



# LTC201A/LTC202/LTC203

## Micropower, Low Charge Injection, Quad CMOS Analog Switches

### FEATURES

- Micropower Operation
- Single 5V or ±15V Supply Operation
- Low Charge Injection
- Low  $R_{ON}$
- Low Leakage
- Guaranteed Break Before Make
- Latch Resistant Design
- TTL/CMOS Compatible
- Improved Second Source for DG201A/DG202

### DESCRIPTION

The LTC201A, LTC202, and LTC203 are micropower, quad CMOS analog switches which typically dissipate only 250µW from ±15V supplies and 40µW from a single 5V supply. The switches have 65Ω typical on resistance and a very high off resistance. A break before make characteristic, inherent in these switches, prevents the shorting of two channels. With a supply voltage of ±15V, the signal range is ±15V. These switches have special charge compensation circuitry which greatly reduces charge injection to a maximum of ±25pC (±15V supplies).

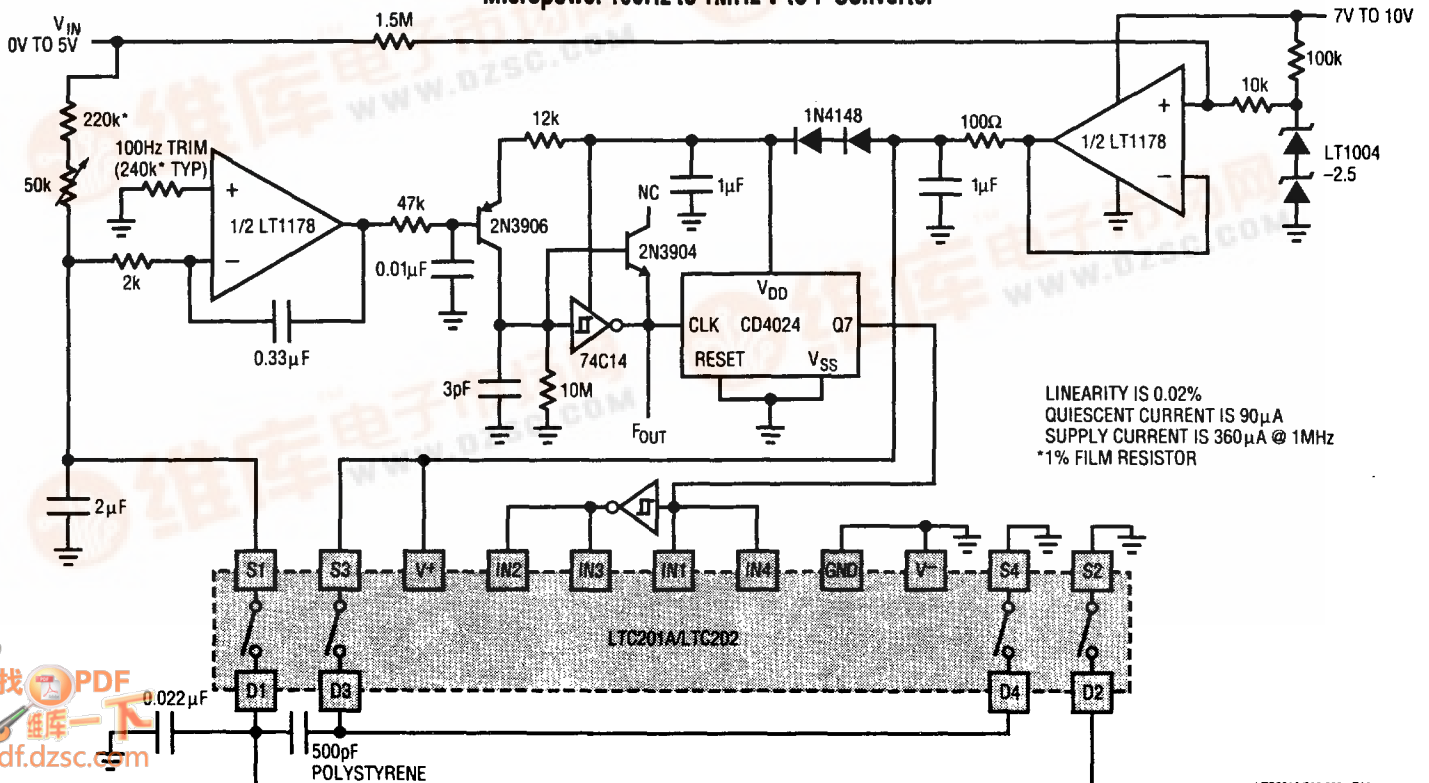
### KEY SPECIFICATIONS

- 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

The LTC201A, LTC202, and LTC203 are designed for applications such as programmable gain amplifiers, analog multiplexers, sample and hold circuits, precision charge switching and remote switching. These three devices are differentiated by the type of switch action, as shown in the logic table.

### TYPICAL APPLICATION

Micropower 100Hz to 1MHz V-to-F Converter



# LTC201A/LTC202/LTC203

## ABSOLUTE MAXIMUM RATINGS

(Note 1)

Voltages Referenced to V<sup>-</sup>

V<sup>+</sup> ..... 44V

GND ..... 25V

Digital Inputs, S,D (Note 2) ..... -2V to (V<sup>+</sup>+2V) or 20mA, Whichever Occurs First

Current

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

Continuous S or D ..... 20mA

Peaks S or D (Pulsed at 1ms, 10% Duty Cycle Max). ..... 70mA

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

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

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

Operating Temperature Range

LTC201AC/LTC202C/LTC203C ..... 0°C to 70°C

LTC201AM/LTC202M/LTC203M ..... -55°C to 125°C

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

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

## PACKAGE/ORDER INFORMATION

| TOP VIEW                           |                                  | ORDER PART NUMBER  |
|------------------------------------|----------------------------------|--|
|                                    |                                  | LTC201AMJ<br>LTC201ACJ<br>LTC201ACN<br>LTC201ACS<br>LTC202MJ<br>LTC202CJ<br>LTC202CN<br>LTC202CS<br>LTC203MJ<br>LTC203CJ<br>LTC203CN<br>LTC203CS |
| J PACKAGE<br>16-LEAD CERAMIC DIP   | N PACKAGE<br>16-LEAD PLASTIC DIP |  |
| SO PACKAGE<br>16-LEAD PLASTIC SOIC |                                  |  |
|                                    |                                  |  |
|                                    |                                  |  |
|                                    |                                  |  |

