19-3876; Rev 0; 5/06

# Precision Silicon Oscillators with Enable or Autoenable



## General Description

The MAX7393/MAX7394 precision silicon oscillators replace crystals, ceramic resonators, and crystal oscillator modules in systems with a +2.4V to +3.6V operating supply voltage range.

The MAX7393/MAX7394 consist of a temperature-compensated precision oscillator with enable (MAX7394) or autoenable (MAX7393). The MAX7393/MAX7394 are supplied at specific frequencies, just like crystals and resonators. Output frequency accuracy is guaranteed to be within ±0.25% (TDFN) and ±1.3% (µDFN) (0°C to +85°C) and ±1.0% (TDFN) and ±1.8% (µDFN) over the -40°C to +125°C temperature range.

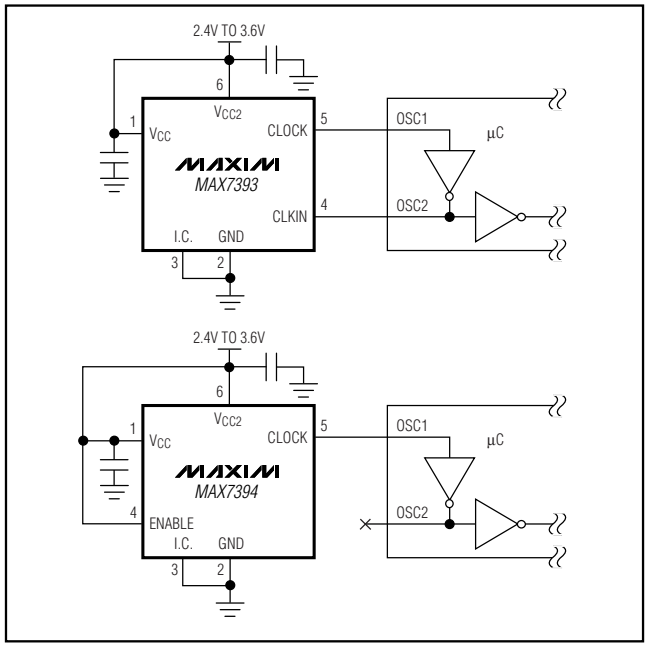
The small size and robust operation of the MAX7393/MAX7394 make them ideal for space-constrained or environmentally demanding applications where high accuracy is required. The high accuracy of the MAX7393/MAX7394 is ideal for use in USB applications, computers, and white goods.

The MAX7393/MAX7394 are available in 6-pin, 3mm x 3mm TDFN and 2mm x 2mm µDFN packages. They are specified for the -40°C to +125°C temperature range.

## Applications

USB
CAN Nodes
Automotive Systems
Computers
Handheld Products
White Goods

## Typical Application Circuits




## Features

- ±0.25% (TDFN) and ±1.3% (µDFN) Total Accuracy for 0°C to +85°C
- ±1.0% (TDFN) and ±1.8% (µDFN) Total Accuracy for -40°C to +125°C
- Resistant to Humidity and Vibration
- 12mA Operating Current (48MHz Version)
- 5ns Output Rise/Fall Time
- 40% to 60% Maximum Duty Cycle
- No External Components Required
- +2.4V to +3.6V Operation
- Available Factory-Set Frequencies from 922kHz to 48MHz
- Space-Saving TDFN and µDFN Surface-Mount Packages

## Ordering Information

| PART* | TEMP RANGE | PIN-PACKAGE | PKG CODE |
|---|---|---|---|
| **MAX7393**ALT_ _+ | -40°C to +125°C | 6 µDFN | L622-1 |
| MAX7393ATT_ _+ | -40°C to +125°C | 6 TDFN | T633-1 |
| **MAX7394**ALT_ _+ | -40°C to +125°C | 6 µDFN | L622-1 |
| MAX7394ATT_ _+ | -40°C to +125°C | 6 TDFN | T633-1 |

**The two-letter frequency suffix following the part number is found in the* Selector Guide.
*+Denotes lead-free package.*

***Note:*** *The MAX7394 is available in factory-set frequencies from 922kHz to 48MHz. The MAX7393 is available in factory-set frequencies from 922kHz to 20MHz. There are 10 standard frequencies (see the* Selector Guide*) with a required 2.5k order increment. Nonstandard frequencies are also available with a required 10k order increment. For nonstandard versions, contact factory for availability and ordering information.*

***Selector Guide and Pin Configurations appear at end of data sheet.***



***For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at 1-888-629-4642, or visit Maxim's website at www.maxim-ic.com.***

