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# 8kHz Reference Clock Synthesizer with Multiple Outputs at 35.328MHz

MAX9486

## General Description

The MAX9486 low-cost, high-performance clock synthesizer with an 8kHz input reference clock provides six buffered LVTTTL clock outputs at 35.328MHz. The clock synthesizer can be used to generate the clocks for T1, E1, T3, E3, and xDSL.

The MAX9486 has two phase-lock loops (PLLs). The first PLL uses a voltage-controlled crystal oscillator (VCXO). The second PLL is a frequency multiplier. With the two PLLs, the MAX9486 generates the output frequency at 35.328MHz. In addition, this device generates a jitter-suppressed 8kHz output that provides a better source for the reference clock relay.

The MAX9486 is available in a 24-pin TSSOP package and operates over the extended operating temperature range of -40°C to +85°C and a single +3V to +3.6V power-supply range.

## Applications

Telecom Equipment Using T1, E1, T3, E3, and ISDN Protocols

xDSL Equipment in CO with Interface to the Telecom Protocols

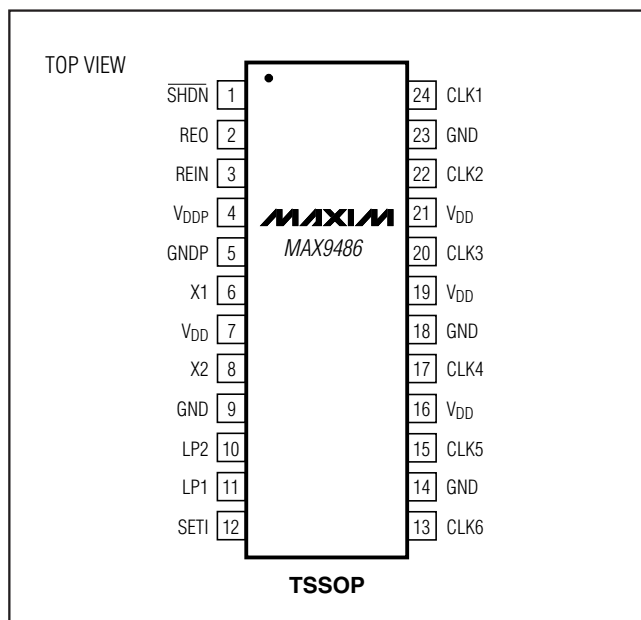
## Features

- ◆ 8kHz Input Reference CLK
- ◆ High-Jitter Rejection on the Reference CLK
- ◆ Synthesizer Locks to the 8kHz Reference with a  $\pm 200\text{ppm}$  Range
- ◆ Output Frequency: 35.328MHz
- ◆ Six Buffered LVTTTL Low-Jitter Outputs
- ◆ One 8kHz Reference CLK Relay Output
- ◆ +3.3V Supply Operation
- ◆ 24-Pin TSSOP Package

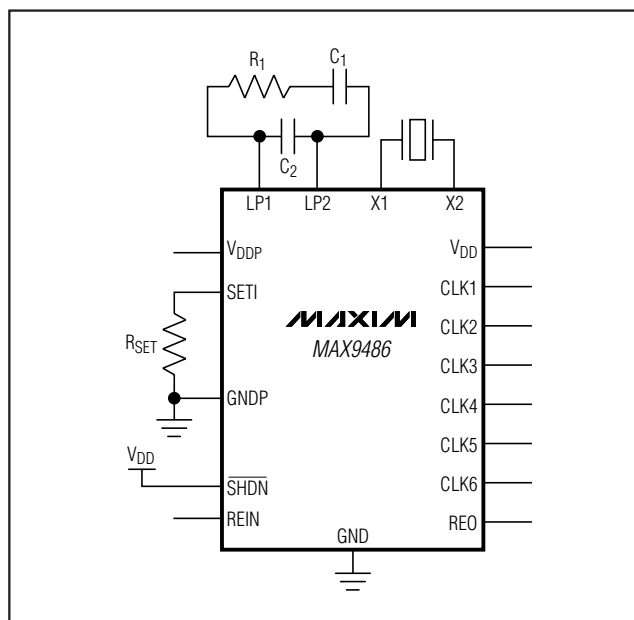
## Ordering Information

| PART       | TEMP RANGE     | PIN-PACKAGE |
|------------|----------------|-------------|
| MAX9486EUG | -40°C to +85°C | 24 TSSOP    |

