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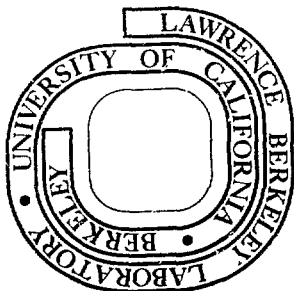
(1)

ONE SHOTS AND ALTERNATIVES IN SYNCHRONOUS DIGITAL SYSTEM DESIGN

Steve Hui & John D. Meng

The one shot or monostable multivibrator is quite often regarded as a "black sheep" in ditigal integrated circuits. Its distinctions and versatility are well known and do not necessitate mentioning. Some of the potential problems with this black sheep are summarized as follows:

1. A one shot may respond to glitches either on power supplies or on ground lines.

2. Noise pick up is a potential problem. If the leads of the RC timing components are long, noise pick up will result in faultly operation. An example is having a trimmer of RC components mounted on the front panel and the one shot on the printed circuit board a few inches away.

3. Faulty operation of a one shot is frequently not a complete integrated circuit failure, such as sticking at one or zero. It is intermittent, making troubleshooting relatively difficult.

4. Incomplete triggering has been observed. When the width of the triggering pulse narrows sufficiently, the output width may decrease drastically out not disappear. There may be problems if the one shot's output pulse is used for driving more than one device. Detection of these problems are not easy.

(2)

Even if technology eliminates all of the above problems, one shots still have the following undesirable features in digital systems:

1. In using a one shot, we potentially have the problem of having the pulse width too long or too short, requiring adjustment. Such trimming is undesirable in systems which must be mass reproduced

2. It is very convenient for debugging if one can step through a system's operation one clock pulse at a time. Such a single stepping scheme may not work with systems including one shots. For example, assume a system is malfuntioning at normal clock rate. Suppose the input to the one shot changes during the output pulse and the output pulse is extended. At a slow clock rate or with single step clocking, the condition causing such problems is not present and the cause may not be identified. (If it is a fully synchronous system, the time relationship between all signal changes and state changes remains unchanged in spite of the clock being fast or slow. We can do single step clocking).

3. As mentioned previously, a one shot's failure is very likely not a sticking at one or zero, but today, fault detection and location are often based on sticking at one or zero. Consequently, implementation and automation of fault detection, fault recovery and correction are oriented towards this capability. Typical examples are

diagnostic software and firmware for computer based
systems and fully automatic fault location for digital
systems. They check states of the machines but not the
transients. (In a manual mode of fault location, logic
analyzers can spot transients).

4. A one shot is an asynchronous circuit. Placing a one
shot in a synchronous circuit may destroy some of the
virtues of being synchronous. In a fully synchronous
circuit, circuit states only change on clock edges.
During the time between these clock edges, the entire
circuit remains unchanged, independent of the
environment. That is, the circuit is immune to
transients and noise except for the short time during
clock edges. Using one shots in a synchronous circuit
may eliminate this very desirable advantage.

The above is not to suggest complete elimination of one shots
from our applications. The one shot is a useful device, an
excellent choice for certain applications. In other applications,
particularly in sychronous digital circuits, alternatives to one
shots are worth considering. Some of these alternatives for
synchronous circuits are offered and implemented below:

Replacement of One Shots by Flip Flops and Gates in Synchronous
Circuits

A. Input triggers an output pulse of one clock period as in
Figure 1. The input in Figure 1 must be synchronous with the
circuit and longer than one clock period for reliable

operation. There is always one pulse generated for each time the input goes from low to high, regardless of the time the input stays high.

B. Input triggers an output pulse of two clock periods in Figure 2 and three clock periods in Figure 3. The conditions in A above also apply here.

C. Input triggers an output of four or more clock periods in Figure 4. The conditions in A above also apply here. The counter used in this scheme must be "synchronous load" and long output pulse widths can be achieved by cascading counters. Case B can also use this method if cost is not a serious consideration.

D. Input triggers a delayed output pulse as in Figure 5. The delay and pulse width can be lengthened cascading counters. The conditions of case A also apply here.

