

Dual Precision Instrumentation Switched Capacitor Building Block

FEATURES

- Instrumentation Front End with 120dB CMRR
- Precise, Charge-Balanced Switching
- Operates from 3V to 18V
- Internal or External Clock
- Operates up to 5MHz Clock Rate
- Low Power
- Two Independent Sections with One Clock

APPLICATIONS

- Precision Instrumentation Amplifiers
- Ultra Precision Voltage Inverters, Multipliers and Dividers
- V-F and F-V Converters
- Sample-and-Hold
- Switched Capacitor Filters

DESCRIPTION

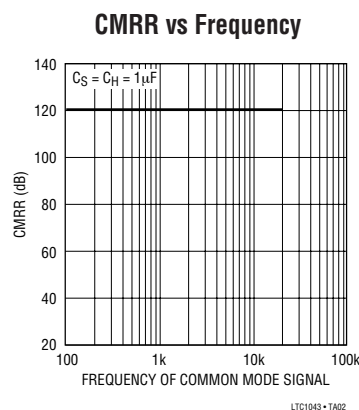
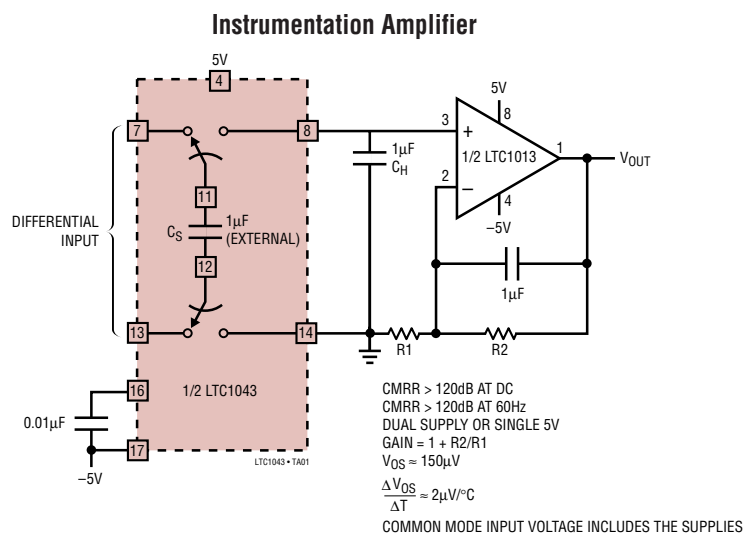
The LTC[®]1043 is a monolithic, charge-balanced, dual switched capacitor instrumentation building block. A pair of switches alternately connects an external capacitor to an input voltage and then connects the charged capacitor across an output port. The internal switches have a break-before-make action. An internal clock is provided and its frequency can be adjusted with an external capacitor. The LTC1043 can also be driven with an external CMOS clock.

The LTC1043, when used with low clock frequencies, provides ultra precision DC functions without requiring precise external components. Such functions are differential voltage to single-ended conversion, voltage inversion, voltage multiplication and division by 2, 3, 4, 5, etc. The LTC1043 can also be used for precise V-F and F-V circuits without trimming, and it is also a building block for switched capacitor filters, oscillators and modulators.

The LTC1043 is manufactured using Linear Technology's enhanced LTCMOS[™] silicon gate process.

LT, LTC and LT are registered trademarks of Linear Technology Corporation.
 LTCMOS is a trademark of Linear Technology Corporation.

TYPICAL APPLICATION



ABSOLUTE MAXIMUM RATINGS

(Note 1)

Supply Voltage	18V
Input Voltage at Any Pin	$-0.3V \leq V_{IN} \leq V^+ + 0.3V$
Operating Temperature Range	
LTC1043C	$-40^{\circ}\text{C} \leq T_A \leq 85^{\circ}\text{C}$
LTC1043M (OBSOLETE)	$-55^{\circ}\text{C} \leq T_A \leq 125^{\circ}\text{C}$
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

PACKAGE/ORDER INFORMATION

TOP VIEW N PACKAGE 18-LEAD PDIP SW PACKAGE 18-LEAD PLASTIC SO T_{JMAX} = 100°C, θ_{JA} = 100°C/W PACKAGE (N) T_{JMAX} = 150°C, θ_{JA} = 85°C/W PACKAGE (SW) D PACKAGE 18-LEAD SIDE BRAZED (HERMETIC) OBSOLETE PACKAGE Consider the N18 Package as an Alternate Source	ORDER PART NUMBER
	LTC1043CN LTC1043CSW
	LTC1043MD

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

ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at $T_A = 25^{\circ}\text{C}$. $V^+ = 10\text{V}$, $V^- = 0\text{V}$, LTC1043M operates from $-55^{\circ}\text{C} \leq T_A \leq 125^{\circ}\text{C}$; LTC1043C operates from $-40^{\circ}\text{C} \leq T_A \leq 85^{\circ}\text{C}$, unless otherwise noted.

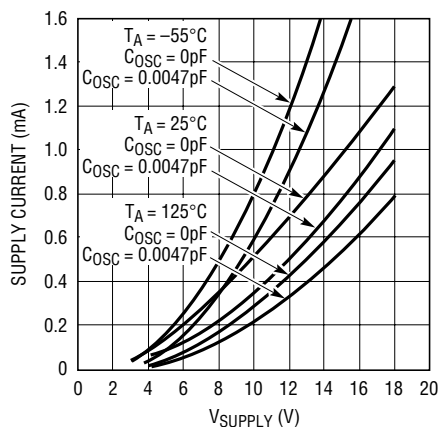
SYMBOL	PARAMETER	CONDITIONS	LTC1043M			LTC1043C			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
I _S	Power Supply Current	Pin 16 Connected High or Low	●	0.25	0.4	0.25	0.4		mA
					0.7		0.7		mA
I _I	OFF Leakage Current	C _{OSC} (Pin 16 to V ⁻) = 100pF	●	0.4	0.65	0.4	0.65		mA
					1		1		mA
R _{ON}	ON Resistance	Test Circuit 2, V _{IN} = 7V, I = ±0.5mA V ⁺ = 10V, V ⁻ = 0V	●	240	400	240	400		Ω
					700		700		Ω
R _{ON}	ON Resistance	Test Circuit 2, V _{IN} = 3.1V, I = ±0.5mA V ⁺ = 5V, V ⁻ = 0V	●	400	700	400	700		Ω
					1		1		kΩ
f _{OSC}	Internal Oscillator Frequency	C _{OSC} (Pin 16 to V ⁻) = 0pF		185		185			kHz
		C _{OSC} (Pin 16 to V ⁻) = 100pF		20	34	20	34	50	kHz
		Test Circuit 3	●	15	75	15	75		kHz
I _{OSC}	Pin Source or Sink Current	Pin 16 at V ⁺ or V ⁻	●	40	70	40	70		μA
					100		100		μA
	Break-Before-Make Time			25		25			ns
	Clock to Switching Delay	C _{OSC} Pin Externally Driven		75		75			ns
f _M	Max External CLK Frequency	C _{OSC} Pin Externally Driven with CMOS Levels		5		5			MHz
CMRR	Common Mode Rejection Ratio	V ⁺ = 5V, V ⁻ = -5V, -5V < V _{CM} < 5V DC to 400Hz		120		120			dB

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

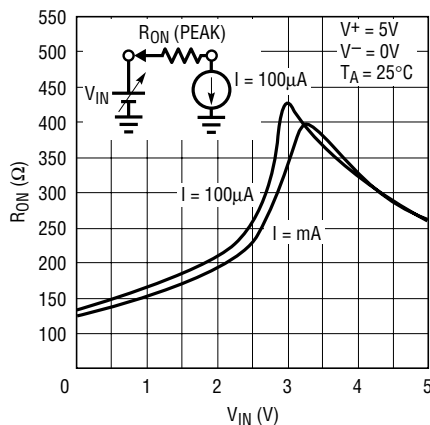
Note 2: OFF leakage current is guaranteed but not tested at 25°C.

TYPICAL PERFORMANCE CHARACTERISTICS (Test Circuits 2 through 4)

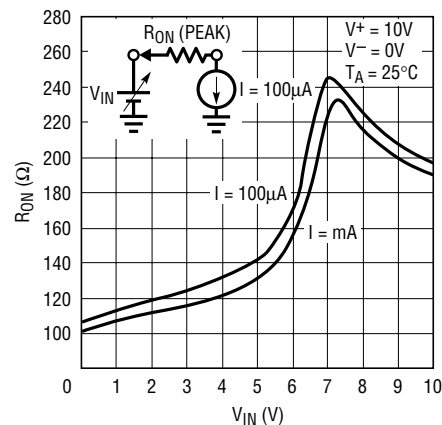
Power Supply Current vs Power Supply Voltage



