



### Description

The MK2049 is a Phase-Locked Loop (PLL) based clock synthesizer, which accepts an 8 kHz clock input as a reference and generates T1, E1, T3, E3, and OC3 frequencies. The device can also accept a T1, E1, T3, or E3 input clock and provide the same output for loop timing. All outputs are frequency locked together and to the input. This allows for the generation of locked clocks to an 8 kHz backplane clock, simplifying clock distribution in communications systems.

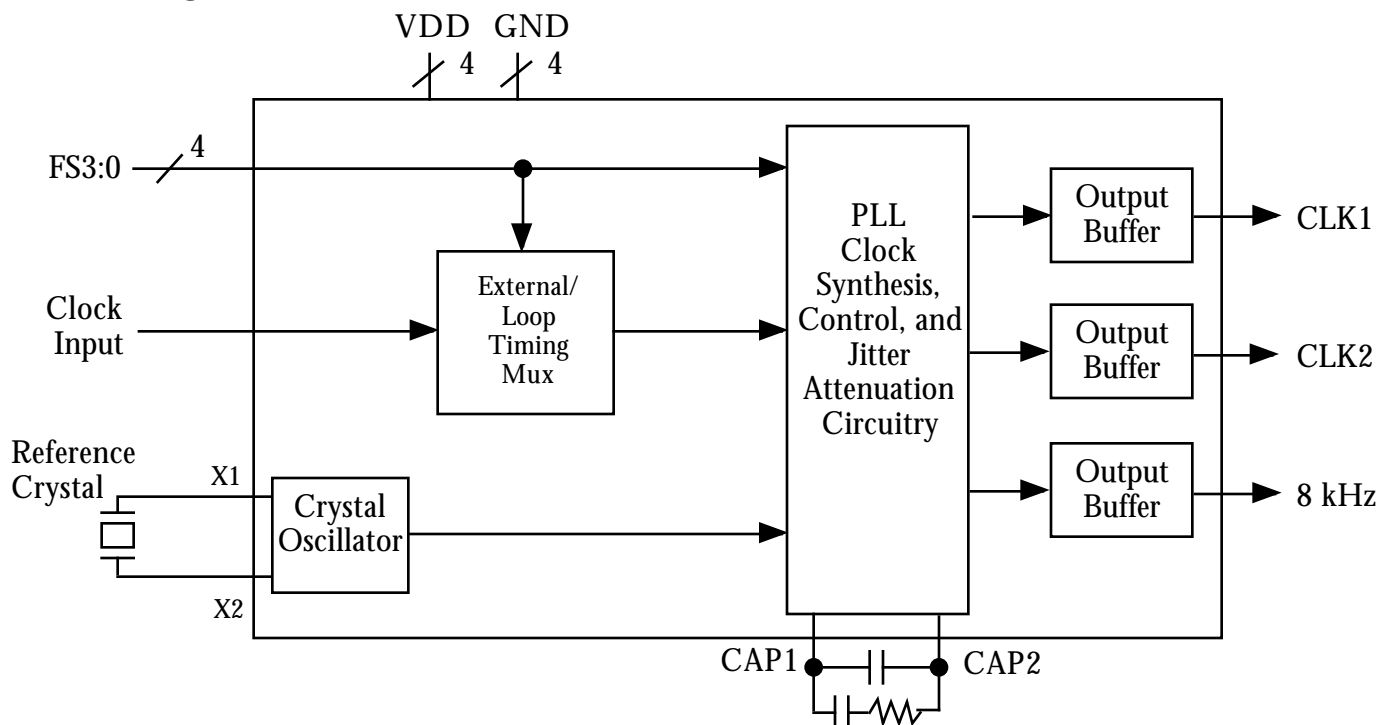
MicroClock can customize this device for many other different frequencies. Contact your MicroClock representative for more details.

For a fixed input-output phase relationship, refer to the MK2049-02, -03, or -3x. The MK2049-3x are 3.3 V devices.