The above designs from Case A to case E are intended for fully snychronous circuits (preset and clear inputs are not used), making them applicable in high speed application. The tolerance on pulse width generated is equal to the tolerance on clock rate. No trimming and adjustments are required

Replacement of One Shots by Delay Lines

Complexity (number of connections) and requirements for synchronous inputs are disadvantages of the above approaches. Simplicity, asynchronous inputs, improved reliability and accuracy can be obtained at higher cost by using delay lines as shown in Figure 6.

The input pulse width must be longer than the delay caused by the delay line. TTL, LSTTL and ECL delay lines are commercially

available with excellent specificiations. Programmable, multiple output (different delay times) delay lines are also available. Delay lines are expensive (about $10 apiece) but are compact, reliable and excellent for accurate timing purposes. For example, timing in a dynamic memory is a good application for delay lines.

The delay line approach and the flip flop and counter approach can be combined or mixed to meet different cost, reliability, delay and pulse width requirements.

Replacement of One Shot Functions with Other Methods

If exactness of pulse width is not of importance while cost and simplicity are, the approaches in Figures 7 and 8 are handy. Care must be taken in choosing the capacitor value, which should be small. These approaches are suitable for generating pulses in the nanosecond range.

Figure 9 is an example of using a one shot integrated circuit (IC) not as a one shot. We utilize the schmidt trigger inside the IC and the RC components for generating a delay.

CLOCK

INPUT

TW
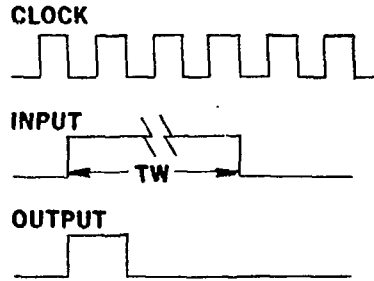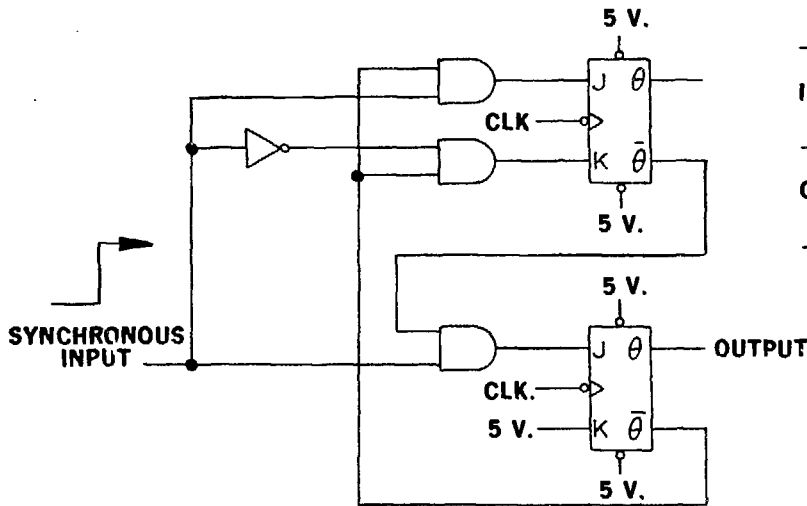
OUTPUT

