

# 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 .....  $I^+ = 40\mu A$ ,  $I^- = 5\mu A$  Max
- Charge Injection
  - ±15V Supplies ..... ±25pC Max
  - Single 5V Supply ..... 2pC Typ
- $R_{ON}$  ..... 65Ω Typ
- Signal Range ..... ±15V

## DESCRIPTION

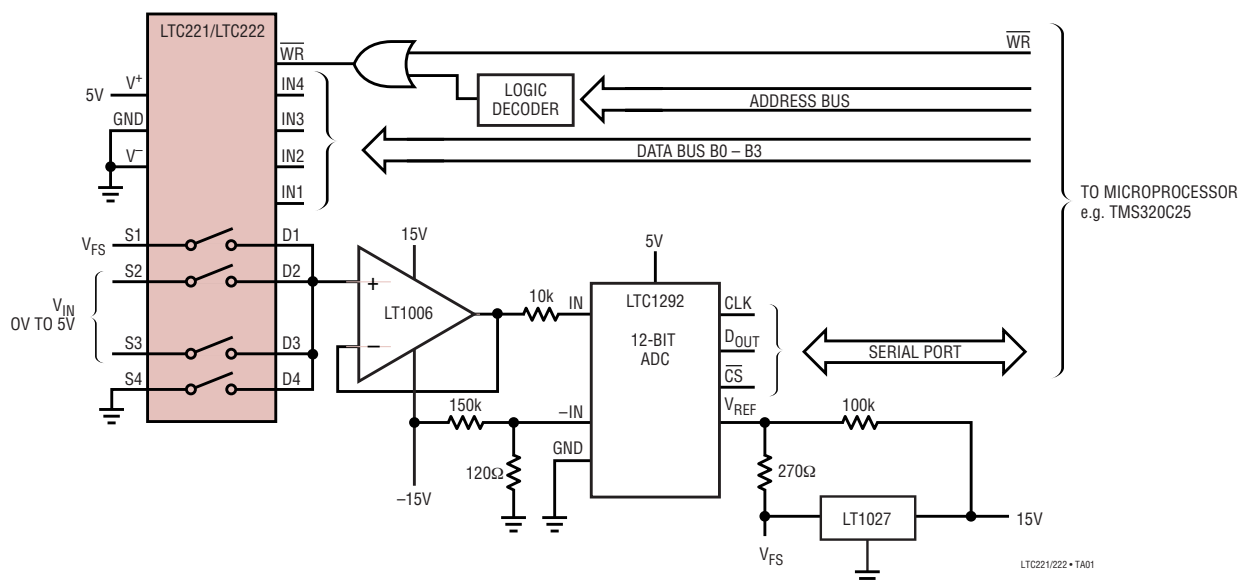
The LTC<sup>®</sup>221 and LTC222 are micropower, quad CMOS analog switches which typically dissipate only 250μW from ±15V supplies and 40μW from a single 5V supply. Onboard latches allow the LTC221 and LTC222 to interface directly to most microprocessor buses. The switches have 65Ω typical on resistance 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.

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## TYPICAL APPLICATION

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



LTC221/222 • TA01

# LTC221/LTC222

## 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) .....

Power Dissipation (Plastic) .....

Power Dissipation (Ceramic) .....

Operating Temperature Range

LTC221C/LTC222C .....

LTC221M/LTC222M (OBSOLETE).....

Storage Temperature Range .....

Lead Temperature (Soldering, 10 sec).....

## PACKAGE/ORDER INFORMATION

<p>N PACKAGE 16-LEAD PDIP <math>J_{MAX} = 110^{\circ}C</math>, <math>\theta_{JA} = 120^{\circ}C/W</math></p> <p>S PACKAGE 16-LEAD PLASTIC SO <math>J_{MAX} = 110^{\circ}C</math>, <math>\theta_{JA} = 130^{\circ}C/W</math></p> <p>J PACKAGE 16-LEAD CERDIP</p> <p><b>OBSOLETE PACKAGE</b> Consider the N or S Package for Alternate Source</p>	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  $T_A = 25^{\circ}C$ .  $V^+ = \pm 15V$ ,  $V^- = -15V$ , GND = 0V, unless noted.

