



Phase-Frequency Detector

The MC12040 is a phase-frequency detector intended for use in systems requiring zero phase and frequency difference at lock. In combination with a voltage controlled oscillator (such as the MC1648, MC12147, MC12148 or MC12149), it is useful in a broad range of phase-locked loop applications.

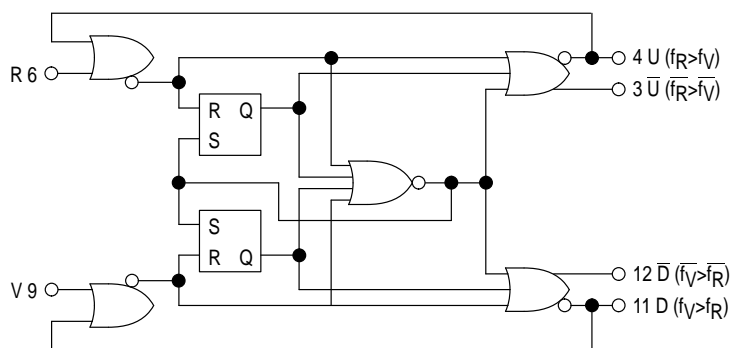
- Operating Frequency = 80 MHz Typical

Pin Conversion Table

| | | | | | | | | | | | | | | |
|-------------|---|---|---|---|---|---|----|----|----|----|----|----|----|----|
| 14 Pin DIP | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 20 Pin PLCC | 2 | 3 | 4 | 6 | 8 | 9 | 10 | 12 | 13 | 14 | 16 | 18 | 19 | 20 |

| Inputs | | Outputs | | | |
|--------|---|---------|---|-----------|-----------|
| R | V | U | D | \bar{U} | \bar{D} |
| 0 | 0 | X | X | X | X |
| 0 | 1 | X | X | X | X |
| 1 | 1 | X | X | X | X |
| 0 | 1 | X | X | X | X |
| 1 | 1 | 1 | 0 | 0 | 1 |
| 0 | 1 | 1 | 0 | 0 | 1 |
| 1 | 1 | 1 | 0 | 0 | 1 |
| 1 | 0 | 1 | 0 | 0 | 1 |
| 1 | 1 | 0 | 0 | 1 | 1 |
| 1 | 0 | 0 | 0 | 1 | 1 |
| 1 | 1 | 0 | 1 | 1 | 0 |
| 1 | 0 | 0 | 1 | 1 | 0 |
| 1 | 1 | 0 | 1 | 1 | 0 |
| 0 | 1 | 0 | 1 | 1 | 0 |
| 1 | 1 | 0 | 0 | 1 | 1 |

LOGIC DIAGRAM



V_{CC1} = Pin 1
 V_{CC2} = Pin 14
 V_{EE} = Pin 7

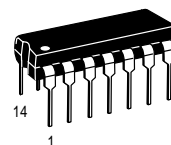
TRUTH TABLE

This is not strictly a functional truth table; i.e., it does not cover all possible modes of operation. However, it gives a sufficient number of tests to ensure that the device will function properly in all modes of operation.

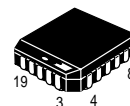
MC12040

PHASE-FREQUENCY DETECTOR

SEMICONDUCTOR TECHNICAL DATA



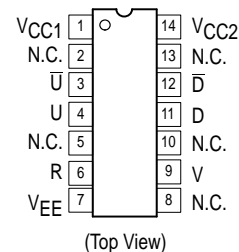
P SUFFIX
PLASTIC PACKAGE
CASE 646



FN SUFFIX
PLASTIC PACKAGE
CASE 775
(PLCC)

Not Recommended for New Designs

PIN CONNECTIONS



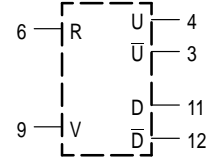
ORDERING INFORMATION

| Device | Operating Temperature Range | Package |
|----------|---------------------------------|---------|
| MC12040P | $T_A = 0$ to 75°C | Plastic |

MC12040

ELECTRICAL CHARACTERISTICS

The MC12040 has been designed to meet the dc specifications shown in the test table after thermal equilibrium has been established. Outputs are terminated through a 50 Ω resistor to 3.0 V for 5.0 V tests and through a 50 Ω resistor to -2.0 V for -5.2 V tests.



