V_{is(p-p)}$ = 5 V (sine wave centered on 0 V), $R_L$ = 1 kΩ | | | | | 1 | | MHz |
| $I_{is}$ | Input/output leakage current (switch off) (max) | $V_C$ = 0 V, $V_{is}$ = 18 V, $V_{os}$ = 0 V; and $V_C$ = 0 V, $V_{is}$ = 0 V, $V_{os}$ = 18 V | | 18 | ±0.1 | ±1 | $\pm 10^{-5}$ | ±0.1 | µA |
| | –50-dB crosstalk frequency | $V_C$(A) = $V_{DD}$ = 5 V, $V_C$(B) = $V_{SS}$ = -5 V, $V_{is}$(A) = 5 $V_{p-p}$, 50-Ω source, $R_L$ = 1 kΩ | | | | | 8 | | MHz |
| $t_{pd}$ | Propagation delay (signal input to signal output) | $R_L$ = 200 kΩ, $V_C = V_{DD}$, $V_{SS}$ = GND, $C_L$ = 50 pF, $V_{is}$ = 10 V (square wave centered on 5 V), $t_r$, $t_f$ = 20 ns | | 5 | | | 20 | 40 | ns |
| | | | | 10 | | | 10 | 20 | |
| | | | | 15 | | | 7 | 15 | |
| $C_{is}$ | Input capacitance | $V_{DD}$ = 5 V, $V_C = V_{SS}$ = –5 V | | | | | 8 | | pF |
| $C_{os}$ | Output capacitance | $V_{DD}$ = 5 V, $V_C = V_{SS}$ = –5 V | | | | | 8 | | pF |
| $C_{ios}$ | Feedthrough | $V_{DD}$ = 5 V, $V_C = V_{SS}$ = –5 V | | | | | 0.5 | | pF |

## ELECTRICAL CHARACTERISTICS (continued)

over operating free-air temperature range (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | $V_{IN}$ (V) | $V_{DD}$ (V) | LIMITS AT INDICATED TEMPERATURES | | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | –40°C | 125°C | 25°C TYP | 25°C MAX | |
| **CONTROL ($V_C$)** | | | | | | | | | |
| $V_{ILC}$ | Control input, low voltage (max) | $\|I_{is}\|$ < 10 mA, $V_{is} = V_{SS}$, $V_{OS} = V_{DD}$, and $V_{is} = V_{DD}$, $V_{OS} = V_{SS}$ | | 5 | 1 | 1 | | 1 | V |
| | | | | 10 | 2 | 2 | | 2 | |
| | | | | 15 | 2 | 2 | | 2 | |
| $V_{IHC}$ | Control input, low voltage | See Figure 6 | | 5 | 3.5 (MIN) | | | | V |
| | | | | 10 | 7 (MIN) | | | | |
| | | | | 15 | 11 (MIN) | | | | |
| $I_{IN}$ | Input current (max) | $V_{is} \le V_{DD}$, $V_{DD} - V_{SS}$ = 18 V, $V_{CC} \le V_{DD} - V_{SS}$ | | 18 | ±0.1 | ±1 | $\pm 10^{-5}$ | ±0.1 | µA |
| | Crosstalk (control input to signal output) | $V_C$ = 10 V (square wave), $t_r$, $t_f$ = 20 ns, $R_L$ = 10 kΩ | | 10 | | | 50 | | mW |
| | Turn-on and turn-off propagation delay | $V_{IN} = V_{DD}$, $t_r$, $t_f$ = 20 ns, $C_L$ = 50 pF, $R_L$ = 1 kΩ | | 5 | | | 35 | 70 | ns |
| | | | | 10 | | | 20 | 40 | |
| | | | | 15 | | | 15 | 30 | |
| | Maximum control input repetition rate | $V_{is} = V_{DD}$, $V_{SS}$ = GND, $R_L$ = 1 kΩ to GND, $C_L$ = 50 pF, $V_C$ = 10 V (square wave centered on 5 V), $t_r$, $t_f$ = 20 ns, $V_{os}$ = 1/2 $V_{os}$ at 1 kHz | | 5 | | | 6 | | MHz |
| | | | | 10 | | | 9 | | |
| | | | | 15 | | | 9.5 | | |
| $C_i$ | Input capacitance | | | | | | 5 | | pF |