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

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## DIGITAL AND DC ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ .  $V^+ = \pm 15\text{V}$ ,  $V^- = -15\text{V}$ ,  $\text{GND} = 0\text{V}$ , unless noted.

PARAMETER	CONDITIONS	LTC221M/LTC222M			LTC221C/LTC222C			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
$I^-$			0.1	5	0.1	5	$\mu\text{A}$	
		●		10		10		

## AC ELECTRICAL CHARACTERISTICS

$V^+ = 15\text{V}$ ,  $V^- = -15\text{V}$ ,  $\text{GND} = 0\text{V}$ , unless otherwise noted.

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

## DIGITAL AND DC ELECTRICAL CHARACTERISTICS

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

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

## AC ELECTRICAL CHARACTERISTICS $V^+ = 5V, V^- = GND = 0V$ , unless otherwise noted.

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

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

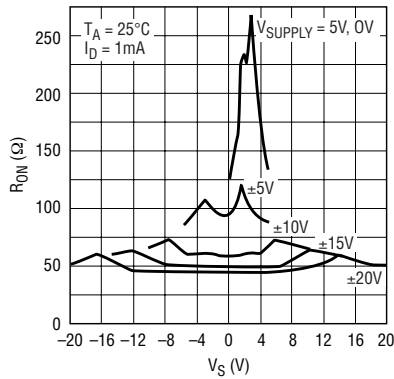
**Note 2:** Signals on S, D, or IN exceeding  $V^+$  or  $V^-$  will be clamped by internal diodes. Limit forward diode current to maximum current rating.

**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  $\pm 15V$  leakage current.

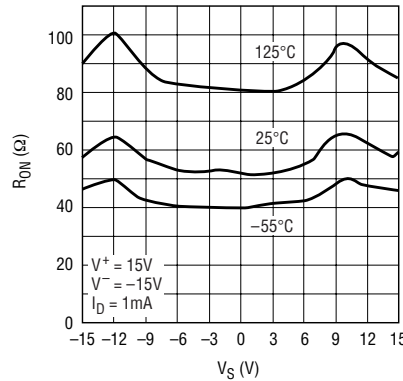
## TYPICAL PERFORMANCE CHARACTERISTICS

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



LTC221/222 • TPC01

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



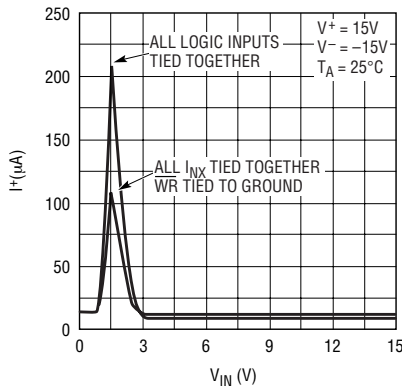
LTC221/222 • TPC02

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



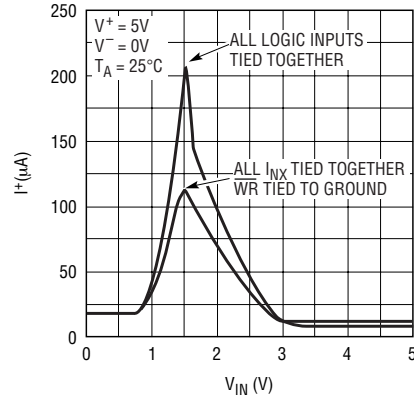
LTC221/222 • TPC03

**Positive Supply Current vs Logic Input Voltage**



LTC221/222 • TPC04

**Positive Supply Current vs Logic Input Voltage**



LTC221/222 • TPC05

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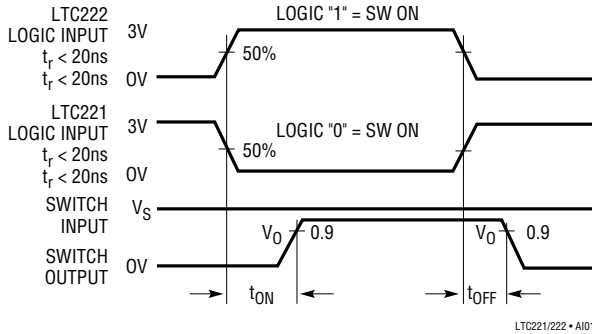
# APPLICATIONS INFORMATION