## LOGIC TABLE

| IN <sub>x</sub> | LTC201A | LTC202  | LTC203  |         |
|-----------------|---------|---------|---------|---------|
|                 | IN1-IN4 | IN1-IN4 | IN1,IN4 | IN2,IN3 |
| 0               | ON      | OFF     | OFF     | ON      |
| 1               | OFF     | ON      | ON      | OFF     |

## DIGITAL AND DC ELECTRICAL CHARACTERISTICS

V<sup>+</sup> = +15V, V<sup>-</sup> = -15V, GND = 0V unless otherwise noted.

| PARAMETER   | CONDITIONS   | LTC201AM/LTC202M/LTC203M |     |         | LTC201AC/LTC202C/LTC203C |      |     | UNITS |
|---|--|--------------------------|-----|---------|--------------------------|------|-----|-------|
|   |  | MIN                      | TYP | MAX     | MIN                      | TYP  | MAX |       |
| Analog Signal Range   |  | ±15                      |     |         | ±15                      |      |     | V     |
| R <sub>ON</sub>   | V <sub>S</sub> = ±10V<br>I <sub>D</sub> = 1mA              | T <sub>MIN</sub>         | 110 |         | 125                      |      | Ω   |       |
|   |  | 25°C                     | 65  | 110     | 65                       | 125  |     |       |
|   |  | T <sub>MAX</sub>         | 160 |         | 160                      |      |     |       |
| ΔR <sub>ON</sub> vs V <sub>S</sub>                              |  | 20                       |     | 20      |                          | %    |     |       |
| ΔR <sub>ON</sub> vs Temperature                                 |  | 0.5                      |     | 0.5     |                          | %/°C |     |       |
| R <sub>ON</sub> Match   | V <sub>S</sub> = 0V, I <sub>DS</sub> = 1mA                 | 5                        |     | 5       |                          | %    |     |       |
| Off Input Leakage I <sub>S</sub> (OFF)                          | V <sub>D</sub> = ±14V, V <sub>S</sub> = ∓14V<br>Switch Off | 0.01 ±1                  |     | 0.01 ±5 |                          | nA   |     |       |
|   |  | ±100                     |     | ±100    |                          |      |     |       |
| Off Output Leakage I <sub>D</sub> (OFF)                         | V <sub>D</sub> = ±14V, V <sub>S</sub> = ∓14V<br>Switch Off | 0.01 ±1                  |     | 0.01 ±5 |                          | nA   |     |       |
|   |  | ±100                     |     | ±100    |                          |      |     |       |
| On Channel Leakage I <sub>D</sub> (ON)                          | V <sub>D</sub> = V <sub>S</sub> = ±14V<br>Switch On        | 0.02 ±1                  |     | 0.02 ±5 |                          | nA   |     |       |
|   |  | ±200                     |     | ±200    |                          |      |     |       |
| Input High Voltage V <sub>INH</sub>                             |  | 2.4                      |     | 2.4     |                          | V    |     |       |
| Input Low Voltage V <sub>INL</sub>                              |  | 0.8                      |     | 0.8     |                          | V    |     |       |
| Input High or Low Current I <sub>INH</sub> and I <sub>INL</sub> | V <sub>IN</sub> = 15V, 0V                                  | ±1                       |     | ±1      |                          | μA   |     |       |

# LTC201A/LTC202/LTC203

## DIGITAL AND DC ELECTRICAL CHARACTERISTICS

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

| PARAMETER      | CONDITIONS  | LTC201AM/LTC202M/LTC203M |     |     | LTC201AC/LTC202C/LTC203C |     |     | UNITS   |
|----------------|---|--------------------------|-----|-----|--------------------------|-----|-----|---------|
|                |   | MIN                      | TYP | MAX | MIN                      | TYP | MAX |         |
| $C_S(OFF)$     |   |                          | 5   |     |                          | 5   |     | pF      |
| $C_D(OFF)$     |   |                          | 12  |     |                          | 12  |     | pF      |
| $C_D, C_S(ON)$ |   |                          | 30  |     |                          | 30  |     | pF      |
| $I^+$          | All Logic Inputs Tied Together<br>$V_{IN} = 0V$ or $4.0V$ |                          | 16  | 40  |                          | 16  | 40  | $\mu A$ |
|                |   | •                        |     |     | 60                       |     |     |         |
| $I^-$          |   |                          | 0.1 | 5   |                          | 0.1 | 5   |         |
|                |   | •                        |     | 10  |                          |     | 10  |         |

## AC ELECTRICAL CHARACTERISTICS $V^+ = +15V$ , $V^- = -15V$ , $GND = 0V$ unless otherwise noted.

| PARAMETER                     | CONDITIONS   | LTC201AM/LTC202M/LTC203M |      |          | LTC201AC/LTC202C/LTC203C |      |          | UNITS |
|-------------------------------|--|--------------------------|------|----------|--------------------------|------|----------|-------|
|                               |  | MIN                      | TYP  | MAX      | MIN                      | TYP  | MAX      |       |
| $T_{ON}$                      | $V_S = 2V$ , $R_L = 1k\Omega$ , $C_L = 35pF$       |                          | 290  | 400      |                          | 290  | 400      | ns    |
| $T_{OFF}$                     |  |                          | 210  | 300      |                          | 210  | 300      |       |
| $T_{OPEN}$                    |  | 20                       | 85   |          | 20                       | 85   | ns       |       |
| Off Isolation                 | $V_S = 2V_{p-p}$ , $R_L = 1k\Omega$ , $f = 100kHz$ |                          | 75   |          |                          | 75   |          | dB    |
| Crosstalk                     |  |                          | 90   |          |                          | 90   |          |       |
| Charge Injection $Q_{INJ}$    | $R_S = 0\Omega$ , $C_L = 1000pF$ , $V_S = 0V$      |                          | 5    | $\pm 25$ |                          | 8    | $\pm 25$ | pC    |
| Total Harmonic Distortion THD | $V_S = 2V_{p-p}$ , $R_L = 10k\Omega$               |                          | 0.01 |          |                          | 0.01 |          | %     |

