

**4423**

## PRECISION QUADRATURE OSCILLATOR

### FEATURES

- SINE AND COSINE OUTPUTS
- RESISTOR-PROGRAMMABLE FREQUENCY
- WIDE FREQUENCY RANGE: 0.002Hz to 20kHz
- LOW DISTORTION: 0.2% max up to 5kHz
- EASY ADJUSTMENTS
- SMALL SIZE
- LOW COST

### DESCRIPTION

The Model 4423 is a precision quadrature oscillator. It has two outputs 90 degrees out of phase with each other, thus providing sine and cosine wave outputs available at the same time. The 4423 is resistor programmable and is easy to use. It has low distortion (0.2% max up to 5kHz) and excellent frequency and amplitude stability.

The Model 4423 also includes an uncommitted operational amplifier which may be used as a buffer, a level shifter, or as an independent operational amplifier. The 4423 is packaged in a versatile, small, low-cost DIP package.

# SPECIFICATIONS

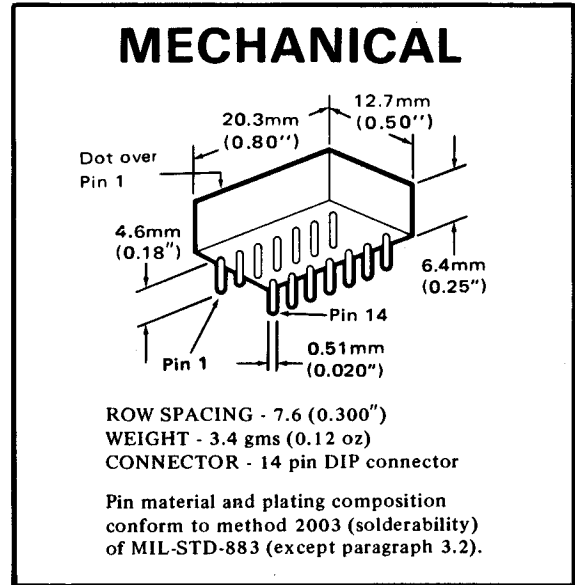
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Specifications typical at 25°C and ±15VDC  
Power Supply Unless Otherwise Noted.

ELECTRICAL				
	MIN	TYP	MAX	UNITS
<b>FREQUENCY</b>				
Initial Frequency (no adjustments)	20.0k	20.5	21.0k	Hz
Frequency Range (using 2 R's only)	2k		20k	Hz
Frequency Range (using 2 R's and 2 C's)	.0002		20k	Hz
Accuracy of Frequency Equation*		±1	±5	%
Stability vs Temperature		±50	±100	ppm/°C
Quadrature Phase Error		±0.1		degree
<b>DISTORTION</b>				
Sine Output (pin 1)				
0.002Hz to 5kHz			0.2	%
5kHz to 20kHz			0.5	%
Cosine Output (pin 7)				
0.002Hz to 5kHz		0.2		%
5kHz to 20kHz		0.8		%
Distortion vs Temperature		0.015		%/°C
<b>OUTPUT</b>				
Amplitude (Sine)				
At 20 kHz	6.5	7	7.5	V rms
vs Temperature		0.05		%/°C
vs Supply		0.4		V/V
Output Current	1.5	5		mA
Output impedance			1	Ω
<b>UNCOMMITTED OP AMP</b>				
Input Offset Voltage		1.5		mV
Input Bias Current		275		nA
Input Impedance		1		MΩ
Open Loop Gain		90		dB
Output Current	5			mA
<b>POWER SUPPLY</b>				
Rated Supply Voltage		±15		VDC
Supply Voltage Range	±12		±18	VDC
Quiescent Current		±9	±18	mA
<b>TEMPERATURE RANGE</b>				
Specifications	0		+70	°C
Operation	-25		+85	°C
Storage	-55		+125	°C

\* May be trimmed for better accuracy.