NOTE: For more information on using an ECL device in a 5.0 V system, refer to Motorola Application Note AN1406/D, "Designing with PECL (ECL at 5.0 V)"

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@ Test Temperature

0°C

25°C

75°C

TEST VOLTAGE VALUES

(Volts)

| V _{IH} max | V _{IL} min | V _{IH} Amin | V _{IL} Amax | V _{EE} |
|---------------------|---------------------|----------------------|----------------------|-----------------|
| -0.840 | -1.870 | -1.145 | -1.490 | -5.2 |
| -0.810 | -1.850 | -1.105 | -1.475 | -5.2 |
| -0.720 | -1.830 | -1.045 | -1.450 | -5.2 |

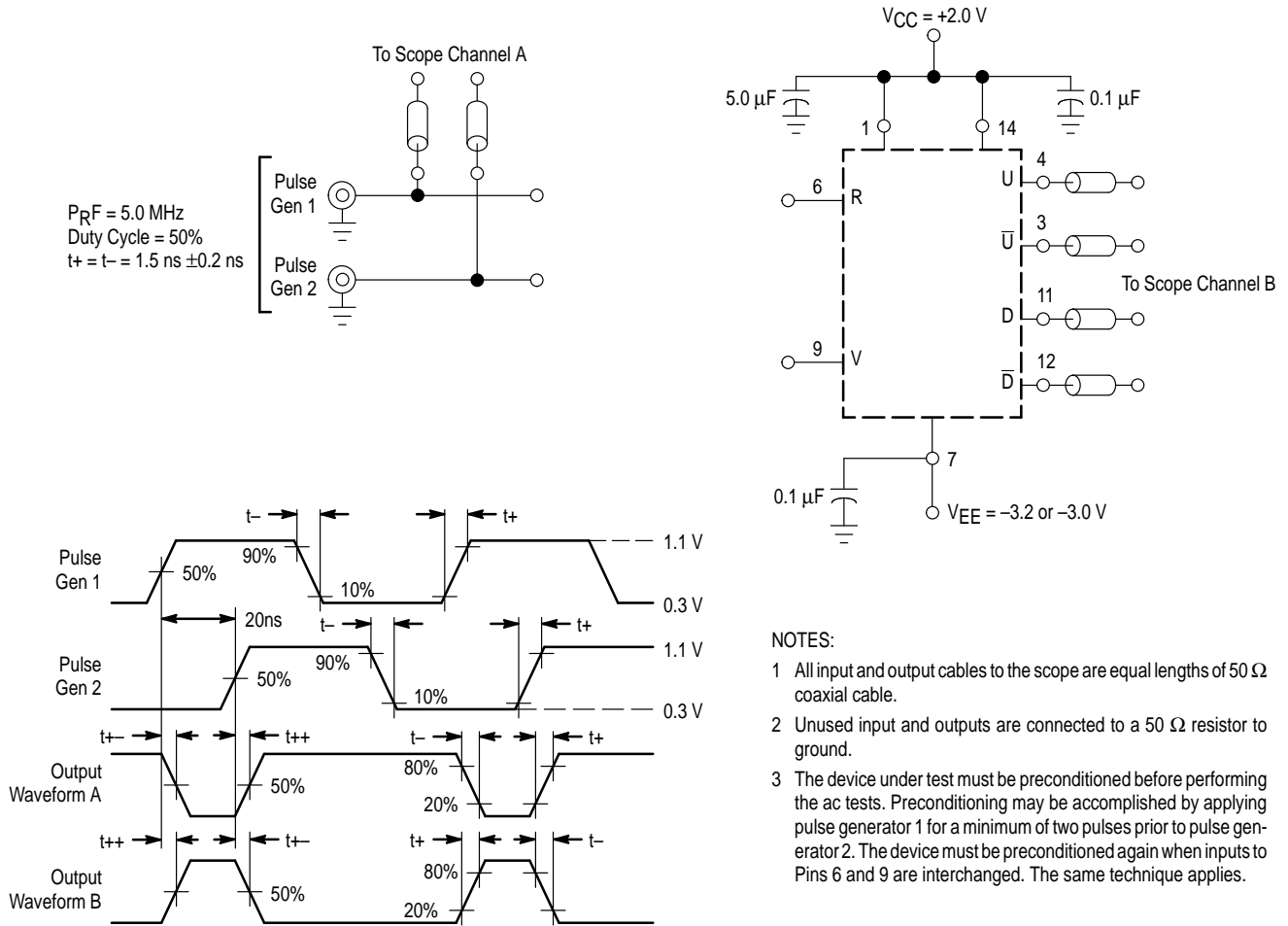
Supply Voltage = -5.2V

| Symbol | Characteristics | Pin Under Test | MC12040 | | | | | | | TEST VOLTAGE APPLIED TO PINS BELOW | | | | | (V _{CC}) Gnd |
|-------------------------------|--------------------------|--------------------|---------|--------|--------|------------|--------|--------|------|------------------------------------|---------------------|----------------------|----------------------|-----------------|---------------------------|
| | | | 0°C | | 25°C | | 75°C | | Unit | V _{IH} max | V _{IL} min | V _{IH} Amin | V _{IL} Amax | V _{EE} | |
| | | | Min | Max | Min | Max | Min | Max | | | | | | | |
| I _E | Power Supply Drain | 7 | | | -120 | -60 | | | mAdc | | | | | 7 | 1,14 |
| I _{INH} | Input Current | 6 9 | | | | 350 350 | | | μAdc | 6 9 | | | | 7 7 | 1,14 1,14 |
| V _{OH} ¹ | Logic "1" Output Voltage | 3 4 11 12 | -1.000 | -0.840 | -0.960 | -0.810 | -0.900 | -0.720 | Vdc | | | | | 7 | 1,14 |
| V _{OL} ¹ | Logic "0" Output Voltage | 3 4 11 12 | -1.870 | -1.635 | -1.850 | -1.620 | -1.830 | -1.595 | Vdc | | | | | 7 | 1,14 |
| V _{OHA} ² | Logic "1" Input Voltage | 3 4 11 12 | -1.020 | | -0.980 | | -0.920 | | Vdc | | | 6.9 | | 7 | 1,14 |