## SWITCHING CHARACTERISTICS

| $V_{DD}$ (V) | SWITCH INPUT | | | | SWITCH OUTPUT, $V_{os}$ (V) | |
|---|---|---|---|---|---|---|
| | $V_{is}$ (V) | $I_{is}$ (mA) | | | | |
| | | –40°C | 25°C | 125°C | MIN | MAX |
| 5 | 0 | 0.61 | 0.51 | 0.36 | | 0.4 |
| 5 | 5 | –0.61 | –0.51 | –0.36 | 4.6 | |
| 10 | 0 | 1.5 | 1.3 | 0.9 | | |
| 10 | 10 | –1.6 | –1.3 | –0.9 | | |
| 15 | 0 | 4 | 3.4 | 2.4 | | 1.5 |
| 15 | 15 | –4 | –3.4 | –2.4 | 13.5 | |

## TYPICAL CHARACTERISTICS

TYPICAL ON-STATE RESISTANCE
vs
INPUT SIGNAL VOLTAGE (ALL TYPES)

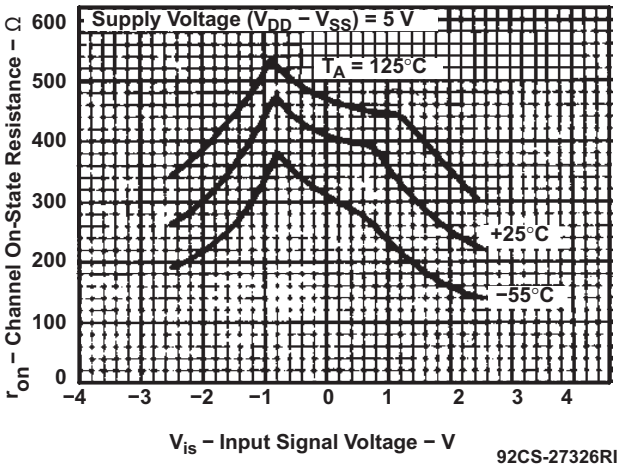



Figure 2.

TYPICAL ON-STATE RESISTANCE
vs
INPUT SIGNAL VOLTAGE (ALL TYPES)

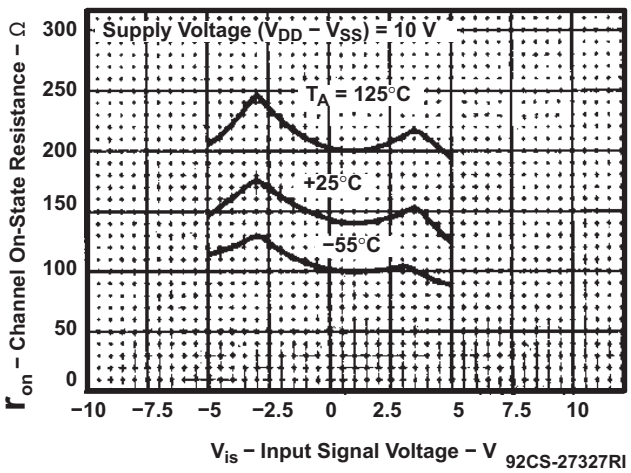



Figure 3.

TYPICAL ON-STATE RESISTANCE
vs
INPUT SIGNAL VOLTAGE (ALL TYPES)

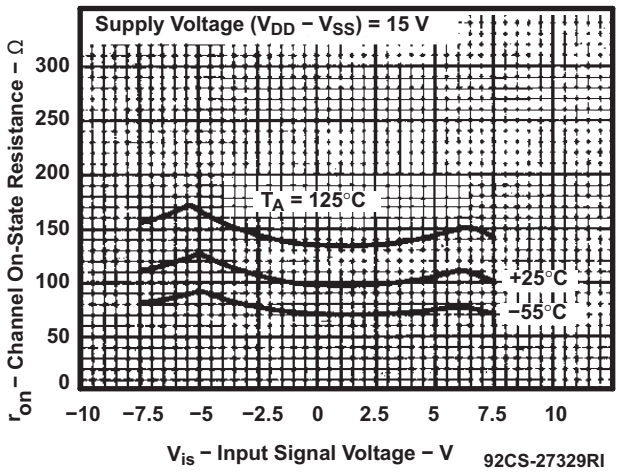



Figure 4.