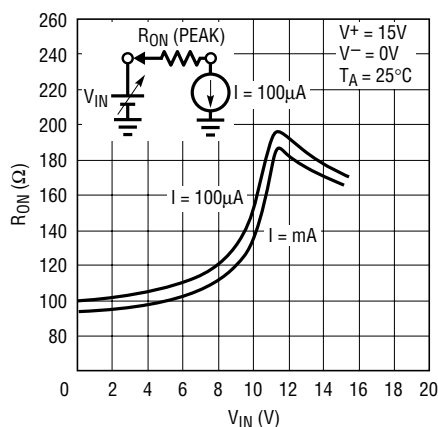
R_{ON} vs V_{IN}



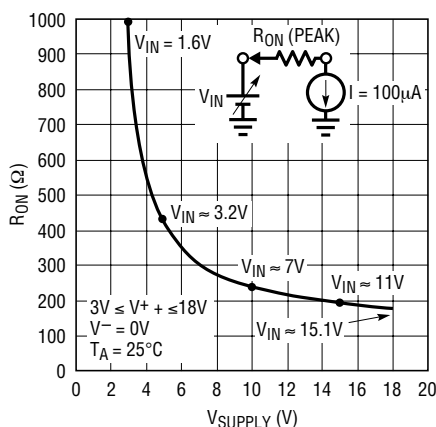
R_{ON} vs V_{IN}



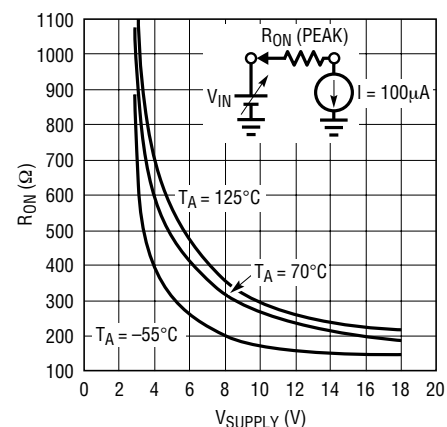
R_{ON} vs V_{IN}



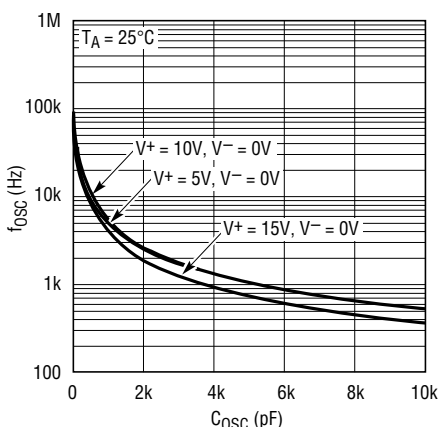
R_{ON} (Peak) vs Power Supply Voltage



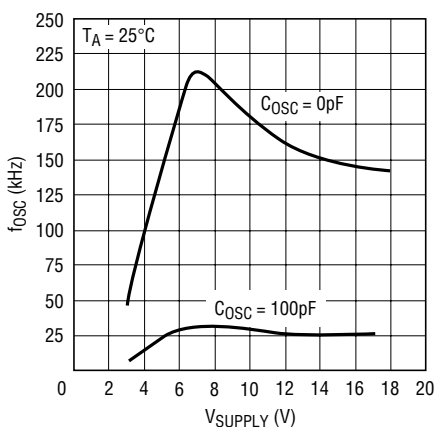
R_{ON} (Peak) vs Power Supply Voltage and Temperature



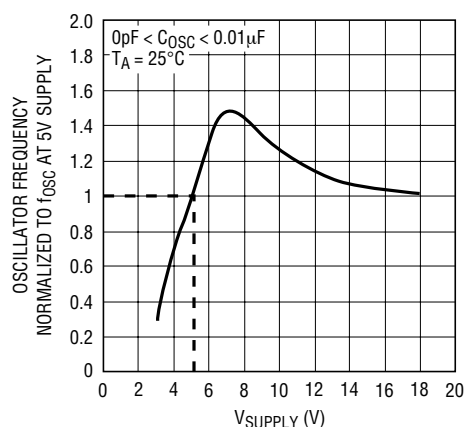
Oscillator Frequency, f_{OSC} vs C_{OSC}



Oscillator Frequency, f_{OSC} vs Supply Voltage

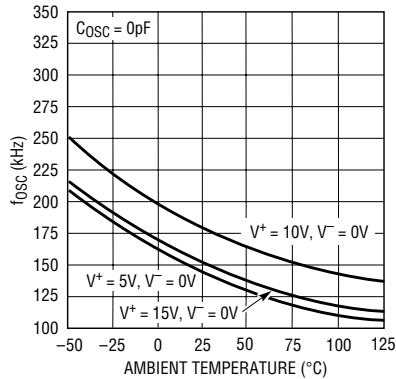


Normalized Oscillator Frequency, f_{OSC} vs Supply Voltage

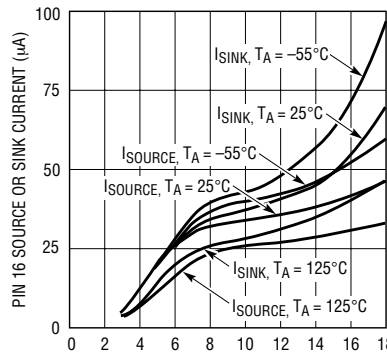


TYPICAL PERFORMANCE CHARACTERISTICS (Test Circuits 2 through 4)

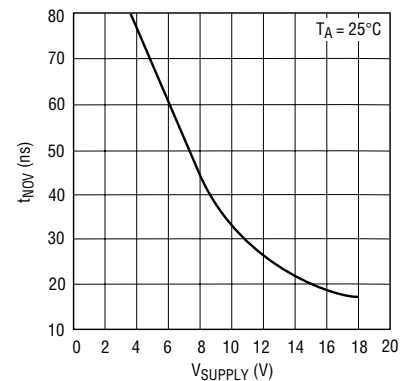
Oscillator Frequency, f_{osc}
vs Ambient Temperature, T_A



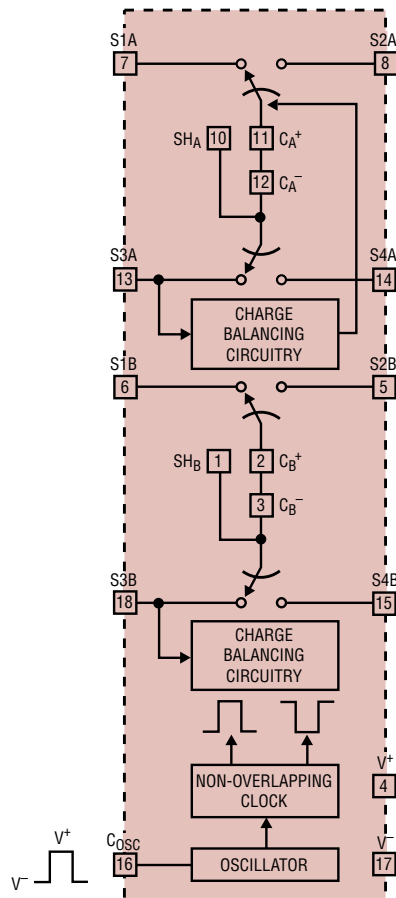
C_{osc} Pin I_{SINK} , I_{SOURCE}
vs Supply Voltage



Break-Before-Make Time, t_{NOV} ,
vs Supply Voltage



BLOCK DIAGRAM

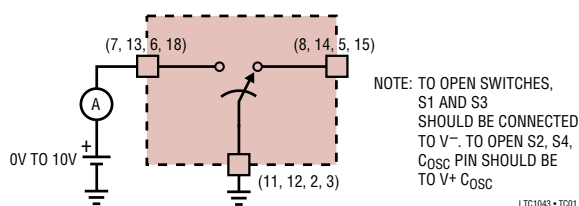


THE SWITCHES ARE TIMED AS SHOWN WITH PIN 16 HIGH

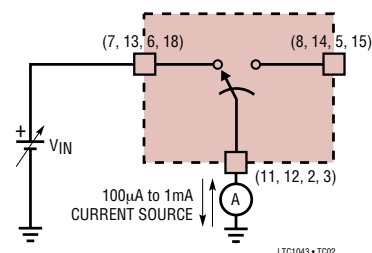
LTC1043 • BD01

TEST CIRCUITS

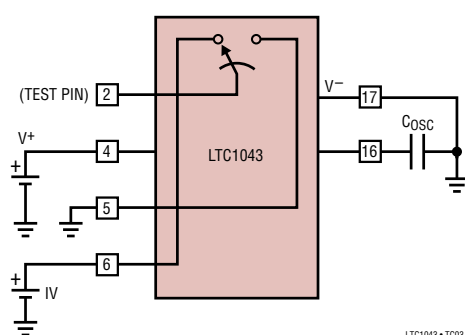
Test Circuit 1. Leakage Current Test



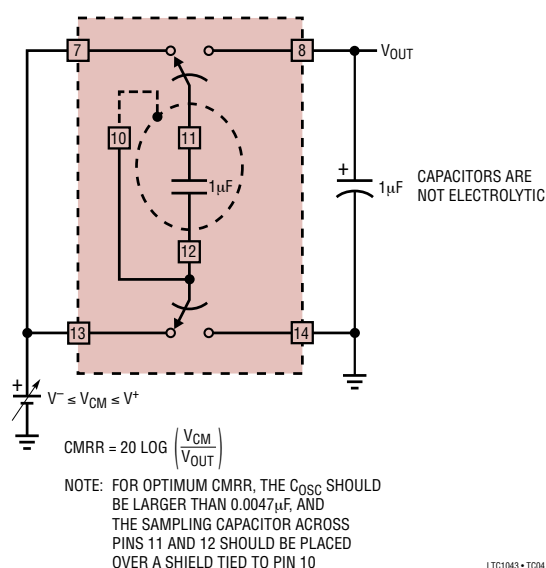
Test Circuit 2. R_{ON} Test



Test Circuit 3. Oscillator Frequency, f_{OSC}



Test Circuit 4. CMRR Test



APPLICATIONS INFORMATION

Common Mode Rejection Ratio (CMRR)

The LTC1043, when used as a differential to single-ended converter rejects common mode signals and preserves differential voltages (Figure 1). Unlike other techniques, the LTC1043's CMRR does not degrade with increasing common mode voltage frequency. During the sampling mode, the impedance of Pins 2, 3 (and 11, 12) should be reasonably balanced, otherwise, common mode signals will appear differentially. The value of the CMRR depends on the value of the sampling and holding capacitors (C_S , C_H) and on the sampling frequency. Since the common mode voltages are not sampled, the common mode signal frequency can well exceed the sampling frequency without experiencing aliasing phenomena. The CMRR of Figure 1 is measured by

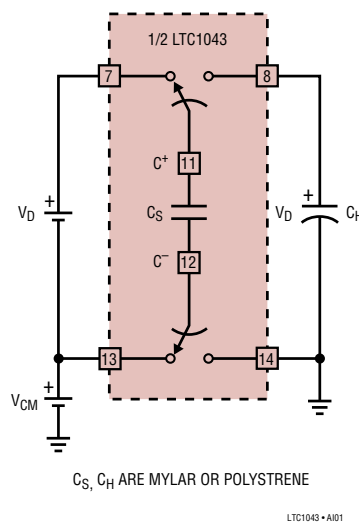


Figure 1. Differential to Single-Ended Converter

APPLICATIONS INFORMATION

shorting Pins 7 and 13 and by observing, with a precision DVM, the change of the voltage across C_H with respect to an input CM voltage variation. During the sampling and holding mode, charges are being transferred and minute voltage transients will appear across the holding capacitor. Although the R_{ON} on the switches is low enough to allow fast settling, as the sampling frequency increases, the rate of charge transfer increases and the average voltage measured with a DVM across it will increase proportionally; this causes the CMRR of the sampled data system, as seen by a “continuous” instrument (DVM), to decrease (Figure 2).

