# Micropower, Low Charge Injection, Quad CMOS Analog Switches with Data Latches

## FEATURES

- Micropower Operation
- Single 5V or ±15V Supply Operation
- Low Charge Injection
- Low $R_{ON}$
- Low Leakage
- Guaranteed Break Before Make
- Latch Resistant Design
- TLL/CMOS Compatible
- Improved Second Source for DG221/DG222
- Microprocessor Bus Compatible

## KEY SPECIFICATIONS

- Supply Current ..... $I^+$ = 40μA, $I^-$ = 5μA Max
- Charge Injection
  - ±15V Supplies ..... ±25pC Max
  - Single 5V Supply ..... 2pC Typ
- $R_{ON}$ ..... 65ΩTyp
- Signal Range ..... ±15V

## DESCRIPTION

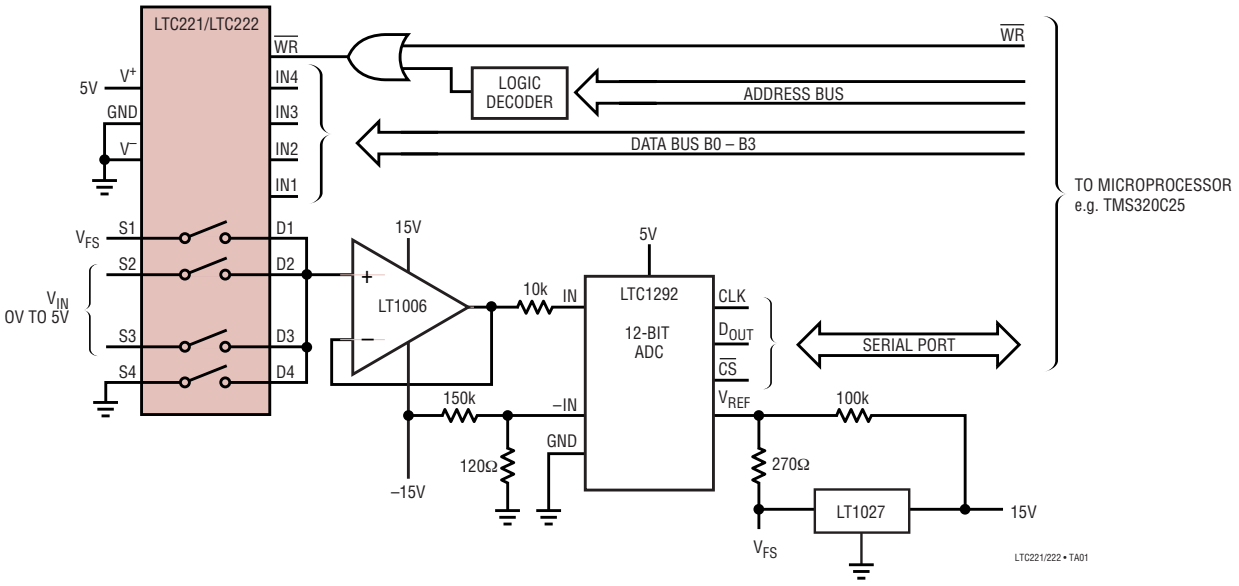
The LTC®221 and LTC222 are micropower, quad CMOS analog switches which typically dissipate only 250μW from ±15V supplies and 40μW from a single 5V supply. Onboard latches allow the LTC221 and LTC222 to interface directly to most microprocessor buses. The switches have 65Ω typical on resistance and a very high off resistance. A break before make characteristic is inherent in these switches to prevent the shorting of two channels. The signal range is ±15V with a supply voltage of ±15V and 0V to 5V with a single 5V supply. The switches have special charge compensation circuitry which greatly reduces charge injection to a maximum of ±25pC (±15V supplies).

The LTC221 and LTC222 are designed for applications such as microprocessor controlled programmable gain amplifiers, automatic test equipment, communication systems, and data acquisition systems. The LTC221 is normally closed and the LTC222 is normally open as shown in the Logic Table.



## TYPICAL APPLICATION

**Two-Channel, 12-Bit, Self Calibrating Data Acquisition System**



## ABSOLUTE MAXIMUM RATINGS

**(Note 1)**

Voltages Referenced to $V^-$

$V^+$ ..... 44V

GND ..... 25V

Digital Inputs, S, D (Note 2) ..... –2V to ($V^+$ 2V) or 20mA, Whichever Occurs First

Current

Any Input Except S or D ..... 30mA

Continuous S or D ..... 20mA

Peak S or D

(Pulsed at 1 ms, 10% Duty Cycle Max) ..... 70mA

ESD Susceptibility (Note 3) ..... 4kV

Power Dissipation (Plastic) ..... 500mW

Power Dissipation (Ceramic) ..... 900mW

Operating Temperature Range

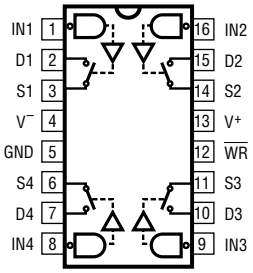
LTC221C/LTC222C ..... 0°C to 70°C

LTC221M/LTC222M **(OBSOLETE)**.....–55°C to 125°C

Storage Temperature Range ..... –65°C to 150°C

Lead Temperature (Soldering, 10 sec)..... 300°C

## PACKAGE/ORDER INFORMATION




N PACKAGE
16-LEAD PDIP
$J_{MAX}$ = 110°C, $\theta_{JA}$ = 120°C/W

S PACKAGE
16-LEAD PLASTIC SO
$J_{MAX}$ = 110°C, $\theta_{JA}$ = 130°C/W

J PACKAGE
16-LEAD CERDIP

**OBSOLETE PACKAGE**
Consider the N or S Package for Alternate Source

| ORDER PART NUMBER |
|---|
| LTC221CN |
| LTC221CS |
| LTC222CN |
| LTC222CS |
| LTC221MJ |
| LTC221CJ |
| LTC222MJ |
| LTC222CJ |

Consult LTC Marketing for parts specified with wider operating temperature ranges.