| V _{OLA} ² | Logic "0" Input Voltage | 3 4 11 12 | | -1.615 | | -1.600 | | -1.575 | Vdc | | | 9 6 9 6 | 6 9 6 9 | 7 | 1,14 |

| Supply Voltage = +5.0V | | | | | | | | | | TEST VOLTAGE VALUES | | | | | (V _{CC}) G _{nd} |
|-------------------------------|--------------------------|--------------------|---------|-------|-------|------------|-------|-------|------|------------------------------------|---------------------|----------------------|----------------------|-----------------|---------------------------------------|
| | | | | | | | | | | (Volts) | | | | | |
| | | | | | | | | | | V _{IH} max | V _{IL} min | V _{IH} Amin | V _{IL} Amax | V _{EE} | |
| | | | | | | | | | | @ Test Temperature | | | | | |
| | | | | | | | | | | | | | | | |
| 0°C | | | | | | | | | | +4.160 | +3.130 | +3.855 | +3.510 | +5.0 | |
| 25°C | | | | | | | | | | +4.190 | +3.150 | +3.895 | +3.525 | +5.0 | |
| 75°C | | | | | | | | | | +4.280 | +3.170 | +3.955 | +3.550 | +5.0 | |
| Symbol | Characteristics | Pin Under Test | MC12040 | | | | | | | TEST VOLTAGE APPLIED TO PINS BELOW | | | | | |
| | | | 0°C | | 25°C | | 75°C | | Unit | V _{IH} max | V _{IL} min | V _{IH} Amin | V _{IL} Amax | V _{EE} | |
| | | | Min | Max | Min | Max | Min | Max | | | | | | | |
| I _E | Power Supply Drain | 7 | | | −115 | −60 | | | mAdc | | | | | 1,14 | 7 |
| I _{INH} | Input Current | 6 9 | | | | 350 350 | | | μAdc | 6 9 | | | | 1,14 1,14 | 7 7 |
| V _{OH} ¹ | Logic "1" Output Voltage | 3 4 11 12 | 4.000 | 4.160 | 4.040 | 4.190 | 4.100 | 4.280 | Vdc | | | | | 1,14 | 7 |
| V _{OL} ¹ | Logic "0" Output Voltage | 3 4 11 12 | 3.190 | 3.430 | 3.210 | 3.440 | 3.230 | 3.470 | Vdc | | | | | 1,14 | 7 |
| V _{OHA} ² | Logic "1" Input Voltage | 3 4 11 12 | 3.980 | | 4.020 | | 4.080 | | Vdc | | | 6.9 | | 1,14 | 7 |
| V _{OLA} ² | Logic "0" Input Voltage | 3 4 11 12 | | 3.450 | | 3.460 | | 3.490 | Vdc | | | 9 6 9 6 | 6 9 6 9 | 1,14 | 7 |