Switch Charge Injection

Figure 3 shows one out of the eight switches of the LTC1043, configured as a basic sample-and-hold circuit. When the switch opens, a “hold step” is observed and its magnitude depends on the value of the input voltage. Figure 4 shows charge injected into the hold capacitor. For instance, a 2pC of charge injected into a 0.01 μ F capacitor causes a 200 μ V hold step. As shown in Figure 4, there is a predictable and repeatable charge injection cancellation when the input voltage is close to half the supply voltage of the LTC1043. This is a unique feature of this product, containing charge-balanced switches fabricated with a self-aligning gate CMOS process. Any switch of the LTC1043, when powered with symmetrical dual supplies, will sample-and-hold small signals around ground without any significant error.

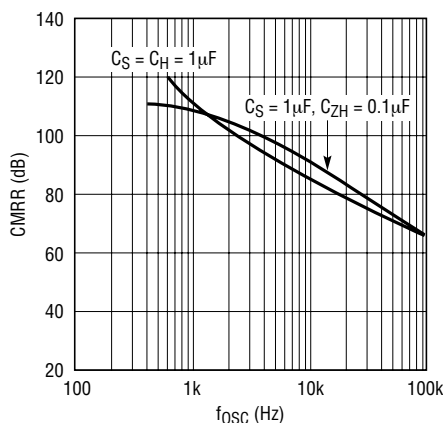


Figure 2. CMRR vs Sampling Frequency

Shielding the Sampling Capacitor for Very High CMRR

Internal or external parasitic capacitors from the C^+ pin(s) to ground affect the CMRR of the LTC1043 (Figure 1). The common mode error due to the internal junction capacitances of the C^+ Pin(s) 2 and 11 is cancelled through internal circuitry. The C^+ pin, therefore, should be used as the top plate of the sampling capacitor. The interpin capacitance between pin 2 and dummy Pin 1 (11 and 10) appears in parallel with the sampling capacitor so it does not degrade the CMRR. A shield placed underneath the sampling capacitor and connected to either Pin 1 or 3 helps to boost the CMRR in excess of 120dB (Figure 5).

Excessive external parasitic capacitance between the C^- pins and ground indirectly degrades CMRR; this becomes visible especially when the LTC1043 is used with clock frequencies above 2kHz. Because of this, if a shield is used, the parasitic capacitance between the shield and circuit ground should be minimized.

It is recommended that the outer plate of the sampling capacitor be connected to the C^- pin(s).

Input Pins, SCR Sensitivity

An internal 60 Ω resistor is connected in series with the input of the switches (Pins 5, 6, 7, 8, 13, 14, 15, 18) and it is included in the R_{ON} specification. When the input voltage exceeds the power supply by a diode drop, current will flow into the input pin(s). The LTC1043 will not latch until the input current reaches 2mA–3mA. The device will

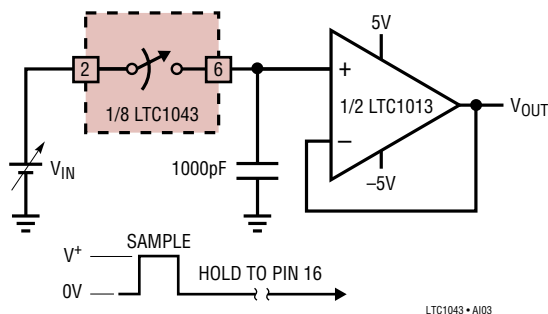


Figure 3

APPLICATIONS INFORMATION

recover from the latch mode when the input drops 3V to 4V below the voltage value which caused the latch. For instance, if an external resistor of 200Ω is connected in series with an input pin, the input can be taken 1.3V above the supply without latching the IC. The same applies for the C^+ and C^- pins.

C_{OSC} Pin (16), Figure 6

The C_{OSC} pin can be used with an external capacitor, C_{OSC} , connected from Pin 16 to Pin 17, to modify the internal oscillator frequency. If Pin 16 is floating, the internal 24pF capacitor, plus any external interpin capacitance, set the oscillator frequency around 190kHz with $\pm 5V$ supply. The typical performance characteristics curves provide the necessary information to set the oscillator frequency for various power supply ranges. Pin 16 can also be driven

with an external clock to override the internal oscillator. Although standard 7400 series CMOS gates do not guarantee CMOS levels with the current source and sink requirements of Pin 16, they will in reality drive the C_{OSC} pin. CMOS gates conforming to standard B series output drive have the appropriate voltage levels and more than enough output current to simultaneously drive several LTC1043 C_{OSC} pins. The typical trip levels of the Schmitt trigger (Figure 6) are given below.

SUPPLY	TRIP LEVELS
$V^+ = 5V, V^- = 0V$	$V_H = 3.4V, V_L = 1.35V$
$V^+ = 10V, V^- = 0V$	$V_H = 6.5V, V_L = 2.8V$
$V^+ = 15V, V^- = 0V$	$V_H = 9.5V, V_L = 4.1V$

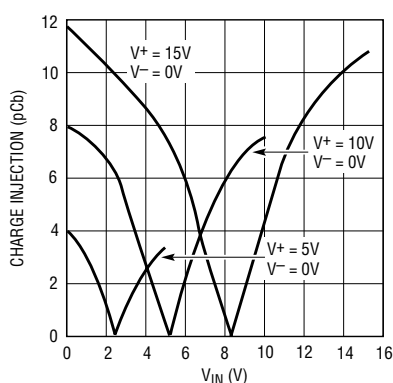


Figure 4. Individual Switch Charge Injection vs Input Voltage

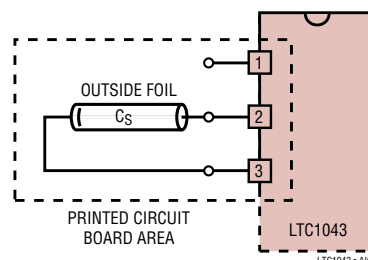


Figure 5. Printed Circuit Board Layout Showing Shielding the Sampling Capacitor

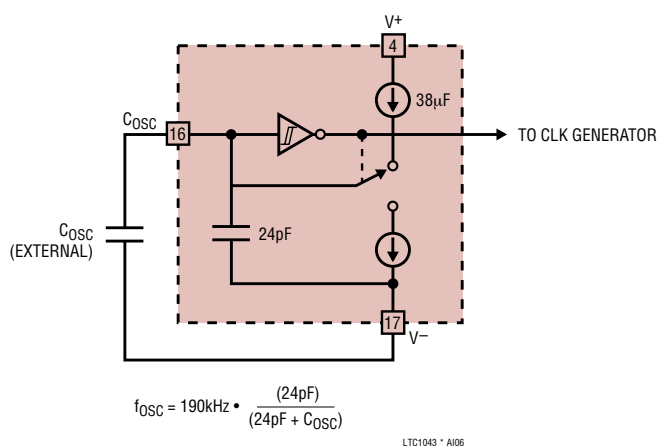
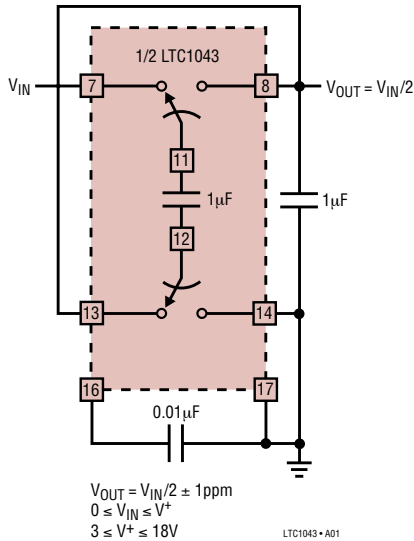