## Switching Time Test Circuit

Switch output waveform shown for  $V_S = \text{constant}$  with logic input waveform as shown. Note that  $V_S$  may be (+) or (-) as per switching time test circuit.  $V_O$  is the steady

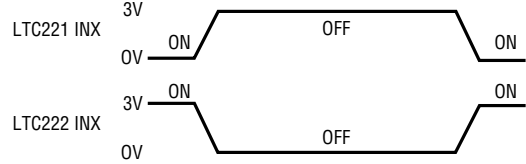
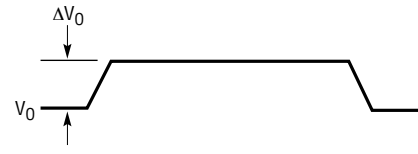
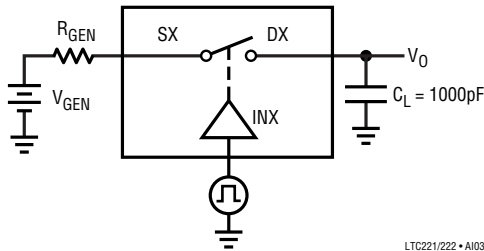
state output switch on. Feedthrough via gate capacitance may result in spikes at leading and trailing edge of output waveform.

### Switching Time Test Circuit



LTC221/222 • AI02

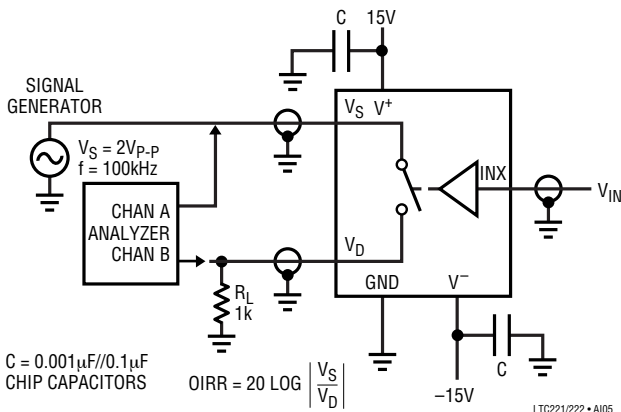
### Charge Injection Test Circuit



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

LTC221/222 • AI04

### OIRR-Off Isolation Test Circuit

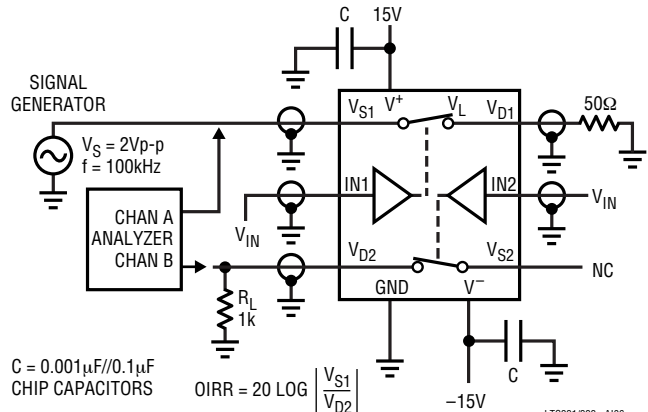