## DIGITAL AND DC ELECTRICAL CHARACTERISTICS

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

| PARAMETER  | CONDITIONS   | LTC201AM/LTC202M/LTC203M |      |         | LTC201AC/LTC202C/LTC203C |      |           | UNITS         |     |
|--|--|--------------------------|------|---------|--------------------------|------|-----------|---------------|-----|
|  |  | MIN                      | TYP  | MAX     | MIN                      | TYP  | MAX       |               |     |
| Analog Signal Range                                  |  | •                        | 0    | 5       |                          | 0    | 5         | V             |     |
| $R_{ON}$   | $V_S = +1.5V, +3V$<br>$I_D = 0.25mA$                   | $T_{MIN}$                |      | 450     |                          |      | 520       | $\Omega$      |     |
|  |  | $25^\circ C$             |      | 280     | 450                      |      | 280       |               | 525 |
|  |  | $T_{MAX}$                |      |         | 650                      |      |           |               | 650 |
| $\Delta R_{ON}$ vs $V_S$                             |  |                          | 20   |         |                          | 20   |           | %             |     |
| $\Delta R_{ON}$ vs Temperature                       |  |                          | 0.5  |         |                          | 0.5  |           | %/ $^\circ C$ |     |
| $R_{ON}$ Match                                       | $V_S = 2.5V$ , $I_{DS} = 0.25mA$                       |                          | 5    |         |                          | 5    |           | %             |     |
| Off Input Leakage $I_S(OFF)$                         | $V_D = 4V, 1V$ ; $V_S = 1V, 4V$ (Note 4)<br>Switch Off |                          | 0.01 | $\pm 1$ |                          | 0.01 | $\pm 5$   | nA            |     |
|  |  | •                        |      |         |                          |      | $\pm 100$ |               |     |
| Off Output Leakage $I_D(OFF)$                        | $V_D = 4V, 1V$ ; $V_S = 1V, 4V$ (Note 4)<br>Switch Off |                          | 0.01 | $\pm 1$ |                          | 0.01 | $\pm 5$   | nA            |     |
|  |  | •                        |      |         |                          |      | $\pm 100$ |               |     |
| On Channel Leakage $I_D(ON)$                         | $V_D = V_S = 1V, 4V$ (Note 4)<br>Switch On             |                          | 0.01 | $\pm 1$ |                          | 0.01 | $\pm 5$   | nA            |     |
|  |  | •                        |      |         |                          |      | $\pm 200$ |               |     |
| Input High Voltage $V_{INH}$                         |  | •                        | 2.4  |         |                          | 2.4  |           | V             |     |
| Input Low Voltage $V_{INL}$                          |  | •                        |      | 0.8     |                          |      | 0.8       | V             |     |
| Input High or Low Current<br>$I_{INH}$ and $I_{INL}$ | $V_{IN} = 5V, 0V$                                      | •                        |      | $\pm 1$ |                          |      | $\pm 1$   | $\mu A$       |     |

## DIGITAL AND DC ELECTRICAL CHARACTERISTICS

V<sup>+</sup> = +5V, V<sup>-</sup> = GND = 0V unless otherwise noted.

| PARAMETER                            | CONDITIONS   | LTC201AM/LTC202M/LTC203M |     |     | LTC201AC/LTC202C/LTC203C |     |     | UNITS |
|--------------------------------------|--|--------------------------|-----|-----|--------------------------|-----|-----|-------|
|                                      |  | MIN                      | TYP | MAX | MIN                      | TYP | MAX |       |
| C <sub>S</sub> (OFF)                 |  |                          | 5   |     |                          | 5   |     | pF    |
| C <sub>D</sub> (OFF)                 |  |                          | 12  |     |                          | 12  |     | pF    |
| C <sub>D</sub> , C <sub>S</sub> (ON) |  |                          | 30  |     |                          | 30  |     | pF    |
| I <sup>+</sup>                       | All Logic Inputs Tied Together<br>V <sub>IN</sub> = 0V or 4.0V |                          | 8   | 20  |                          | 8   | 20  | μA    |
|                                      |  | •                        |     | 30  |                          |     | 30  |       |

## AC ELECTRICAL CHARACTERISTICS V<sup>+</sup> = +5V, V<sup>-</sup> = GND = 0V unless otherwise noted.

| PARAMETER                         | CONDITIONS  | LTC201AM/LTC202M/LTC203M |      |     | LTC201AC/LTC202C/LTC203C |      |     | UNITS |
|-----------------------------------|---|--------------------------|------|-----|--------------------------|------|-----|-------|
|                                   |   | MIN                      | TYP  | MAX | MIN                      | TYP  | MAX |       |
| T <sub>ON</sub>                   | V <sub>S</sub> = 2V, R <sub>L</sub> = 1kΩ, C <sub>L</sub> = 35pF    |                          | 450  | 600 |                          | 450  | 600 | ns    |
| T <sub>OFF</sub>                  |   |                          | 190  | 300 |                          | 190  | 300 |       |
| T <sub>OPEN</sub>                 |   | 100                      | 250  |     | 100                      | 250  | ns  |       |
| Off Isolation                     | V <sub>S</sub> = 2Vp-p, R <sub>L</sub> = 1kΩ, f = 100kHz            |                          | 75   |     |                          | 75   |     | dB    |
| Crosstalk                         |   |                          | 90   |     |                          | 90   |     |       |
| Charge Injection Q <sub>INJ</sub> | R <sub>S</sub> = 0Ω, C <sub>L</sub> = 1000pF, V <sub>S</sub> = 2.5V |                          | 2    |     |                          | 2    |     | pC    |
| Total Harmonic Distortion THD     | V <sub>S</sub> = 2Vp-p, R <sub>L</sub> = 10kΩ                       |                          | 0.01 |     |                          | 0.01 |     | %     |

The • denotes the specifications which apply over full operating temperature range. All other limits and typicals T<sub>A</sub> = 25°C.