# Precision Silicon Oscillators with Enable or Autoenable

## ABSOLUTE MAXIMUM RATINGS

$V_{CC}$, $V_{CC2}$ to GND.....-0.3V to +4.0V
CLOCK, CLKIN, ENABLE, I.C. to GND .....-0.3V to ($V_{CC}$ + 0.3V)
CLOCK Output Current .....±50mA
Continuous Power Dissipation ($T_A$ = +70°C)
6-Pin µDFN (derate 4.5mW/°C over +70°C) .....358mW
6-Pin TDFN (derate 18.2mW/°C over +70°C) .....1455mW
Operating Temperature Range .....-40°C to +125°C
Junction Temperature.....+150°C
Storage Temperature Range .....-65°C to +150°C
Lead Temperature (soldering, 10s) .....+300°C

*Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.*

## ELECTRICAL CHARACTERISTICS

($V_{CC}$ = $V_{CC2}$ = +2.4V to +3.6V, $C_L$ = 10pF, $T_A$ = -40°C to +125°C, unless otherwise noted. Typical values are at $V_{CC}$ = $V_{CC2}$ = +3.3V, $T_A$ = +25°C, unless otherwise noted.) (Note 1)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| **DC CHARACTERISTICS** | | | | | | |
| Operating Supply Voltage | $V_{CC}$ | | 2.4 | | 3.6 | V |
| Operating Output Supply Voltage | $V_{CC2}$ | | 2.4 | | 3.6 | V |
| Total Operating Supply Current (Note 2) | $I_{TOT}$ | 922kHz, MAX739_ _ _ _LY | | | 4.4 | mA |
| | | 4MHz, MAX739_ _ _ _RD | | | 5.4 | |
| | | 8MHz, MAX739_ _ _ _TP | | | 5.8 | |
| | | 16MHz, MAX739_ _ _ _WB | | | 6.5 | |
| | | 32MHz, MAX7394_ _ _ YN | | | 9.2 | |
| | | 33MHz, MAX7394_ _ _ YQ | | | 9.5 | |
| | | 48MHz, MAX7394_ _ _ ZY | | | 12 | |
| Total Shutdown Supply Current | $I_{SHDN}$ | Oscillator disabled, CLKIN = high (MAX7393), ENABLE = low (MAX7394) (Note 2) | | 1 | 2 | µA |
| **LOGIC INPUTS (ENABLE, CLKIN)** | | | | | | |
| Logic Input High Voltage | $V_{IH}$ | | 0.7 x $V_{CC2}$ | | | V |
| Logic Input Low Voltage | $V_{IL}$ | | | | 0.3 x $V_{CC2}$ | V |
| **CLOCK OUTPUT** | | | | | | |
| Output High Voltage | $V_{OH}$ | $V_{CC2}$ ≥ 2.4V, $I_{SOURCE}$ = 5mA | $V_{CC2}$ - 0.3 | | | V |
| Output Low Voltage | $V_{OL}$ | $V_{CC2}$ ≥ 2.4V, $I_{SINK}$ = 5mA | | | 0.3 | V |
| Output Rise Time | $t_R$ | (Note 3) | | 5 | | ns |
| Output Fall Time | $t_F$ | (Note 3) | | 5 | | ns |
| Duty Cycle | | (Note 3) | | 47 | | % |
| Startup Time | | Time for output to stabilize | | 2 | | ms |
| Output Jitter (Note 3) | | Peak-to-peak jitter, 16MHz (MAX7394) | | 180 | | ps |
| | | Peak-to-peak jitter, 48MHz (MAX7394) | | 140 | | |

## ELECTRICAL CHARACTERISTICS (continued)

($V_{CC}$ = $V_{CC2}$ = +2.4V to +3.6V, $C_L$ = 10pF, $T_A$ = -40°C to +125°C, unless otherwise noted. Typical values are at $V_{CC}$ = $V_{CC2}$ = +3.3V, $T_A$ = +25°C, unless otherwise noted.) (Note 1)

| PARAMETER | SYMBOL | CONDITIONS | | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|---|
| **FREQUENCY ACCURACY** | | | | | | | | |
| Clock Frequency Coefficient of Temperature | | $V_{CC}$ = $V_{CC2}$ = 3.3V | $T_A$ = 0°C to +70°C | | | ±20 | | ppm/°C |
| | | | $T_A$ = -40°C to +125°C | | | ±50 | | |
| Clock Frequency Coefficient of Supply Voltage | | $T_A$ = +25°C | | | | 0.1 | 0.15 | %/V |
| Total Accuracy | | $V_{CC}$ = $V_{CC2}$ = 3.3V | $T_A$ = 0°C to +85°C, $V_{CC}$ = ±10% | TDFN (Note 4) | | | ±0.25 | % |
| | | | | µDFN (Note 5) | | | ±1.3 | |
| | | | $T_A$ = -40°C to +125°C, $V_{CC}$ = ±10% | TDFN (Note 4) | | | ±1.0 | |
| | | | | µDFN (Note 5) | | | ±1.8 | |

**Note 1:** All parameters are production tested at $T_A$ = +25°C. Specifications over temperature are guaranteed by design and characterization.