MC12040

Figure 1. AC Tests



| Symbol | Characteristic | Pin Under Test | Output Waveform | MC12040 | | | Unit | TEST VOLTAGES/WAVEFORMS APPLIED TO PINS LISTED | | | |
|--|-------------------|--|--------------------------------------|--|--|--|------|--|--------------------------------------|-------------------------|----------------|
| | | | | 0°C | 25°C | 85°C | | Pulse Gen 1 | Pulse Gen 2 | V_{EE} -3.0 or -3.2 V | V_{CC} 2.0 V |
| | | | | Max | Max | Max | | | | | |
| t_{6+4+} t_{6+12+} t_{6+3-} t_{6+11-} t_{9+11+} t_{9+3+} t_{9+12-} t_{9+4-} | Propagation Delay | 6,4 6,12 6,3 6,11 9,11 9,3 9,12 9,4 | B A A B B A A B | 4.6 6.0 4.5 6.4 4.6 6.0 4.5 6.4 | 4.6 6.0 4.5 6.4 4.6 6.0 4.5 6.4 | 5.0 6.6 4.9 7.0 5.0 6.6 4.9 7.0 | ns | 6 9 6 9 9 6 9 6 | 9 6 9 6 6 9 6 9 | 7 | 1,14 |
| t_{3+} t_{4+} t_{11+} t_{14+} | Output Rise Time | 3 4 11 14 | A B B A | 3.4 | 3.4 | 3.8 | ns | 6 6 9 9 | 9 9 6 6 | 7 | 1,14 |
| t_{3-} t_{4-} t_{11-} t_{14-} | Output Fall Time | 3 4 11 14 | A B B A | 3.4 | 3.4 | 3.8 | ns | 6 6 9 9 | 9 9 6 6 | 7 | 1,14 |

APPLICATIONS INFORMATION

The MC12040 is a logic network designed for use as a phase comparator for MECL-compatible input signals. It determines the "lead" or "lag" phase relationship and the time difference between the leading edges of the waveforms. Since these edges occur only once per cycle, the detector has a range of $\pm 2\pi$ radians.

Operation of the device may be illustrated by assuming two waveforms, R and V (Figure 2), of the same frequency but differing in phase. If the logic had established by past history that R was leading V, the U output of the detector (pin 4) would produce a positive pulse width equal to the phase difference and the D output (Pin 11) would simply remain low.

On the other hand, it is also possible that V was leading R (Figure 2), giving rise to a positive pulse on the D output and a constant low level on the U output pin. Both outputs for the sample condition are valid since the determination of lead or lag is dependent on past edge crossing and initial conditions at start-up. A stable phase-locked loop will result from either condition.

Phase error information is contained in the output duty cycle—that is, the ratio of the output pulse width to total period. By integrating or low-pass filtering the outputs of the detector and shifting the level to accommodate ECL swings, usable analog information for the voltage controlled oscillator can be developed. A circuit useful for this function is shown in Figure 3.

Proper level shifting is accomplished by differentially driving the operational amplifier from the normally high outputs of the phase detector (U and D). Using this technique the quiescent differential voltage to the operational amplifier is zero (assuming matched "1" levels from the phase detector). The U and D outputs are then used to pass along phase information to the operational amplifier. Phase error summing is accomplished through resistors R1 connected to the inputs of the operational amplifier. Some R-C filtering imbedded within the input network (Figure 3) may be very beneficial since the very narrow correctional pulses of the MC12040 would not normally be integrated by the amplifier. Phase detector gain for this configuration is approximately 0.16 volts/radian.

System phase error stems from input offset voltage in the operational amplifier, mismatching of nominally equal resistors, and mismatching of phase detector "high" states between the outputs used for threshold setting and phase measuring. All these effects are reflected in the gain constant. For example, a 16 mV offset voltage in the amplifier would cause an error of $0.016/0.16 = 0.1$ radian or 5.7 degrees of error. Phase error can be trimmed to zero initially by trimming either input offset or one of the threshold resistors (R1 in Figure 3). Phase error over temperature depends on how much the offending parameters drift.