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

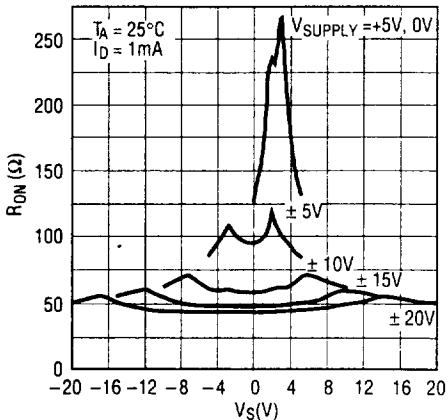
**Note 2:** Signals on S, D, or IN exceeding V<sup>+</sup> or V<sup>-</sup> will be clamped by internal diodes. Limit forward diode current to maximum current rating.

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

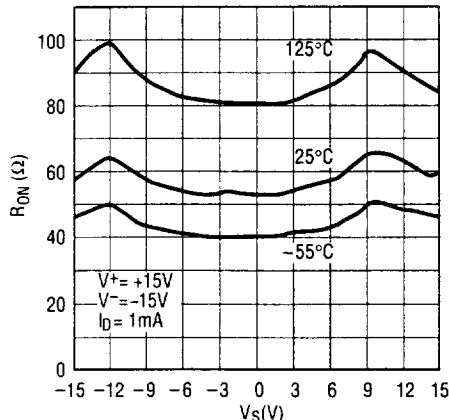
**Note 4:** Leakage current with a single 5V supply is guaranteed by correlation with the ±15V leakage current.

## TYPICAL PERFORMANCE CHARACTERISTICS

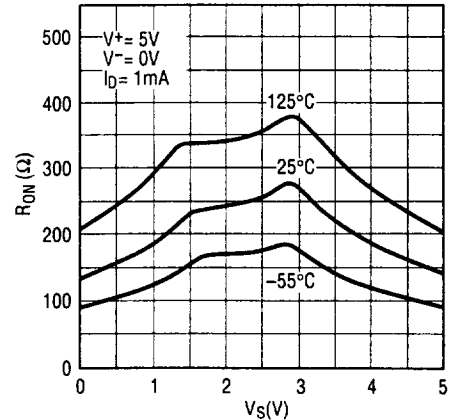
R<sub>ON</sub> vs V<sub>S</sub> Over Supply Voltage



R<sub>ON</sub> vs V<sub>S</sub> Over Temperature

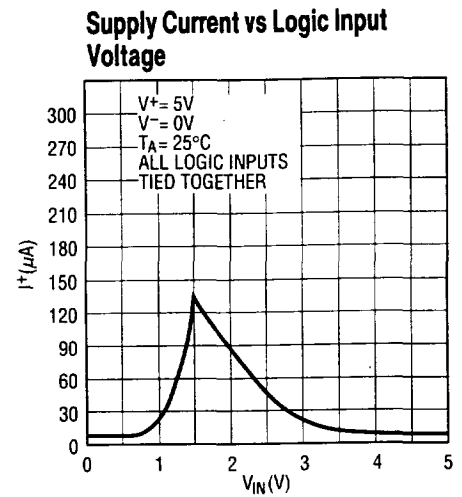
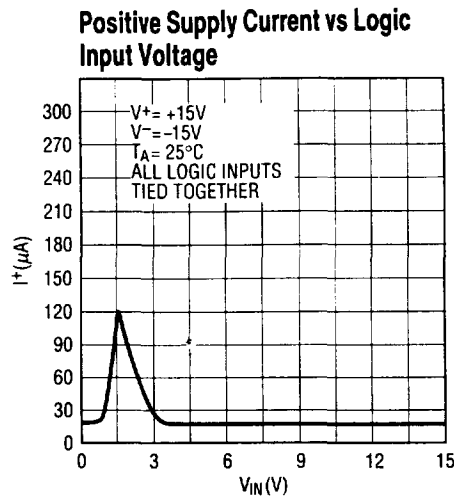
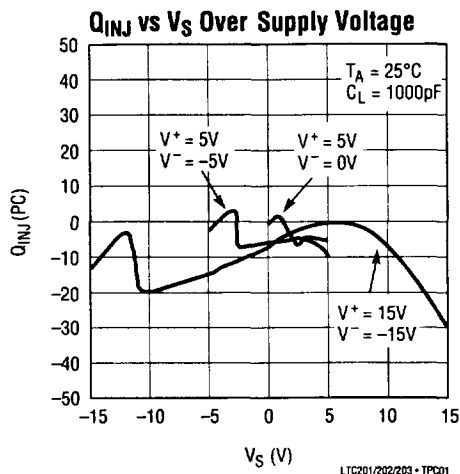


R<sub>ON</sub> vs V<sub>S</sub> Over Temperature



# LTC201A/LTC202/LTC203

## TYPICAL PERFORMANCE CHARACTERISTICS



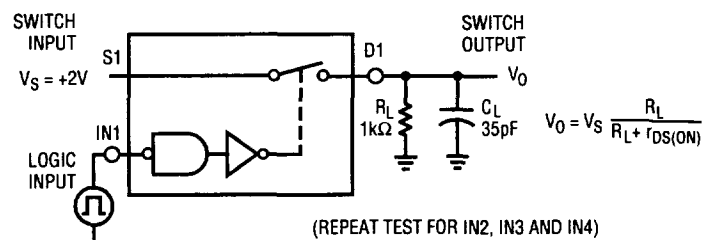
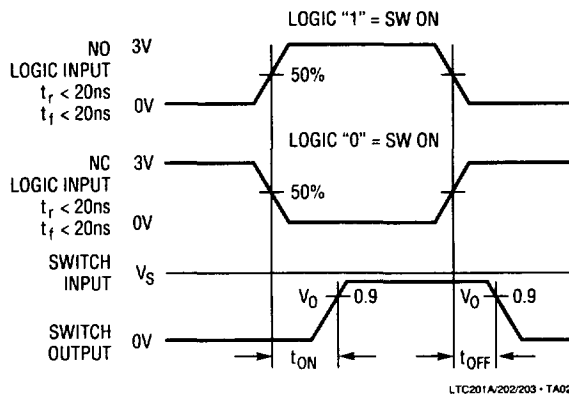
## APPLICATIONS INFORMATION