TYPICAL ON-STATE RESISTANCE
vs
INPUT SIGNAL VOLTAGE (ALL TYPES)

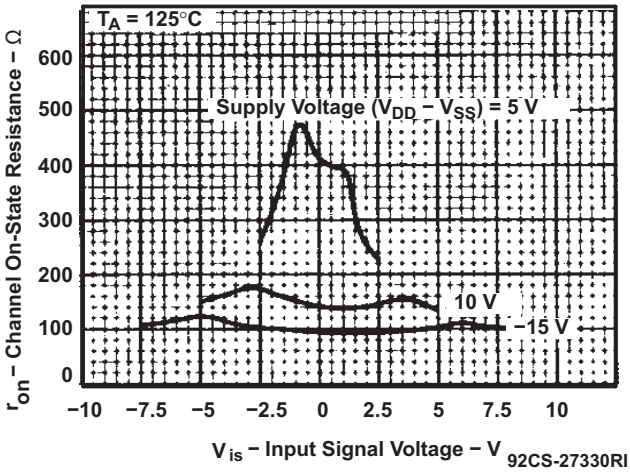



Figure 5.

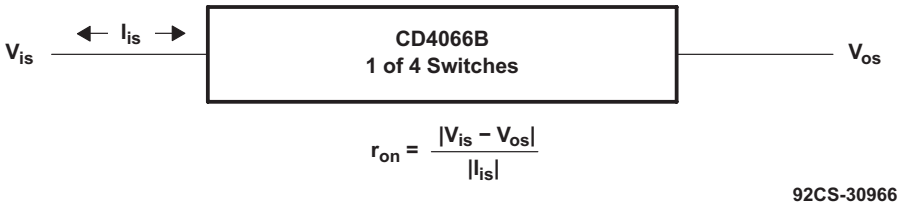



**Figure 6. Determination of ron as a Test Condition for Control-Input High-Voltage (VIHC) Specification**

## TYPICAL CHARACTERISTICS (continued)

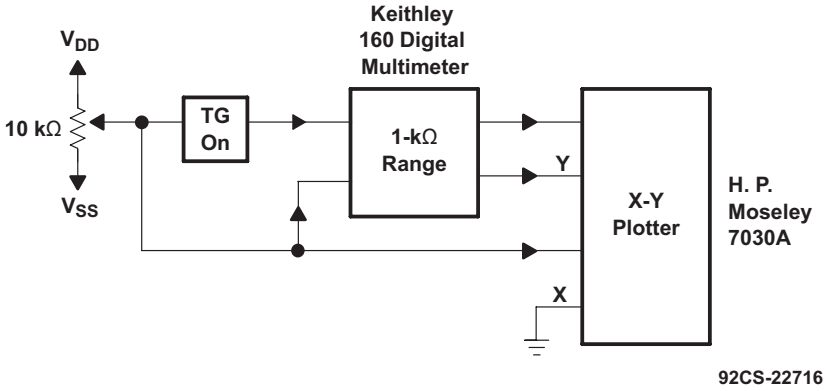



**Figure 7. Channel On-State Resistance Measurement Circuit**

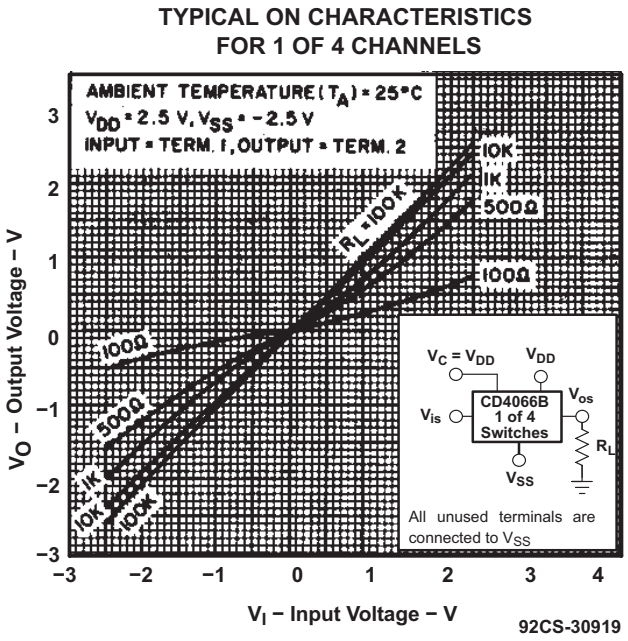



**Figure 8.**

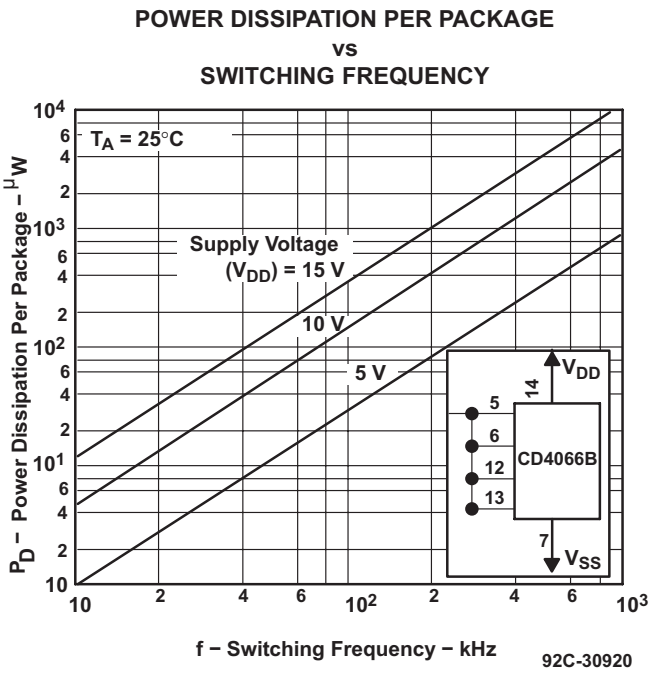
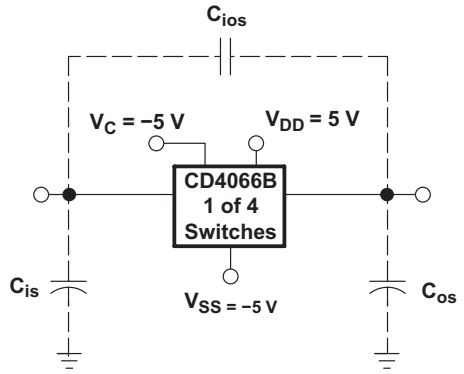



**Figure 9.**

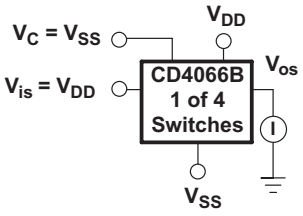
## TYPICAL CHARACTERISTICS (continued)




92CS-30921