### Features

- Packaged in 20 pin SOIC
- Meets the TR62411, ETS300 011, and GR-1244 specification for MTIE, Pull-in/Hold-in Range, Phase Transients, and Jitter Generation for Stratum 3, 4, and 4E
- Accepts multiple inputs: 8 kHz backplane clock or Loop Timing frequencies
- Locks to 8 kHz  $\pm 100$  ppm (External mode)
- Exact internal ratios eliminate the need for external dividers
- Zero ppm synthesis error in all output clocks.
- Output clock rates include T1, E1, T3, E3, and OC3÷8
- 5 V  $\pm 5\%$  operation
- Offered in Commercial and Industrial temperature versions

### Block Diagram





## Pin Assignment

FS1 <input type="checkbox"/>	1		20	FS0 <input type="checkbox"/>
X2 <input type="checkbox"/>	2		19	GND <input type="checkbox"/>
X1 <input type="checkbox"/>	3		18	CAP2 <input type="checkbox"/>
VDD <input type="checkbox"/>	4		17	GND <input type="checkbox"/>
VDD <input type="checkbox"/>	5		16	CAP1 <input type="checkbox"/>
VDD <input type="checkbox"/>	6		15	VDD <input type="checkbox"/>
GND <input type="checkbox"/>	7		14	GND <input type="checkbox"/>
CLK2 <input type="checkbox"/>	8		13	ICLK <input type="checkbox"/>
CLK1 <input type="checkbox"/>	9		12	FS3 <input type="checkbox"/>
8K <input type="checkbox"/>	10		11	FS2 <input type="checkbox"/>

20 pin (300 mil) SOIC

## Output Decoding Table – External Mode (MHz)

Input	FS3	FS2	FS1	FS0	CLK1	CLK2	Crystal
8 kHz	0	0	0	0	1.544	3.088	12.288
8 kHz	0	0	0	1	2.048	4.096	12.288
8 kHz	0	0	1	0	22.368	44.736	12.288
8 kHz	0	0	1	1	17.184	34.368	12.288
8 kHz	0	1	1	1	19.44	38.88	12.96

## Output Decoding Table – Loop Timing Mode (MHz)

Input	FS3	FS2	FS1	FS0	CLK1	CLK2	Crystal
1.544	1	0	0	0	1.544	3.088	12.288
2.048	1	0	0	1	2.048	4.096	12.288
44.736	1	0	1	0	22.368	44.736	12.288
34.368	1	0	1	1	17.184	34.368	12.288

- 0 = connect directly to ground, 1 = connect directly to VDD.
- Crystal is applied to pins 2 and 3; clock input is applied to pin 13.

## Pin Descriptions

Number	Name	Type	Description
1	FS1	I	Frequency Select 1. Determines CLK input/outputs per tables above.
2	X2	O	Crystal connection. Connect to a 12.288 MHz or 12.96 MHz crystal.
3	X1	I	Crystal connection. Connect to a 12.288 MHz or 12.96 MHz crystal.
4	VDD	P	Connect to +5V.
5	VDD	P	Connect to +5V.
6	VDD	P	Connect to +5V.
7	GND	P	Connect to ground.
8	CLK2	O	Clock 2 output determined by status of FS3:0 per tables above.
9	CLK1	O	Clock 1 output determined by status of FS3:0 per tables above. CLK2 divided by 2.
10	8K	O	Recovered 8 kHz clock output. On External mode only.
11	FS2	I	Frequency Select 2. Determines CLK input/outputs per tables above.
12	FS3	I	Frequency Select 3. Determines CLK input/outputs per tables above.
13	ICLK	I	Input clock connection. Connect to 8 kHz backplane or to Loop Timing clock.
14	GND	P	Connect to ground.
15	VDD	P	Connect to +5V.
16	CAP1	LF	Connect a 0.030 $\mu$ F ceramic capacitor and a 7.5 M $\Omega$ resistor in series between this pin and CAP2.
17	GND	P	Connect to ground.
18	CAP2	LF	Connect a 0.030 $\mu$ F ceramic capacitor and a 7.5 M $\Omega$ resistor in series between this pin and CAP1.
19	GND	P	Connect to ground.
20	FS0	I	Frequency Select 0. Determines CLK input/outputs per tables above.