### Switching Time Test Circuit

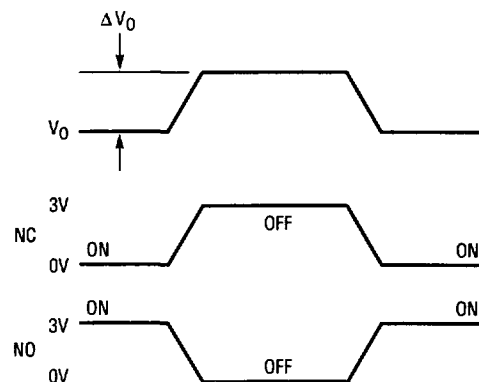
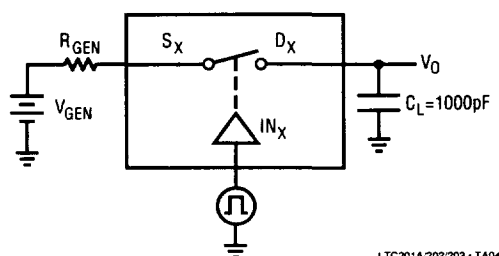
Switch output waveform shown for V<sub>S</sub> = constant with logic input waveform as shown. Note that V<sub>S</sub> may be + or - as per switching time test circuit. V<sub>0</sub> is the steady state

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

### Switching Time Test Circuit



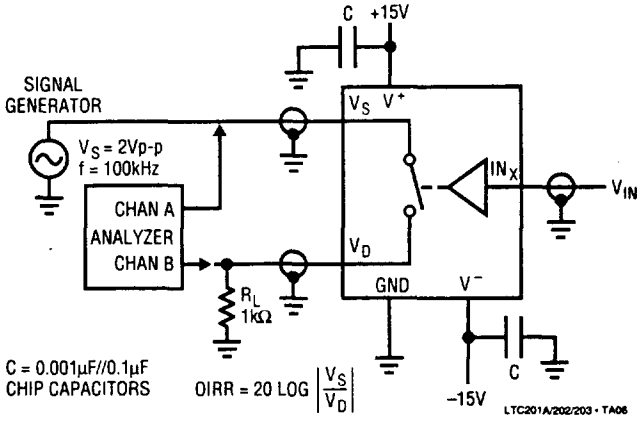
### Charge Injection Test Circuit



ΔV<sub>0</sub> IS THE MEASURED VOLTAGE ERROR DUE TO CHARGE INJECTION. THE ERROR VOLTAGE IN COULOMBS IS ΔQ = C<sub>L</sub> × ΔV<sub>0</sub>.

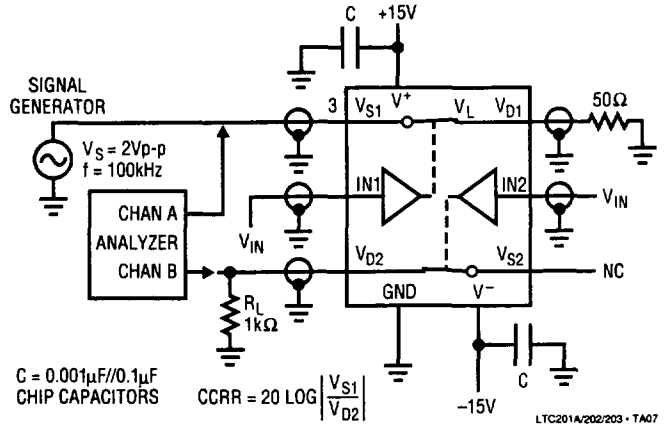
APPLICATIONS INFORMATION

OIRR-Off Isolation Test Circuit



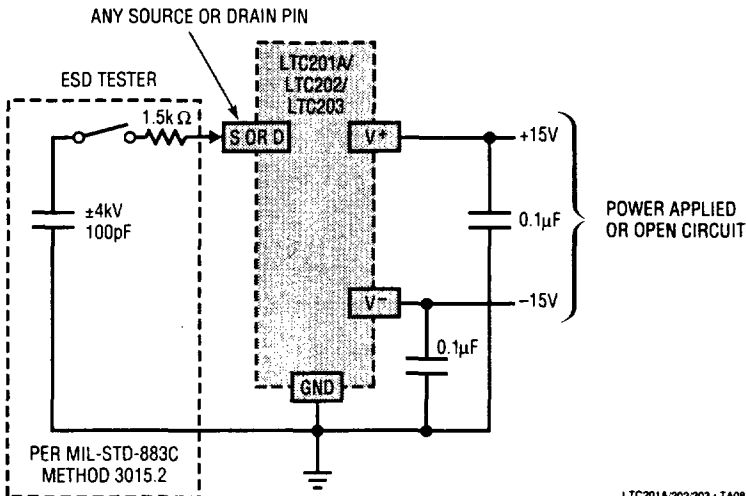
| $V_{IN}$ |    |
|----------|----|
| 3V       | NC |
| 0V       | NO |