Measured on Boonton capacitance bridge, model 75a (1 MHz); test-fixture capacitance nulled out.

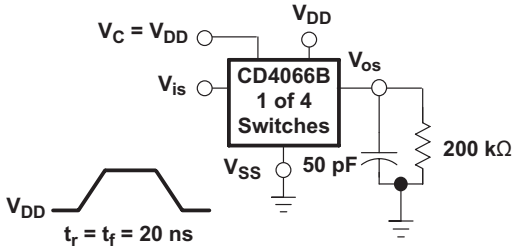
**Figure 10. Typical On Characteristics for One of Four Channels**




92CS-30922

All unused terminals are connected to $V_{SS}$.

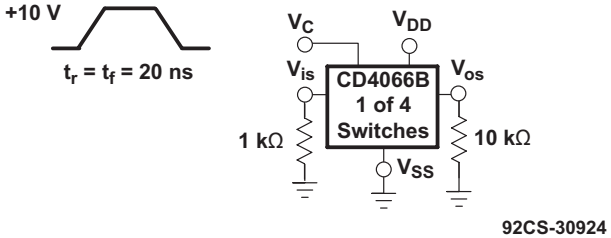
**Figure 11. Off-Switch Input or Output Leakage**




92CS-30923

All unused terminals are connected to $V_{SS}$.

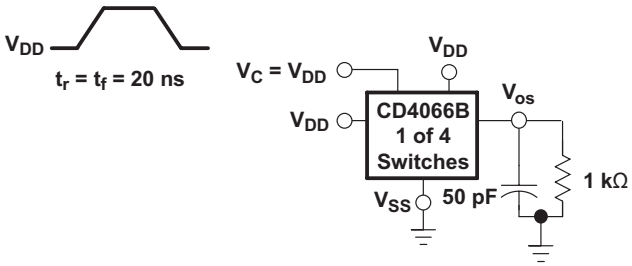
**Figure 12. Propagation Delay Time Signal Input ($V_{is}$) to Signal Output ($V_{os}$)**




92CS-30924

All unused terminals are connected to $V_{SS}$.