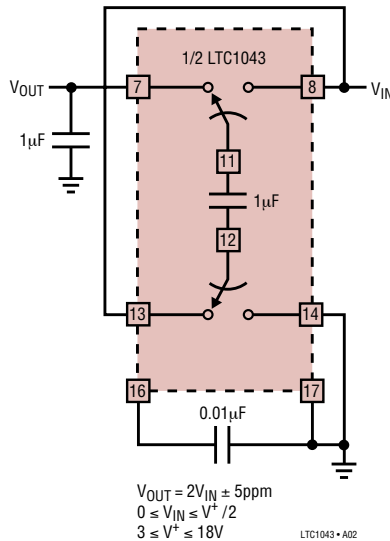
Figure 6. Internal Oscillator

TYPICAL APPLICATIONS

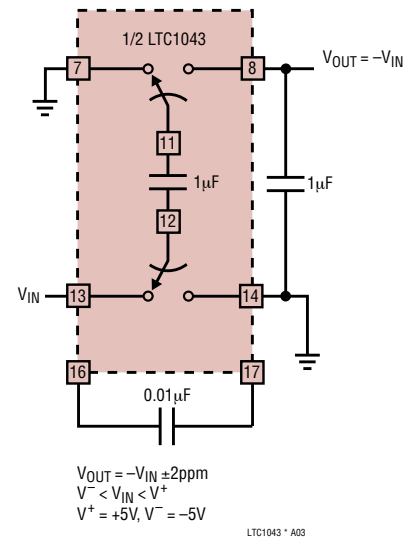
Divide by 2



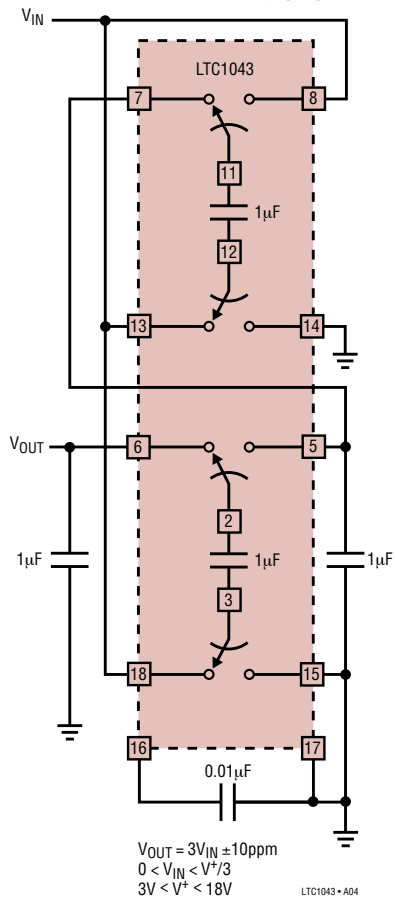
Multiply by 2



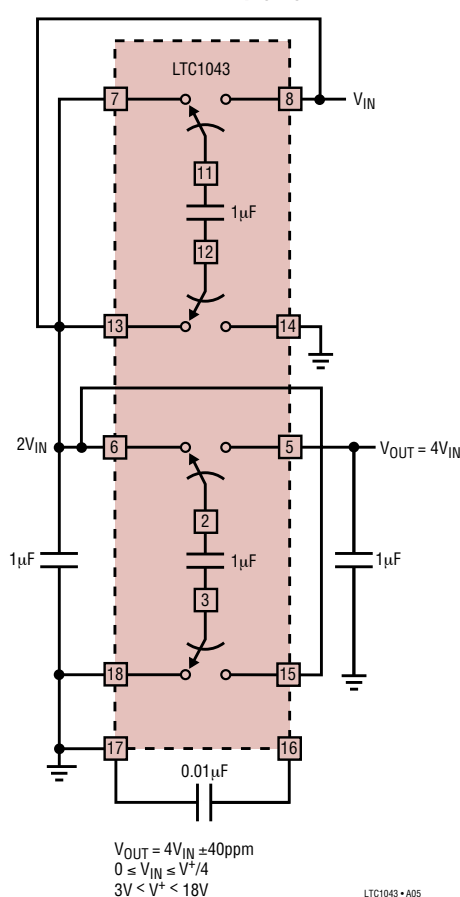
Ultra Precision Voltage Inverter



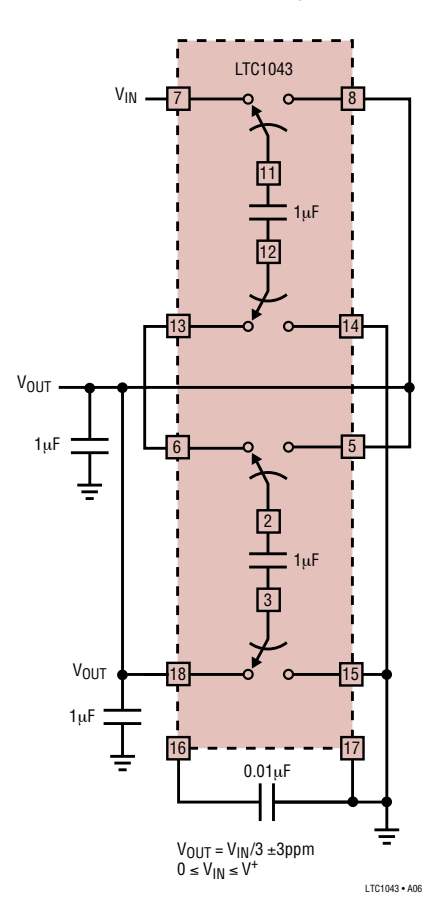
Precision Multiply by 3



Precision Multiply by 4

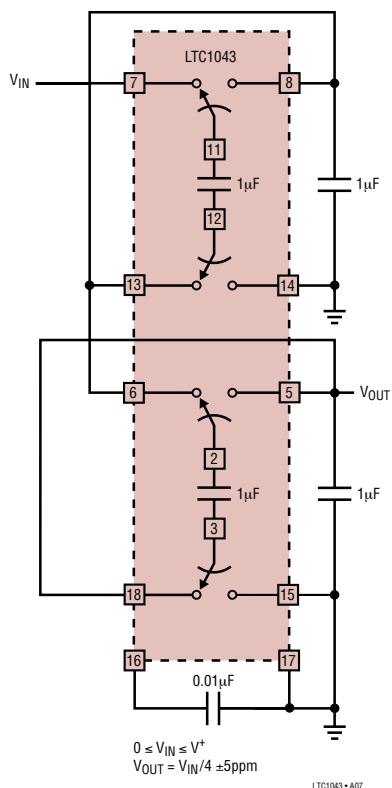


Divide by 3

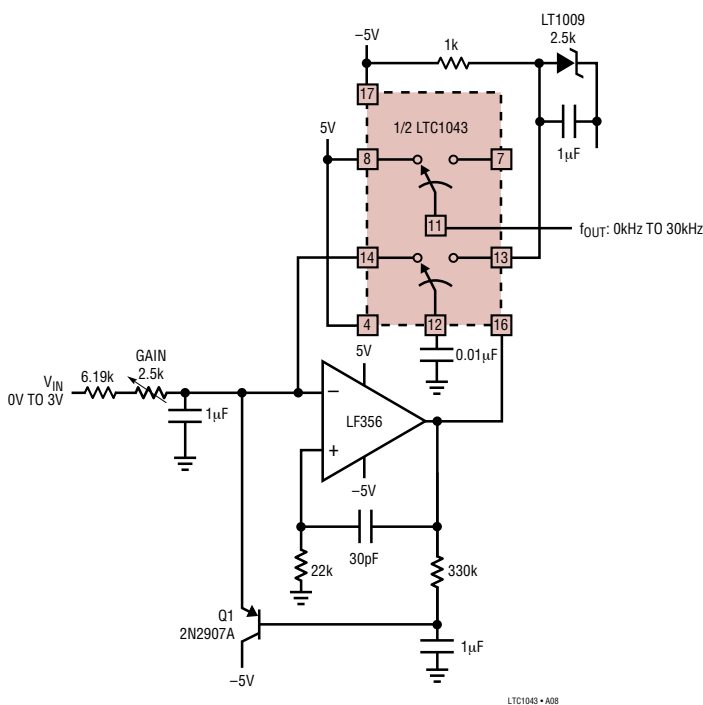


TYPICAL APPLICATIONS

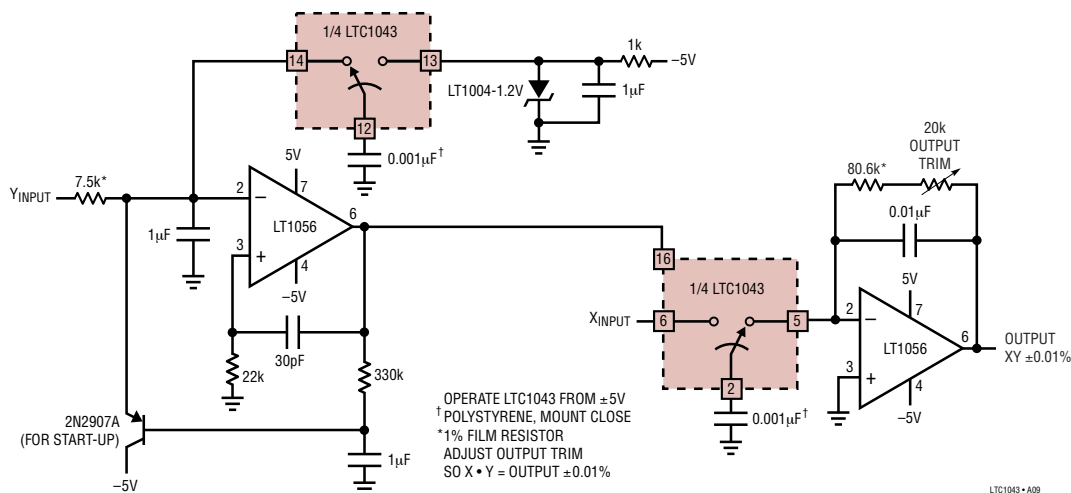
