Further Information on Testing of COPS™ Microcontrollers

National Semiconductor
Application Brief 4
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COP Note 7 describes the basic approach and philosophy for testing COPS microcontrollers. This application brief is intended to complement and expand COP Note 7. It is assumed that the reader is familiar with and has access to COP Note 7.

TEST MODE

On COPS microcontrollers, test mode is entered by forcing the SO output to a logic ''1'' when it should otherwise be a logic ''0''. The easiest way to do this is to hold the COPS device in reset, hold the $\overline{\text{RESET}}$ pin low, and pull SO up to a logic ''1'' level. WARNING: *Do not force more than 3.0V on SO, as damage to the device may occur.* SO should be forced to approximately 2.5V to guarantee entry into test mode and to protect the device from damage.

Once the device is in test mode, the state of the SI input controls the type of test. SI at a logic ''1'' (high level) conditions the device to accept instructions from an external source via the L port. In test mode, when SI is high, the internal ROM is disabled. SI at a logic ''0'' (low level) forces the device to dump the internal ROM to the L port where the user can read and verify the ROM contents.

INSTRUCTION INPUT

With the device in test mode and SI at a logic ''1'', the microcontroller will read the data at the L port as instructions. The instructions must be presented at the beginning of each cycle time and must remain valid during the whole cycle time. The chip SK output is the instruction cycle clock in test mode and can be used as the timing reference. *Figure 1* indicates the timing for instruction input using the chip's SK output as the reference. A new instruction must be valid at the L inputs within approximately 200 ns of the rising edge of SK. The user should make every effort to make this time (t2 in *Figure 1*) as short as possible.

It is possible to create an external SK signal which more closely duplicates the internal SK. This requires building a divider from CKI and synchronizing the resultant signal with the device under test. This is significant because it is the internal version of the SK signal which is the master timing signal for the microcontroller. The short time from the rising edge of the SK output to instruction valid is necessary because the actual objective is to provide new instructions at the rising edge, or close to it, of the internal timing signal. If the user creates the external timing signal, the 200 ns time is not applicable. A new instruction, or ROM word, would be presented at each rising edge of the external signal. A method for generating and using this external SK is described in COP Note 7.

ROM DUMP

With SI at logic ''0'' in test mode, the microcontroller will dump the ROM to the L port. ROM will be dumped sequentially, one word at a time, starting at whatever value the program counter contains. A new ROM word appears at the L lines every falling edge of the chip SK signal. The output timing (t1 in *Figure 1*) is the L output timing as found in the various device data sheets. The device will remain in ROM dump mode as long as SI is at logic ''0'' in test mode. The program counter will wrap around from the maximum address to 000 and ROM dump will continue.

To get a ROM dump, the user cannot simply enter test mode and force SI to logic ''0''. Some conditioning of the device is necessary. This requires that the user first go into instruction input mode and set up the device. The suggested sequence is as follows:

1. Enter test mode—pull $\overline{\text{RESET}}$ low, force SO to about 2.5V.
2. Force SI to logic ''1'' and force 0s on L lines—RESET still low.
3. Force RESET high and input the following sequence to the device:

```
CLRA
JMP     3FC   (modify for ROM size)
LQID
O44H
LEI     4
NOP
```

4. During the NOP, change SI from high to low as shown in *Figure 2.* The ROM dump should start at address 000H at the time shown in *Figure 2.*

Figure 3 presents a general timing diagram for the entire sequence above. The jump instruction (JMP 3FC) in the sequence is used merely to position the program counter so that the ROM dump will begin at a specified location. That jump will be modified to reflect different ROM sizes or different desired starting locations for the ROM dump.

CHANGING BETWEEN INSTRUCTION INPUT AND ROM DUMP

The change from instruction input to ROM dump is accomplished according to the timing in *Figure 2.* It is necessary to do this to perform a valid ROM dump. However, it is not recommended to go the other direction, from ROM dump to instruction input, ''on the fly''. The instruction input mode should only be entered while the device is reset, $\overline{\text{RESET}}$ line low, to guarantee proper timing.

CONCLUSION

With COP Note 7 and this application brief, the user should be able to create a workable functional test for his COPS microcontroller. The relative timing is presented here and general techniques and sequences are provided in COP Note 7.

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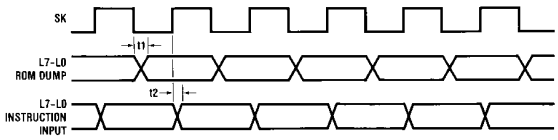

t1 = L output timing (t_{PD1}, t_{PD0}) as found in data sheet

t2 ~ 200 ns max

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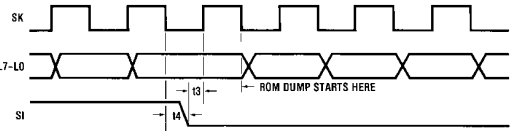
FIGURE 1. Basic Test Mode Timing



t4 ≈ t3 ~ 1 μs min for 4 μs devices

t4 ≈ t3 ~ 4 μs min for 16 μs devices

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FIGURE 2. Timing for Changing from Instruction Input to ROM Dump—Test Mode

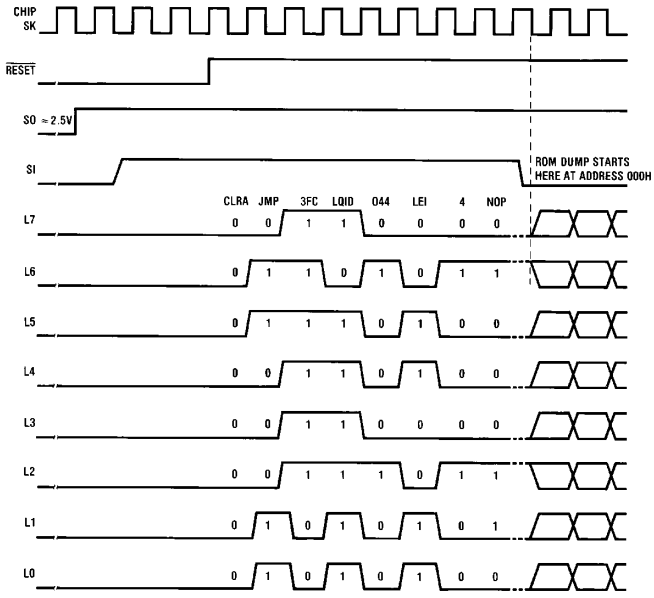

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FIGURE 3. Relative Timing for Suggested Sequence to Generate ROM Dump

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