$C = 0.001\mu\text{F}/0.1\mu\text{F}$   
CHIP CAPACITORS

$$\text{OIRR} = 20 \text{ LOG} \left| \frac{V_S}{V_D} \right|$$

LTC221/222 • AI05

### CCRR-Channel to Channel Crosstalk Test Circuit



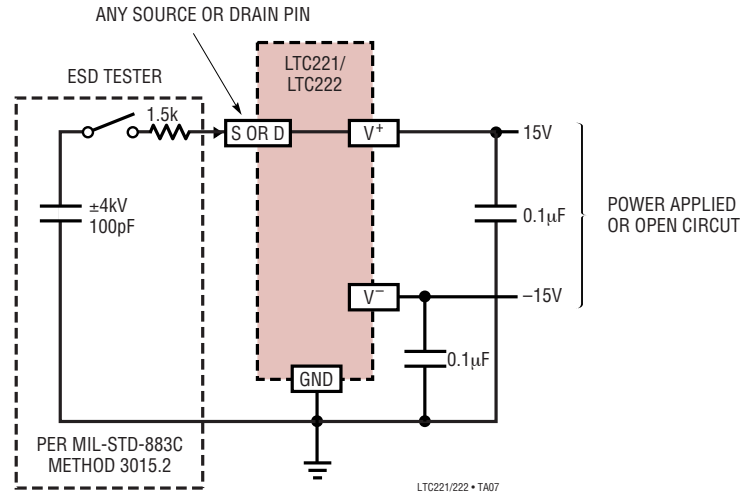
$C = 0.001\mu\text{F}/0.1\mu\text{F}$   
CHIP CAPACITORS

$$\text{OIRR} = 20 \text{ LOG} \left| \frac{V_{S1}}{V_{D2}} \right|$$

LTC221/222 • AI06

## APPLICATIONS INFORMATION

### In-Circuit ESD Test Circuit



### WR Switching Time Test Circuit



### WR Setup Conditions



### WR/Input Minimum Timing Requirements

PARAMETER	MIN LIMIT	UNITS
t <sub>WW</sub>	230	ns
t <sub>DW</sub>	180	ns
t <sub>WD</sub>	30	ns

# APPLICATIONS INFORMATION

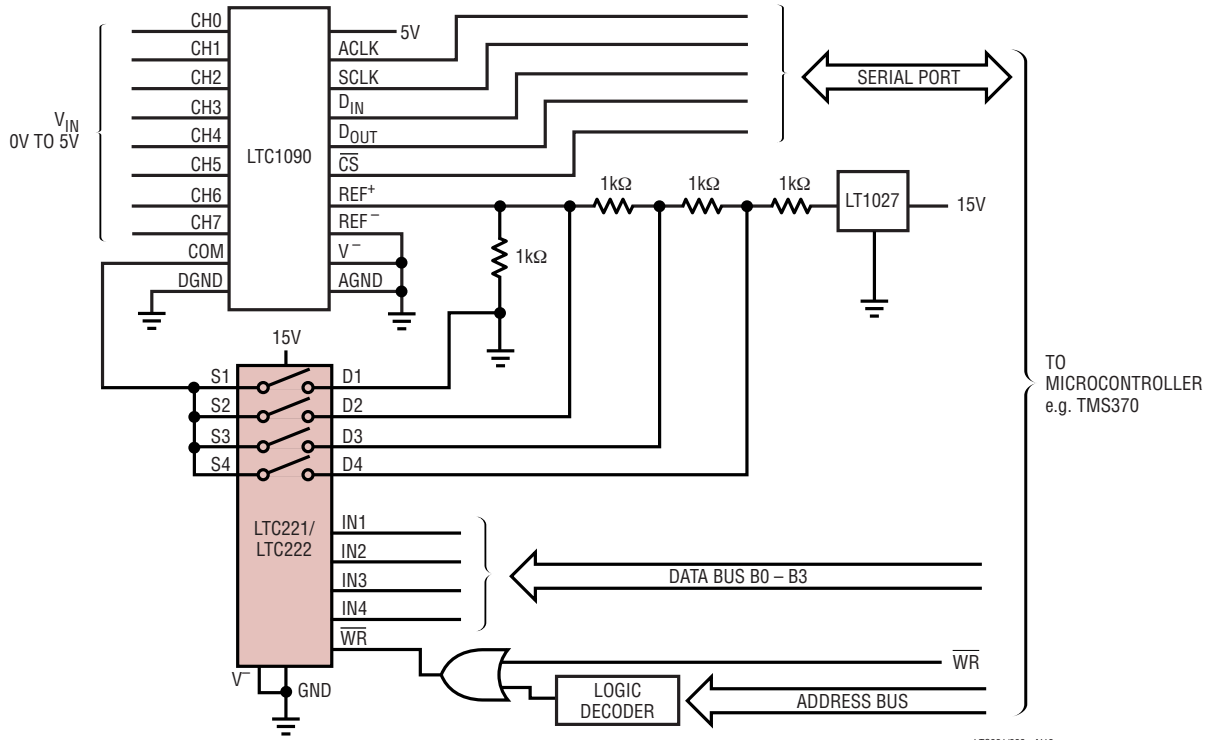
Auto Ranging an 8-Channel, 10-Bit A/D Converter