CCRR-Channel to Channel Crosstalk Test Circuit

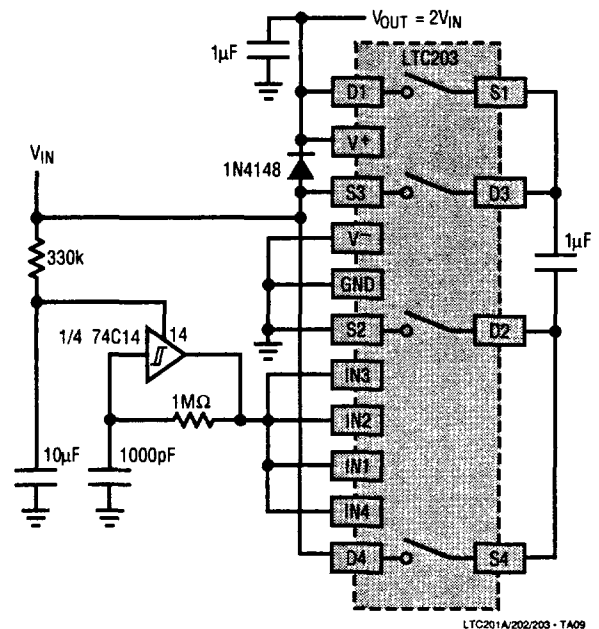


| $V_{IN}$ |    |
|----------|----|
| 3V       | NC |
| 0V       | NO |

In-Circuit ESD Test Circuit



Micropower, 4.5V–15V Input, Voltage Doubler Using the LTC203

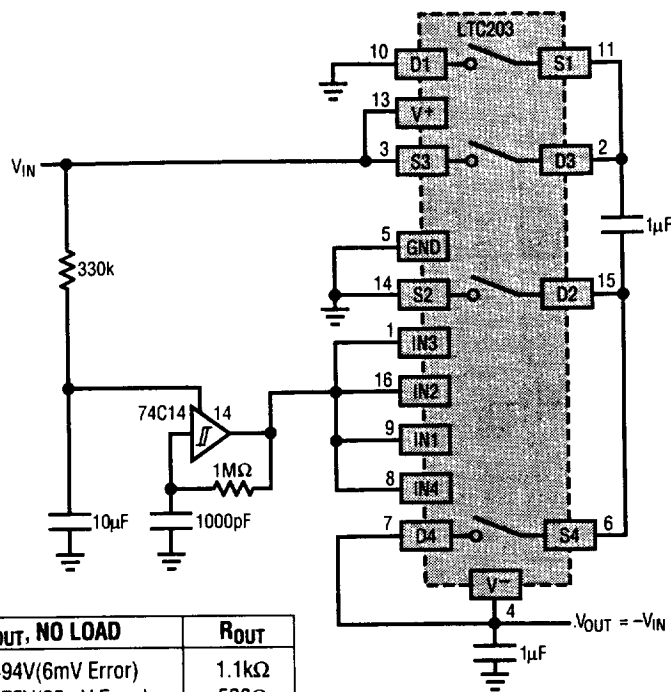


| $V_{IN}$ | $I_Q$ | $V_{OUT, \text{ NO LOAD}}$ | $R_{OUT}$ |
|----------|-------|----------------------------|-----------|
| 4.5V     | 20μA  | 8.988V(12mV Error)         | 1.2k      |
| 15V      | 130μA | 29.96V(40mV Error)         | 600Ω      |

# LTC201A/LTC202/LTC203

## APPLICATIONS INFORMATION

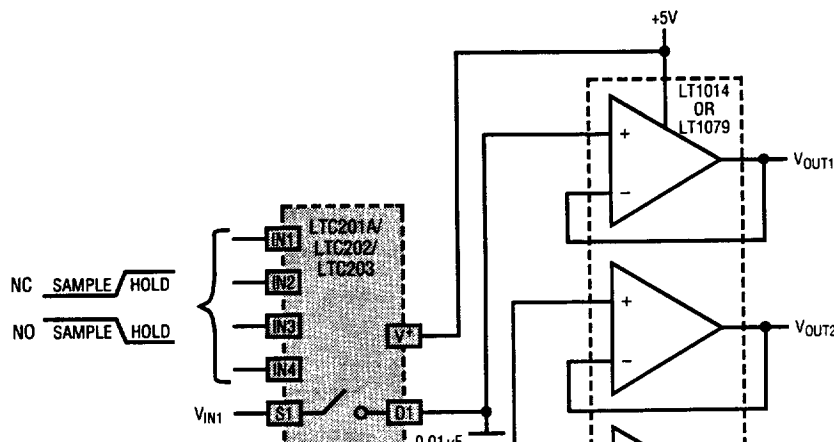
Micropower,  $\pm 4.5V - \pm 15V$ , Voltage Inverter Using the LTC203



| $V_{IN}$ | $I_Q$ | $V_{OUT, NO LOAD}$   | $R_{OUT}$ |
|----------|-------|----------------------|-----------|
| 4.5V     | 15µA  | -4.494V(6mV Error)   | 1.1kΩ     |
| 15V      | 125µA | -14.975V(25mV Error) | 520Ω      |

LTC201A/202/203 • TA10

Quad 12-Bit Sample and Hold



|                        | LT1014 | LT1079 |
|------------------------|--------|--------|
| Sample-to-Sample Error | 0.6mV  | 0.6mV  |