Divide by 4



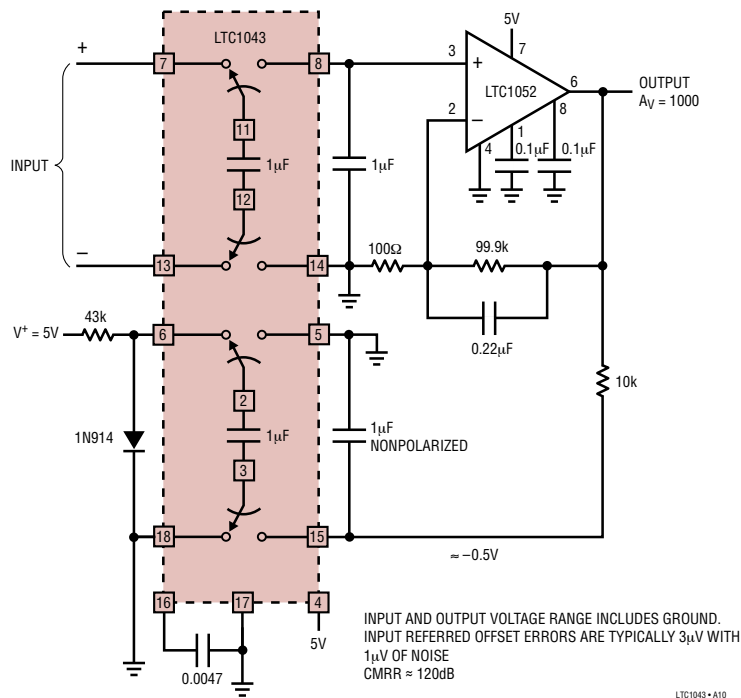
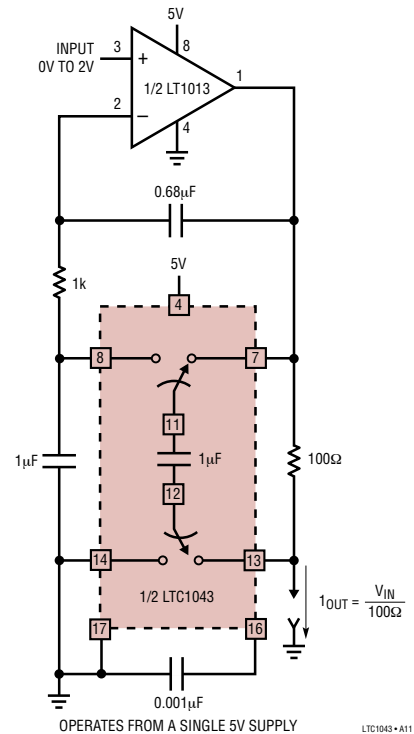
0.005% V/F Converter



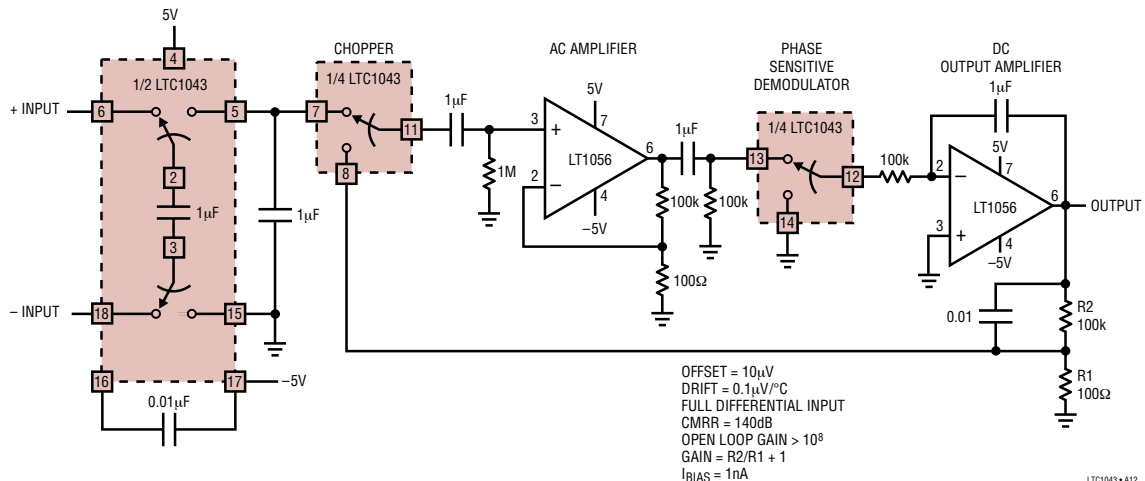
0.01% Analog Multiplier



TYPICAL APPLICATIONS

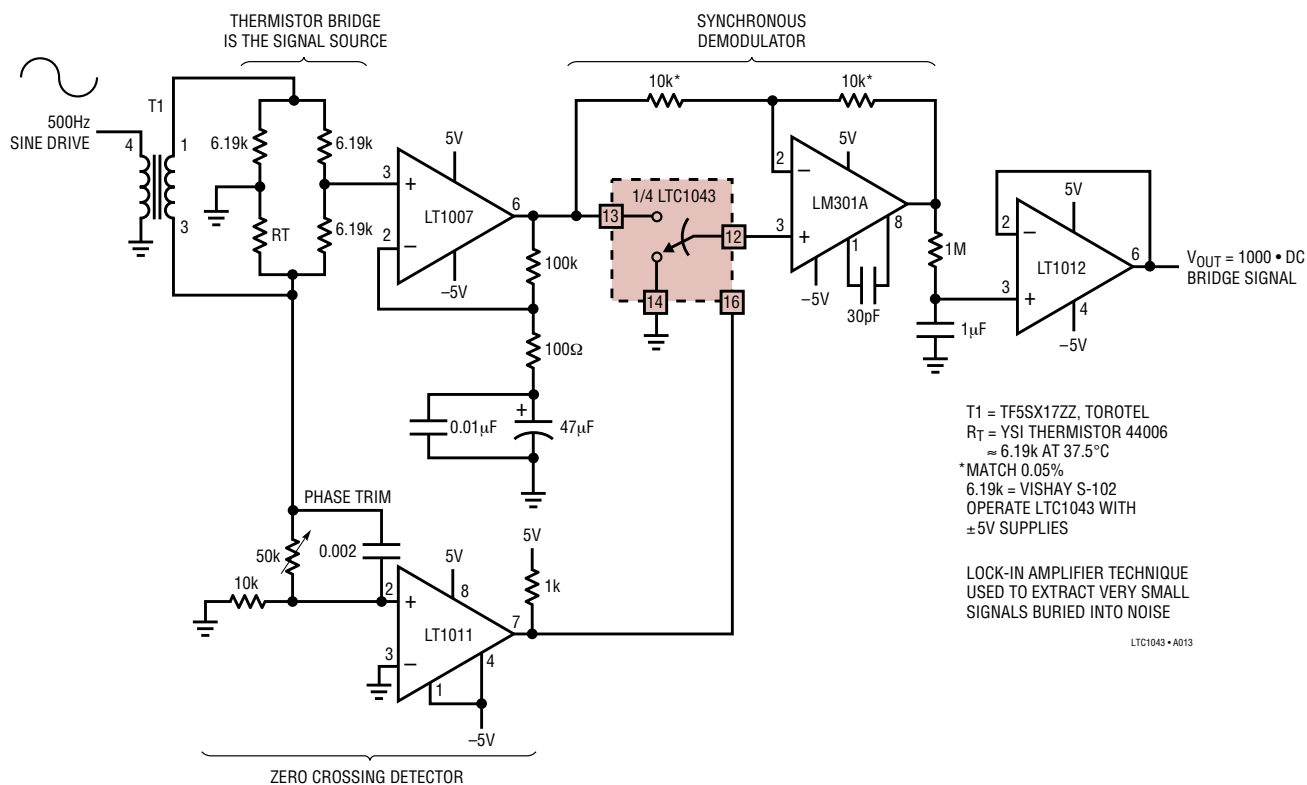
Single 5V Supply, Ultra Precision
Instrumentation AmplifierVoltage Controlled Current Source with
Ground Referred Input and Output

Precision Instrumentation Amplifier

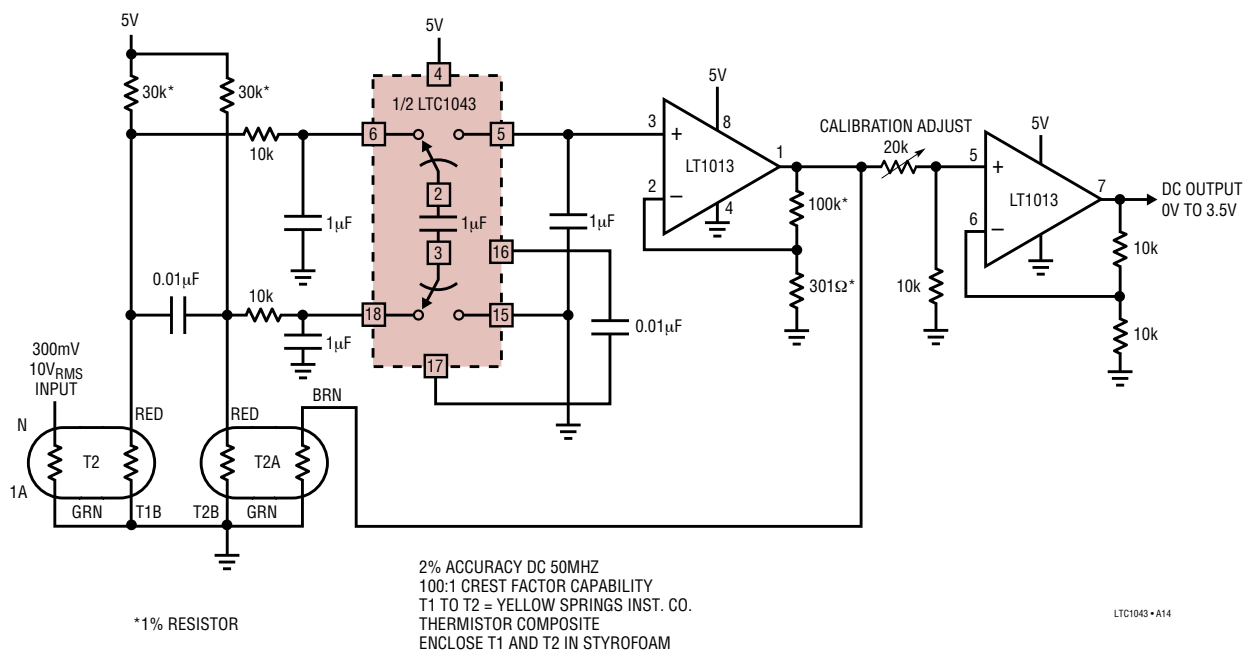


TYPICAL APPLICATIONS

Lock-In Amplifier (= Extremely Narrow-Band Amplifier)