TIMING

TW ≥ 1 CLOCK PERIOD

CLK = CLOCK INPUT

INITIALLY θ = ZERO

JK FLIP FLOP: 74LS112 OR 74S112

FIGURE - 1: INPUT TRIGGERS AN OUTPUT PULSE OF ONE CLOCK PERIOD
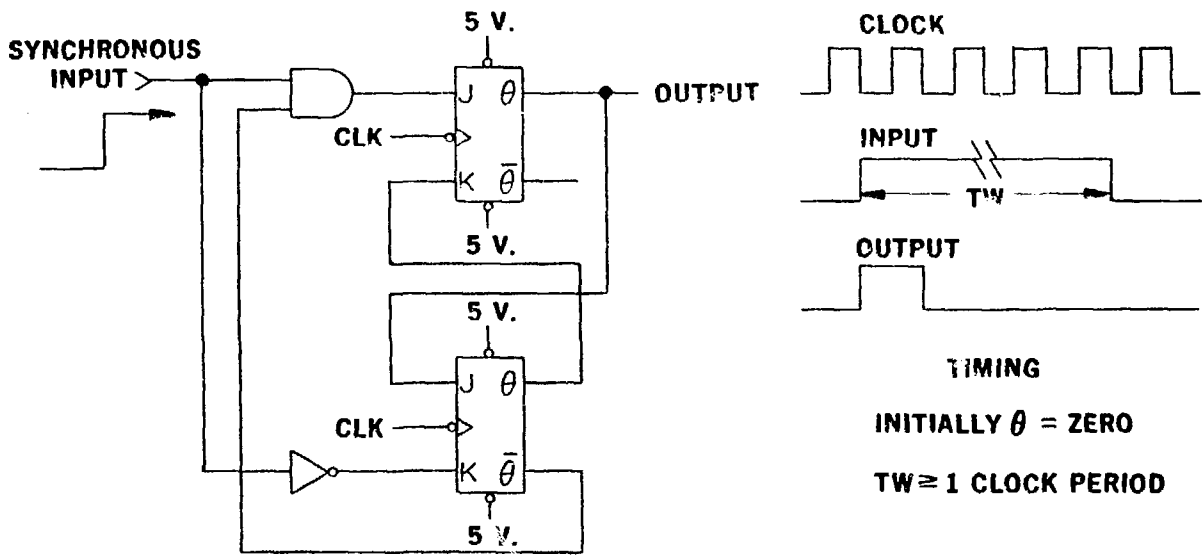
XBL 7812-14024

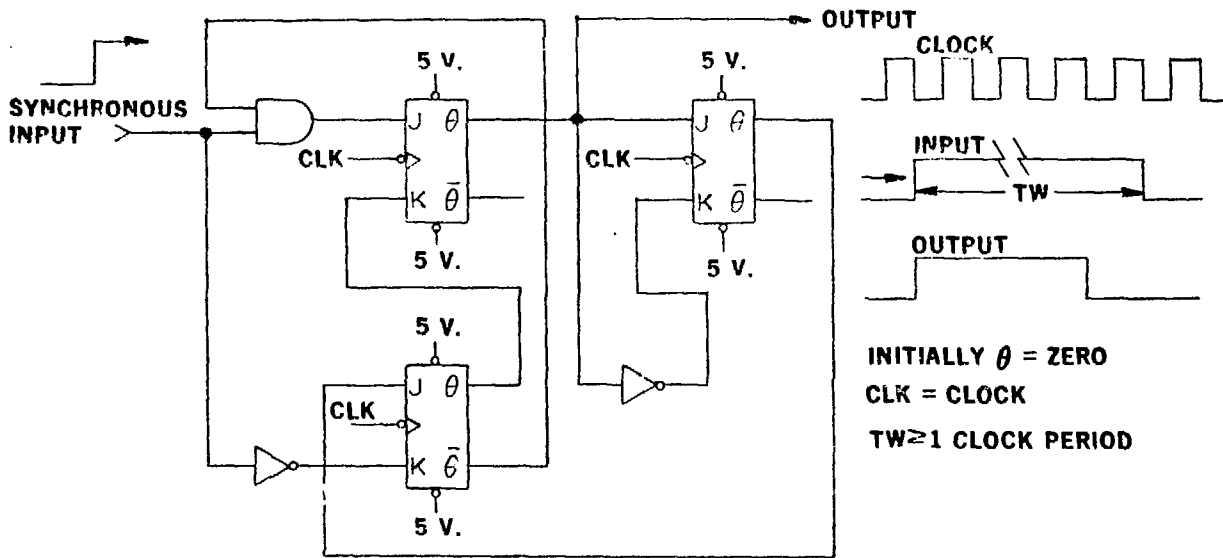FIGURE - 2 : INPUT TRIGGERS AN OUTPUT PULSE OF TWO CLOCK PERIODS.

