Chapter 7
One-Shot Applications

ONE-SHOT OPERATING MODES

The Am9513 is capable of providing a variety of retriggerable and non-retriggerable one-shot functions, usually with no external logic. One-shot timing functions may be triggered in one of three manners: by a software ARM command, by an active-going gate edge, or by an ARM command followed by a gate edge.

Triggering by a software ARM command, shown in Figure 7-1a, is provided by Mode A. This triggering mode is particularly useful when the one-shot's firing is to be controlled by the microprocessor, independent of any external signals.

Triggering by a hardware gate edge, shown in Figure 7-1b, is provided by Mode F for non-retriggerable one-shot operation, and by Mode R, for retriggerable one-shot operation. This trigger type is useful when the one-shot is to be repetitively fired by an external signal, independent of the host microprocessor. When using this triggering option, the next count cycle can be triggered after the counter reaches TC. In fact, if the TC output is fed back to the counter's gate, as shown in Figure 7-2, the counter will essentially free-run after being started by an external gate pulse. The counter can trigger off either edge of the TC pulse in this configuration. Figure 7-2 shows the TC output being fed back through

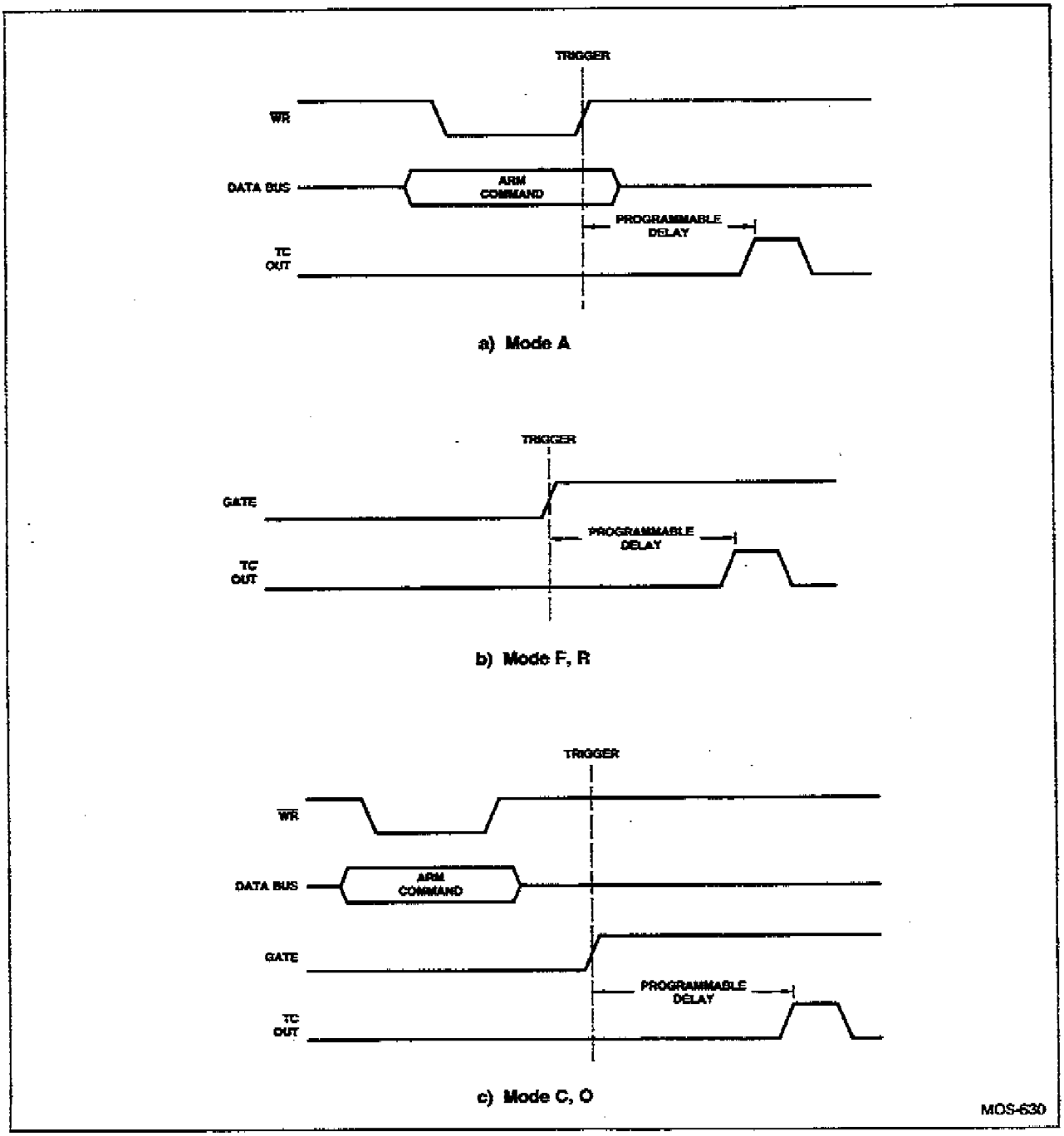

Figure 7-1. One-Shot Trigger Options

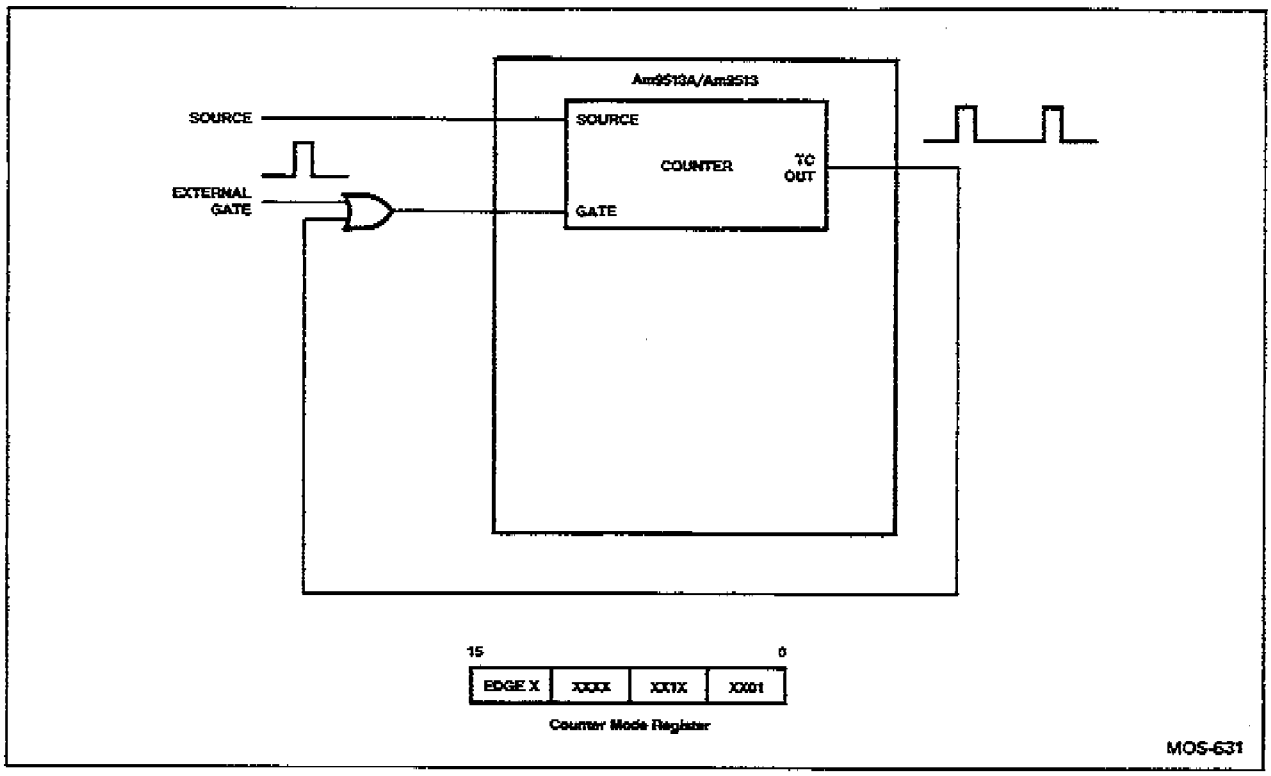

Figure 7-2. TC Feedback Connection

an external OR gate. Applications using an 8-bit data bus can use the AND function provided by the auxiliary Gate inputs as a negative logic OR, eliminating the need for an external gate.