PIN CONNECTIONS	
1. E <sub>1</sub> , Sine Output	8. Frequency Adjustment
2. Frequency Adjustment	9. -V <sub>CC</sub> , -15VDC
3. Frequency Adjustment	10. +V <sub>CC</sub> , +15VDC
4. +In, Uncommitted Op Amp	11. Common
5. -In, Uncommitted Op Amp	12. Frequency Adjustment
6. Output, Uncommitted Op Amp	13. Frequency Adjustment
7. E <sub>2</sub> , Cosine Output	14. Frequency Adjustment



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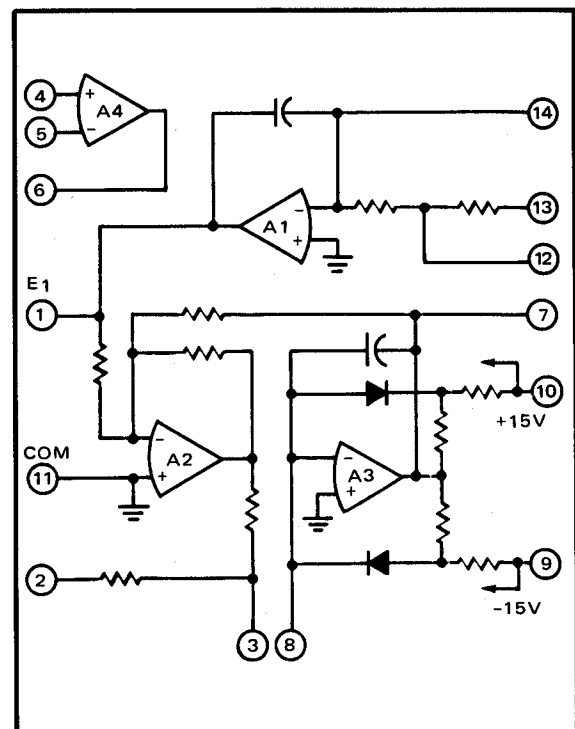


FIGURE 1. Equivalent Circuit.

# TYPICAL PERFORMANCE CURVES

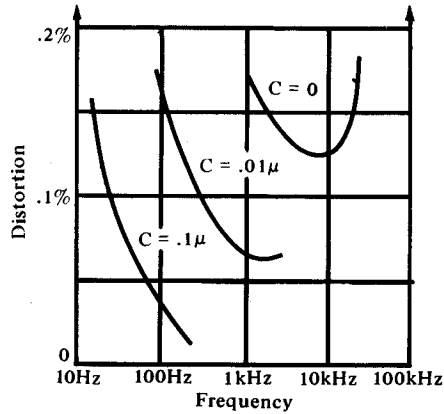


FIGURE 2.

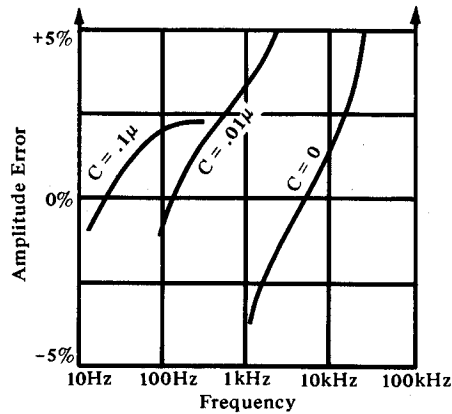


FIGURE 3.

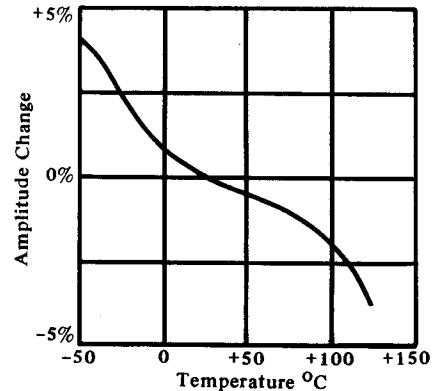


FIGURE 4.

## EXTERNAL CONNECTIONS

### 1. 20 kHz Quadrature Oscillator

The 4423 does not require any external component to obtain a 20 kHz quadrature oscillator. The connection diagram is as shown in Figure 5.

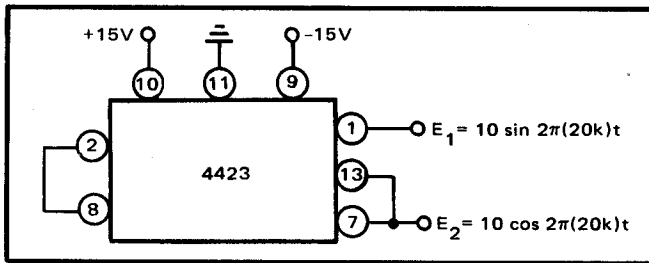


FIGURE 5.