**Note 2:** The total supply current is the sum of $I_{CC}$ and $I_{CC2}$.

**Note 3:** Guaranteed by design and characterization. Not production tested.

**Note 4:** Output frequency is production tested at $T_A$ = +25°C and $T_A$ = +85°C.

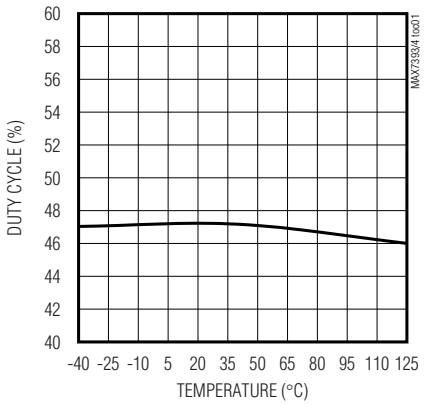
**Note 5:** Output frequency is production tested at $T_A$ = +25°C.

# Precision Silicon Oscillators with Enable or Autoenable

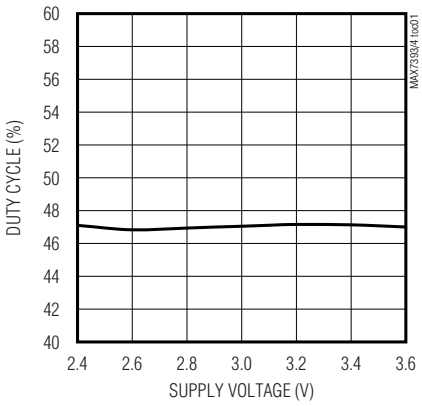
## Typical Operating Characteristics

($V_{CC}$ = $V_{CC2}$ = 3.3V, $T_A$ = +25°C, MAX7394, 48MHz output, unless otherwise noted.)