XBL 7812-14025

FIGURE - 3: INPUT TRIGGERS AN OUTPUT PULSE OF THREE CLOCK PERIODS.
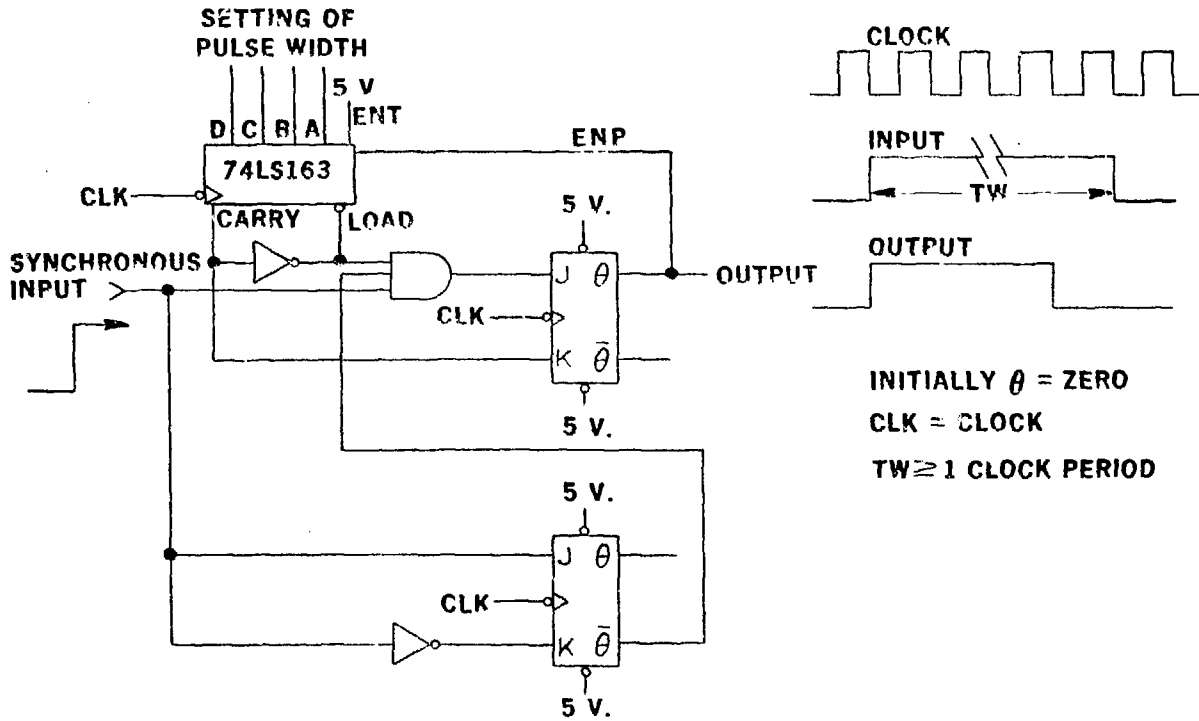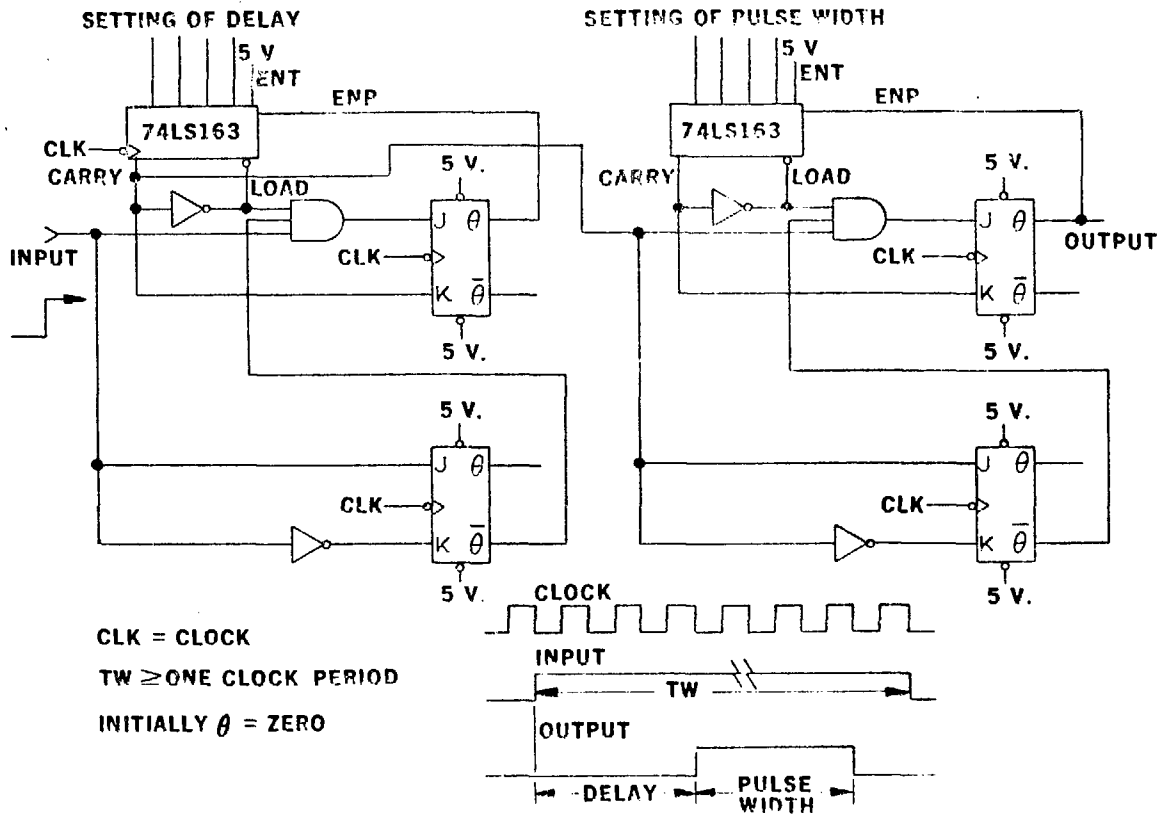
XBL 7812-14026