Figure 2. Timing Diagram

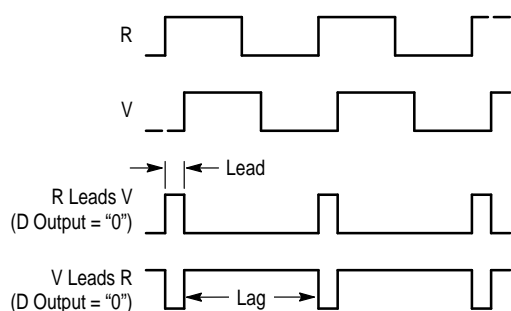
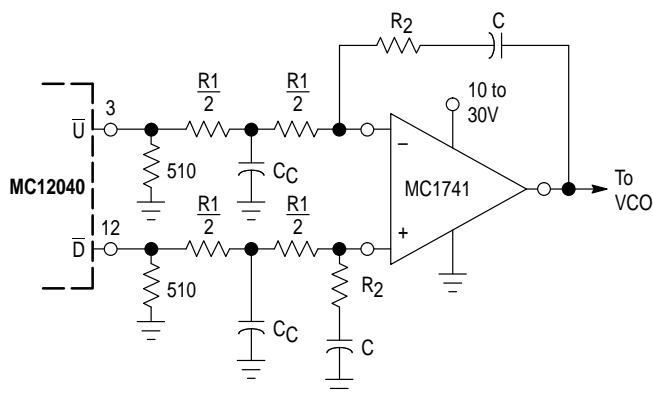


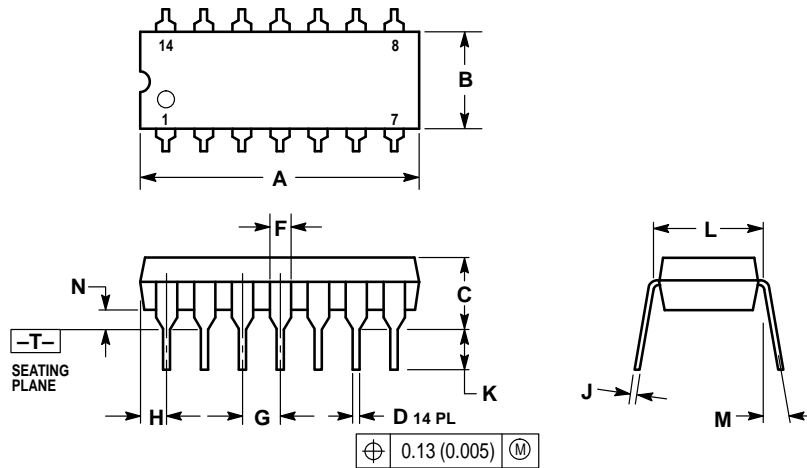
Figure 3. Typical Filter and Summing Network



MC12040

OUTLINE DIMENSIONS

P SUFFIX
PLASTIC PACKAGE
CASE 646-06
ISSUE M



NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION L TO CENTER OF LEADS WHEN FORMED PARALLEL.
4. DIMENSION B DOES NOT INCLUDE MOLD FLASH.
5. ROUNDED CORNERS OPTIONAL.

| DIM | INCHES | | MILLIMETERS | |
|-----|-----------|-------|-------------|-------|
| | MIN | MAX | MIN | MAX |
| A | 0.715 | 0.770 | 18.16 | 18.80 |
| B | 0.240 | 0.260 | 6.10 | 6.60 |
| C | 0.145 | 0.185 | 3.69 | 4.69 |
| D | 0.015 | 0.021 | 0.38 | 0.53 |
| F | 0.040 | 0.070 | 1.02 | 1.78 |
| G | 0.100 BSC | | 2.54 BSC | |
| H | 0.052 | 0.095 | 1.32 | 2.41 |
| J | 0.008 | 0.015 | 0.20 | 0.38 |
| K | 0.115 | 0.135 | 2.92 | 3.43 |
| L | 0.290 | 0.310 | 7.37 | 7.87 |
| M | 10° | | 10° | |
| N | 0.015 | 0.039 | 0.38 | 1.01 |

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