The third trigger type, shown in Figure 7-1c, will fire the one-shot when a software ARM command and a hardware gate edge are applied in that order. This triggering operation is useful in applications which need the microprocessor to qualify when triggering can occur but which actually trigger the one-shot from an external signal.

In addition to the three triggering modes, there are three different types of one-shot output waveforms that may be generated by the Am9513, as shown in Figure 7-3. The type of output waveform obtained is selected by the particular counting mode used and the programming of the Output Control field in the counter's Mode register.

The strobed or TC one-shot output generates an active pulse for a one clock cycle duration when the counter reaches TC. This waveform is useful for triggering other counters or can be used to set, clear or toggle flip-flops to generate more complex signals.

The second one-shot output, called the traditional output, is useful only when gate edge triggering is used. The traditional output goes active following application of the gate edge and remains active until the counter reaches TC. This waveform is the type found on traditional linear one-shots, hence its name.

Although the Am9513 requires an external flip-flop to generate the traditional one-shot output, it is capable of directly generating a more general-purpose signal which has a quasi-traditional output as a special case. This more general signal is the third waveform type and provides a delayed-pulse one-shot. After the counter is triggered, the counter output remains inactive for some programmable delay. The output then goes active for a programmable period. Note that both the delay to the start of the pulse and the pulse width are separately programmable. With the minimum delay to start-of-pulse of 1 clock cycle programmed, the delayed-pulse one-shot signal becomes similar to the traditional one-shot output. The only difference between these modes is that in the traditional one-shot, the output goes active on the gate edge and in the delayed-pulse one-shot, the output goes active on the second source edge after the gate edge.

In some applications it is desirable to restart the timing sequence from the initial value after the counter starts counting but before it reaches TC. This operation, called retriggering in this document, effectively increases the time to TC. The strobed one-shot mode may be operated in a retriggerable mode in the Am9513 without external hardware. With the addition of a few external devices, retriggerable traditional and delayed-pulse one-shot waveforms can be generated.

A matrix can be constructed illustrating the combination of trigger types, output waveforms and retriggering options available with the Am9513. Such a diagram is presented in Figure 7-4. Since the combination of triggering on an ARM command and retriggering by an external gate is not a reasonable operating configuration, it is not included in the chart.

One-Shot Count Sequences

Because the Am9513 counters always reload on the rising TC edge and always count on the trailing TC edge, one-shot count sequences may be different from what users might intuitively expect. Figure 7-5 shows a typical non-retriggerable one-shot count sequence. Initially the counter contents are 5. When a gate edge is applied, the counter begins counting. On the count source