## Pin Configuration



## Typical Application Circuit



# 8kHz Reference Clock Synthesizer with Multiple Outputs at 35.328MHz

## ABSOLUTE MAXIMUM RATINGS

V<sub>DD</sub> to GND .....-0.3V to +4.0V  
V<sub>DDP</sub> to GNDP .....-0.3V to +4.0V  
SHDN, REO, REIN, X1, X2, CLK\_ to GND ...-0.3V to (V<sub>DD</sub> + 0.3V)  
LP1, SETI to GNDP .....-0.3V to (V<sub>DD</sub> + 0.3V)  
LP2 Internally Connected to GNDP  
Short-Circuit Duration of Outputs .....Continuous

Continuous Power Dissipation (T<sub>A</sub> = +70°C)  
24-Pin TSSOP (derate 12.2mW/°C above +70°C) .....976mW  
Operating Temperature Range .....-40°C to +85°C  
Maximum Junction Temperature .....+150°C  
Storage Temperature Range .....-60°C to +150°C  
ESD Rating (Human Body Model) .....±2kV  
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.

## DC ELECTRICAL CHARACTERISTICS

(V<sub>DD</sub> = V<sub>DDP</sub> = +3.0V to +3.6V, T<sub>A</sub> = -40°C to +85°C, unless otherwise noted. Typical values are at V<sub>DD</sub> = V<sub>DDP</sub> = +3.3V, T<sub>A</sub> = +25°C.) (Note 1)

| PARAMETER                                             | SYMBOL                             | CONDITIONS                        | MIN                    | TYP | MAX | UNITS |
|-------------------------------------------------------|------------------------------------|-----------------------------------|------------------------|-----|-----|-------|
| <b>DIGITAL INPUTS (REIN, SHDN)</b>                    |                                    |                                   |                        |     |     |       |
| Input High Logic Level                                | V <sub>IH</sub>                    |                                   | 2.0                    |     |     | V     |
| Input Low Logic Level                                 | V <sub>IL</sub>                    |                                   |                        |     | 0.8 | V     |
| Input-Current High Level                              | I <sub>IH</sub>                    | V <sub>IN</sub> = V <sub>DD</sub> |                        |     | 20  | μA    |
| Input-Current Low Level                               | I <sub>IL</sub>                    | V <sub>IN</sub> = 0               | -20                    |     |     | μA    |
| <b>DIGITAL OUTPUT CLOCKS (CLK1–CLK6, REO)</b>         |                                    |                                   |                        |     |     |       |
| Output High Logic Level                               | V <sub>OH</sub>                    | I <sub>OH</sub> = -4mA            | V <sub>DD</sub> - 0.6V |     |     | V     |
| Output Low Logic Level                                | V <sub>OL</sub>                    | I <sub>OL</sub> = 4mA             |                        |     | 0.4 | V     |
| <b>POWER SUPPLY (V<sub>DD</sub>, V<sub>DDP</sub>)</b> |                                    |                                   |                        |     |     |       |
| Power-Supply Range                                    | V <sub>DD</sub>                    |                                   | 3.0                    |     | 3.6 | V     |
| PLL Power-Supply Range                                | V <sub>DDP</sub>                   |                                   | 3.0                    |     | 3.6 | V     |
| Power-Supply Current                                  | I <sub>DD</sub> + I <sub>DDP</sub> | (Note 2)                          |                        | 13  | 25  | mA    |
| Shutdown Supply Current                               | I <sub>SHDN</sub>                  |                                   |                        | 8   | 30  | μA    |