FIGURE - 4: INPUT TRIGGERS AN OUTPUT PULSE OF VARIABLE PULSE WIDTH

XBL 7812-14027

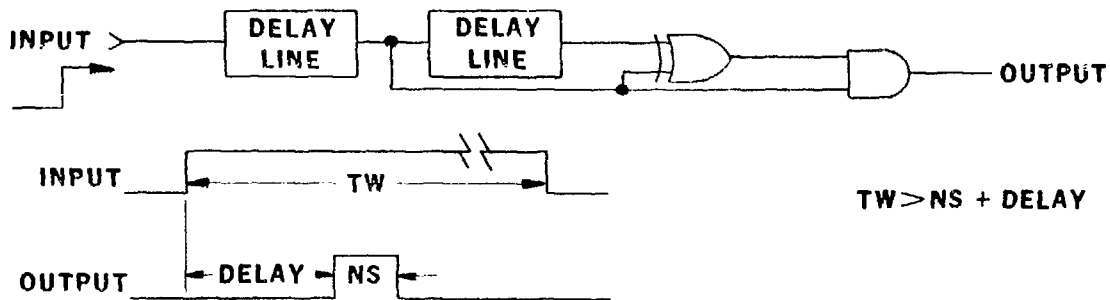FIGURE 5: INPUT TRIGGERS AN OUTPUT PULSE WITH VARIABLE DELAY AND PULSE WIDTH
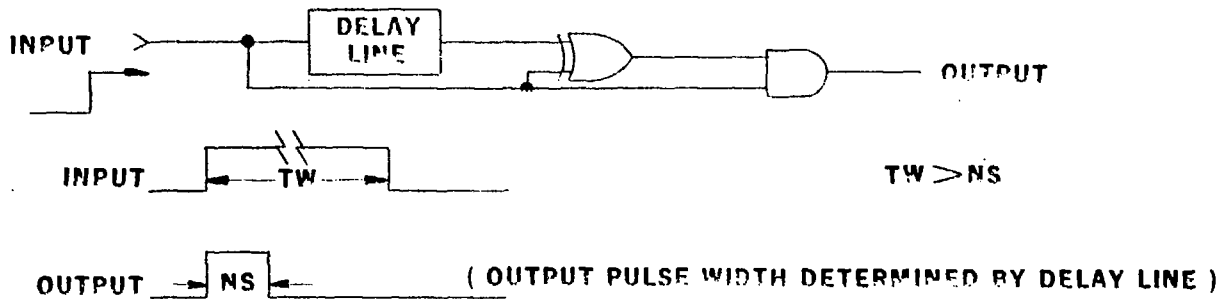
YBL 7812-14028

INPUT

DELAY LINE

OUTPUT

INPUT ___ TW ___

TW > NS

OUTPUT __ NS __ (OUTPUT PULSE WIDTH DETERMINED BY DELAY LINE)