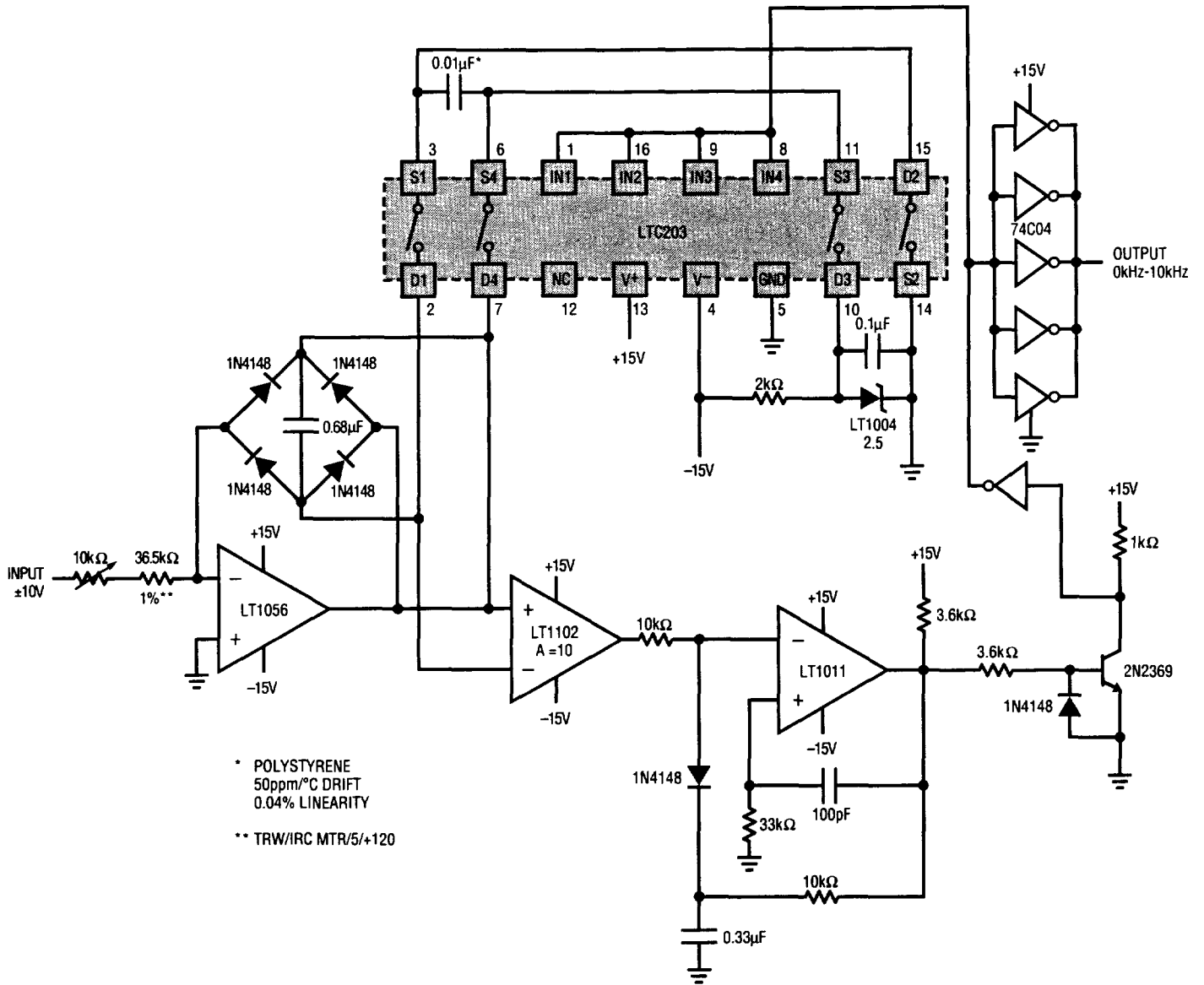




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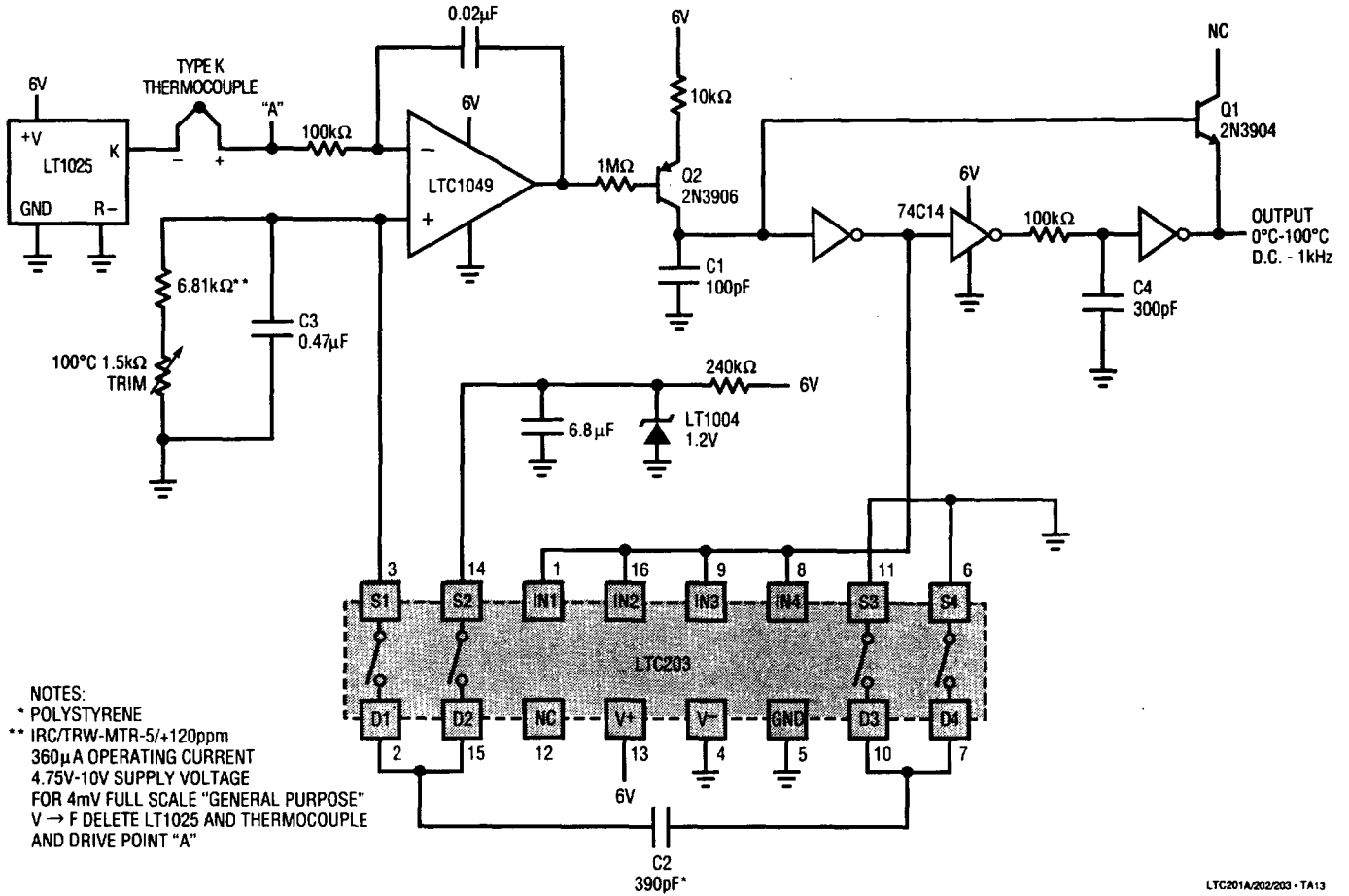
## APPLICATIONS INFORMATION

