The COP444L Evaluation

National Semiconductor
COP Note 4
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The 444L-EVAL is a software programm intended to be used with the COP444LP to demonstrate operating characteristics and facilitate user familiarization and evaluation of the COP444L and the COPS™ family in general. This software program is available on Dial-a-Helper.

The 444L-EVAL has two mutually exclusive operating modes: an up/down counter/timer or a simple music synthesizer. The state of pin L7 at power up determines the operating mode.

1.0 THE 444L-EVAL AS A SIMPLE MUSIC SYNTHESIZER

Figure 1 indicates the connection of the 444L-EVAL as a simple music synthesizer. As the diagram indicates, the connections required for operation are minimal. The oscillator may be a crystal circuit using CKI and CKO; an external oscillator to CKI; or an RC network using CKI and CKO. As should be expected, the crystal circuit provides the greatest frequency stability and precision. The RC network will provide an acceptable oscillation frequency but that frequency will be neither precise nor stable over temperature and voltage. The external oscillator, of course, is as good as its source. The frequencies for the various notes and delay times are set up assuming that the oscillator frequency is 2 MHz. Three modes of operation are available in the music synthesizer mode: play a note; play one of four stored tunes; or record a tune for subsequent replay.

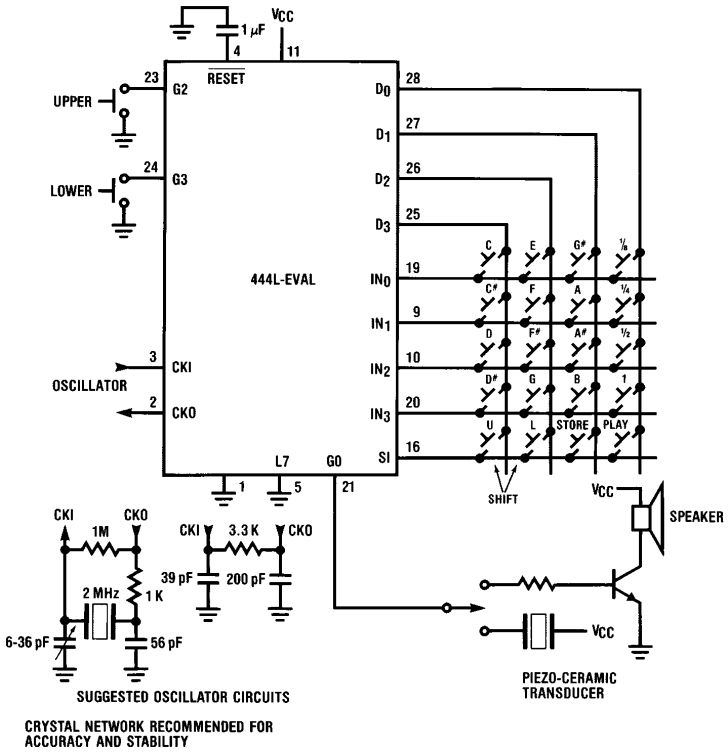

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FIGURE 1. 444L-EVAL as Simple Music Synthesizer

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1.A. PLAY A NOTE

Twelve keys, representing the twelve notes in one octave, are labeled ''C'' through ''B''. Depressing a key causes a square wave of the corresponding frequency to output at GO. The user may drive a piezo-ceramic transducer directly with this signal. With the appropriate buffering, the user may use this signal to drive anything he wishes. A simple transistor driver is sufficient to drive a small speaker. The user can be as simple or as complex as he desires at this point—e.g. he can do some wave shaping, add an audio amplifier, and drive a high quality speaker.

The 444L-EVAL has a range of two and one-half octaves: the basic octave on the keyboard (which is middle C and the 11 notes above it in the chromatic scale), one full octave above the basic octave and one-half octave below the basic octave. The notes in the basic octave are played by depressing the appropriate key (one key at a time—the keyboard has no rollover provisions). A note in the upper octave is played by first depressing and releasing the U SHIFT key and then depressing the note key. Similarly, a note in the lower one-half octave is played by first depressing and releasing the L SHIFT key and then depressing the note key. Two other shift keys are present: UPPER and LOWER. All notes played while the UPPER key is held down will be in the upper octave. Similarly, note F# through B when played while the LOWER key is held down will be in the lower one-half octave. The lower octave notes C through F are not present and depressing any of these 6 keys while the LOWER key is held down or after depressing the L SHIFT key will play the note in the basic octave.