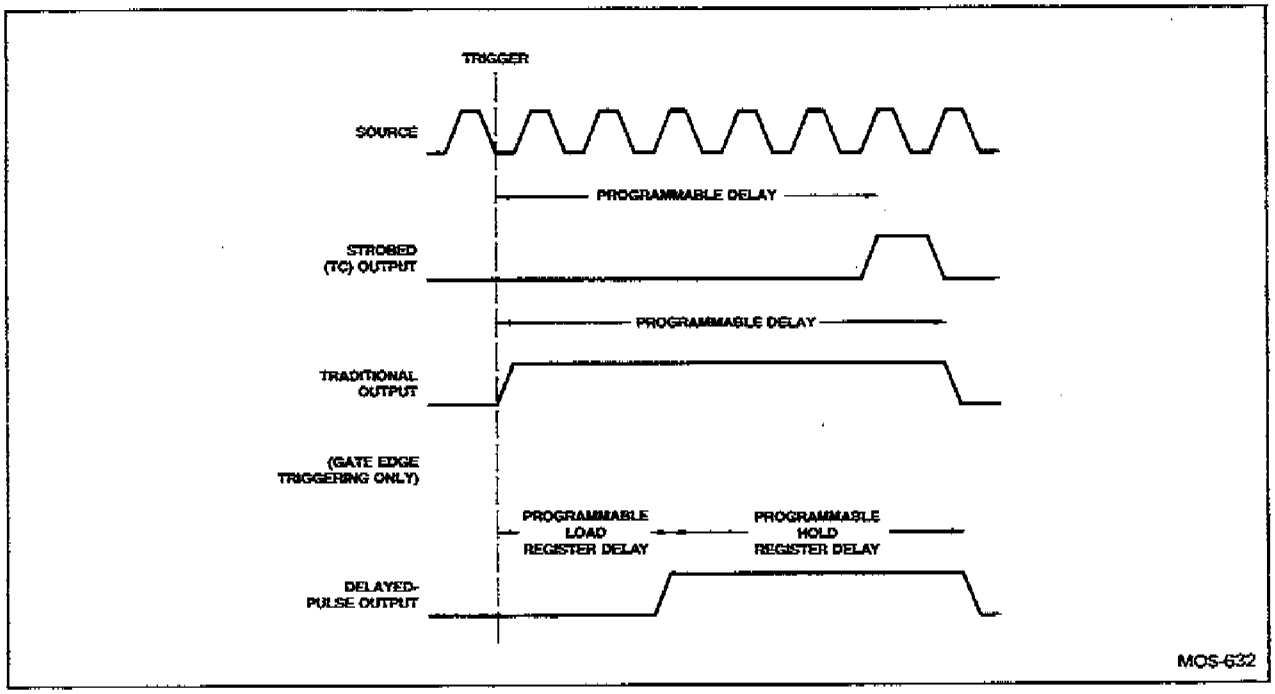

Figure 7-3. One-Shot Output Options

Retrigger Option	Non-Retriggerable			Retriggerable	
Trigger Option	**ARM**	**Gate**	**ARM and Gate**	**Gate**	**ARM and Gate**
Output Options					
Strobed Output	Mode A	Mode F	Mode C	Mode R	Mode O
Traditional Output	Mode A*	Mode F*	Mode C*	Mode R*	Mode O*
Delayed-Pulse Output	Mode G	Mode L	Mode I		

*Additional hardware required.

Figure 7-4. Matrix of Am9513 One-Shot Modes

edge that occurs when the counter contents are 1, the counter goes into TC and reloads itself from the Load register, which contains the value 6. On the trailing TC edge the counter decrements the 6 to 5 and then awaits a subsequent gate edge. Note that because the counter counts on the trailing TC edge, although the Load register contents were 6, in fact only 5 counts occur between the gate edge and the end of TC. Another more subtle point is that on initialization the user should load the Load register, execute the LOAD command and then issue a STEP command before arming the counter. The STEP command will increment/decrement the counter contents by 1 to mimic the reload-and-count-once operation which occurs on TC. This ensures that 5, not 6, will be in the counter when it is triggered by the gate edge and ensures that the time from the first gate edge to the first TC will be the same as the time from subsequent gate edges to subsequent TCs.