Type: I = Input, O = output, P = power supply connection, LF = loop filter connection



### Electrical Specifications

Parameter	Conditions	Minimum	Typical	Maximum	Units
<b>ABSOLUTE MAXIMUM RATINGS (Note 1)</b>					
Supply Voltage, VDD	Referenced to GND			7	V
Inputs and Clock Outputs		-0.5		VDD+0.5	V
Ambient Operating Temperature		0		70	°C
	MK2049-01SI only	-40		85	°C
Soldering Temperature	Max of 10 seconds			250	°C
Storage Temperature		-65		150	°C
<b>DC CHARACTERISTICS (VDD = 5 V unless noted)</b>					
Operating Voltage, VDD		4.75		5.25	V
Input High Voltage, VIH		2			V
Input Low Voltage, VIL				0.8	V
Output High Voltage	IOH=-4mA	VDD-0.4			V
Output High Voltage	IOH=-25mA	2.4			V
Output Low Voltage	IOL=25mA			0.4	V
Operating Supply Current, IDD	No Load, VDD=5.0V		20		mA
Short Circuit Current	Each output		±100		mA
Input Capacitance, FS3:0			7		pF
<b>AC CHARACTERISTICS (VDD = 5 V unless noted)</b>					
Input Frequency, External Mode	ICLK		8.0000		kHz
Input Crystal Frequency	X1, X2		12.2880		MHz
Input Crystal Frequency	X1, X2. Selection 0111		12.9600		MHz
Output Clock Rise Time	0.8 to 2.0V			1.5	ns
Output Clock Fall Time	2.0 to 0.8V			1.5	ns
Output Clock Duty Cycle, High Time	At VDD/2	40	49 to 51	60	%
Actual mean frequency error versus target	Any clock selection		0	0	ppm

Notes:

- Stresses beyond those listed under Absolute Maximum Ratings could cause permanent damage to the device. Prolonged exposure to levels above the operating limits but below the Absolute Maximums may affect device reliability.



### OPERATING MODES

The MK2049-01 has two operating modes: External and Loop Timing. Although both modes use an input clock to generate various output clocks, there are important differences in their input requirements.

#### External Mode

The MK2049-01 accepts an external 8 kHz clock and will produce a number of common communication clock frequencies. The 8 kHz input clock does not need to have a 50% duty cycle; a “high” or “on” pulse as narrow as 10 ns is acceptable.

#### Loop Timing Mode

This mode can be used to remove the jitter from standard high-frequency communication clocks. For T1 and E1 inputs, the CLK1 output will be the same as the input frequency, with CLK2 at twice the input frequency. For T3 and E3 inputs, CLK1 will be 1/2 the input frequency and CLK2 will be the same as the input frequency.

### FREQUENCY LOCKING TO THE INPUT

In both modes, the output clocks are frequency-locked to the input. The output will remain at the specified output frequency as long as the combined variation of the input frequency and the crystal does not exceed 100 ppm. For example, if the crystal can vary  $\pm 40$  ppm (initial accuracy + temperature + aging), then the input frequency can vary by up to 60 ppm and still have the output clock remain frequency-locked.

### INPUT AND OUTPUT SYNCHRONIZATION

The rising edges of CLK1 and CLK2 do not have a fixed phase alignment with the rising edge of ICLK. Each time the device is powered-up, the phase relationship could change. Refer to one of the other MK2049 versions (e.g., MK2049-02, -03, -34) if input-output phase alignment is important in your application.



## LAYOUT AND EXTERNAL COMPONENTS

The MK2049-01 requires a minimum number of external components for proper operation. Decoupling capacitors of  $0.01\mu\text{F}$  must be connected between VDD and GND pins close to the chip (especially pins 4 and 7, 15 and 17), and 33 series terminating resistors should be used on clock outputs with traces longer than 1 inch (assuming 50 traces). The loop filter components should be connected as close to the chip as possible. Refer to the next section for more information.

### PC Board Layout

A proper board layout is critical to the successful use of the MK2049. In particular, the CAP1 and CAP2 pins are very sensitive to noise and leakage (CAP2 at pin 18 is the most sensitive). Traces must be as short as possible and the two capacitors and resistor must be mounted next to the device as shown below. The capacitor shown between pins 15 and 17, and the one between pins 5 and 7 are the power supply decoupling capacitors. The high frequency output clocks on pins 8 and 9 should have a series termination of 33 connected close to the pin. Additional improvements will come from keeping all components on the same side of the board, minimizing vias through other signal layers, and routing other signals away from the MK2049. You may also refer to MAN05 for additional suggestions on layout of the crystal section.

The crystal traces should include pads for small capacitors from X1 and X2 to ground; these are used to adjust the stray capacitance of the board to match the crystal load capacitance. The typical telecom reference frequency is accurate to much less than 1 ppm, so the MK2049 may lock and run properly even if the board capacitance is not adjusted with these fixed capacitors. However, ICS MicroClock recommends that the adjustment capacitors be included to minimize the effects of variation in individual crystals, temperature, and aging. The value of these capacitors (typically 0-4 pF) is determined once for a given board layout, using the procedure described later in this section, titled "Determining the Crystal Frequency Adjustment Capacitors".