## LOGIC TABLE

| INX | $\overline{WR}$ | LTC221 | LTC222 |
|---|---|---|---|
| 0 | 0 | On | Off |
| 1 | 0 | Off | On |
| X | 1 | Maintain Previous State | Maintain Previous State |

## DIGITAL AND DC ELECTRICAL CHARACTERISTICS

**The ● denotes the specifications which apply over full operating temperature range, otherwise specifications are at $T_A$ = 25°C. $V^+$ = ±15V, $V^-$ = –15V, GND = 0V, unless noted.**

| PARAMETER | CONDITIONS | | | LTC221M/LTC222M MIN | LTC221M/LTC222M TYP | LTC221M/LTC222M MAX | LTC221C/LTC222C MIN | LTC221C/LTC222C TYP | LTC221C/LTC222C MAX | UNITS |
|---|---|---|---|---|---|---|---|---|---|---|
| Analog Signal Range | | | ● | | | ±15 | | | ±15 | V |
| $R_{ON}$ | $V_S$ = ±10V, $I_D$ = 1mA | $T_{MIN}$ | | | | 90 | | | 90 | Ω |
| | | 25°C | | | 65 | 90 | | 65 | 90 | Ω |
| | | $T_{MAX}$ | | | | 135 | | | 135 | Ω |
| Off Input Leakage $I_S$ (OFF) | $V_D$ = 14V, $V_S$ = ±14V | | | | 0.01 | ±1 | | 0.01 | ±5 | nA |
| | | | ● | | | ±100 | | | ±100 | nA |
| Off Output Leakage $I_D$ (OFF) | $V_{IN}$ = 2.4V, LTC221 | | | | 0.01 | ±1 | | 0.01 | ±5 | nA |
| | $V_{IN}$ = 0.8V, LTC222 | | ● | | | ±100 | | | ±100 | nA |
| On Channel Leakage $I_D$ (ON) | $V_D$ = $V_S$ = ±14V, $V_{IN}$ = 2.4V, LTC222 | | | | 0.02 | ±1 | | 0.02 | ±5 | nA |
| | $V_{IN}$ = 0.8V, LTC221 | | ● | | | ±200 | | | ±200 | nA |
| Input High Voltage $V_{INH}$, $V_{\overline{WR}H}$ | | | ● | 2.4 | | | 2.4 | | | V |
| Input Low Voltage $V_{INL}$, $V_{\overline{WR}L}$ | | | ● | | | 0.8 | | | 0.8 | V |
| Input High or Low Current $I_{INH}$, $I_{INL}$, $I_{\overline{WR}H}$, $I_{\overline{WR}L}$ | $V_{IN}$ = 15V, 0V; $V_{\overline{WR}}$ = 15V, 0V | | ● | | | ±1 | | | ±1 | µA |
| $C_S$ (OFF) | | | | | 5 | | | 5 | | pF |
| $C_D$ (OFF) | | | | | 12 | | | 12 | | pF |
| $C_D$, $C_S$ (ON) | | | | | 30 | | | 30 | | pF |
| $I^+$ | All Channels On or Off | | | | 16 | 40 | | 16 | 40 | µA |
| | $V_{IN}$ = $V_{\overline{WR}}$ = 0V or 4.0V | | ● | | | 60 | | | 60 | µA |

## DIGITAL AND DC ELECTRICAL CHARACTERISTICS

**The ● denotes the specifications which apply over full operating temperature range, otherwise specifications are at $T_A$ = 25°C. $V^+$ = ±15V, $V^-$ = –15V, GND = 0V, unless noted.**

| PARAMETER | CONDITIONS | | LTC221M/LTC222M MIN | TYP | MAX | LTC221C/LTC222C MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|---|---|
| $I^-$ | | | | 0.1 | 5 | | 0.1 | 5 | µA |
| | | ● | | | 10 | | | 10 | |

## AC ELECTRICAL CHARACTERISTICS

**$V^+$ = 15V, $V^-$ = –15V, GND = 0V, unless otherwise noted.**

| PARAMETER | CONDITIONS | LTC221M/LTC222M MIN | TYP | MAX | LTC221C/LTC222C MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|---|
| $t_{ON}$ | $V_S$ = 2V, $R_L$ = 1kΩ, $C_L$ = 35pF | | 290 | 400 | | 290 | 400 | ns |
| $t_{OFF}$ | | | 210 | 300 | | 210 | 300 | |
| $t_{OPEN}$ | | 20 | 85 | | 20 | 85 | | ns |
| Off Isolation | $V_S$ = 2Vp-p, $R_L$ = 1kΩ | | 75 | | | 75 | | dB |
| Crosstalk | f = 100kHz | | 90 | | | 90 | | |
| Charge Injection $O_{INJ}$ | $R_{GEN}$ = 0Ω, $C_L$ = 1000pF, $V_{GEN}$ = 0 | | 5 | ±25 | | 8 | ±25 | pC |
| Total Harmonic Distortion THD | $V_S$ = 2Vp-p, $R_L$ = 10kΩ | | 0.01 | | | 0.01 | | % |
| $t_{ON}$, $\overline{WR}$ | $V_S$ = 2V, $R_L$ = 1kΩ, $C_L$ = 35pF | | 270 | 400 | | 270 | 400 | ns |
| $t_{OFF}$, $\overline{WR}$ | | | 160 | 300 | | 160 | 300 | |