Count Sequences may also differ from what a user would expect when a counter is operated in a retrigger mode (Modes N, O, Q and R). In these modes, each active-going gate edge applied to the counter will transfer the counter contents into the Hold register. On the first source edge following the gate edge, the Load register contents will be transferred into the counter. Counting will occur on the second source edge after the gate edge. Note that the first gate edge applied to the counter will both start the counter and trigger a save/reload sequence. Accordingly, there will be a two count difference in retriggerable one-shot count sequences vis-a-vis non-retriggerable one-shot sequences. Figure 7-6 shows a retriggerable one-shot count sequence and can be compared to the non-retriggerable sequence shown in Figure 7-5. Since the retriggerable counter uses the first source edge after the gate edge to reload the counter, it reaches TC two clock cycles later than a non-retriggerable counter with the same Load register contents.

Non-Retriggerable One-Shots

The non-retriggerable strobed one-shot is the most basic one-shot timing mode. In this mode the output goes active for one clock cycle when the counter reaches TC. This mode is generated by selecting a TC output in the counter's output control field. For hardware gate triggering of the one-shot process, counting Mode C or F should be used. In Mode C, a new ARM command followed by a gate edge must be issued to the counter to start

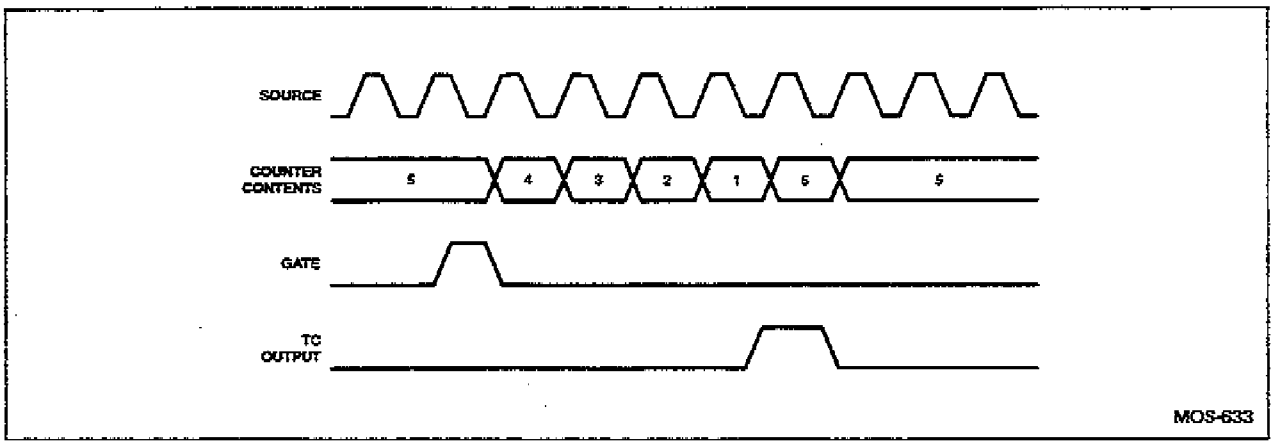

Figure 7-5. Timing Waveforms for Typical Non-Retriggerable One-Shot

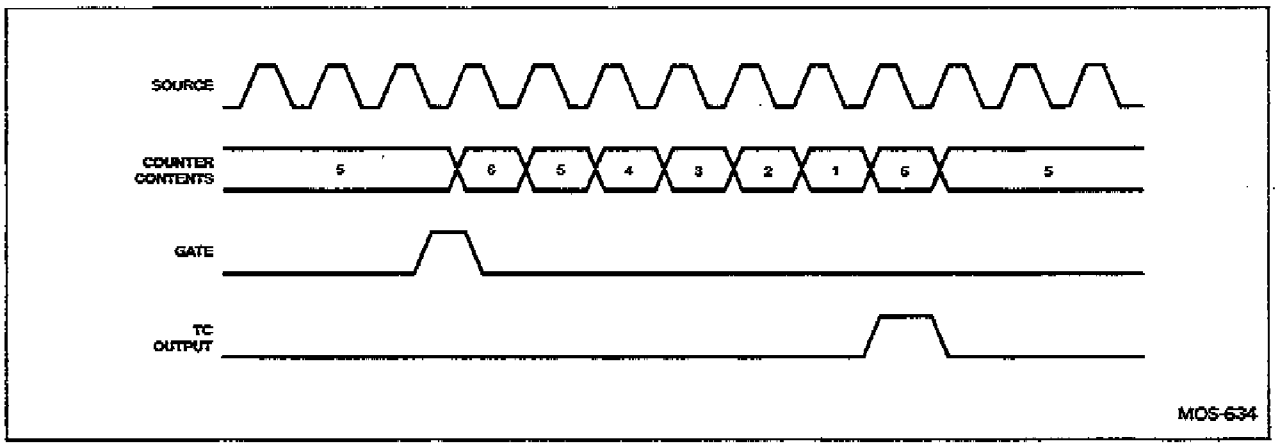

Figure 7-6. Timing Waveforms for Typical Retriggerable One-Shots

each one-shot cycle. In Mode F, the counter will perform one-shot cycles each time a gate edge is applied without requiring a new ARM command for each count cycle. In both Modes C and F, if a gate edge is applied during the count cycle before TC goes active, the edge is disregarded. Mode A provides the third variation of strobed one-shot timing. In this mode, the software ARM command is used to trigger the one-shot operation and the hardware gate input is disregarded. Strobed one-shot functions are useful in marking a particular point in time. The output will often be used to set, clear or toggle flip-flops.

With a minimal amount of external logic, an Am9513 counter can emulate a non-retriggerable, linear one-shot generating the traditional output, as shown in Figure 7-7. The advantages of digital one-shots over their linear counterparts are digital one-shot's high resolution, stable operation and their ability to easily interface with microcomputers. In the circuit shown in Figure 7-7, the counter is programmed for down counting in Mode F. An active-low TC output mode is selected. When a gate edge is applied to the counter, the flip-flop clears and the