**Figure 13. Crosstalk-Control Input to Signal Output**

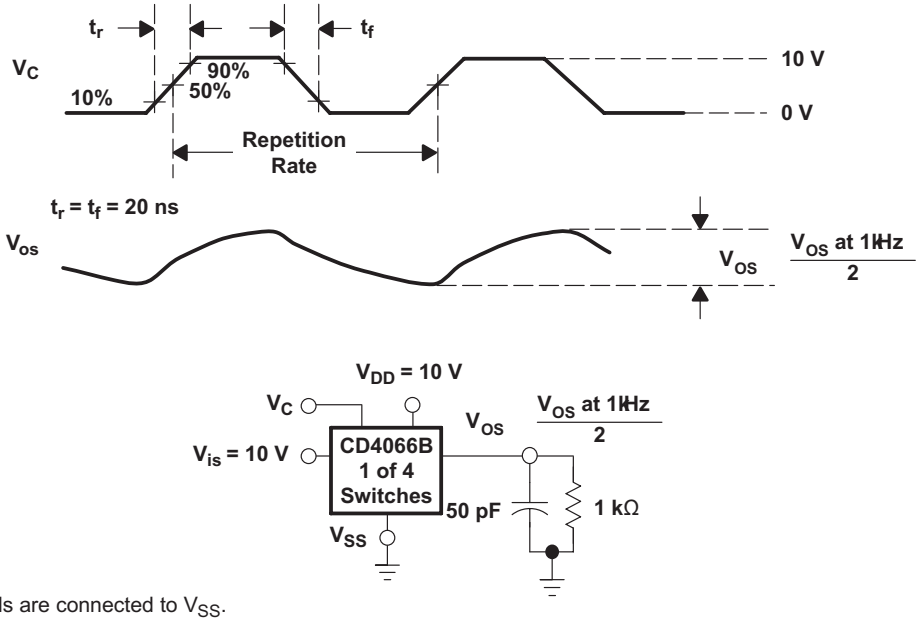



92CS-30925

NOTES: A.All unused terminals are connected to $V_{SS}$.
B. Delay is measured at $V_{os}$ level of +10% from ground (turn-on) or on-state output level (turn-off).

**Figure 14. Propagation Delay, $t_{PLH}$, $t_{PHL}$ Control-Signal Output**

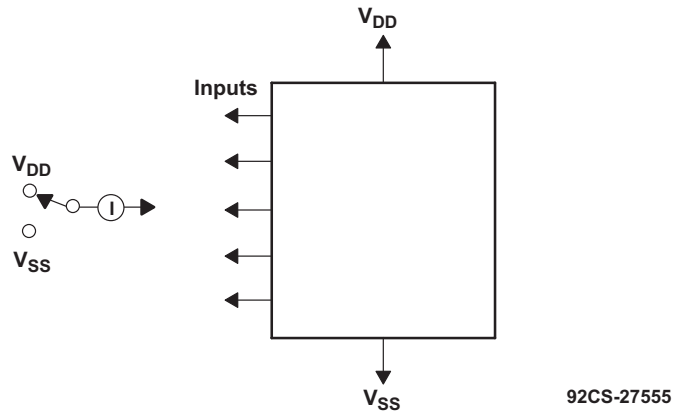
## TYPICAL CHARACTERISTICS (continued)




All unused terminals are connected to $V_{SS}$.

92CS-30925

**Figure 15. Maximum Allowable Control-Input Repetition Rate**




92CS-27555

Measure inputs sequentially to both $V_{DD}$ and $V_{SS}$. Connect all unused inputs to either $V_{DD}$ or $V_{SS}$. Measure control inputs only.