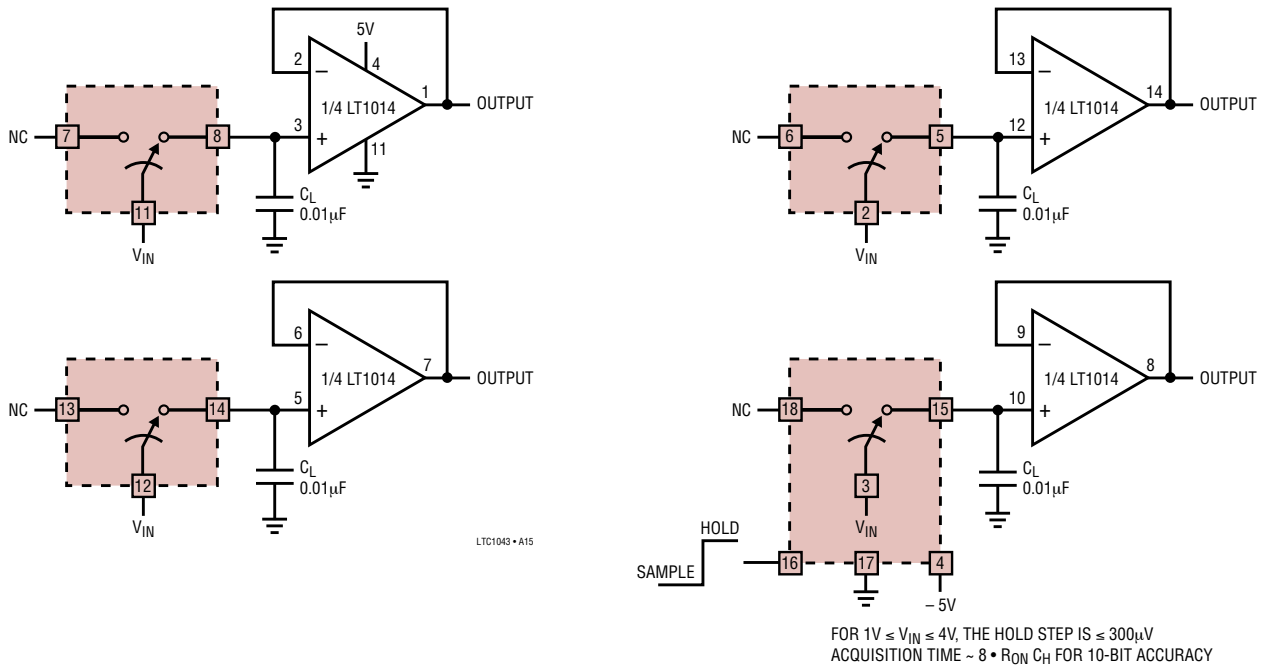


50MHz Termal RMS/DC Converter



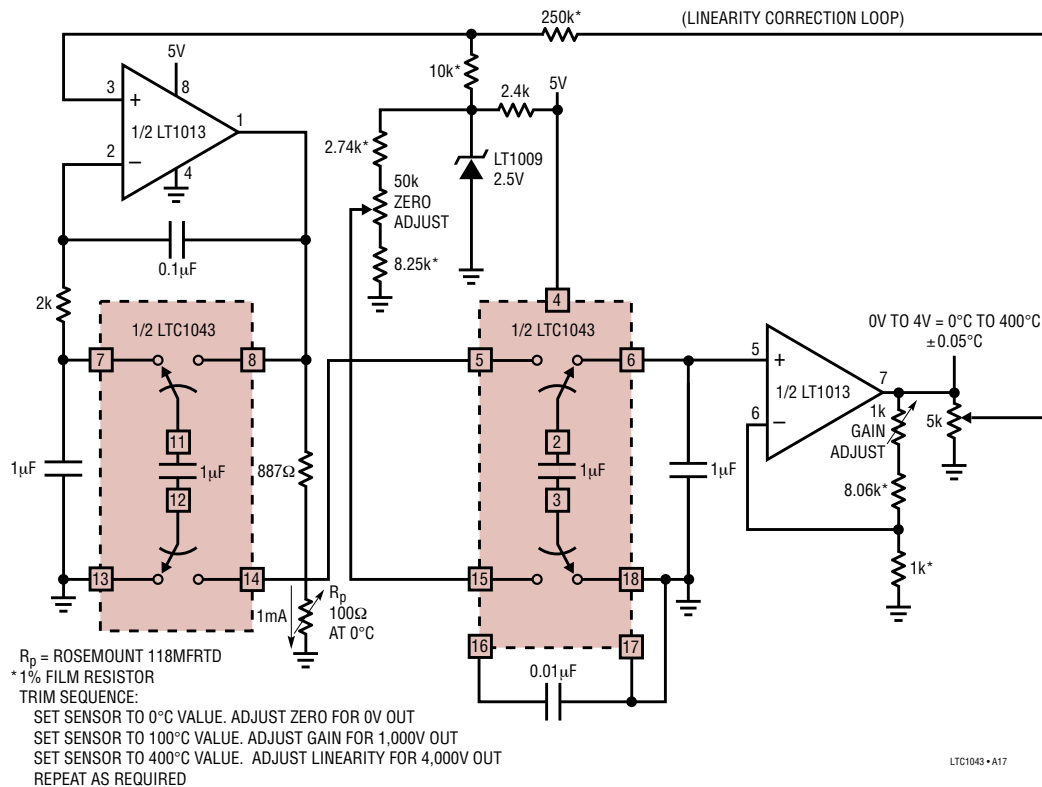
TYPICAL APPLICATIONS

Quad Single 5V Supply, Low Hold Step, Sample-and-Hold



LTC1043 • A16

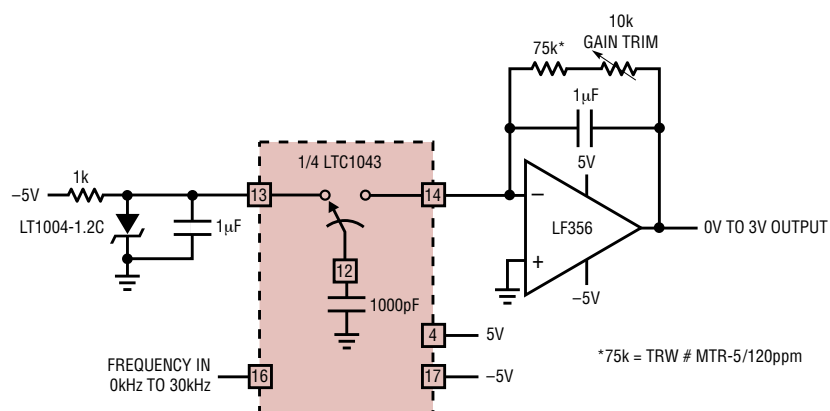
Single Supply Precision Linearized Platinum RTD Signal Conditioner