LTC221/222 • A111

## APPLICATIONS INFORMATION

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

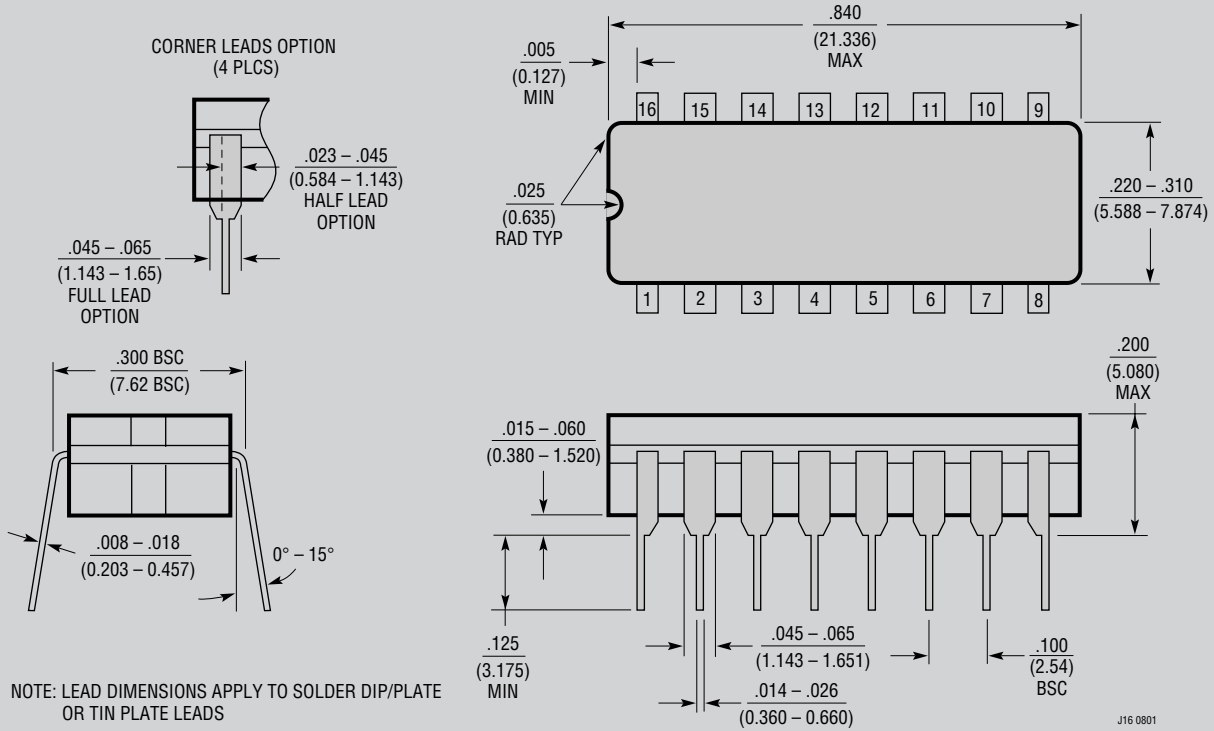


LTC221/222 • AI12



**PACKAGE DESCRIPTION**

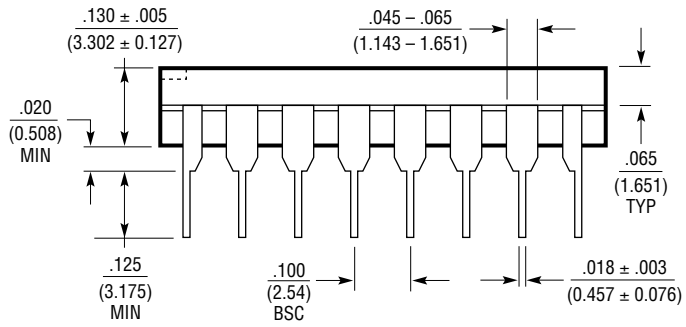
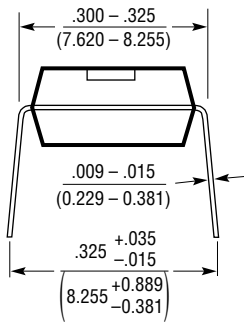
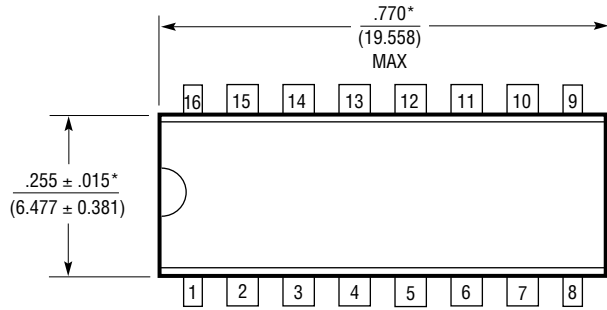
**J Package**  
**16-Lead CERDIP (Narrow .300 Inch, Hermetic)**  
 (Reference LTC DWG # 05-08-1110)