## DIGITAL AND DC ELECTRICAL CHARACTERISTICS

**The ● denotes the specifications which apply over full operating temperature range, otherwise specifications are at $T_A$ = 25°C. $V^+$ = 5V, $V^-$ = GND = 0V, unless noted.**

| PARAMETER | CONDITIONS | | | LTC221M/LTC222M MIN | TYP | MAX | LTC221C/LTC222C MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|---|---|---|
| Analog Signal Range | | | ● | 0 | | 5 | 0 | | 5 | V |
| $R_{ON}$ | $V_S$ = 1.5V, 3V | $T_{MIN}$ | | | | 450 | | | 520 | Ω |
| | $I_D$ = 0.25mA | 25°C | | | 280 | 450 | | 280 | 520 | Ω |
| | | $T_{MAX}$ | | | | 650 | | | 650 | Ω |
| Off Input Leakage $I_S$ (OFF) | $V_D$ = 4V, 1V; $V_S$ = 1V, 4V | | | | 0.01 | ±1 | | 0.01 | ±5 | nA |
| | (Note 4) | | ● | | | ±100 | | | ±100 | nA |
| Off Output Leakage $I_D$ (0FF) | | | | | 0.01 | ±1 | | 0.01 | ±5 | nA |
| | | | ● | | | ±100 | | | ±100 | nA |
| On Channel Leakage $I_D$ (ON) | $V_D$ = $V_S$ = 1V, 4V | | | | 0.01 | ±1 | | 0.01 | ±5 | nA |
| | (Note 4) | | ● | | | ±200 | | | ±200 | nA |
| Input High Voltage $V_{INH}$, $V_{\overline{WRH}}$ | | | ● | 2.4 | | | 2.4 | | | V |
| Input Low Voltage $V_{INL}$, $V_{\overline{WRL}}$ | | | ● | | | 0.8 | | | 0.8 | V |
| Input High or Low Current $I_{INH}$, $I_{INL}$, $I_{\overline{WRH}}$, $I_{\overline{WRL}}$ | $V_{IN}$ = 5V, 0V<br>$V_{\overline{WR}}$ = 5V, 0V | | ● | | | ±1 | | | ±1 | µA |
| $C_S$(OFF) | | | | | 5 | | | 5 | | pF |
| $C_D$ (OFF) | | | | | 12 | | | 12 | | pF |
| $C_D$, $C_S$ (ON) | | | | | 30 | | | 30 | | pF |
| $I^+$ | All Channels On or Off | | | | 8 | 20 | | 8 | 20 | µA |
| | $V_{IN}$ = $V_{\overline{WR}}$ = 0V or 4.0V | | ● | | | 30 | | | 30 | µA |

## AC ELECTRICAL CHARACTERISTICS

**$V^+$ = 5V, $V^-$ = GND = 0V, unless otherwise noted.**

| PARAMETER | CONDITIONS | LTC221M/LTC222M MIN | TYP | MAX | LTC221C/LTC222C MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|---|
| $t_{ON}$ | $V_S$ = 2V, $R_L$ = 1kΩ, $C_L$ = 35pF | | 450 | 600 | | 450 | 600 | ns |
| $t_{OFF}$ | | | 190 | 300 | | 190 | 300 | ns |
| $t_{OPEN}$ | | 100 | 250 | | 100 | 250 | | ns |
| Off Isolation | $V_S$ = $2V_{P-P}$, $R_L$ = 1kΩ | | 75 | | | 75 | | dB |
| Crosstalk | f = 100kHz | | 90 | | | 90 | | dB |
| Charge Injection $O_{INJ}$ | $R_{GEN}$ = 0Ω, $C_L$ = 1000pF, $V_{GEN}$ = 2.5V | | 2 | | | 2 | | pC |
| Total Harmonic Distortion THD | $V_S$ = $2V_{P-P}$, $R_L$ = 10kΩ | | 0.01 | | | 0.01 | | % |
| $t_{ON}$, $\overline{WR}$ | $V_S$ = 2V, $R_L$ = 1kΩ, $C_L$ = 35pF | | 430 | 600 | | 430 | 600 | ns |
| $t_{OFF}$, $\overline{WR}$ | | | 160 | 300 | | 160 | 300 | ns |

**Note 1:** Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

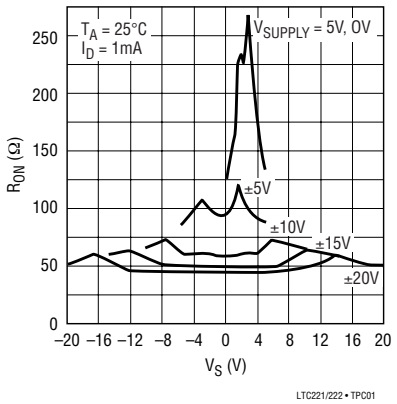
**Note 2:** Signals on S, D, or IN exceeding $V^+$ or $V^-$ will be clamped by internal diodes. Limit forward diode current to maximum current rating.