### 2. Resistor Programmable Quadrature Oscillator

For resistor programmable frequencies in the 2 kHz to 20 kHz frequency range, the connection diagram is shown in Figure 6. Note that only two resistors of equal value are required. The resistor R can be expressed by,

$$R = \frac{3.785f}{42.05 - 2f} \quad , R \text{ in } k\Omega \quad f \text{ in } kHz$$

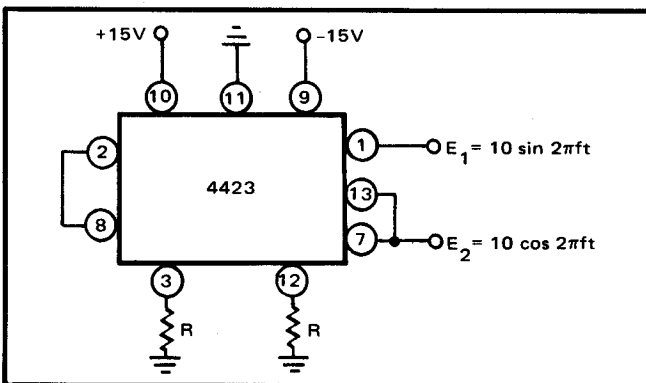


FIGURE 6.

### 3. Quadrature Oscillator Programmable to 0.002 Hz

For oscillator frequencies below 2000 Hz, use of two capacitors of equal value and two resistors of equal value as shown in Figure 7 is recommended. Connections shown in Figure 7 can be used to get oscillator frequency in the 0.002 Hz to 20 kHz range.

The frequency f can be expressed by:

$$f = \frac{42.05 R}{(C + 0.001) (3.785 + 2R)}$$

where, f is in Hz  
C is in  $\mu F$   
and R is in  $k\Omega$

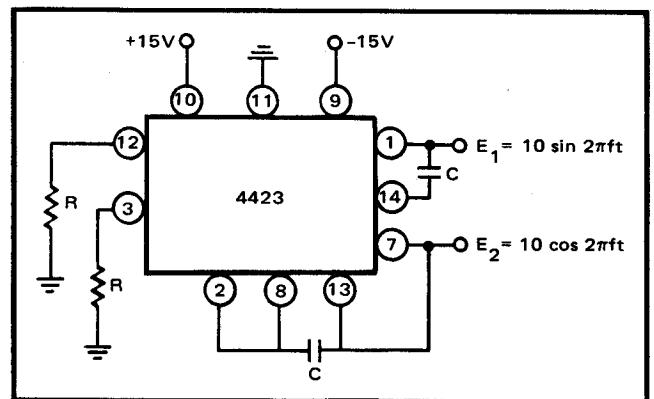


FIGURE 7.

For best results, the capacitor values shown in Table I should be selected with respect to their frequency ranges.

f	20 kHz to 2 kHz	2 kHz to 200 Hz	200 Hz to 20 Hz
C	0	0.01 $\mu F$	0.1 $\mu F$
20 Hz to 2 Hz	2 Hz to 0.2 Hz	0.2 Hz to 0.02 Hz	0.02 Hz to 0.002 Hz
1 $\mu F$	10 $\mu F$	100 $\mu F$	1000 $\mu F$

TABLE I.

After selecting the capacitor for a particular frequency the value of the required resistor can be obtained by using the resistor selection curve shown in Figure 8 or by the expression:

$$R = \frac{3.785f (C + 0.001)}{42.05 - 2f (C + 0.001)}$$

where,  
R is in  $k\Omega$   
f is in Hz  
and C is in  $\mu F$

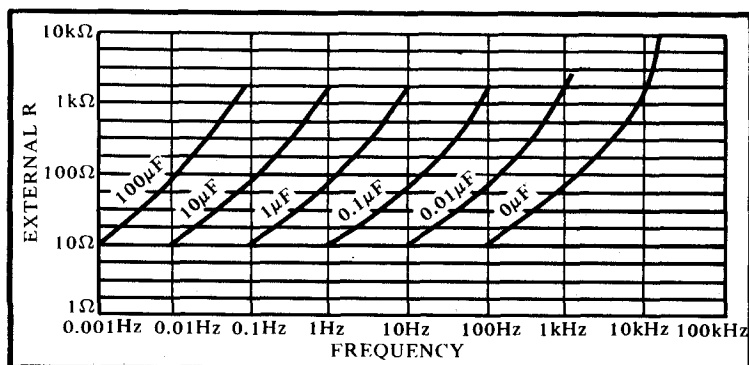


FIGURE 8.

The curves shown in Figure 8 are provided only as a nomographic design aid. The selection of capacitor values is not limited to the values shown in Figure 8. Any suitable combination of R and C values which satisfies the expression relating R, F and C as shown above, would work satisfactorily with the 4423.