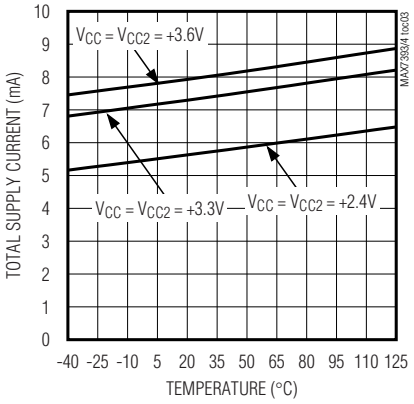
**DUTY CYCLE vs. TEMPERATURE**



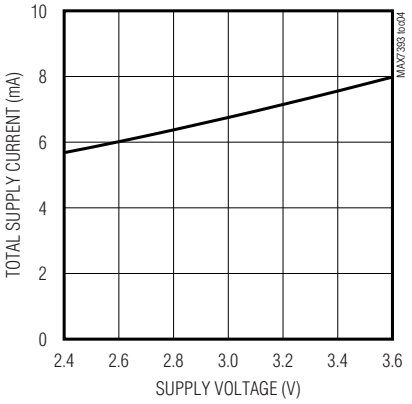

**DUTY CYCLE vs. SUPPLY VOLTAGE**



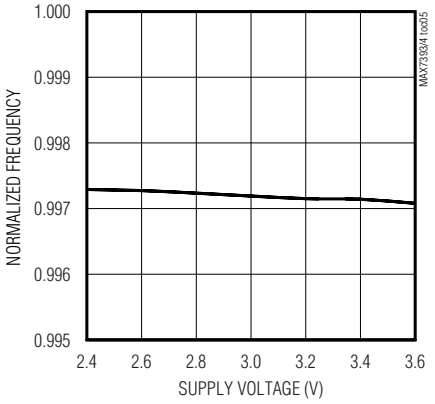

**TOTAL SUPPLY CURRENT vs. TEMPERATURE**



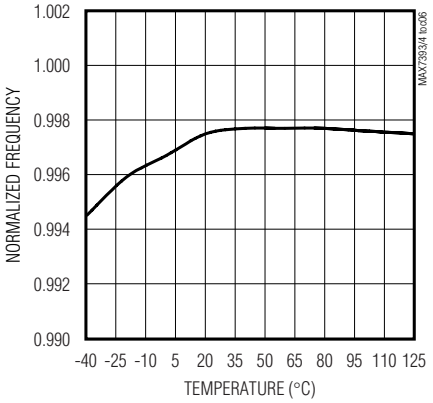

**TOTAL SUPPLY CURRENT vs. SUPPLY VOLTAGE**



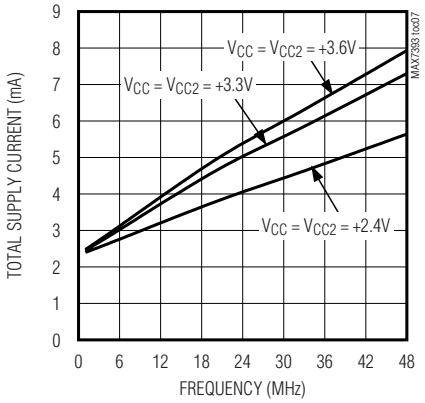

**NORMALIZED FREQUENCY vs. SUPPLY VOLTAGE**



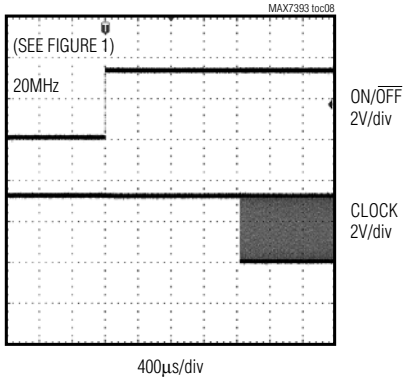

**NORMALIZED FREQUENCY vs. TEMPERATURE**




**TOTAL SUPPLY CURRENT vs. FREQUENCY**



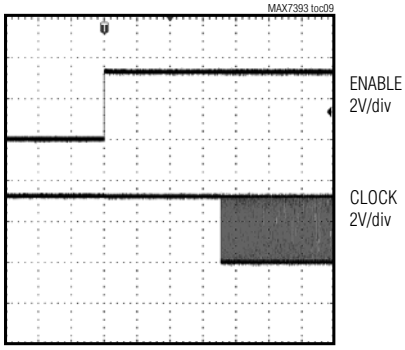

**MAX7393 SETTLING TIME FROM START**



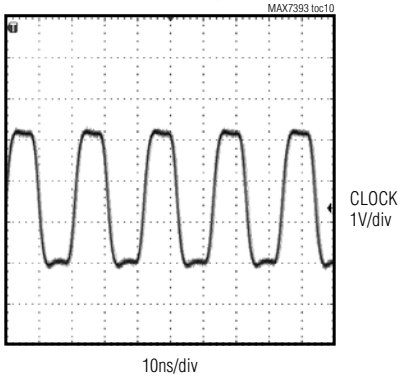
## Typical Operating Characteristics (continued)

($V_{CC}$ = $V_{CC2}$ = 3.3V, $T_A$ = +25°C, MAX7394, 48MHz output, unless otherwise noted.)

**MAX7394 SETTLING TIME FROM START**




**CLOCK OUTPUT WAVEFORM WITH $C_L$ = 10pF**




## Pin Description

| PIN | | NAME | FUNCTION |
|---|---|---|---|
| MAX7393 | MAX7394 | | |
| 1 | 1 | $V_{CC}$ | Positive Supply Voltage Input. Bypass $V_{CC}$ to GND with 0.1µF capacitors placed as close to the device as possible. Connect $V_{CC}$ to $V_{CC2}$. |
| 2 | 2 | GND | Ground |
| 3 | 3 | I.C. | Internally Connected. Connect I.C. to GND. Do not connect I.C. to any other input or output. Do not leave I.C. unconnected. |
| 4 | — | CLKIN | Clock Input. Connect CLKIN to a returned clock signal source (see the *Autoenable (CLKIN, MAX7393)* section). |
| 5 | 5 | CLOCK | Clock Output. CLOCK is a rail-to-rail, push-pull output. |
| 6 | 6 | $V_{CC2}$ | Positive Supply Voltage Input for Output Driver. Bypass $V_{CC2}$ to GND with a 0.1µF capacitor placed as close to the device as possible. Connect $V_{CC2}$ to $V_{CC}$. |
| — | 4 | ENABLE | Enable Input. Drive ENABLE low to place the MAX7394 in shutdown mode. Drive ENABLE high for normal operation. |
| — | — | EP | Exposed Paddle, TDFN Version Only. Connect EP to ground. Do not connect EP to any other input or output. |

# Precision Silicon Oscillators with Enable or Autoenable

## Detailed Description

The MAX7393/MAX7394 precision silicon oscillators replace crystals, ceramic resonators, and crystal oscillator modules in systems with a +2.4V to +3.6V operating supply voltage range. The MAX7393/MAX7394 consist of a temperature-compensated precision oscillator with enable (MAX7394) or autoenable (MAX7393). The ENABLE input on the MAX7394 manually enables or disables the oscillator. The CLKIN input on the MAX7393 monitors a returned clock signal to automatically enable or disable the MAX7393 oscillator.