# 8kHz Reference Clock Synthesizer with Multiple Outputs at 35.328MHz

MAX9486

## AC ELECTRICAL CHARACTERISTICS

( $V_{DD} = V_{DDP} = +3.0V$  to  $+3.6V$ ,  $C_L = 20pF$ ,  $T_A = -40^{\circ}C$  to  $+85^{\circ}C$ , unless otherwise noted. Typical values are at  $V_{DD} = V_{DDP} = +3.3V$ ,  $T_A = +25^{\circ}C$ .) (Note 3)

| PARAMETER                                | SYMBOL    | CONDITIONS                                         | MIN  | TYP      | MAX  | UNITS |
|------------------------------------------|-----------|----------------------------------------------------|------|----------|------|-------|
| <b>DIGITAL OUTPUT CLOCKS (CLK1–CLK6)</b> |           |                                                    |      |          |      |       |
| Frequency Range                          | $f_{OUT}$ |                                                    |      | 35.328   |      | MHz   |
| Clock Rise Time                          | $T_{R1}$  | 20% to 80% $V_{DD}$                                |      | 1.8      |      | ns    |
| Clock Fall Time                          | $T_{F1}$  | 80% to 20% $V_{DD}$                                |      | 1.8      |      | ns    |
| Duty Cycle                               |           |                                                    | 40   | 50       | 60   | %     |
| Period Jitter                            | $J_{PP1}$ | Peak-to-peak                                       |      | 120      |      | ps    |
| Output Skew                              | $t_S$     | Peak-to-peak                                       |      | 185      |      | ps    |
| <b>REFERENCE CLOCK OUTPUT (REO)</b>      |           |                                                    |      |          |      |       |
| Frequency                                | $f_{REF}$ |                                                    |      | 8        |      | kHz   |
| Clock Rise Time                          | $T_{R2}$  |                                                    |      | 1.8      |      | ns    |
| Clock Fall Time                          | $T_{F2}$  |                                                    |      | 1.8      |      | ns    |
| Duty Cycle                               |           |                                                    | 40   | 50       | 60   | %     |
| <b>VCXO</b>                              |           |                                                    |      |          |      |       |
| Crystal Frequency                        | $f_{XTL}$ |                                                    |      | 17.664   |      | MHz   |
| Crystal Accuracy                         |           | Including frequency accuracy and temperature range |      | $\pm 25$ |      | ppm   |
| VCXO Pulling Range                       |           | (Note 4)                                           | -200 |          | +200 | ppm   |
| Input Reference CLK Pulse Width          | $t_W$     | Measured at high or low states                     | 10   |          |      | ns    |

**Note 1:** Specifications are 100% tested at  $T_A = +25^{\circ}C$ . Specifications over temperature are guaranteed by design and characterization.

**Note 2:** No load on clock outputs.

**Note 3:** Guaranteed by design.

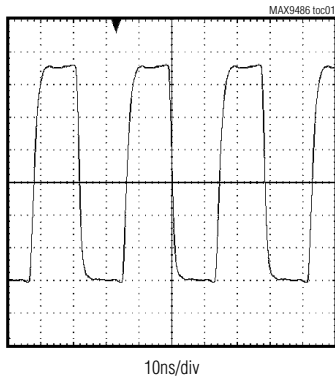
**Note 4:** Crystal loading capacitance is 14pF.