**Note 3:** In-circuit ESD on the switch pins (S or D) exceeds 4kV (see test circuit).

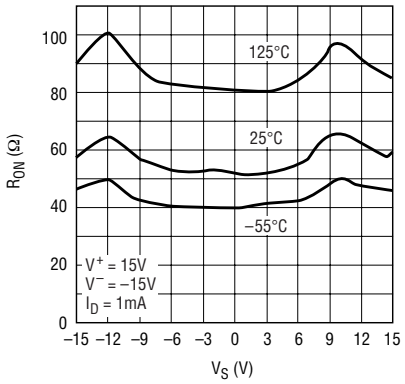
**Note 4:** Leakage current with a 5V supply is guaranteed by correlation with the ±15V leakage current.

## TYPICAL PERFORMANCE CHARACTERISTICS

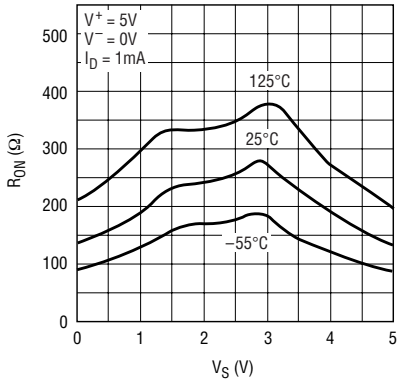
**$R_{ON}$ vs $V_S$ Over Supply Voltage**



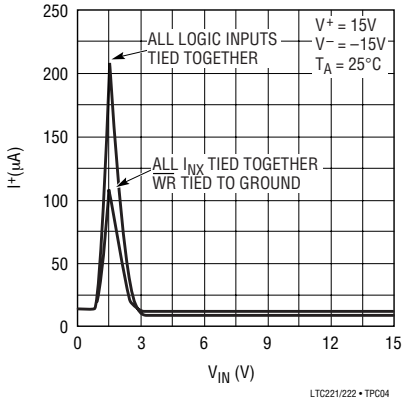

**$R_{ON}$ vs $V_S$ Over Temperature**



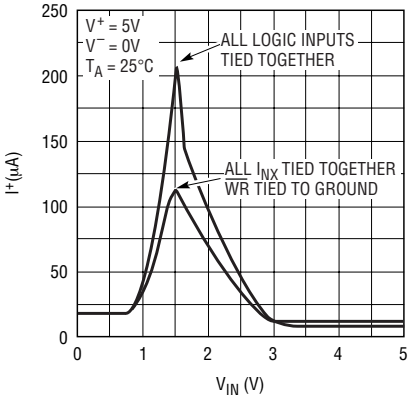

**$R_{ON}$ vs $V_S$ Over Temperature**




**Positive Supply Current vs Logic Input Voltage**




**Positive Supply Current vs Logic Input Voltage**

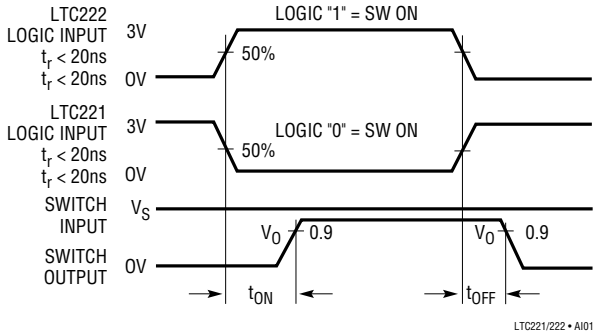


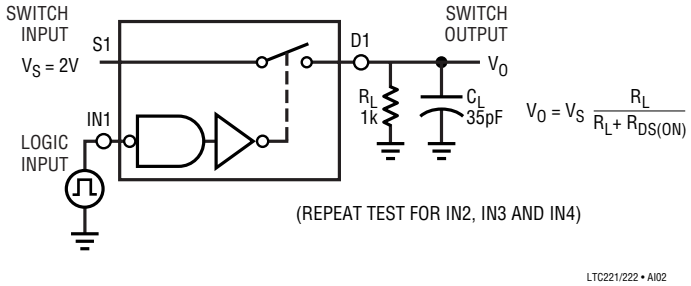
# APPLICATIONS INFORMATION

## Switching Time Test Circuit

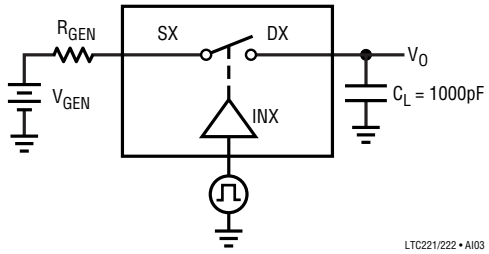
Switch output waveform shown for $V_S$ = constant with logic input waveform as shown. Note that $V_S$ may be (+) or (–) as per switching time test circuit. $V_O$ is the steady state output switch on. Feedthrough via gate capacitance may result in spikes at leading and trailing edge of output waveform.