1.B. PLAY STORED TUNE

The 444L-EVAL can play four preprogrammed tunes. Depressing PLAY followed by ''1/8'', ''1/4'', ''1/2'', or ''1'' will cause one of these tunes to be played. The tunes are:

PLAY 1 —Music Box Dancer

PLAY 1/2 —Santa Lucia

PLAY 1/4 —Godfather Theme

PLAY 1/8 —Theme from Tchaikowsky Piano Concerto #1

1.C. RECORD A TUNE

Any combination of notes and rests up to a total of 48 may be stored in RAM for later replay. A note is stored by depressing the appropriate key(s), followed by the duration of the note (1/16 note, 1/8 note, 3/16 note, 1/4 note, 3/8 note, 1/2 note, 3/4 note, whole(1) note), followed by STORE. A rest is stored by selecting the duration and depressing STORE. The rests or durations of 1/16, 3/16, 3/8, and 3/4 are obtained by first depressing L SHIFT and then 1/8, 1/4, 1/2, or 1 respectively. When the tune is complete press PLAY followed by STORE. The tune will be played for immediate audition. Subsequent depression of PLAY and then STORE will play the last stored tune.

Only one tune may be stored, regardless of length. Attempts to store a new or second tune will erase the previously stored tune. There are no editing features in this mode. (In a ''real system'' of this type some form of editing would be desirable. It would not be difficult to add editing features.)

Note: The accuracy of the tones produced is a function of the oscillator accuracy and stability. The crystal oscillator, or an accurate, stable external oscillator is recommended.

2.0. THE 444L-EVAL AS AN UP/DOWN COUNTER/TIMER

By connecting pin L7 to V_{CC} and providing power and oscillator the 444L-EVAL functions as an 8 digit binary/BCD up/down counter. In addition, an approximate 1 Hz signal is produced by the device. The 444L-EVAL can drive a single digit LED display directly. With the appropriate driver (COP472, COP470, MM5450/5451) the device can drive a 4 digit LCD, VF, or LED display. Any combination of these displays can be connected at any given time.

The binary/BCD and and up/down modes are controlled by the states of input pins IN0 and IN2 as indicated below:

IN0 = 1 (Default state) —BCD counter
IN0 = 0 —Binary Counter
IN2 = 1 (Default state) —Count Up
IN2 = 0 —Count Down

The up/down control may be changed at any time. Changing the binary-BCD control during operation clears the counter before counting begins in the new mode.

Pins G2 and G3 provide display control to the user. He can choose to view either the most significant 4 digits of the counter or the least significant 4 digits of the counter. Further, the user can disable the update of the 4 digit displays. The controls are as follows:

G2 = 1 (Default state) —Enable update of 4 digit displays
G2 = 0 —Disable update of 4 digit displays
G3 = 1 (Default state) —Display least significant 4 digits of counter
G3 = 0 —Display most significant 4 digits of counter

The single digit LED display displays the least significant digit of the counter. (Note, the direct drive capability for the single digit LED display refers to a small LED digit—NSA1541A, NSA1166k, or equivalent.)

2.A. I/O MODE

The 444L-EVAL has the capability to allow the user to read or write the 8 digit counter through the L port. In the I/O mode, the single digit LED display is disabled. The 4 digit displays are not affected. In this mode pins D0 and IN3 are used for the handshaking sequence. D0 is a Ready/Write signal from the 444L-EVAL to the outside; IN3 is a Write/Acknowledge from the outside to the 444L-EVAL. Data I/O is via L0–L3 with L0 being the least significant bit. Data is standard BCD for the BCD counter mode or standard hex for the binary counter mode. The digit address is on pins L4–L6 with L4 being the least significant bit. Digit address