# 8kHz Reference Clock Synthesizer with Multiple Outputs at 35.328MHz

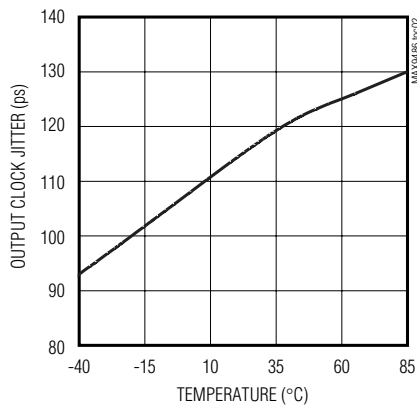
## Typical Operating Characteristics

( $V_{DD} = V_{DDP} = +3.3V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

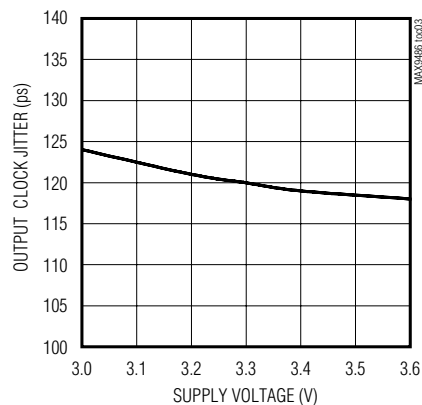
OUTPUT WAVEFORM



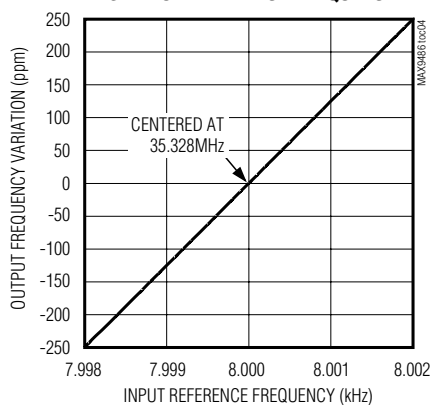
OUTPUT CLOCK JITTER (p-p)  
vs. TEMPERATURE



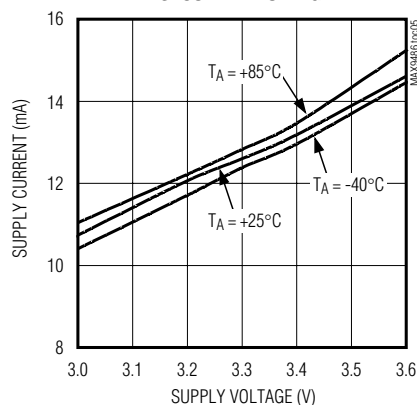
OUTPUT CLOCK JITTER (p-p)  
vs. SUPPLY VOLTAGE



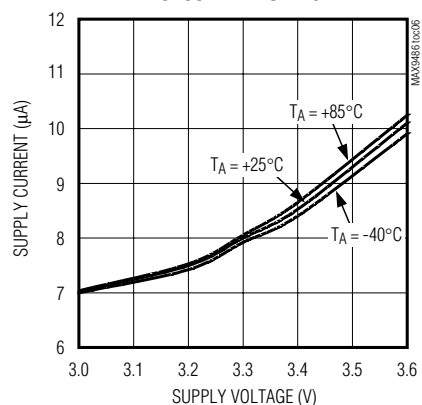
OUTPUT FREQUENCY VARIATION  
vs. INPUT REFERENCE FREQUENCY