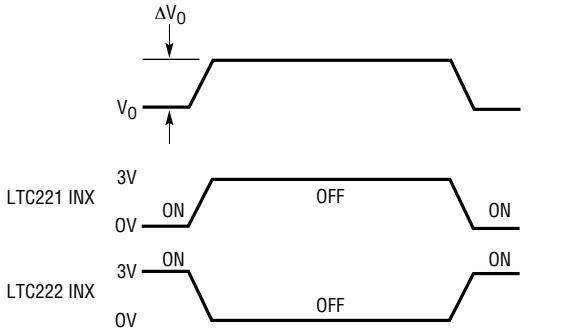
### Switching Time Test Circuit




### Charge Injection Test Circuit

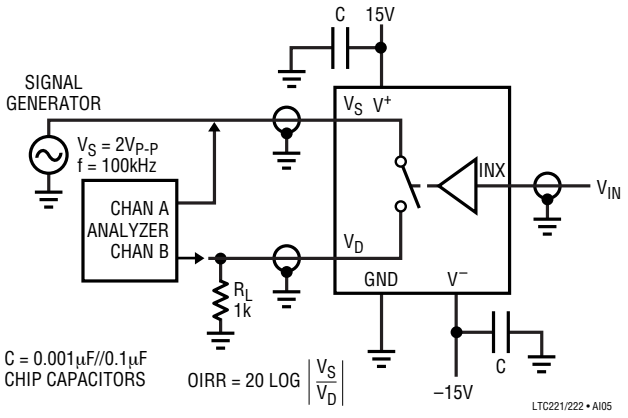


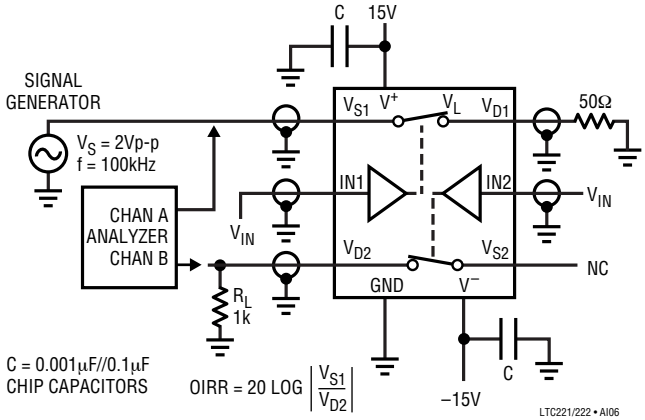

$\Delta V_O$ IS THE MEASURED VOLTAGE ERROR DUE TO CHARGE INJECTION. THE ERROR VOLTAGE IN COULOMBS IS $\Delta Q = V_L \bullet \Delta V_O$