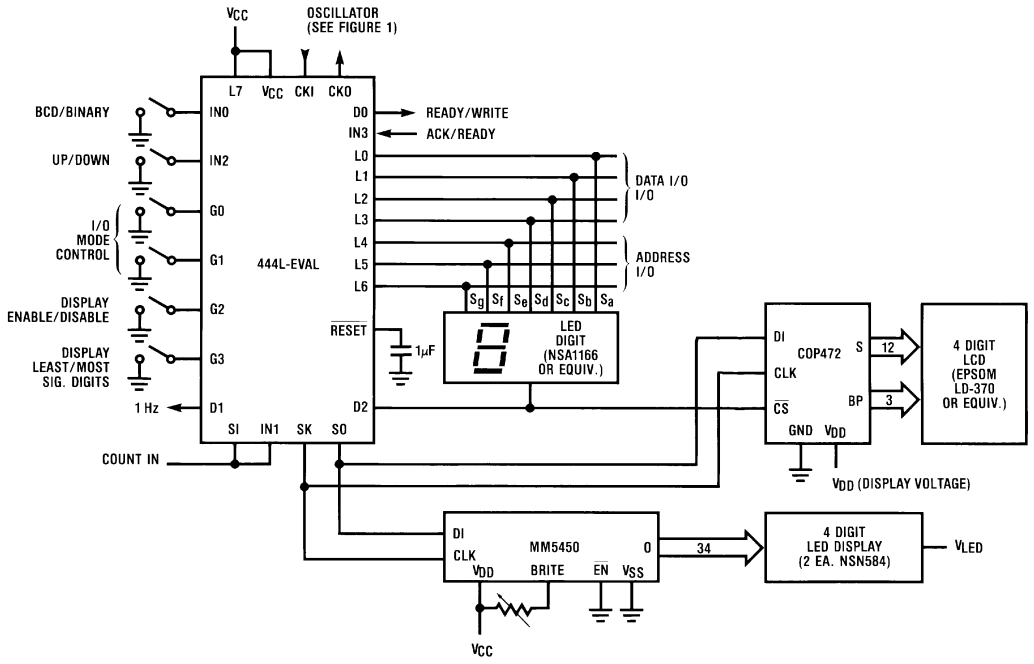

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FIGURE 2. 444L-EVAL in Counter Mode

0 is the least significant digit of the counter; digit address 7 is the most significant digit of the counter. The I/O modes are controlled by pins G0 and G1 as follows:

G0	G1	
0	0	Output data with handshake, single digit LED off
0	1	Input data with handshake, single digit LED off
1	0	Auto output, no handshake, single digit LED on
1	1	Default condition, No I/O, single digit LED displays least significant digit of counter

2.A.1. Output Data with Handshake

With this mode selected the 444L-EVAL will output data with a handshake sequence. Note that the outputting of data is relatively slow as the device is counting and updating displays between successive digit outputs.

Before data is output, or the next digit of the counter is output, the 444L-EVAL must see IN3 (Acknowledge or ready from the external world high). The Ready/Write pin (D0) is assumed to be high at this point. With D0 high and IN3 high, the device will output the data and digit address. After the data and address are output, the D0 line—functioning as a write strobe here—goes low. The 444L-EVAL then expects the signal at IN3 to go low indicating that the external world has read the data. When the device sees IN3 go low, D0 will be brought high indicating that the sequence is ready to repeat as soon as IN3 goes high again. The counter digits are output sequentially from least significant digit (digit address 0) through most significant digit (digit address 7). The sequence will continuously repeat as long as this mode is selected.

2.A.2. Input Data with Handshake

The 444L-EVAL will take data supplied to it and load the counter. The sequence is similar to that described above for the output mode. The external device(s) supplies both the data and the digit address where that data is to be loaded.

When sending data to the 444L-EVAL, the external circuitry must test that the device is ready to receive data (D0 high). Then the data and address should be presented at the L port. Then the Write signal (IN3) should be driven low. The 444L-EVAL will read the data and then drive D0 low. When D0 goes low, the external circuitry should bring IN3 high. After IN3 returns high, the 444L-EVAL will signal it is ready to receive data by sending D0 high. Note that this sequence is relatively slow. The 444L-EVAL is performing several operations between successive read operations.

2.A.3. Automatic Output Mode

In the automatic output mode, the single digit LED is on. It is not displaying the least significant digit of the counter in this mode. The display is on so that the user can connect this LED digit, select the automatic output mode, and observe the states of the L lines without having to put more sophisticated equipment or circuitry external to the 444L-EVAL. Segments a through d are pins L0 thorugh L3; segments,

e, f, g are pins L4, L5, and L6. Thus the user can observe the digit address changing and observe the corresponding data.

In this mode, the state of pin IN3 is irrelevant. The 444L-EVAL sequentially outputs the digits of the counter. D0 goes high when the data and address is being changed. D0 goes low when the data is valid. As in the other I/O modes, the process is slow. There is about 4 to 5 milliseconds between the successive digit outputs.

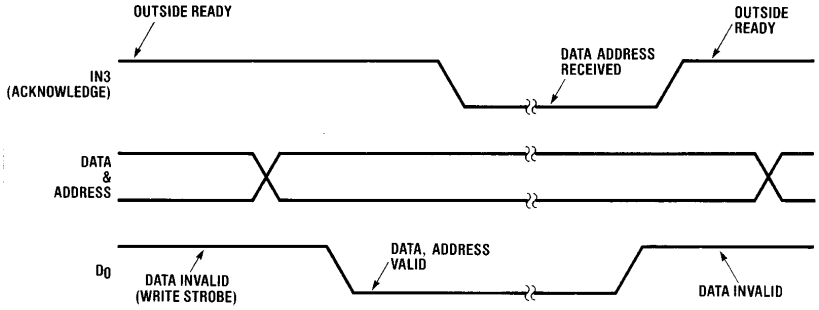

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FIGURE 3A. Relative Timing—Output Handshake