#### NOTES ON TYPES OF CAPACITORS TO USE:

There are various kinds of capacitors available for use. There are polarized, also known as DC capacitors and non-polarized, also known as AC capacitors available. Of these two types, the polarized capacitors cannot be used with 4423 to set the frequencies.

Commonly available non-polarized capacitors include NPO ceramic, silver mica, teflon, polystyrene, polycarbonate, mylar, ceramic disc etc. A comparison is shown in Table II.

	Capacitance Range ( $\mu\text{F}$ )	Temperature Coefficients ppm/ $^{\circ}\text{C}$	Dissipation Factor (%)
NPO Ceramic	5pF - 0.1 $\mu\text{F}$	30	0.05
Silver Mica	5pF - 0.047 $\mu\text{F}$	60	0.05
Teflon	0.001 - 100 $\mu\text{F}$	200	0.01
Polystyrene	0.001 - 500 $\mu\text{F}$	100	0.03
Polycarbonate	0.001 - 1000 $\mu\text{F}$	90	0.08
Metalized Teflon	0.001 - 100 $\mu\text{F}$	60	0.1
Metalized Polycarbonate	0.001 - 1000 $\mu\text{F}$	10	0.4
Mylar	0.001 - 1000 $\mu\text{F}$	700	0.7
Metalized Mylar	0.001 - 2000 $\mu\text{F}$	700	1
Ceramic Disc	5pF - 0.5 $\mu\text{F}$	10,000	3

TABLE II.

For use with the 4423 oscillator, the choice of capacitors depends mainly on the user's application, error budget and cost budget. Note that the specifications of 4423 do not include the error contribution of the external components. The errors sourced by external components normally have to be added to the 4423 specifications.

As a general selection criteria we recommend the use of the above table. Start from the top of the list in the above table. If the capacitor is found unsuitable due to it being too large in size, too expensive, or is not easily available, then move down in the list for the next best selection. In any case do not choose or use any capacitors with dissipation factors greater than 1%. Such a capacitor would stop 4423 oscillation.

#### DISSIPATION FACTOR (DF)

A capacitor can be modeled by an ideal capacitor in parallel with an internal resistor whose value depends on its dissipation factor (DF). Mathematically, the internal resistor R is given by,

$$R = \frac{1}{2\pi f C(\text{DF})}$$

where R is in  $\Omega$ , f is the Hz, and C is in farads.

For example, the DF of ceramic disc capacitors is of the order of 3%, which for a 0.01  $\mu\text{F}$  capacitor would look like having an internal resistor of 530k $\Omega$  at 1 kHz. The 530 k $\Omega$  value resistor is small enough to stop the 4423 oscillator from oscillating.

Some capacitor manufacturers use the terms "Power Factor" (PF) or "Q Factor" (Q) instead of the term "Dissipation Factor". These terms are similar in meaning and are mathematically related by,

$$(\text{PF}) = \frac{(\text{DF})}{\sqrt{1 + (\text{DF})^2}} ; \quad Q = \frac{1}{(\text{DF})}$$

#### OSCILLATION AMPLITUDE

It takes a finite time to build up the amplitude of the oscillation to its final full scale value. There is a relationship between the amplitude build-up time and the frequency. The lower the frequency, the longer the amplitude build-up time. For example, typically it takes 250 seconds at 1 Hz, 30 seconds at 10 Hz, 4 seconds at 100 Hz, 400 milliseconds at 1 kHz, and 40 milliseconds at 10 kHz oscillator frequencies.

There are two methods available to shorten this normal amplitude build-up time. But there is also a relationship between the amplitude build-up time and distortion at final amplitude value. When the amplitude build-up time is shortened, the distortion can get worse.

One method to shorten the amplitude build-up time is to connect a resistor between pin 3 and pin 14. The lower this resistor is the shorter will be the time to build up amplitude of the oscillation, and worse will be the distortion of the output waveform. For example, a 100k $\Omega$  resistor would shorten the amplitude build up time from 15 seconds to 1 second at 20 Hz frequency, but the distortion could be degraded from typically 0.05% to 0.5%.

The other method is to momentarily insert a 1k $\Omega$  resistor via a reset switch between pin 3 and pin 14. The amplitude of oscillation is built up instantaneously when the reset switch is pushed. There will be no degradation of distortion with this method since the 1k $\Omega$  resistor does not remain in the circuit continuously.

**PACKAGING INFORMATION**

ORDERABLE DEVICE	STATUS(1)	PACKAGE TYPE	PACKAGE DRAWING	PINS	PACKAGE QTY
4423P	NRND	PDIP	NSQ	14	50

(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.

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

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