SUPPLY CURRENT ( $I_{DD} + I_{DDP}$ )  
vs. SUPPLY VOLTAGE



SHUTDOWN SUPPLY CURRENT  
vs. SUPPLY VOLTAGE



# 8kHz Reference Clock Synthesizer with Multiple Outputs at 35.328MHz

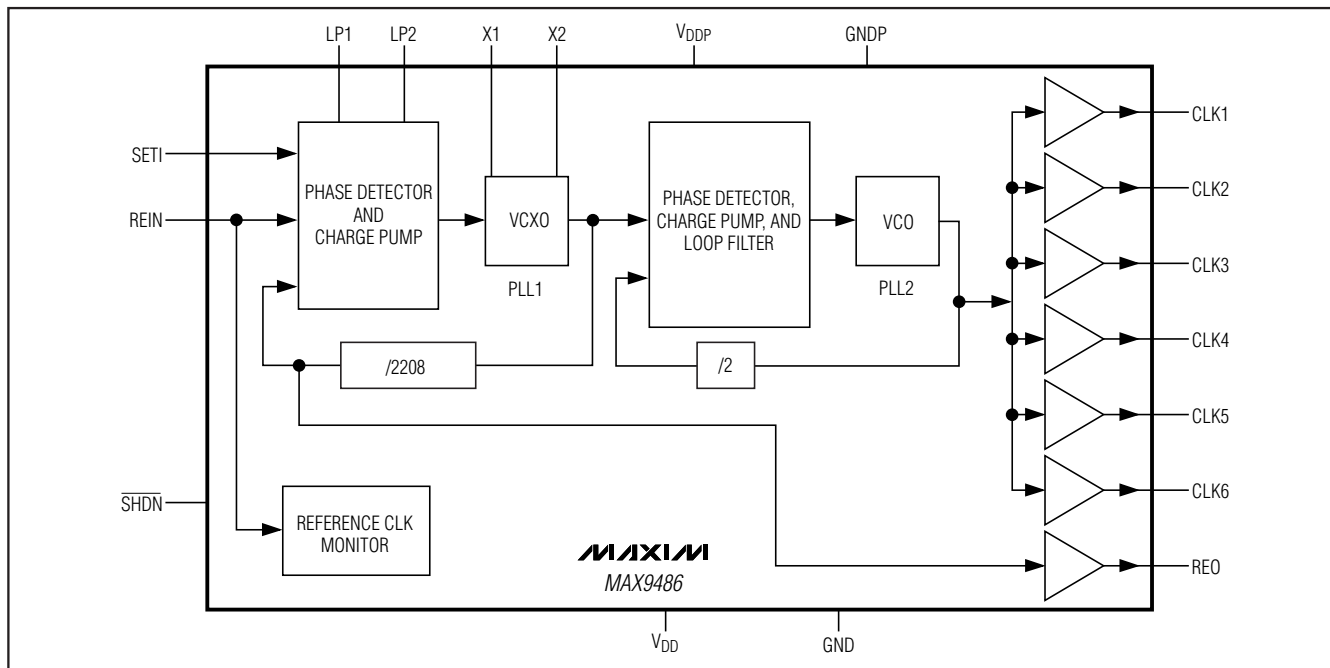
## Pin Description

| PIN           | NAME | FUNCTION                                                                                                                                                                     |
|---------------|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1             | SHDN | Active-Low Shutdown Input                                                                                                                                                    |
| 2             | REO  | Reference Clock Output. REO is an 8kHz reference clock output with jitter suppression.                                                                                       |
| 3             | REIN | Reference Input                                                                                                                                                              |
| 4             | VDDP | Phase-Lock Loop (PLL) Power Supply. Bypass VDDP with 0.1μF and 0.001μF capacitors to GNDP.                                                                                   |
| 5             | GNDP | PLL Ground                                                                                                                                                                   |
| 6             | X1   | Crystal Input 1. Connect X1 to a fundamental mode crystal for the VCXO.                                                                                                      |
| 7, 16, 19, 21 | VDD  | Digital Power Supply. Bypass VDD with 0.1μF and 0.001μF capacitors to GND.                                                                                                   |
| 8             | X2   | Crystal Input 2. Connect X2 to a fundamental mode crystal for the VCXO.                                                                                                      |
| 9, 14, 18, 23 | GND  | Ground                                                                                                                                                                       |
| 10            | LP2  | External Filter 2. Connect the loop filter capacitors and a resistor between LP1 and LP2 (see the <i>Typical Application Circuit</i> ). LP2 is internally connected to GNDP. |
| 11            | LP1  | External Filter 1. Connect the loop filter capacitors and a resistor between LP1 and LP2 (see the <i>Typical Application Circuit</i> ).                                      |
| 12            | SETI | Charge-Pump Current-Setting Input. Connect a resistor from SETI to GNDP to set PLL charge-pump current (see the <i>Detailed Description</i> section).                        |
| 13            | CLK6 | Clock Output 6 at 35.328MHz                                                                                                                                                  |
| 15            | CLK5 | Clock Output 5 at 35.328MHz                                                                                                                                                  |
| 17            | CLK4 | Clock Output 4 at 35.328MHz                                                                                                                                                  |
| 20            | CLK3 | Clock Output 3 at 35.328MHz                                                                                                                                                  |
| 22            | CLK2 | Clock Output 2 at 35.328MHz                                                                                                                                                  |
| 24            | CLK1 | Clock Output 1 at 35.328MHz                                                                                                                                                  |