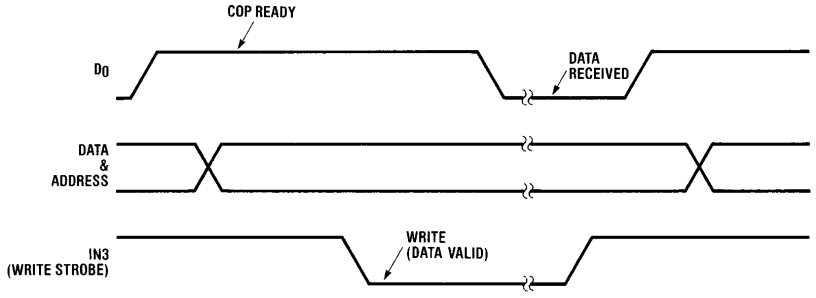

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FIGURE 3B. Relative Timing—Input Handshake

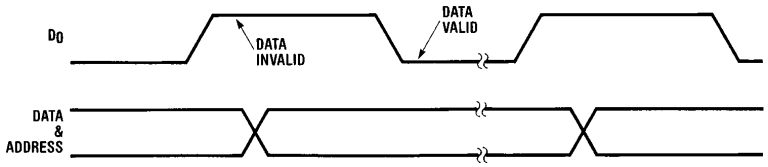

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FIGURE 3C. Relative Timing—Automatic Output

3.0 SELECTED OPTIONS

The 444L-EVAL has the following options selected:

GND	Option 1	= 0	
CKO	Option 2	= 0	CKO is clock generator output to crystal
CKI	Option 3	= 0	CKI oscillator input divide by 32
RESET	Option 4	= 0	Load device to V_{CC} on RESET
L7	Option 5	= 0	Standard output on L7
L6	Option 6	= 2	High current LED direct segment drive on L6
L5	Option 7	= 2	High current LED direct segment drive on L5
L4	Option 8	= 2	High current LED direct segment drive on L4
IN1	Option 9	= 0	Load device to V_{CC} on IN1
IN2	Option 10	= 0	Load device to V_{CC} on IN2
V_{CC}	Option 11	= 1	4.5V to 9.5V operation
L3	Option 12	= 2	High current LED direct segment drive on L3
L2	Option 13	= 2	High current LED direct segment drive on L2
L1	Option 14	= 2	High current LED direct segment drive on L1
L0	Option 15	= 2	High current LED direct segment drive on L0
SI	Option 16	= 0	Load device to V_{CC} on SI
SO	Option 17	= 2	Push-pull output on SO
SK	Option 18	= 2	Push-pull output on SK
IN0	Option 19	= 0	Load device to V_{CC} on IN0
IN3	Option 20	= 0	Load device to V_{CC} on IN3
G0	Option 21	= 0	Very high current standard output on G0
G1	Option 22	= 2	High current standard output on G1
G2	Option 23	= 4	Standard LSTTL output on G2
G3	Option 24	= 4	Standard LSTTL output on G3
D3	Option 25	= 0	Very high current standard output on D3
D2	Option 26	= 0	Very high current standard output on D2
D1	Option 27	= 0	Very high current standard output on D1
D0	Option 28	= 0	Very high current standard output on D0
	Option 29	= 0	Standard TTL input levels on L
	Option 30	= 0	Standard TTL input levels on IN
	Option 31	= 0	Standard TTL input levels on G
	Option 32	= 0	Standard TTL input levels on SI
	Option 33	= 1	Schmitt trigger inputs on RESET
	Option 34	= 0	CKO input levels, not used here
	Option 35	= 0	COP444L
	Option 36	= 0	Normal RESET operation

4.0 CONCLUSION

The 444L-EVAL demonstrates much of the capability of the COP444L. It does not indicate the limits of the device by any means. The I/O features were included to demonstrate that capability. The fact that they are slow is due strictly to the program. If such I/O capability were a necessary part of an application it could be accomplished much much faster than was done here. The counter modes are quite versatile and are generally self explanatory. It was fairly easy to provide a counter with the versatility of that included here. The music synthesis mode demonstrates clearly the program efficiency of the device.

The 444L-EVAL is intended for demonstration. There is no question that aspects of its operation could be improved and tailored to a specific application. It is unlikely that this particular combination of features would be found in any one application. It is also interesting to note that the program memory in the device is not full. There is still a significant amount of room left in the ROM. This should serve to make it clear that the capabilities of the device have not been stretched at all in order to include these demonstration functions.

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