The MAX7393/MAX7394 are supplied at specific frequencies, like crystals and resonators. A variety of popular standard frequencies are available (see the *Selector Guide*). Output frequency accuracy is guaranteed to be within ±0.25% (TDFN) and ±1.3% (µDFN) (0°C to +85°C) and ±1.0% (TDFN) and ±1.8% (µDFN) over the -40°C to +125°C temperature range. No external components are required to generate the specific frequency.

### ENABLE (MAX7394)

The ENABLE input on the MAX7394 turns the oscillator on and off. Drive ENABLE to a logic-high for normal operation. Drive ENABLE to a logic-low to place the device in shutdown mode. During shutdown, the oscillator is turned off, and the CLOCK output is weakly driven high with an internal 10kΩ to $V_{CC2}$. In shutdown mode, the total supply current reduces to less than 2µA.

### Autoenable (CLKIN, MAX7393)

The MAX7393 features a CLKIN input that automatically enables or disables the oscillator by sensing the condition of a returned clock signal. The MAX7393 is automatically enabled whenever an active inversion function is sensed between CLOCK and CLKIN. When no inversion function is detected, the MAX7393 automatically enters shutdown mode. During shutdown, the oscillator is turned off, the CLKIN input is weakly driven to its last state, and the CLOCK output is weakly driven to the logic-level in CLKIN.

The CLKIN input relies on an external inversion function, typically provided by a microcontroller's clock generator, to provide an inverted version of the CLOCK output signal. The MAX7393 interprets high/low voltage or a constant high-impedance node on CLKIN as a disable signal.

Figure 1 shows a test circuit to enable or disable the MAX7393. One input of the NAND gate connects to the CLOCK output of the MAX7393, and the other input is driven with a logic level. A logic-high level enables the oscillator and a logic-low level disables the oscillator. See the *Typical Operating Characteristics* for typical startup performance of the MAX7393.

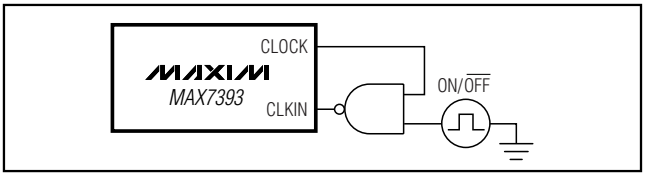



*Figure 1. Test Circuit to Enable or Disable the MAX7393 Oscillator*

### Oscillator (CLOCK)

The CLOCK output is a push-pull, CMOS logic output that is capable of driving a ground-connected 1kΩ load or a positive supply connected 500Ω load to within 300mV of either supply rail. There are no impedance-matching issues when using the MAX7393/MAX7394 CLOCK output. A typical startup characteristic is shown in the *Typical Operating Characteristics*.

### Output Jitter

The MAX7393/MAX7394s' jitter performance is given in the *Electrical Characteristics* table as a peak-to-peak value.

## Applications Information

### Interfacing to a Microcontroller Clock Input

The MAX7393/MAX7394 CLOCK output is a push-pull, CMOS logic output that directly drives any microprocessor (µP) or microcontroller (µC) clock input. There are no impedance-matching issues when using the MAX7393/MAX7394. Operate the MAX7393/MAX7394 and microcontroller from the same supply voltage level of $V_{CC2}$ (see the *Power-Supply Considerations* section for more details). Refer to the microcontroller's data sheet for clock input compatibility with external clock signals.

The MAX7393/MAX7394 require no biasing components or load capacitance. When using the MAX7393/MAX7394 to retrofit a crystal oscillator, remove all biasing components from the oscillator input.