LTC221/222 • AI04

### OIRR-Off Isolation Test Circuit

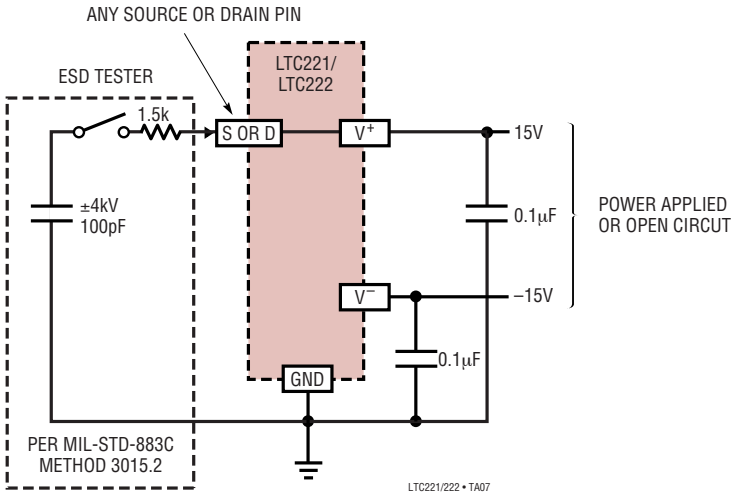



### CCRR-Channel to Channel Crosstalk Test Circuit

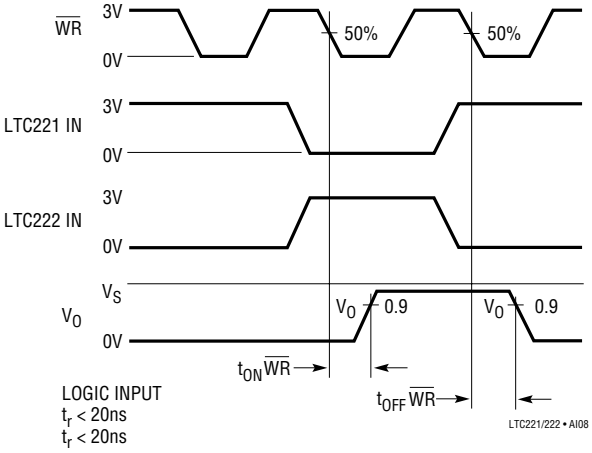


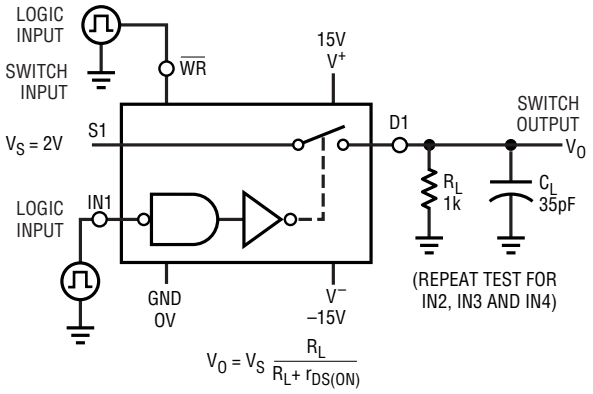
# APPLICATIONS INFORMATION

### In-Circuit ESD Test Circuit

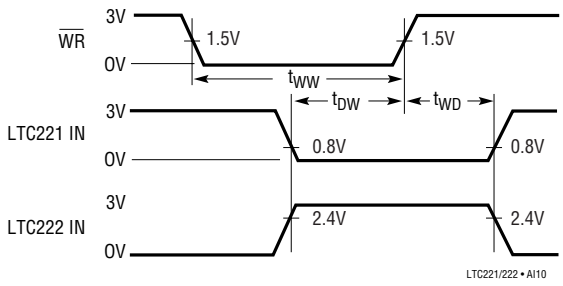



### $\overline{WR}$ Switching Time Test Circuit




### $\overline{WR}$ Setup Conditions

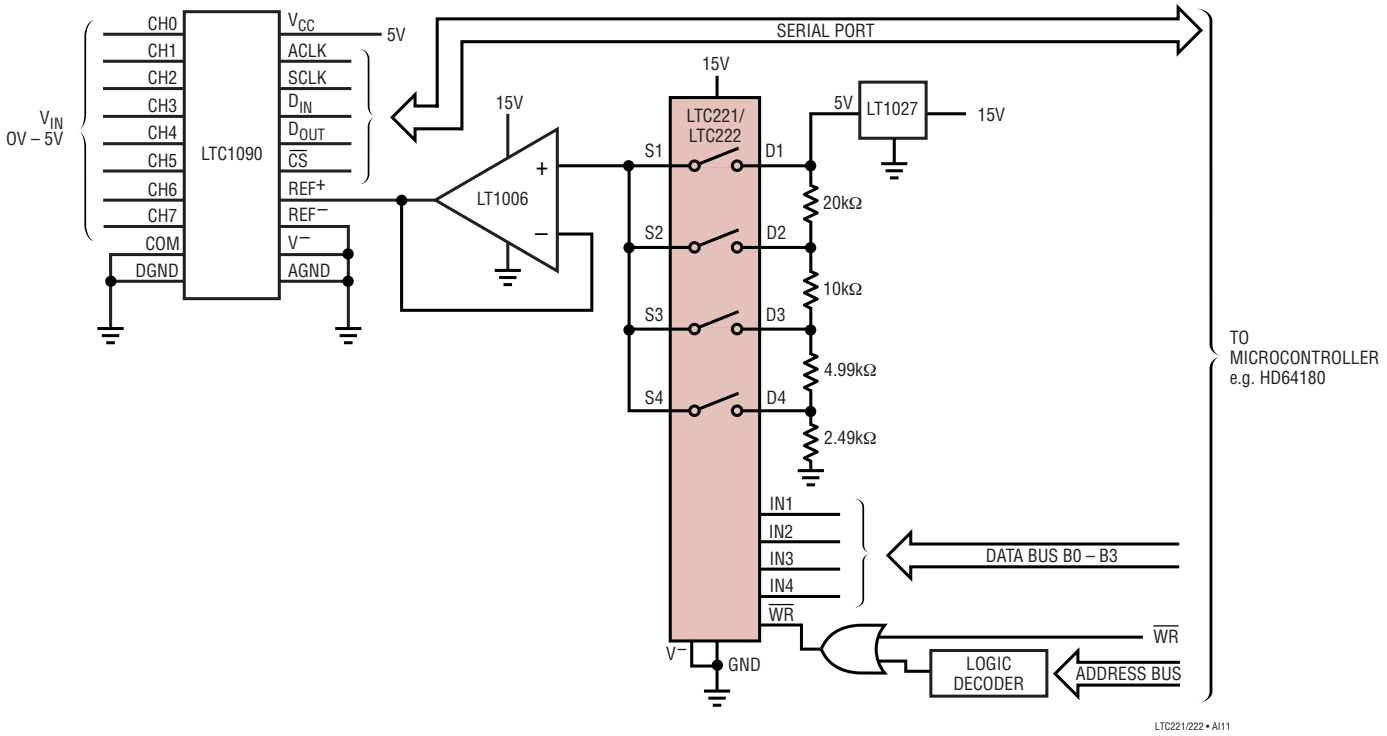



### $\overline{WR}$/Input Minimum Timing Requirements

| | PARAMETER | MIN LIMIT | UNITS |
|---|---|---|---|
| $t_{WW}$ | Write Pulse Width | 230 | ns |
| $t_{DW}$ | Data Valid to Write | 180 | ns |
| $t_{WD}$ | Data Valid After Write | 30 | ns |