**Figure 16. Input Leakage-Current Test Circuit**

## TYPICAL CHARACTERISTICS (continued)

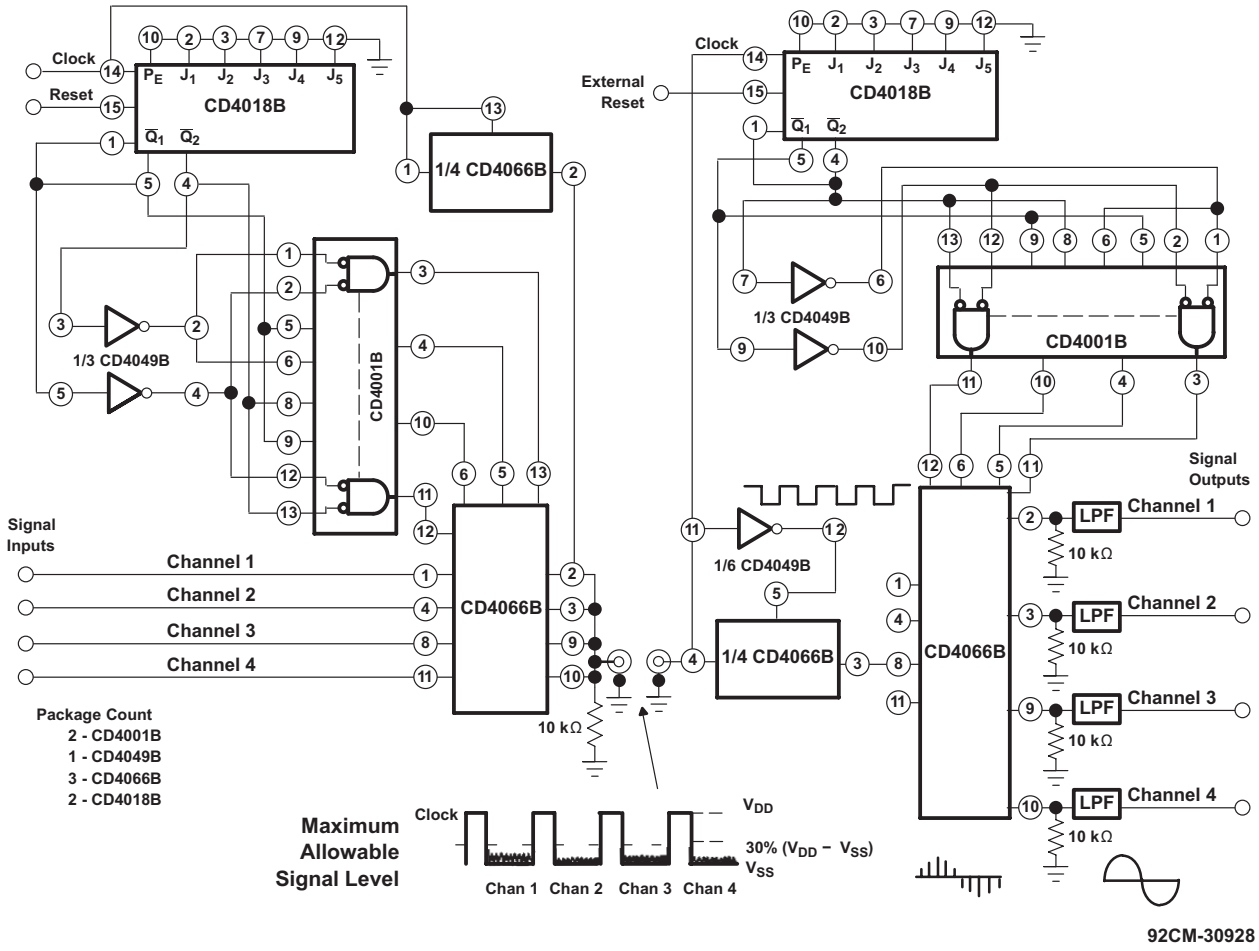



**Figure 17. Four-Channel PAM Multiplex System Diagram**

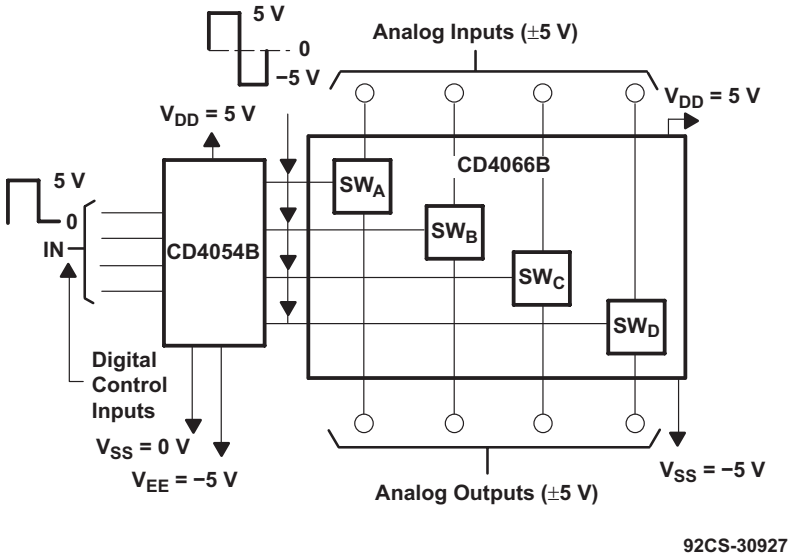



**Figure 18. Bidirectional Signal Transmission Via Digital Control Logic**

## APPLICATION INFORMATION

In applications that employ separate power sources to drive $V_{DD}$ and the signal inputs, the $V_{DD}$ current capability should exceed $V_{DD}/R_L$ ($R_L$ = effective external load of the four CD4066B-Q1 bilateral switches). This provision avoids any permanent current flow or clamp action on the $V_{DD}$ supply when power is applied or removed from the CD4066B-Q1.