MAX9486

# 8kHz Reference Clock Synthesizer with Multiple Outputs at 35.328MHz

## Functional Diagram



## Detailed Description

The MAX9486 is a high-performance clock synthesizer with an 8kHz input reference clock. This device generates six identical buffered LVTTTL clock outputs at 35.328MHz. The MAX9486 features two PLLs. The first PLL (PLL1) uses an internal VCXO, locked to the 8kHz reference CLK, to generate a 17.664MHz CLK output for the second PLL (PLL2). PLL2 multiplies the VCXO frequency by a factor of 2 to produce the 35.328MHz outputs. In addition, this device features a low-jitter 8kHz output that provides a better source for the reference clock relay (see the *Functional Diagram*).

### Power-Up

At power-up, all the outputs are disabled and pulled low (to GND) for at least 256ms. After 256ms, the crystal oscillator starts oscillation. The input reference clock for PLL1 is 8kHz and its output frequency, 17.664MHz, is also the reference clock for PLL2. If the 8kHz reference clock is not present at power-up, the output frequency of PLL1 is locked to the center frequency of the crystal oscillator.

### 8kHz Reference CLK Monitor

The MAX9486 features an internal clock (CLK) monitor circuitry to detect the presence of the external 8kHz reference clock. The internal CLK monitor continuously monitors the number of low-to-high transitions within a

three-cycle (at 8kHz) time window. If the transition number is less than two, the internal CLK monitor states loss of the reference CLK. However, if in a three-cycle time window the monitor counts two or three transitions, it considers the input reference clock as present. When the monitor detects the absence of the 8kHz reference clock, PLL2 is forced to lock to the crystal oscillator frequency. However, when the monitor detects the return of the reference clock, PLL1 locks to the reference clock again.

### Clock Outputs (CLK1 to CLK6) and REO

The MAX9486 uses a 17.664MHz crystal and a reference clock (REIN) to generate six identical outputs, CLK1 to CLK6, at 35.328MHz. All CLK\_ outputs are LVTTTL with a skew of 185ps. The MAX9486 also regenerates the 8kHz reference CLK at REO output.

### Voltage-Controlled Crystal Oscillator (VCXO)

The MAX9486's internal VCXO takes an external 17.664MHz crystal as the base frequency and has a pulling range of approximately  $\pm 200$ ppm. This configuration also makes the VCXO PLL become a narrowband filter to reject high-frequency jitter on the input reference and eliminate it from the REO and CLK\_ outputs.

# 8kHz Reference Clock Synthesizer with Multiple Outputs at 35.328MHz

## SHDN Mode

The MAX9486 features a shutdown mode with a supply current less than 8μA (typ). Drive  $\overline{\text{SHDN}}$  low to get the device into shutdown mode. In this mode, all the outputs go low and both PLLs are powered down. After  $\overline{\text{SHDN}}$  goes high, the outputs still stay low for an additional 256ms to allow both PLLs to be stabilized before the outputs are enabled again.

## Applications Information

### Crystal Selection

The MAX9486 uses a 17.664MHz crystal as the base frequency for the VCXO. It is important to use a correct type of quartz crystal to avoid reducing frequency pulling range, or excessive output phase jitter.