**OBsolete PACKAGE**

**PACKAGE DESCRIPTION**

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

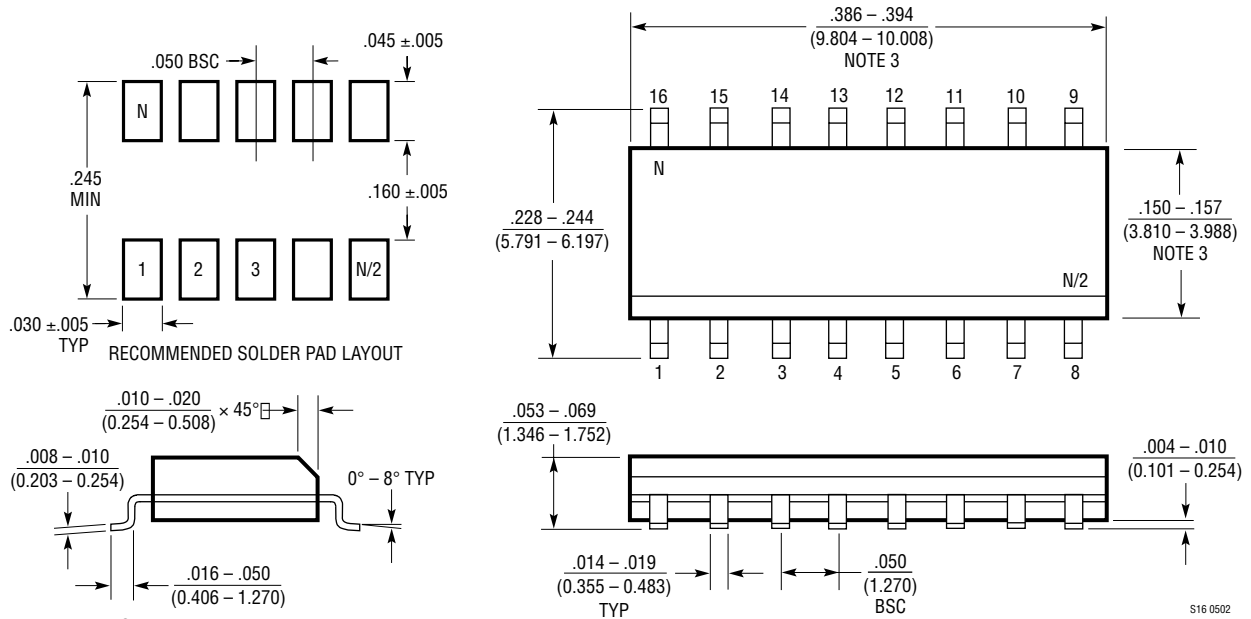


NOTE:  
 1. DIMENSIONS ARE  $\frac{\text{INCHES}}{\text{MILLIMETERS}}$   
 \*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.  
 MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .010 INCH (0.254mm)

N16 0502

# PACKAGE DESCRIPTION

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



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

S16 0502