In certain applications, the external load-resistor current can include both $V_{DD}$ and signal-line components. To avoid drawing $V_{DD}$ current when switch current flows into terminals 1, 4, 8, or 11, the voltage drop across the bidirectional switch must not exceed 0.8 V (calculated from $r_{on}$ values shown).

No $V_{DD}$ current will flow through $R_L$ if the switch current flows into terminals 2, 3, 9, or 10.

## PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead finish/ Ball material (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CD4066BQDRQ1 | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | CD4066BQ | Samples |

(1) The marketing status values are defined as follows:
**ACTIVE:** Product device recommended for new designs.
**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.
**OBSOLETE:** TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.



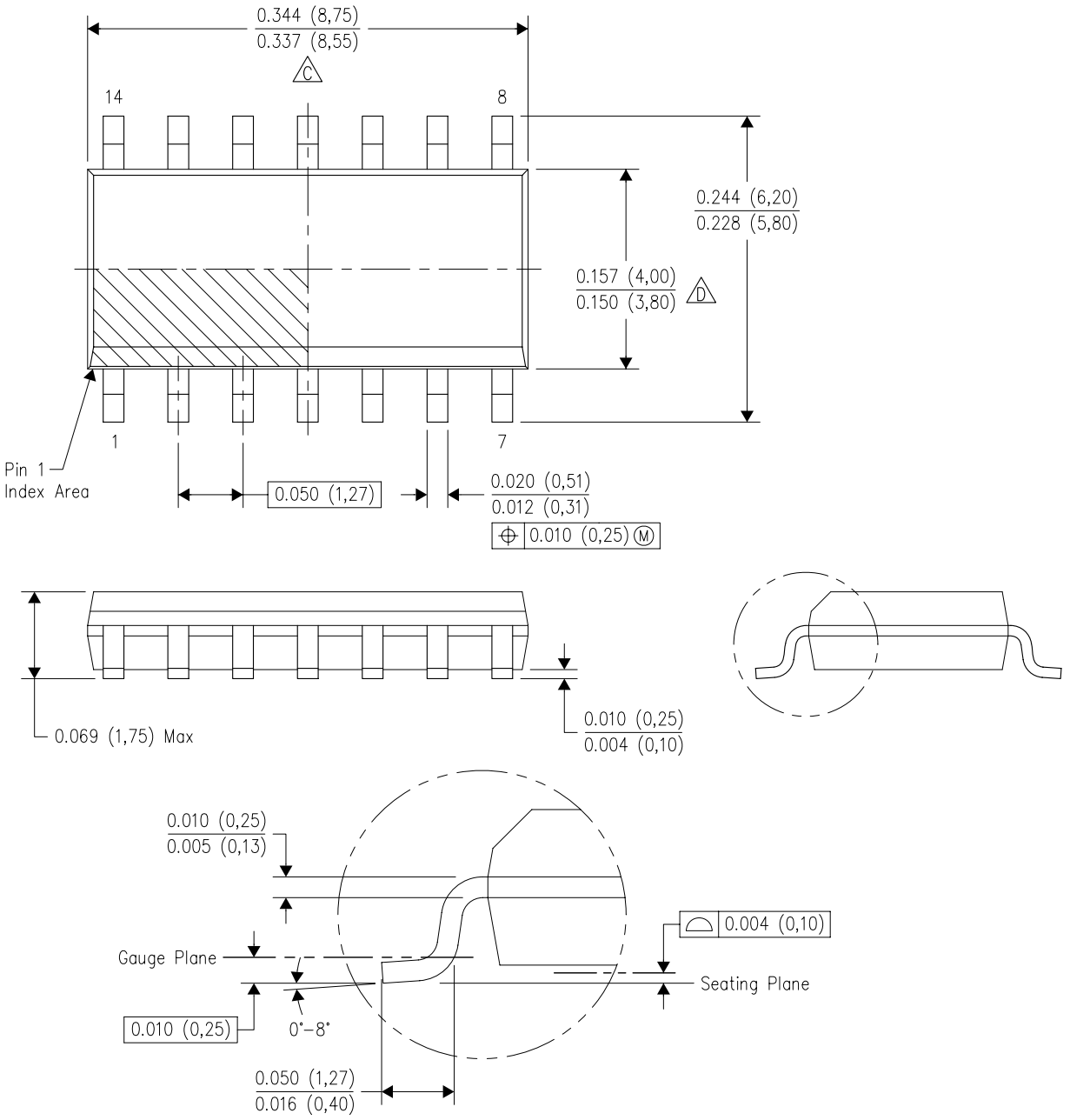
**OTHER QUALIFIED VERSIONS OF CD4066B-Q1 :**