INPUT

DELAY LINE   DELAY LINE

OUTPUT

INPUT ___ TW ___

TW > NS + DELAY

OUTPUT ___ DELAY __ NS __

FIGURE - 6: INPUT TRIGGERS AN OUTPUT PULSE OF FIXED PULSE WIDTH
            AND DELAY BY DELAY LINES

XBL 7812-14029
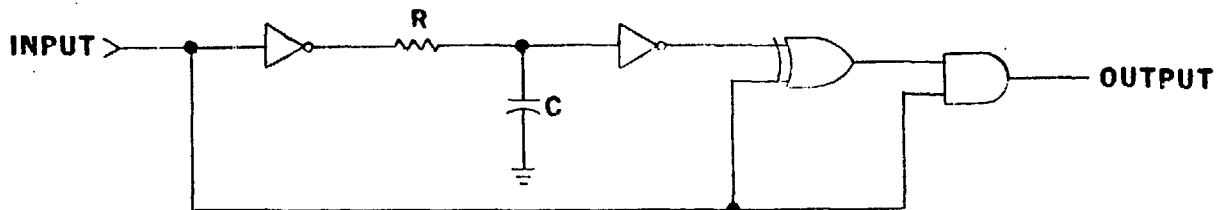
INPUT >
R
C
OUTPUT

FIGURE - 7: INPUT TRIGGERS AN OUTPUT PULSE (IN NANOSECOND RANGE)
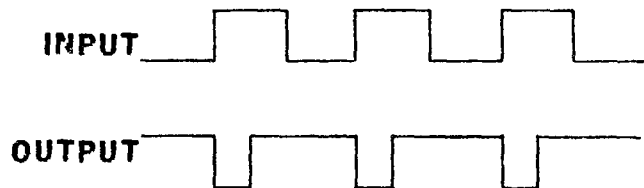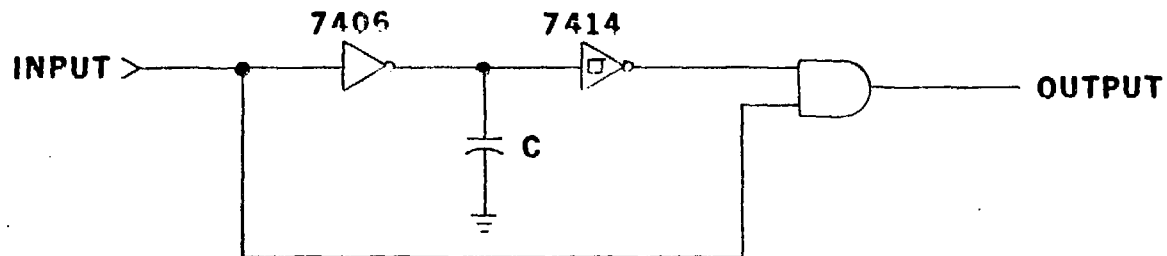
XBL 7812-14030

-12-

LBL 8722

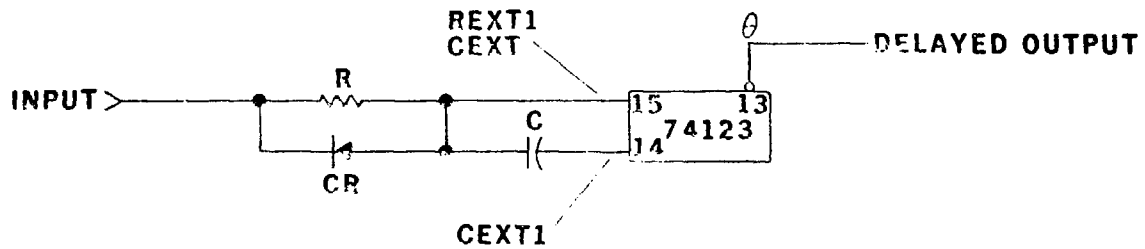FIGURE - 8: INPUT TRIGGERS AN OUTPUT PULSE (NANOSECOND RANGE)

XBL 7812-14031

FIGURE - 9: A ONE SHOT IS USED AS A DELAY ELEMENT

XBL 7812-14032