Choose an AT-cut crystal that oscillates at 17.664MHz on its fundamental mode with a variation of  $\pm 25\text{ppm}$  including frequency accuracy and operating temperature range. The crystal's load capacitance should be 14pF. Pulling range may vary depending on the crystal used. Refer to the MAX9486 evaluation kit for details.

### PLL1 Loop Filter

The MAX9486 features two PLLs: PLL1 and PLL2. The first phased-lock loop, PLL1, contains an integrated VCXO that uses an external crystal to track the input reference signal and attenuate input jitter. Figure 1 shows the external loop filter of the PLL containing resistor R1 and two capacitors, C1 and C2. This loop filter is connected between LP1 and LP2 as shown in the *Typical Operating Circuit*. The loop-filter bandwidth is determined by C1, C2, R1, and  $R_{\text{SET}}$  where  $R_{\text{SET}}$  is used to set the value of the charge-pump current. The typical values of C1, C2, R1, and  $R_{\text{SET}}$  are 22nF, 560pF, 1000kΩ, and 13kΩ, respectively.

Use the following equation to calculate a PLL loop bandwidth in Hz:

$$\text{BW} = (R1 \times I_{\text{SET1}} \times 940) / N$$

where R1 (Ω) is the resistor in the PLL1 loop filter (Figure 1),  $I_{\text{SET1}}$  (A) is the charge-pump current calculated from the equation in the *Charge-Pump Current*

*Setting* section, and N is the crystal PLL frequency divider equal to 2208.

The loop-damping factor is calculated by:

$$\text{DampingFactor} = \frac{R1}{2} \times \sqrt{\frac{5900 \times I_{\text{SET1}} \times C1}{N}}$$

where C1 (F) and R1 (Ω) are the values of the capacitor and the resistor in the PLL1 loop filter shown in Figure 1;  $I_{\text{SET1}}$  is calculated as shown in the *Charge-Pump Current Setting* section and N = 2208.

The following equation shows the relationship between components C1 and C2 in the loop filter:

$$C2 \leq C1/20$$

### Charge-Pump Current Setting

The MAX9486 also allows external setting of the charge-pump current in PLL1. Connect a resistor from SET1 to GNDP to set the PLL1 charge-pump current:

$$\text{Charge-Pump Current} = 2.4 \times 1000 / (R_{\text{SET}}(\text{k}\Omega) + 1)$$

where  $R_{\text{SET}}$  is in kΩ and the value of the charge-pump current is in μA.

The loop response can be adjusted to meet individual application requirements since the charge-pump current and all the filter components for the VCXO loop can be set externally.

### Board Layout and Bypassing

The MAX9486's high-oscillator frequency makes proper layout important to ensure stability. For best performance, place components as close as possible to the device.

Digital or AC transient signals on GND can create noise at the clock outputs. Return GND to the highest quality ground available. Bypass  $V_{\text{DD}}$  and  $V_{\text{DDP}}$  with 0.1μF and 0.001μF capacitors, placed as close to the device as possible. Careful PC board ground layout minimizes crosstalk between the outputs and digital inputs.

Traces must be as short as possible on LP1 and LP2 and connect the capacitors and the resistor as close as possible to the device.