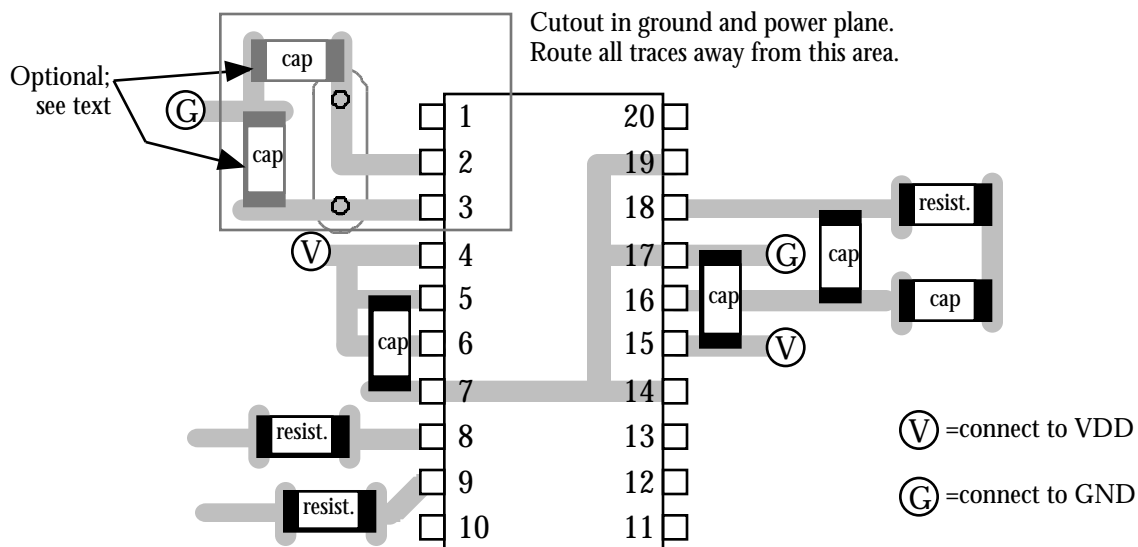


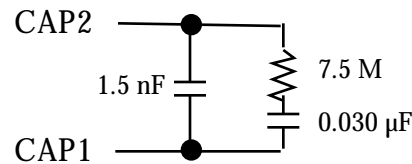
Figure 1. MK2049-01 Layout Example



## LAYOUT AND EXTERNAL COMPONENTS (continued)

### Loop Filter Components

The external loop filter should be connected between CAP1 and CAP2 as shown in Figure 2 below, and as close to the chip as possible. Be sure to follow the recommendations on capacitor types described on page 6.



**Figure 2. Loop Filter component values for most configurations**  
Typical component values are shown. Contact the ICS MicroClock applications department at (408)297-1201 for the recommended values for your application.

### Crystal Operation

The MK2049 operates by phase locking the input signal to a VCXO which consists of the special recommended crystal and the integrated VCXO oscillator circuit on the MK2049. To achieve the best performance and reliability, the layout guidelines shown on the previous page must be closely followed.

The frequency of oscillation of a quartz crystal is determined by its cut and by the load capacitors connected to it. The MK2049 has variable load capacitors on-chip which “pull”, or change the frequency of the crystal. External stray capacitance must be kept to a minimum to ensure maximum pullability of the crystal. To achieve this, the layout should use short traces between the MK2049 and the crystal.



LAYOUT AND EXTERNAL COMPONENTS (continued)

Crystal Specifications

Parameter	Minimum	Typical	Maximum	Units
Operating Temperature Range	0	25	70	°C
Initial Accuracy at 25 C	-20		20	ppm
Temperature stability	-30		30	ppm
Aging, first year	-5		5	ppm
Aging, 10 years	-20		20	ppm
Load Capacitance		Note 1		
Shunt Capacitance, C0			7	pF
Motional Capacitance, C1	none		none	pF
C0/C1 ratio			250	none
Equivalent Series Resistance			35	Ohms

\*This ratio decreases for lower crystal frequencies.