counter starts counting. When TC is reached, the output goes low for one source period, setting the flip-flop. The time that the flip-flop's Q output is high is controlled by the Load register contents. For a Load register value of K, the output high time is given by (K−2). Note that for this circuit the output goes active after application of the gate edge and is driven inactive by a source edge. The uncertainty in the relationship between the gate and the source gives a maximum count error of 1 count in the output active duration. (This uncertainty arises because the gate edge may occur anytime between shortly after a source edge and shortly before the next source edge.) Use of large count values can reduce the percentage of uncertainty to minimal levels. The delayed-pulse output mode can be programmed to drive the output active on the second source edge after the triggering gate edge. In addition to removing the uncertainty regarding the output active duration, this alternative method has the added advantage of not needing external logic.

Delayed-pulse one-shots can be triggered by software ARM command (Mode G), by hardware gate edge (Mode L) or by any ARM command followed by a gate edge (Mode I). For all these modes, the counter's output control field should be programmed for a "TC Toggled" output (CM2-CM0 = 010). If a TC output is programmed (CM2-CM0 = 001 or 101) a dual-pulse one-shot function may be generated. Here, rather than toggle the output on each TC, a one clock period wide pulse is output. The delay from the trigger to the first TC is controlled by the initial counter contents, which are usually set by a reload from the Load register at the end of a previous timing cycle. The delay between the two TC pulses is controlled by the Hold register contents.

Retriggerable One-Shots

Retriggering of one-shots provides a means to extend the time to TC after the one-shot has started timing and is accomplished by applying a retrigger signal to the counter. The retriggering may be done by hardware means, using the gate input, or by software means, using the LOAD command.

Retriggerable one-shots can be initially triggered by a gate edge (in Mode R) or by an ARM command followed by a gate edge (in Mode O). Note that the triggering gate edge also retriggers the counter; see the "One-Shot Count Sequences" section of this chapter for additional details. In both of the above modes, application of a gate edge once the counter is counting will extend the time to TC by reloading the counter from the Load register. (The counter contents are also saved in the Hold register before the reload operation, but this is not relevant to the retriggering operation.) In either mode the counter can be used in a TC output mode (CM2-CM0 = 001 or 101) to generate a strobed output, or may be used with a flip-flop as shown in Figure 7-7 to generate a traditional output.