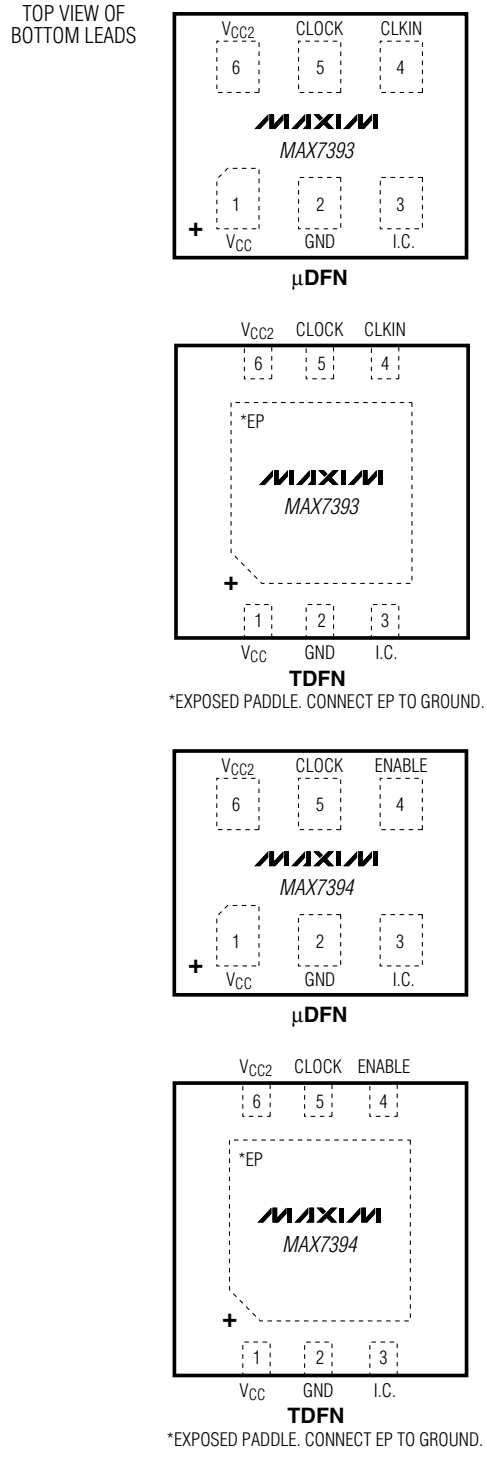
### Power-Supply Considerations

The MAX7393/MAX7394 operate with power-supply voltages in the +2.4V to +3.6V range. Connect $V_{CC}$ and $V_{CC2}$ to the same supply voltage level as the device receiving the clock. Proper power-supply decoupling is required to maintain the power-supply rejection performance of the MAX7393/MAX7394. Connect 0.1µF surface-mount ceramic capacitors from $V_{CC}$ to $V_{CC2}$ to GND. Position these bypass capacitors as close to $V_{CC}$ and $V_{CC2}$ as possible.

A larger $V_{CC2}$ bypass capacitor value is recommended if the MAX7393/MAX7394 are to operate with a large capacitive load. Use a bypass capacitor value on $V_{CC2}$ at least 1000 times that of the output load capacitance.

# Precision Silicon Oscillators with Enable or Autoenable

## Pin Configurations




## Selector Guide

| PART | FREQUENCY | PACKAGE | TOP MARK |
|---|---|---|---|
| MAX7393ATTLY | 922kHz | 6 TDFN | +ANP |
| MAX7393ALTLY | 922kHz | 6 µDFN | +ABO |
| MAX7393ATTMG | 1MHz | 6 TDFN | +ANQ |
| MAX7393ALTMG | 1MHz | 6 µDFN | +ABP |
| MAX7393ATTRD | 4MHz | 6 TDFN | +ANR |
| MAX7393ALTRD | 4MHz | 6 µDFN | +ABQ |
| MAX7393ATTTP | 8MHz | 6 TDFN | +ANS |
| MAX7393ALTTP | 8MHz | 6 µDFN | +ABR |
| MAX7393ATTWB | 16MHz | 6 TDFN | +AMN |
| MAX7393ALTWB | 16MHz | 6 µDFN | +AAR |
| MAX7393ATTWV | 20MHz | 6 TDFN | +AMO |
| MAX7393ALTWV | 20MHz | 6 µDFN | +AAS |
| MAX7394ATTLY | 922kHz | 6 TDFN | +ANV |
| MAX7394ALTLY | 922kHz | 6 µDFN | +ABU |
| MAX7394ATTMG | 1MHz | 6 TDFN | +ANW |
| MAX7394ALTMG | 1MHz | 6 µDFN | +ABV |
| MAX7394ATTRD | 4MHz | 6 TDFN | +ANX |
| MAX7394ALTRD | 4MHz | 6 µDFN | +ABW |
| MAX7394ATTTP | 8MHz | 6 TDFN | +ANY |
| MAX7394ALTTP | 8MHz | 6 µDFN | +ABX |
| MAX7394ATTWB | 16MHz | 6 TDFN | +AMU |
| MAX7394ALTWB | 16MHz | 6 µDFN | +AAY |
| MAX7394ATTWV | 20MHz | 6 TDFN | +AMV |
| MAX7394ALTWV | 20MHz | 6 µDFN | +AAZ |
| MAX7394ATTYN | 32MHz | 6 TDFN | +ANZ |
| MAX7394ALTYN | 32MHz | 6 µDFN | +ABY |
| MAX7394ATTYQ | 33MHz | 6 TDFN | +AMX |
| MAX7394ALTYQ | 33MHz | 6 µDFN | +ABB |
| MAX7394ATTZH | 40MHz | 6 TDFN | +AOA |
| MAX7394ALTZH | 40MHz | 6 µDFN | +ABZ |
| MAX7394ATTZY | 48MHz | 6 TDFN | +AMZ |
| MAX7394ALTZY | 48MHz | 6 µDFN | +ABD |