LTC1043 • A17

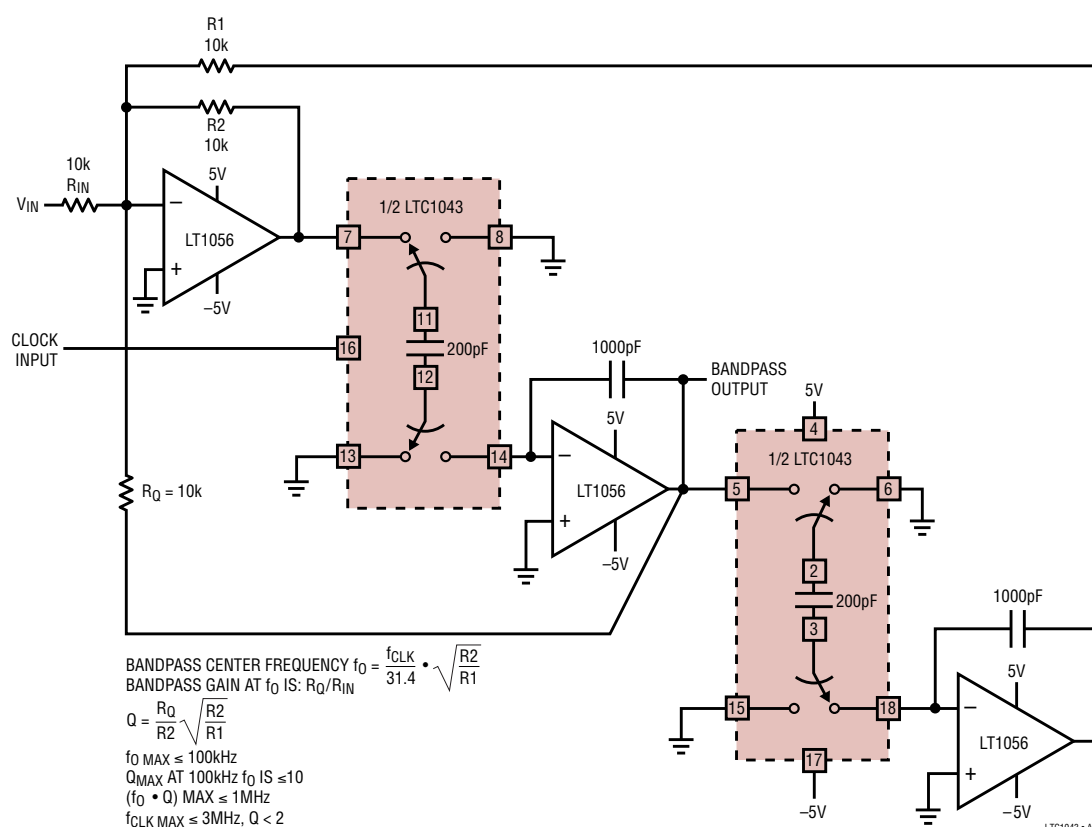
TYPICAL APPLICATIONS

0.005% F/V Converter



LTC1043 • A18

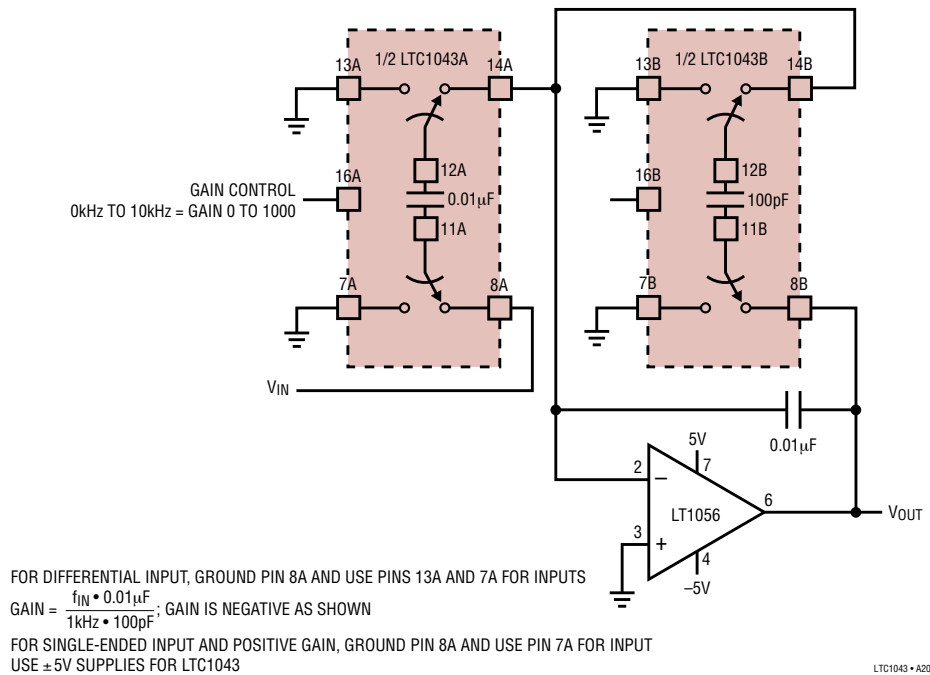
High Frequency Clock Tunable Bandpass Filter



LTC1043 • A19

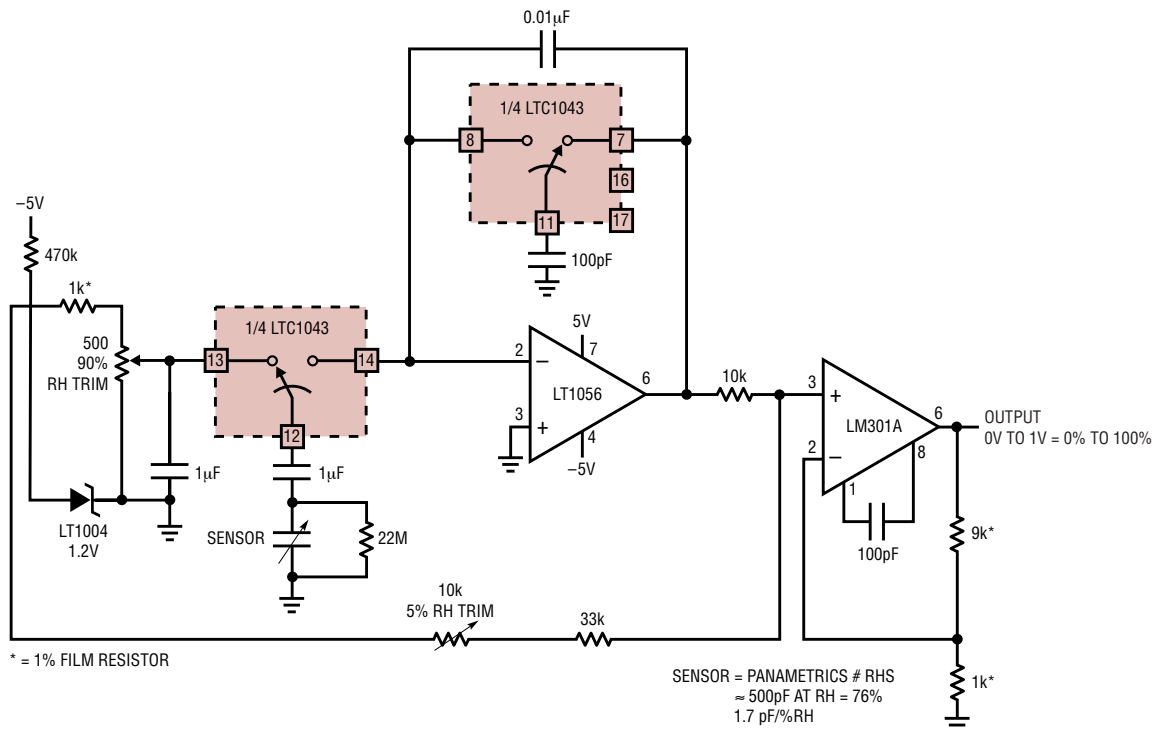
TYPICAL APPLICATIONS

Frequency-Controlled Gain Amplifier



LTC1043 • A20

Relative Humidity Sensor Signal Conditioner



LTC1043 • A21

The schematic diagram illustrates a precision sine wave generator circuit. It features an amplitude-stable sine wave source (LT1013) and a 1.5kHz oscillator (LTC1043). The circuit includes a 1.5kHz sine wave generator (LTC1043), a 1.5kHz sine wave generator (LTC1043), and a 1.5kHz sine wave generator (LTC1043). The output is a 1.5kHz sine wave with an amplitude of 0V to ±2.5V, with a gain trim of 0M to 2.50M.

SHUNT CAN BE IN POSITIVE OR NEGATIVE SUPPLY LEAD

I_{IN}

R_{SHUNT}

1/2 LTC1043

7 8

11 12

1μF

13 14

16 17

0.01μF

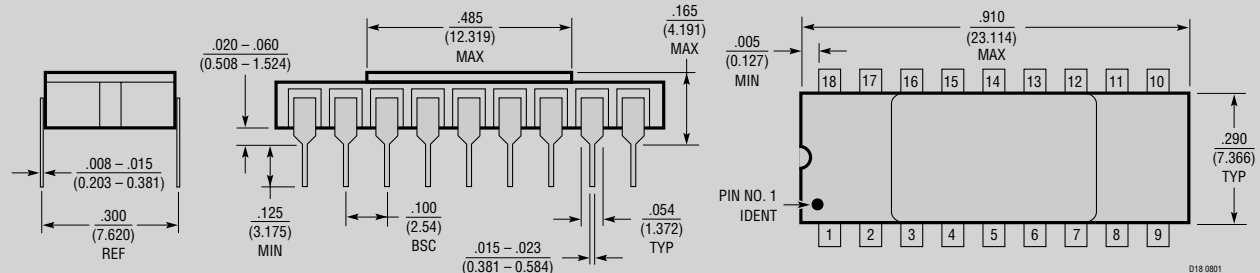
V_{OUT}

1μF

LTC1043 - 822

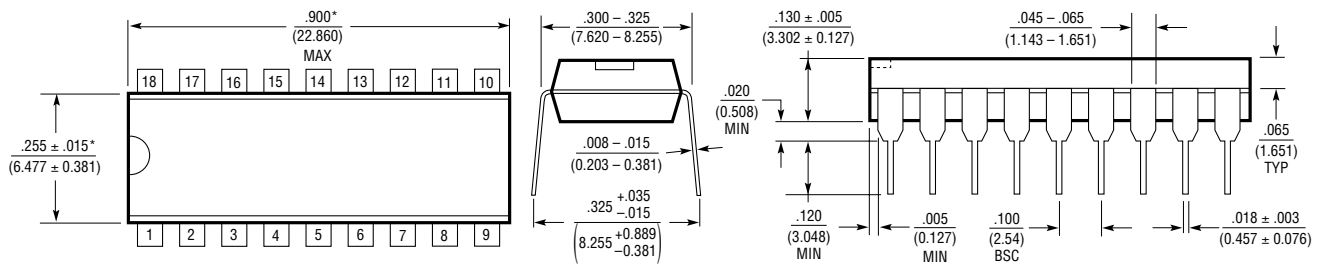
PACKAGE DESCRIPTION

D Package
18-Lead Side Brazed (Hermetic)
 (Reference LTC DWG # 05-08-1210)



OBSOLETE PACKAGE

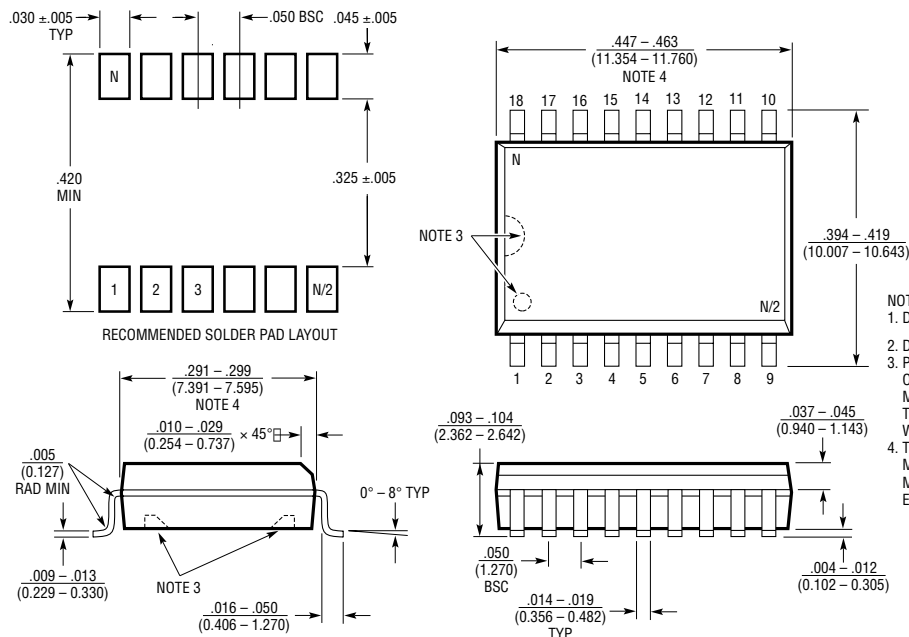
N Package
18-Lead PDIP (Narrow .300 Inch)
 (Reference LTC DWG # 05-08-1510)