One-shot functions may also be generated by software without hardware retriggering. A counter operated in Mode A will perform one count cycle each time it is armed. If the ARM command is viewed as a software trigger, this mode operates like a software triggered one-shot. LOAD commands can be issued to a counter operating in Mode A to extend the time to TC. Here the LOAD command behaves like a software retrigger. In fact, the LOAD command can be used with any of the one-shot modes discussed earlier, excluding the delayed-pulse one-shot mode, to act as a software retrigger, extending the time to TC. The delayed-pulse one-shot mode cannot be retriggered with a LOAD command, because it will reload from the location to be used on the upcoming TC rather than the last TC, which is not a retrigger function.

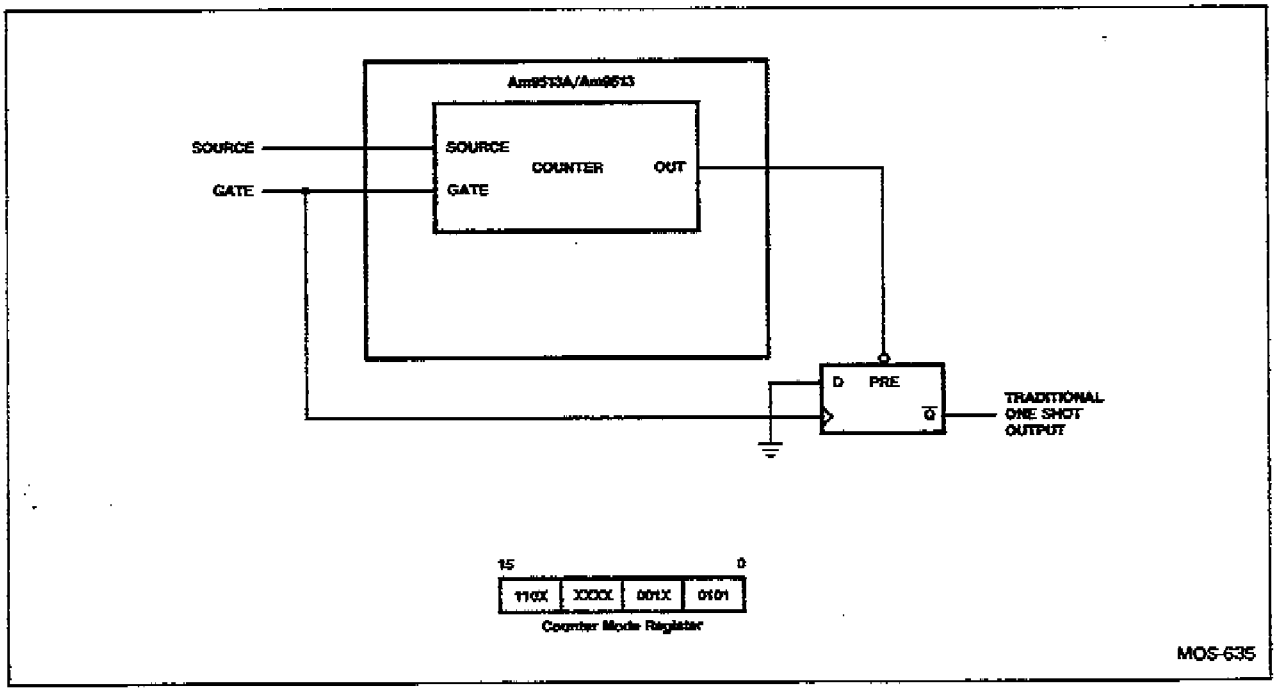

Figure 7-7. Generating a Traditional One-Shot Output