- Note 1: Nominal crystal load capacitance specification varies with frequency.  
Contact the ICS MicroClock applications department at (408)297-1201.
- Note 2: The third overtone mode of the crystal and all spurs must be >200 ppm  
away from 3x the fundamental resonance shown in the table below.

For recommended crystal devices, please contact the ICS MicroClock application department at 408-297-1201.



## LAYOUT AND EXTERNAL COMPONENTS (continued)

### Determining the Crystal Frequency Adjustment Capacitors

To determine the crystal adjustment capacitor values, you will need a PC board of your final layout, a frequency counter capable of less than 1 ppm resolution and accuracy, two power supplies, and some samples of the crystals which you plan to use in production, along with measured initial accuracy for each crystal at the specified load capacitance,  $C_L$ .

To determine the value of the crystal capacitors:

1. Connect VDD of the MK2049 to 5.0 V. Connect pin 18 of the MK2049 to the second power supply. Adjust the voltage on pin 18 to 0.0 V. Measure and record the frequency of the CLK1 or CLK2 output.
2. Adjust the voltage on pin 18 to 3.0 V. Measure and record the frequency of the same output.

To calculate the centering error:

$$\text{Centering error} = 10^6 \left[ \frac{(f_{3.0V} - f_{\text{target}}) + (f_{0.0V} - f_{\text{target}})}{f_{\text{target}}} \right] - \text{error}_{\text{xtal}}$$

Where  $f_{\text{target}} = 44.736000$  MHz, for example, and  $\text{error}_{\text{xtal}}$  = actual initial accuracy (in ppm) of the crystal being measured.

If the centering error is less than  $\pm 15$  ppm, no adjustment is needed. If the centering error is more than 15 ppm negative, the PC board has too much stray capacitance and will need to be redone with a new layout to reduce stray capacitance. (The crystal may be re-specified to a lower load capacitance instead. Contact ICS MicroClock for details.) If the centering error is more than 15 ppm positive, add identical fixed centering capacitors from each crystal pin to ground. The value for each of these caps (in pF) is given by:

$$\text{External Capacitor} = 2 * (\text{centering error}) / (\text{trim sensitivity})$$

Trim sensitivity is a parameter which can be supplied by your crystal vendor. If you do not know the value, assume it is 30 ppm/pF. After any changes, repeat the measurement to verify that the remaining error is acceptably low (less than  $\pm 15$  ppm).

The MicroClock Applications department can perform this procedure on your board. Call us at 408-295-9800, and we will arrange for you to send us a PC board (stuffed or unstuffed) and one of your crystals. We will calculate the value of capacitors needed.





Input Jitter Modulation Frequency (Hz)	Input Jitter Magnitude (UIp-p)	Measured Jitter Output (UIp-p)	
		Output Jitter Magnitude (UIp-p)	Jitter Attenuation (dB)
10	10	1.07	19.41
20	10	0.56	25.04
40	10	0.36	28.87
100	10	0.147	36.65
400	10	0.037	48.64
1000	10	0.016	55.92
2000	10	0.01	60.00
4000	10	0.01	60.00
8000	10	0.01	60.00
10000	10	0.01	60.00
16000	7.75	0.01	57.79
32000	3.98	0.01	52.00
64000	1.74	0.01	44.81

Table 1. Jitter results for a T1 (1.544 MHz) reference frequency, as measured on the HP3785B (10 Hz - 40 kHz output filter).

Input Jitter Modulation Frequency (Hz)	Input Jitter Magnitude (UIp-p)	Measured Jitter Output (UIp-p)	
		Output Jitter Magnitude (UIp-p)	Jitter Attenuation (dB)
100	10.5	0.071	43.4
400	10.5	0.07	43.52
1000	10.5	0.144	37.26
2000	10.5	0.12	38.84
4000	10.5	0.08	42.36
8000	10.5	0.07	43.52
10000	10.5	0.066	44.03
16000	10.5	0.065	44.17
32000	10.5	0.06	44.86
64000	10.5	0.06	44.86
128000	10.5	0.058	45.16
192000	10.5	0.06	44.86
256000	10.5	0.062	44.58

Table 2. Jitter results for a T3 (44.736 MHz) reference frequency, as measured on the HP3785B (10 Hz -1.1 MHz output filter).