Bipolar (AC) Input V → F Converter



APPLICATIONS INFORMATION

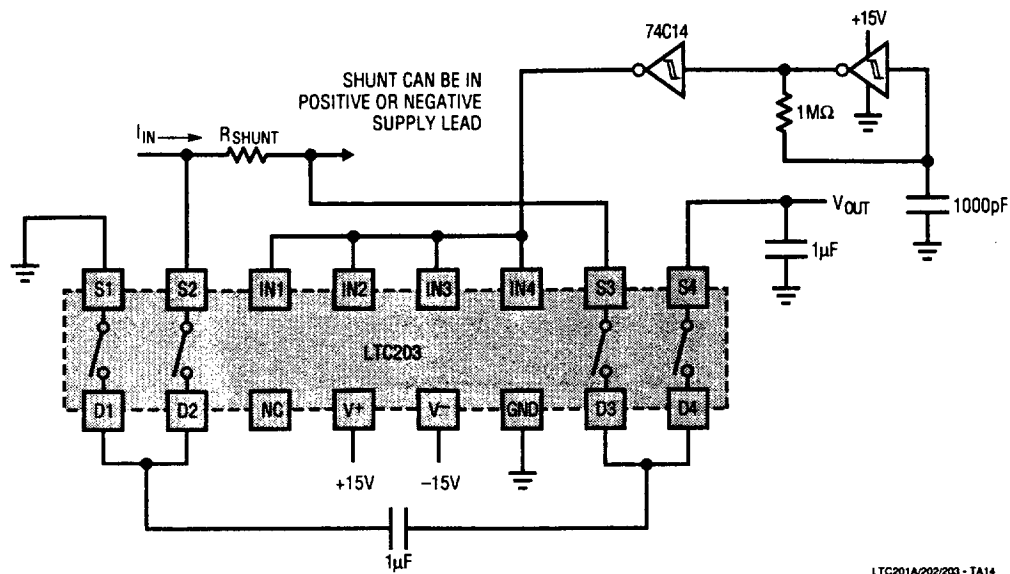
Micropower Thermocouple Temperature to Frequency Converter



LTC201A/202/203 - TA13

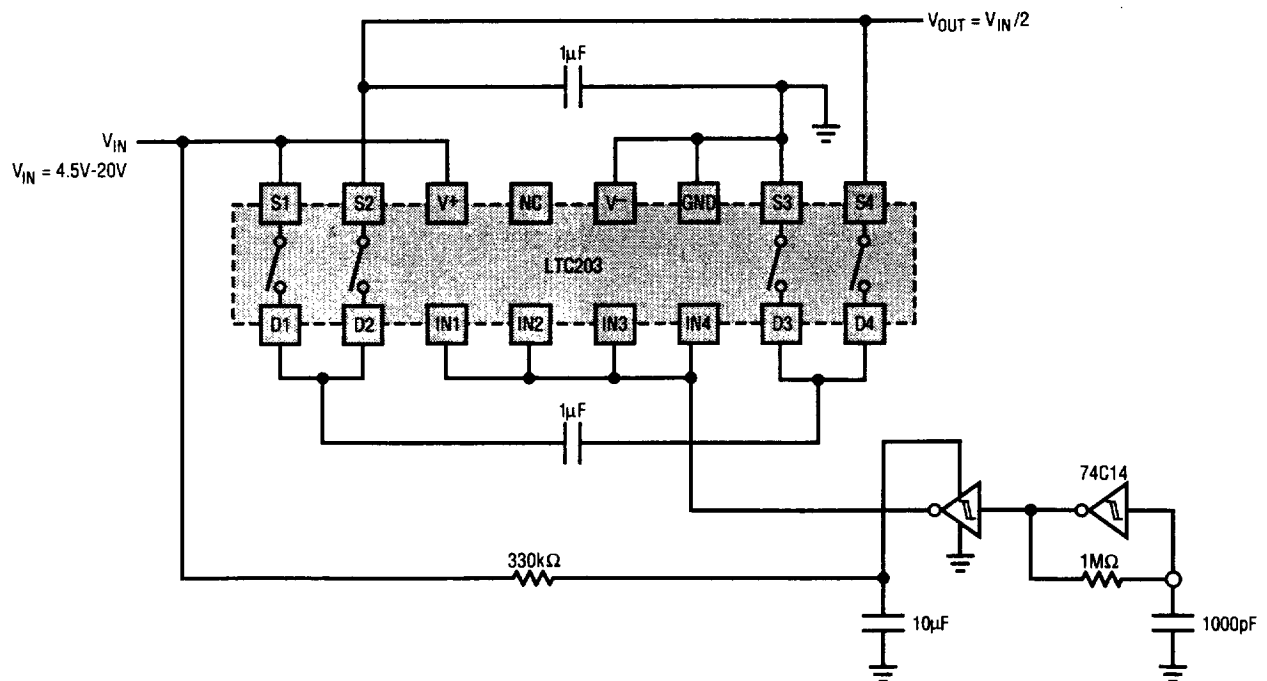
## APPLICATIONS INFORMATION

### Precision Current Sensing in Supply Rails



LTC201A/202/203 - TA14

### Precision Voltage Divide by 2 Circuit



LTC201A/202/203 - TA15