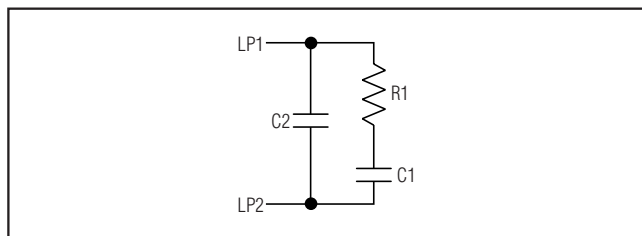


Figure 1. Typical Loop Filter

## Chip Information

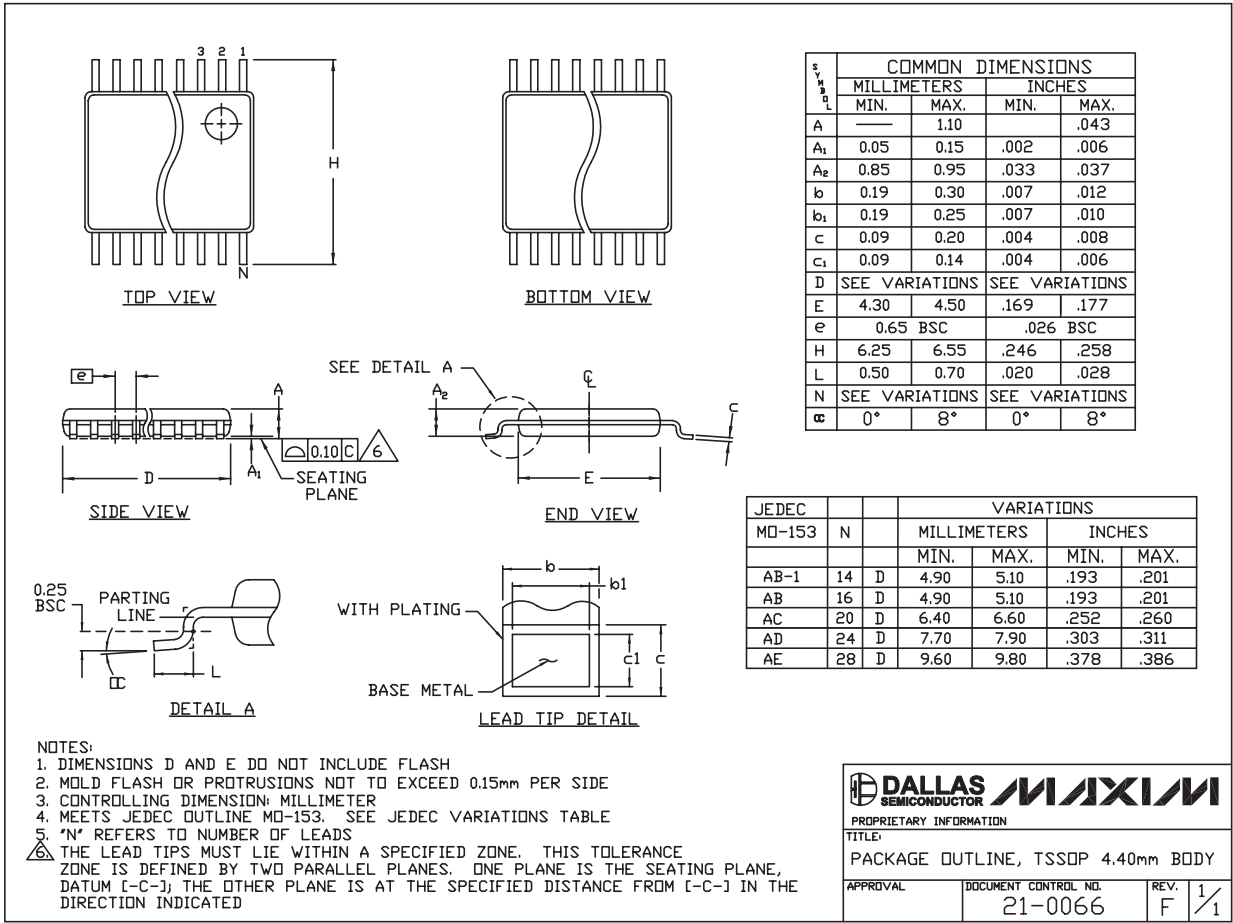
TRANSISTOR COUNT: 7512

PROCESS: CMOS

# 8kHz Reference Clock Synthesizer with Multiple Outputs at 35.328MHz

## 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](http://www.maxim-ic.com/packages).)



TSSOP4.40mm.EPS

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