NOTE:
 1. DIMENSIONS ARE IN INCHES
 MILLIMETERS

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

SW Package
18-Lead Plastic Small Outline (Wide .300 Inch)
 (Reference LTC DWG # 05-08-1620)



NOTE:
 1. DIMENSIONS IN INCHES
 MILLIMETERS
 2. DRAWING NOT TO SCALE
 3. PIN 1 IDENT. NOTCH ON TOP AND CAVITIES
 ON THE BOTTOM OF PACKAGES ARE THE
 MANUFACTURING OPTIONS.
 THE PART MAY BE SUPPLIED WITH OR
 WITHOUT ANY OF THE OPTIONS
 4. THESE DIMENSIONS DO NOT INCLUDE
 MOLD FLASH OR PROTRUSIONS.
 MOLD FLASH OR PROTRUSIONS SHALL NOT
 EXCEED .006" (0.15mm)

S18 (WIDE) 0502

1043fa

Signal Conditioning

Home > Products > Signal Conditioning > Switched Cap Building Blocks > LTC1043

- Operational Amplifiers (Op Amps)
- Comparators
- Filters
- Voltage References
- RMS-DC Conversion
- Thermocouple
- Compensators
- Switched Cap Building Blocks
- Signal Chain μ Module
- Signal Conditioning
- Evaluation Kits



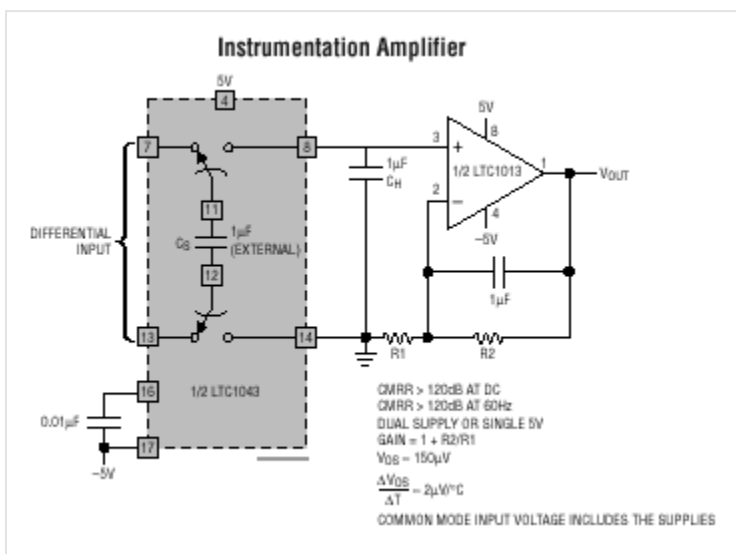
LTC1043 - Dual Precision Instrumentation Switched-Capacitor Building Block

FEATURES | DESCRIPTION | PACKAGING | ORDER INFO | SIMULATE

FEATURES

Instrumentation Front End with 120dB CMRR
Precise, Charge-Balanced Switching
Operates from 3V to 18V
Internal or External Clock
Operates up to 5MHz Clock Rate
Low Power
Two Independent Sections with One Clock

TYPICAL APPLICATION



Order Now

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Request Samples

Documentation

Datasheet

LTC1043 - Dual Precision Instrumentation Switching Capacitor Building Blocks

Application Note

AN11 Designing Linear Regulators for 5V Single Supply Applications

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AN18 Power Gain S Monolithic Amplifier

AN28 Thermocouple Measurement:

[AN3 Applications for Switched-Capacitor Instrumentation Bu](#)

AN42 Voltage Reference Collection:

AN43 Bridge Circuit

[AN45 Measurement
Circuit Collection](#)

AN52 Linear Techn
Magazine Circuit Co
Volume 1:

AN7 Some Techniques for Direct Digitization of Outputs:

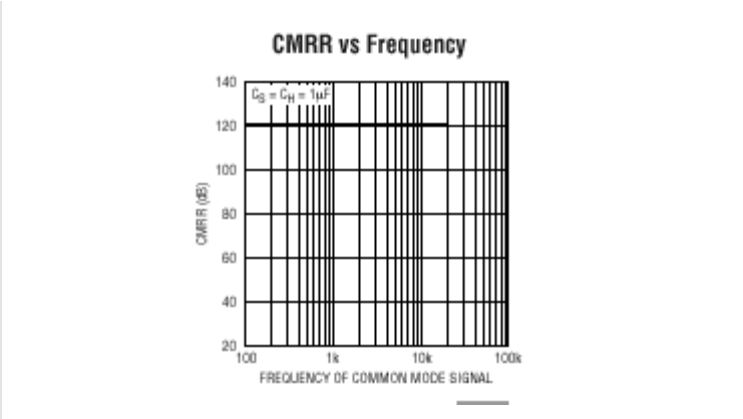
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Differential to Single
Signal Conditioning
Use with the LTC24
No Latency Delta S
an SO-8](#)

AN8 Power Conditioning Techniques for Battery

AN9 - Application Considerations and a New Chopper-Sta Amp:

AN92 Bias Voltage Sense Circuits for APD Photodiodes:

AN93 Instrumentation Applications for a Microcontroller Oscillator: A Clock for



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DESCRIPTION

The LTC™1043 is a monolithic, charge-balanced, dual switched capacitor instrumentation building block. A pair of switches alternately connects an external capacitor to an input voltage and then connects the charged capacitor across an output port. The internal switches have a break-before-make action. An internal clock is provided and its frequency can be adjusted with an external capacitor. The LTC1043 can also be driven with an external CMOS clock.

The LTC1043, when used with low clock frequencies, provides ultra precision DC functions without requiring precise external components. Such functions are differential voltage to single-ended conversion, voltage inversion, voltage multiplication and division by 2, 3, 4, 5, etc. The LTC1043 can also be used for precise V_μF and F_μV circuits without trimming, and it is also a building block for switched capacitor filters, oscillators and modulators.

The LTC1043 is manufactured using Linear Technology's enhanced LTCMOS® silicon gate process.

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PACKAGING

DIP-18, SO-18

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ORDER INFO

Part numbers ending in PBF are [lead free](#). Please contact LTC marketing for information on lead based finish parts.
Part numbers containing TR or TRM are shipped in [tape and reel or 500 unit mini tape and reel](#), respectively
Please refer to our [general ordering information](#) or the product datasheet for more details

Package Variations and Pricing

Part Number	Package	Pins	Temp	Price (1-99)	Price (1k)*	RoHS Data
LTC1043CN	PDIP	18	C	\$3.42	\$2.85	View
LTC1043CN#PBF	PDIP	18	C	\$3.42	\$2.85	View
LTC1043CSW	SQ	18	C	\$3.75	\$3.00	View
LTC1043CSW#PBF	SQ	18	C	\$3.75	\$3.00	View

Reasons

[AN98 - Signal Sour
Conditioners and Po
Circuitry Circuits of
2004](#)

Design Note

[Design Solutions 1.
High Accuracy Diffe
Single-Ended Differ
Single-Ended Conv
Very High Uncalibr
Accuracy and Low \(](#)
[Drift](#)

[Design Solutions 2.
Differential Front-Er
LTC2400 Simple R
Circuit Converts Dif
Signals to Single-Er
and Operates on Si
Supplies Where Re
More Important Tha](#)

[Design Solutions 3.
Input 24-Bit A/D Co
Accepts ±2.5V Inpu
Differential Input 24
Converter Provides
Zero for Bipolar Inp](#)

[Design Solutions 4.
Accuracy, Differenti
Ended Conversion f
Range Bipolar Input
Bipolar Differential t
Ended Converter Di
LTC2400's Input R](#)

[Design Solutions 5.
High Accuracy, Bipo
Differential to Single
Signal Conversion f
Single Supply Differ
Single-Ended Conv
Circuit Amplifies Lo
Bipolar Signals and
the LTC2400's High](#)

[Design Solutions 6.
Differential to Single
Converter for Single
This Converter Has
Accuracy, Very Low
Offset Drift, Rail-to-
Common Mode Ran
\[Live at Zero\]\(#\)](#)

[DN207 LTC2400 Hi
Differential to Single
Converter for ±5V S](#)

LT Magazine

[Jun 1999 LTC2400
Bridge Digitizers](#)

Reliability Data

[R071 Reliability Dat](#)

Software and Simulation

[LTC1043 SPICE M](#)

LTC1043CSW#TR	SQ	18	C		\$3.10	View
LTC1043CSW#TRPBF	SQ	18	C		\$3.10	View
Buy Now						
Request Samples						

* The USA list pricing shown is for BUDGETARY USE ONLY, shown in United States dollars (FOB USA per unit for the stated volume), and is subject to change. International prices may differ due to local duties, taxes, fees and exchange rates. For volume-specific price or delivery quotes, please contact your local Linear Technology [sales office or authorized distributor](#).

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APPLICATIONS

Precision Instrumentation Amplifiers
Ultra Precision Voltage Inverters, Multipliers and Dividers
V-F and F-V Converters
Sample and Hold
Switched-Capacitor Filters

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SIMULATE

To simulate selected Linear Technology products, please download [LTSpice / SwitcherCAD III](#). This powerful schematic capture and simulation tool includes macro models for 80% of Linear Technology's switching regulators, over 200 op amp models, as well as resistors, transistors and MOSFET models.

For other simulation tools, visit our [Design Simulation and Device Models](#) page.

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