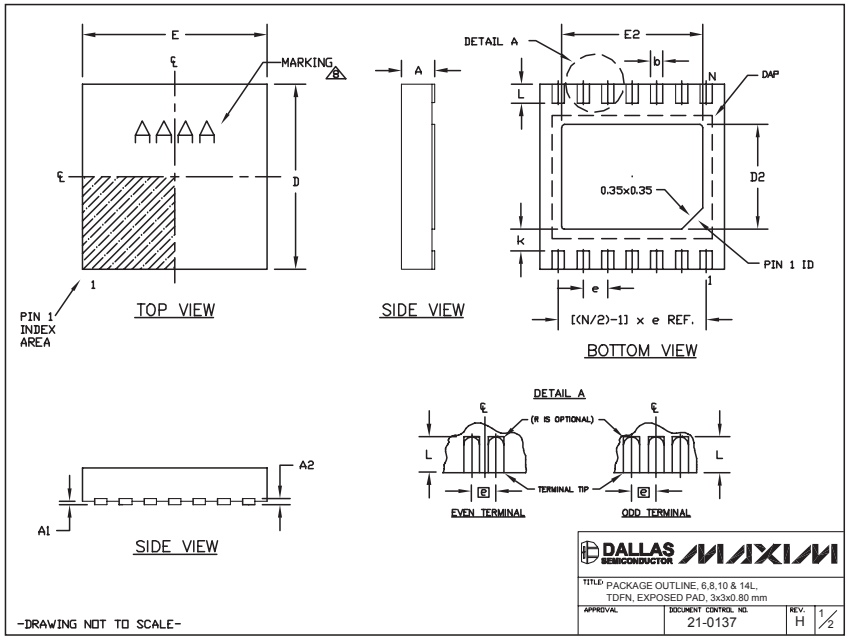
## Chip Information

PROCESS: BiCMOS

# Precision Silicon Oscillators with Enable or Autoenable

## Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to **www.maxim-ic.com/packages**.)




| COMMON DIMENSIONS | | |
|---|---|---|
| SYMBOL | MIN. | MAX. |
| A | 0.70 | 0.80 |
| D | 2.90 | 3.10 |
| E | 2.90 | 3.10 |
| A1 | 0.00 | 0.05 |
| L | 0.20 | 0.40 |
| k | 0.25 MIN. | |
| A2 | 0.20 REF. | |

| PACKAGE VARIATIONS | | | | | | | |
|---|---|---|---|---|---|---|---|
| PKG. CODE | N | D2 | E2 | e | JEDEC SPEC | b | [(N/2)-1] x e |
| T633-1 | 6 | 1.50±0.10 | 2.30±0.10 | 0.95 BSC | MO229 / WEEA | 0.40±0.05 | 1.90 REF |
| T633-2 | 6 | 1.50±0.10 | 2.30±0.10 | 0.95 BSC | MO229 / WEEA | 0.40±0.05 | 1.90 REF |
| T833-1 | 8 | 1.50±0.10 | 2.30±0.10 | 0.65 BSC | MO229 / WEEC | 0.30±0.05 | 1.95 REF |
| T833-2 | 8 | 1.50±0.10 | 2.30±0.10 | 0.65 BSC | MO229 / WEEC | 0.30±0.05 | 1.95 REF |
| T833-3 | 8 | 1.50±0.10 | 2.30±0.10 | 0.65 BSC | MO229 / WEEC | 0.30±0.05 | 1.95 REF |
| T1033-1 | 10 | 1.50±0.10 | 2.30±0.10 | 0.50 BSC | MO229 / WEED-3 | 0.25±0.05 | 2.00 REF |
| T1033-2 | 10 | 1.50±0.10 | 2.30±0.10 | 0.50 BSC | MO229 / WEED-3 | 0.25±0.05 | 2.00 REF |
| T1433-1 | 14 | 1.70±0.10 | 2.30±0.10 | 0.40 BSC | ---- | 0.20±0.05 | 2.40 REF |
| T1433-2 | 14 | 1.70±0.10 | 2.30±0.10 | 0.40 BSC | ---- | 0.20±0.05 | 2.40 REF |