- Catalog: CD4066B
- Military: CD4066B-MIL

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Military - QML certified for Military and Defense Applications

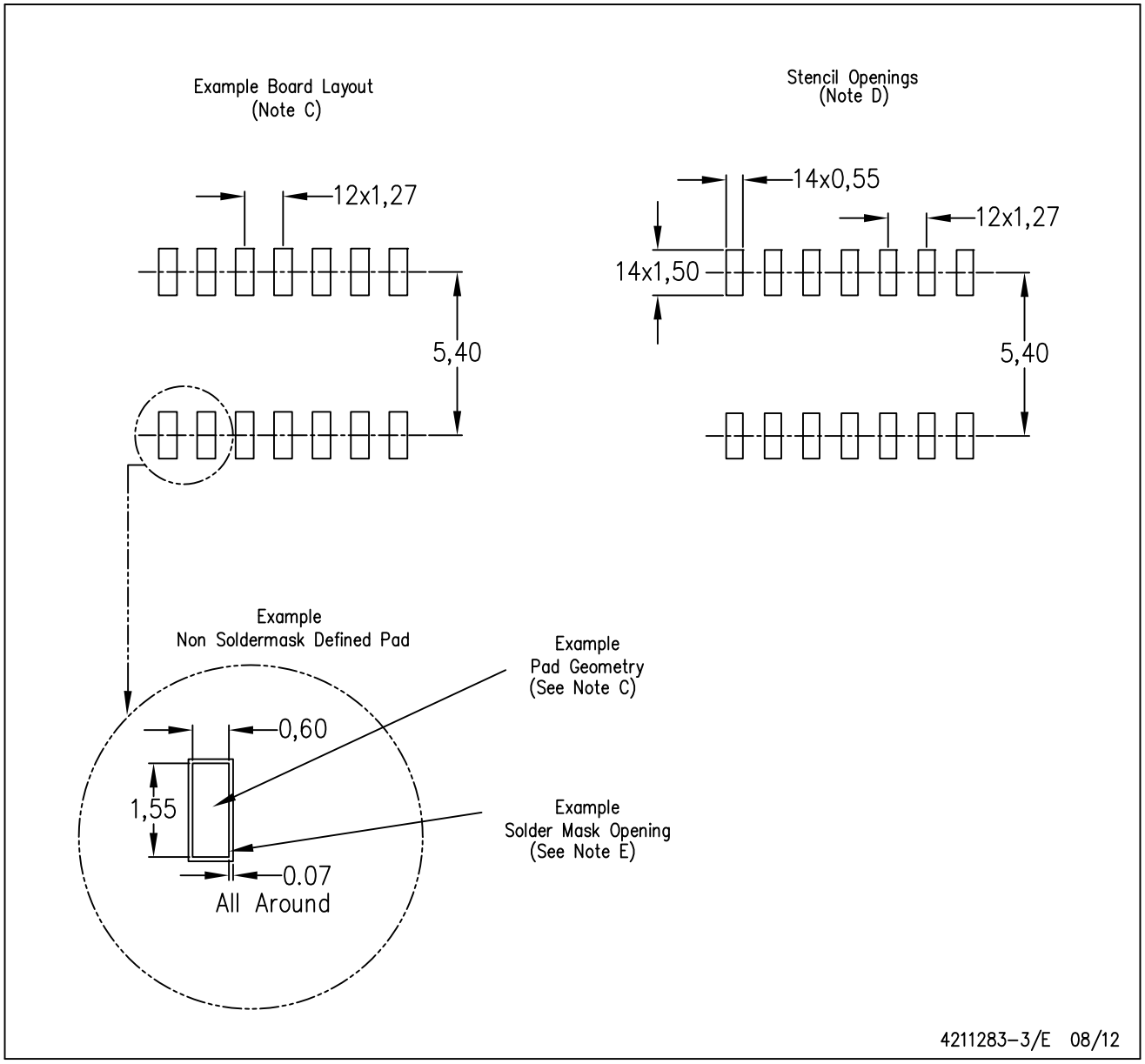
D (R–PDSO–G14) PLASTIC SMALL OUTLINE




4040047–5/M 06/11

NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
E. Reference JEDEC MS–012 variation AB.

D (R–PDSO–G14) PLASTIC SMALL OUTLINE




NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC–7351 is recommended for alternate designs.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC–7525 for other stencil recommendations.
E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265