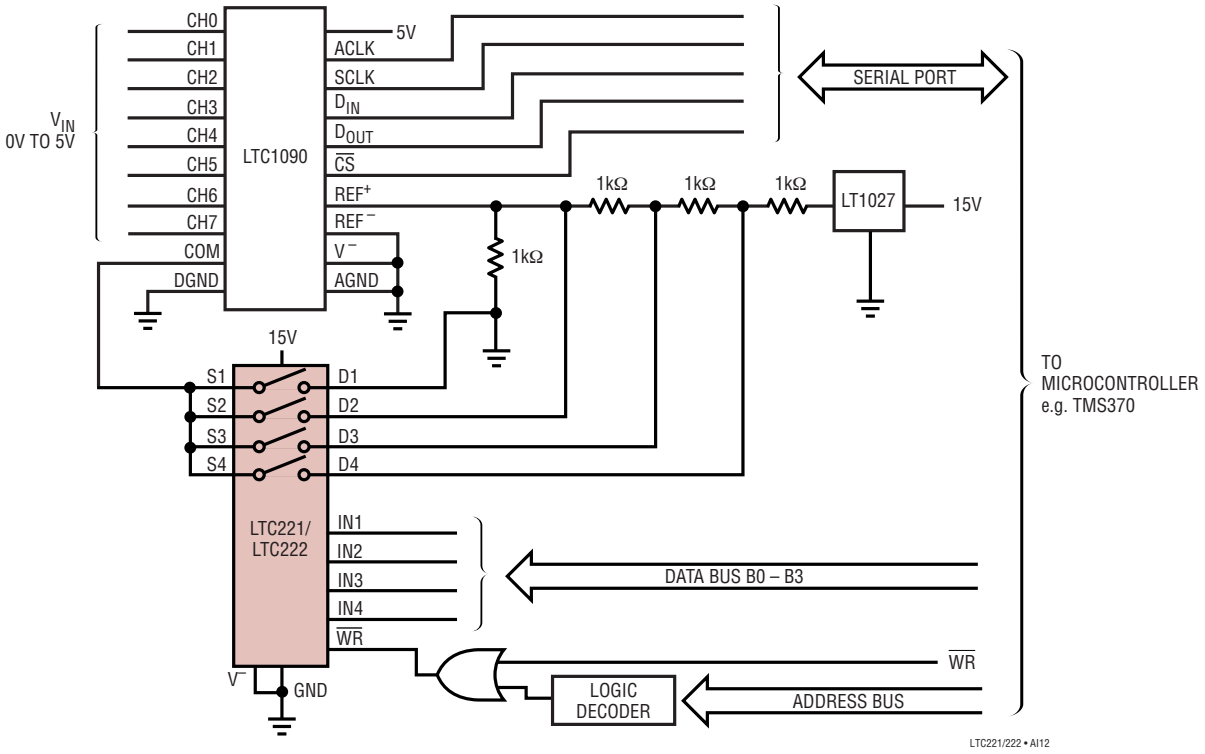
# APPLICATIONS INFORMATION

**Auto Ranging an 8-Channel, 10-Bit A/D Converter**



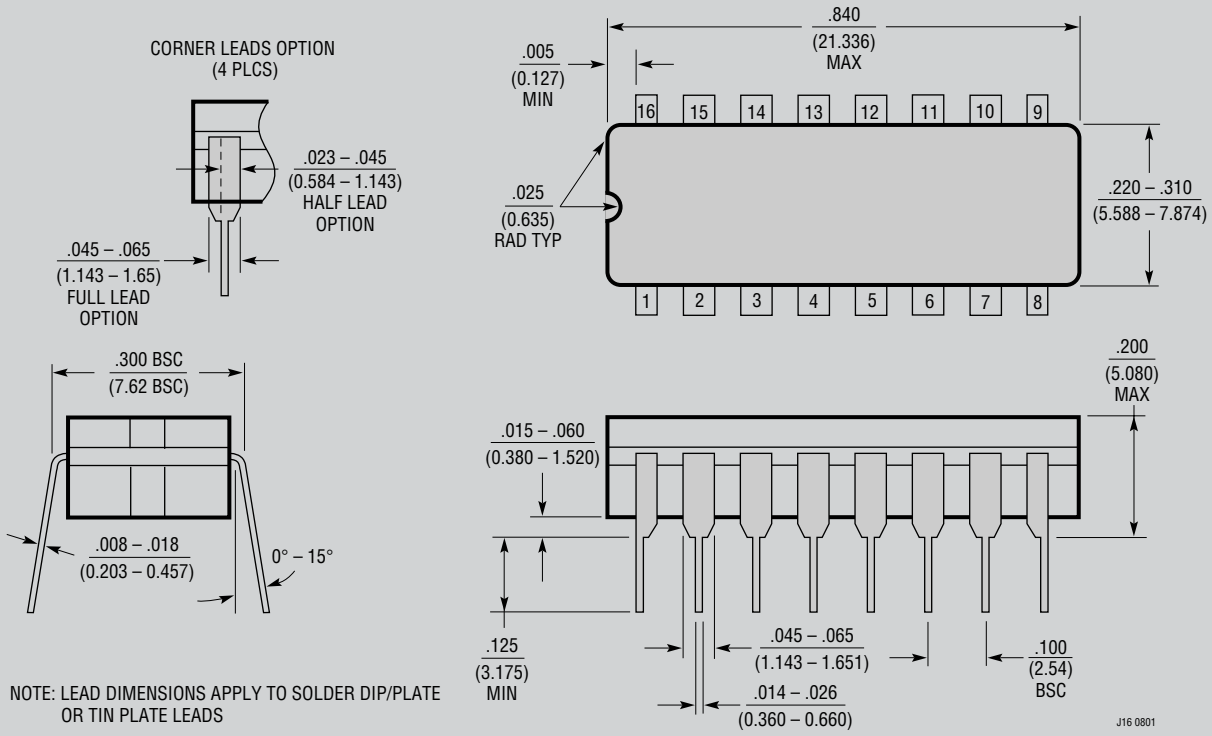
## APPLICATIONS INFORMATION

**8-Channel, 14-Bit A/D Converter**



# PACKAGE DESCRIPTION

**J Package**
**16-Lead CERDIP (Narrow .300 Inch, Hermetic)**
(Reference LTC DWG # 05-08-1110)

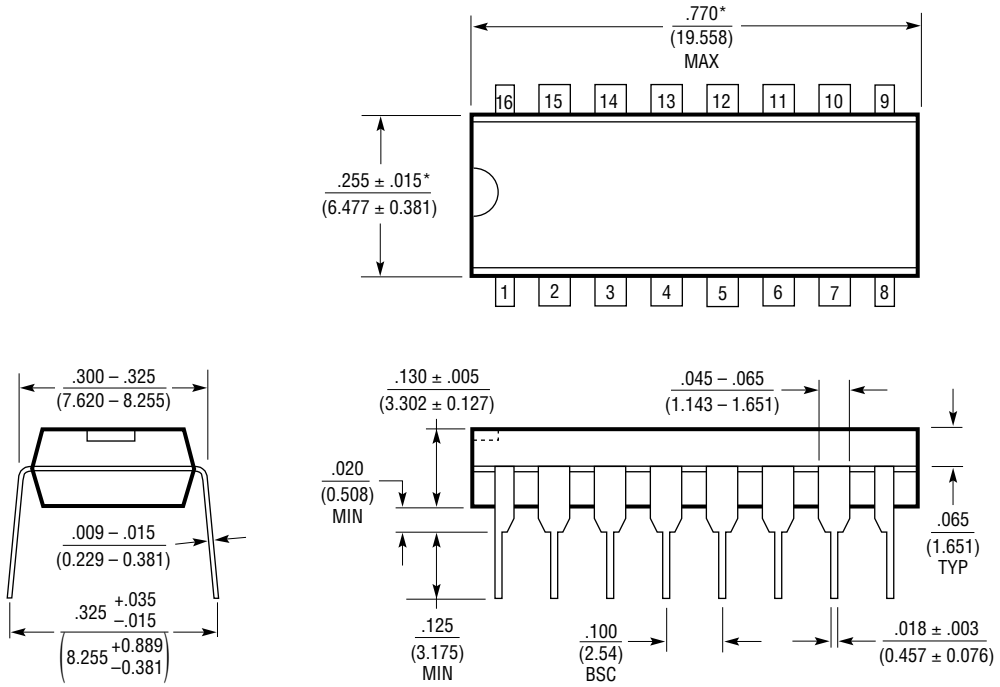



NOTE: LEAD DIMENSIONS APPLY TO SOLDER DIP/PLATE OR TIN PLATE LEADS

**OBSOLETE PACKAGE**

# PACKAGE DESCRIPTION

**N Package**
**16-Lead PDIP (Narrow .300 Inch)**
(Reference LTC DWG # 05-08-1510)



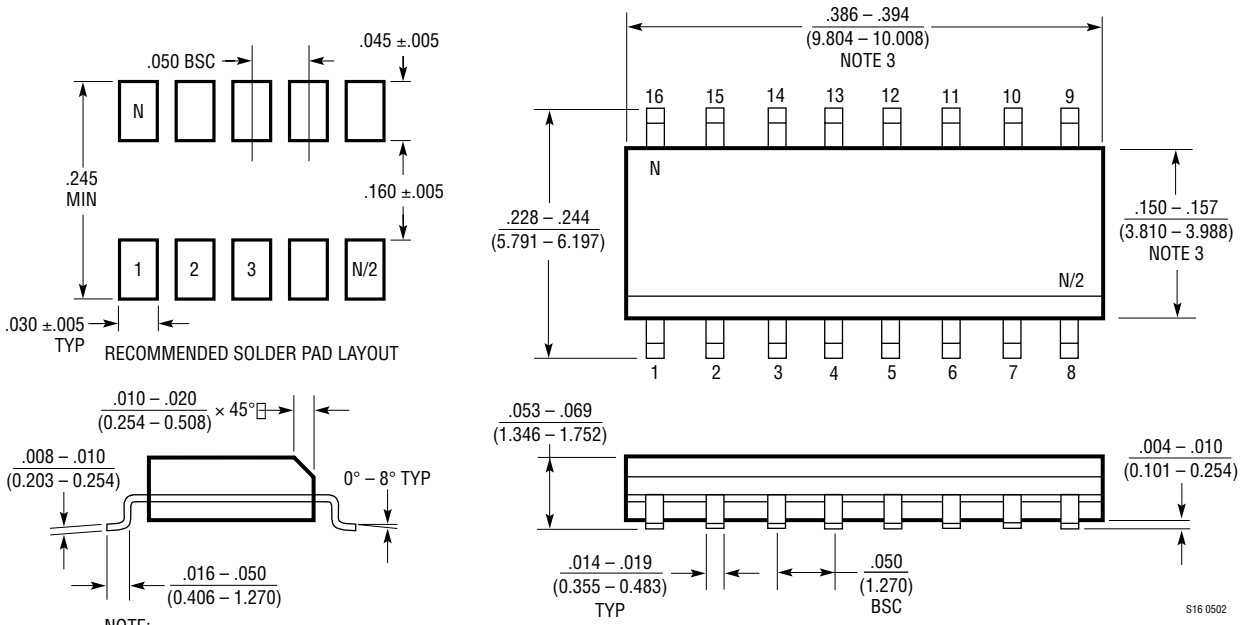

NOTE:
1. DIMENSIONS ARE INCHES / MILLIMETERS

*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .010 INCH (0.254mm)

N16 0502

# PACKAGE DESCRIPTION

**S Package**
**16-Lead Plastic Small Outline (Narrow .150 Inch)**
(Reference LTC DWG # 05-08-1610)




NOTE:
1. DIMENSIONS IN $\frac{\text{INCHES}}{(\text{MILLIMETERS})}$
2. DRAWING NOT TO SCALE
3. THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
   MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .006" (0.15mm)

## RELATED PARTS

| PART NUMBER | DESCRIPTION | COMMENTS |
|---|---|---|
| LTC201/LTC202/LTC203 | Micropower, Low Charge Injection, Quad CMOS Analog Switches | DG201/DG202 Compatible |
| LTC1380/LTC1393 | 8-Channel/4-Channel Analog Multiplexer with SMBus Interface | 3V to ±15V, 8 Single Ended/4 Differential Inputs |
| LTC1390/LTC1391 | 8-Channel, Analog Multiplexer with Serial Interface | 3V to ±15V Operation |

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