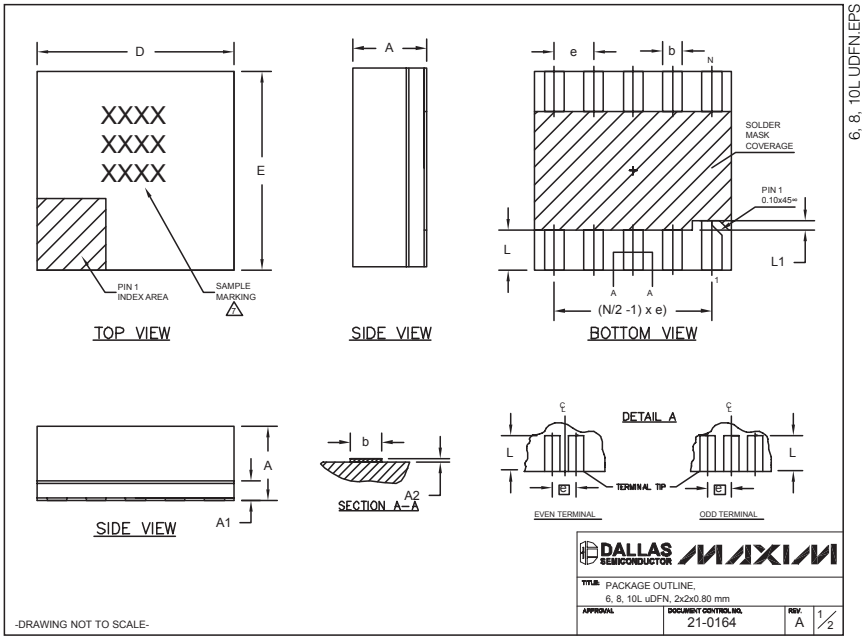
NOTES:
1. ALL DIMENSIONS ARE IN mm. ANGLES IN DEGREES.
2. COPLANARITY SHALL NOT EXCEED 0.08 mm.
3. WARPAGE SHALL NOT EXCEED 0.10 mm.
4. PACKAGE LENGTH/PACKAGE WIDTH ARE CONSIDERED AS SPECIAL CHARACTERISTIC(S).
5. DRAWING CONFORMS TO JEDEC MO229, EXCEPT DIMENSIONS "D2" AND "E2", AND T1433-1 & T1433-2.
6. "N" IS THE TOTAL NUMBER OF LEADS.
7. NUMBER OF LEADS SHOWN ARE FOR REFERENCE ONLY.
8. MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY.

-DRAWING NOT TO SCALE-

DALLAS SEMICONDUCTOR MAXIM
TITLE: PACKAGE OUTLINE, 6,8,10 & 14L, TDFN, EXPOSED PAD, 3x3x0.80 mm
APPROVAL
DOCUMENT CONTROL NO. 21-0137
REV. H
2/2

## Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to **www.maxim-ic.com/packages**.)




| COMMON DIMENSIONS | | | |
|---|---|---|---|
| SYMBOL | MIN. | NOM. | MAX. |
| A | 0.70 | 0.75 | 0.80 |
| A1 | 0.15 | 0.20 | 0.25 |
| A2 | 0.020 | 0.025 | 0.035 |
| D | 1.95 | 2.00 | 2.05 |
| E | 1.95 | 2.00 | 2.05 |
| L | 0.30 | 0.40 | 0.50 |
| L1 | 0.10 REF. | | |

| PACKAGE VARIATIONS | | | | |
|---|---|---|---|---|
| PKG. CODE | N | e | b | (N/2 -1) x e |
| L622-1 | 6 | 0.65 BSC | 0.30±0.05 | 1.30 REF. |
| L822-1 | 8 | 0.50 BSC | 0.25±0.05 | 1.50 REF. |
| L1022-1 | 10 | 0.40 BSC | 0.20±0.03 | 1.60 REF. |

NOTES:
1. ALL DIMENSIONS ARE IN mm. ANGLES IN DEGREES.
2. COPLANARITY SHALL NOT EXCEED 0.08mm.
3. WARPAGE SHALL NOT EXCEED 0.10mm.
4. PACKAGE LENGTH/PACKAGE WIDTH ARE CONSIDERED AS SPECIAL CHARACTERISTIC(S).
5. "N" IS THE TOTAL NUMBER OF LEADS.
6. NUMBER OF LEADS SHOWN ARE FOR REFERENCE ONLY.
7. MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY.


DALLAS SEMICONDUCTOR MAXIM
TITLE: PACKAGE OUTLINE,
6, 8, 10L uDFN, 2x2x0.80 mm
APPROVAL
DOCUMENT CONTROL NO.
21-0164
REV.
A
2/2
-DRAWING NOT TO SCALE-