Input Jitter Modulation Frequency (Hz)	Input Jitter Magnitude (UIp-p)	Measured Jitter Output (UIp-p)	
		Output Jitter Magnitude (UIp-p)	Jitter Attenuation (dB)
20	1.5	0.018	38.42
50	1.5	0.014	40.60
100	1.5	0.01	43.52
200	1.5	0.01	43.52
500	1.5	0.007	46.62
1000	1.5	0.006	47.96
2000	1.5	0.006	47.96
5000	0.72	0.006	41.58
10000	0.36	0.006	35.56
15000	0.24	0.006	32.04
25000	0.20	0.006	30.46
50000	0.20	0.006	30.46
75000	0.20	0.006	30.46

Table 3. Jitter results for an E1 (2.048 MHz) reference frequency, as measured on the HP3785A (100 Hz -800 kHz output filter).

Input Jitter Modulation Frequency (Hz)	Input Jitter Magnitude (UIp-p)	Measured Jitter Output (UIp-p)	
		Output Jitter Magnitude (UIp-p)	Jitter Attenuation (dB)
100	1.5	0.113	22.46
200	1.5	0.094	24.06
500	1.5	0.077	25.79
1000	1.5	0.069	26.74
2000	1.5	0.07	26.62
5000	0.72	0.068	20.5
10000	0.36	0.007	34.22
15000	0.24	0.007	30.7
25000	0.2	0.007	29.12
50000	0.2	0.007	29.12
75000	0.2	0.007	29.12
100000	0.2	0.007	29.12

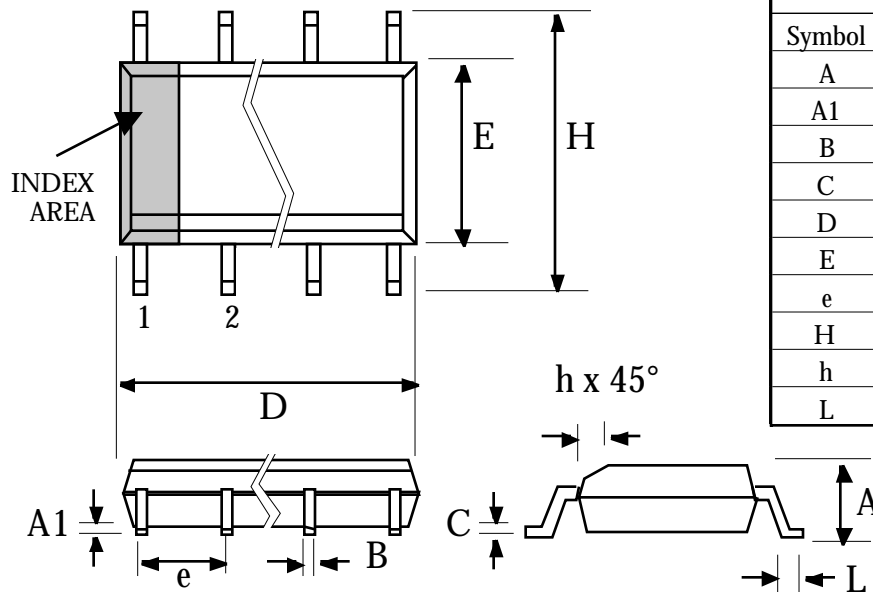
Table 4. Jitter results for an E3 (34.368 MHz) reference frequency, as measured on the HP3785A (100 Hz - 800 kHz output filter).



## Package Outline and Package Dimensions

(For current dimensional specifications, see JEDEC Publication No. 95.)

### 20 pin SOIC



Symbol	Inches		Millimeters	
	Min	Max	Min	Max
A	--	0.104	--	2.65
A1	0.0040	--	0.10	--
B	0.013	0.020	0.33	0.51
C	0.007	0.013	0.18	0.33
D	0.496	0.512	12.60	13.00
E	0.291	0.299	7.40	7.60
e	.050 BSC		1.27 BSC	
H	0.394	0.419	10.01	10.64
h	0.01	0.029	0.25	0.74
L	0.016	0.050	0.41	1.27

## Ordering Information

Part/Order Number	Marking	Package	Temperature
MK2049-01S	MK2049-01S	20 pin SOIC	0 to 70 °C
MK2049-01STR	MK2049-01S	Add Tape & Reel	0 to 70 °C
MK2049-01SI	MK2049-01SI	20 pin SOIC	-40 to 85 °C
MK2049-01SITR	MK2049-01SI	Add Tape & Reel	-40 to 85 °C

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