EEE 3132 - Digital Electronics

Lecture 4 : Digital Electronic Signals and Switches

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References

Our main reference text books in this course are

[1] William Kleitz, Digital Electronics: A Practical Approach with VHDL, 9th Ed., 2012, Prentice Hall ISBN-100131714902

[2] Thomas L. Floyd, Digital Fundamentals with PLD Programming, 9th Ed., 2006, Prentice Hall ISBN-10:0-13-197255-3.

[4] Maini Anil K., Digital Electronics: Principles, Devices and Applications, 2007, John Wiley and Sons Ltd, ISBN 978-0-470-03214-5.

[5] Smith R. J., Dorf R. C., Circuits Devices and Systems, 5th Ed., 2004, John Wiley and Sons Ltd, ISBN 9971-51-172-X.

However, feel free to use some additional text which you might find relevant to our course.

Introduction

- As mentioned in our previous lectures, digital electronics deals with 1s and 0s. These logic states are typically represented by a high and a low voltage level (Usually 1 = 5V and 0 = 0V).
- In this lecture we focus on how these logic states are represented by means of a timing diagram and how electronic switches are used to generate meaningful digital signals.

Digital Signals

- A digital signal is made up of a series of 1s and 0s that represent numbers, letters, symbols, or control signals.
- Figure 4-1 shows the timing diagram of a typical digital signal.
- A Timing diagram is a plot of voltage versus time.

Digital Signals

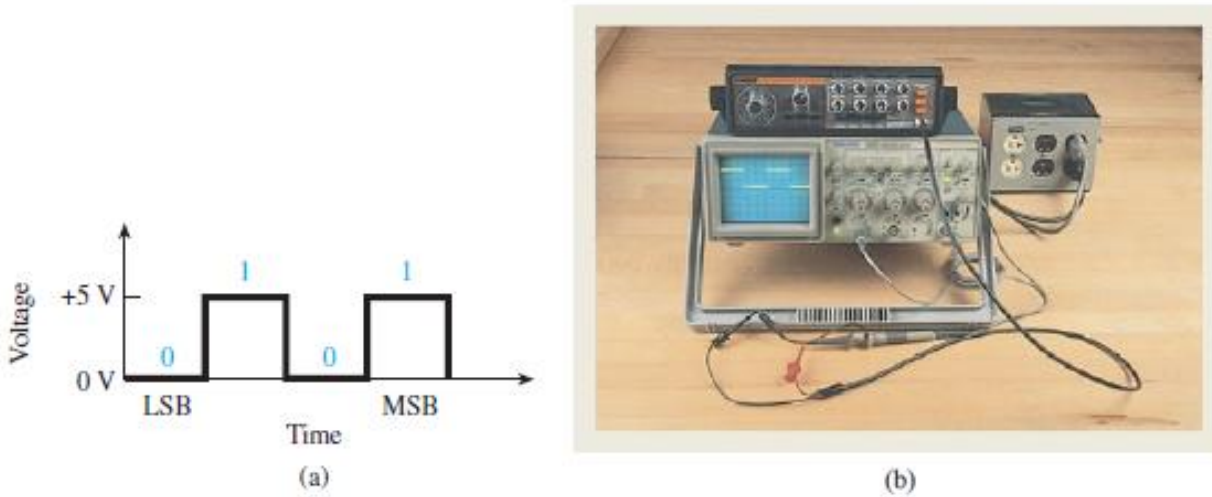


Figure 4-1: (a) Typical digital signal; (b) An oscilloscope displaying the digital waveform.

- ✓ Figure 4-1(a) is a timing diagram showing the bit configuration 1010 as it would appear on an **oscilloscope**.
- ✓ Notice that the LSB comes first in time. Thus the LSB is transmitted first.
- ✓ Nevertheless, the MSB could be transmitted first as long as the system on the receiving end knows which method is used.

Clock Waveform Timing

- ✓ Most digital signals require precise timing.
- ✓ Special clock and timing circuits are used to produce clock waveforms to trigger the digital signals at precise intervals.
- ✓ Figure 4-2 shows a typical *periodic clock waveform* as it would appear on an oscilloscope.
- ✓ The ***period*** of the clock waveform is defined as the length of time from the falling edge of one pulse to the falling edge of the next pulse.
- ✓ The ***frequency*** is thus the reciprocal of the clock period.

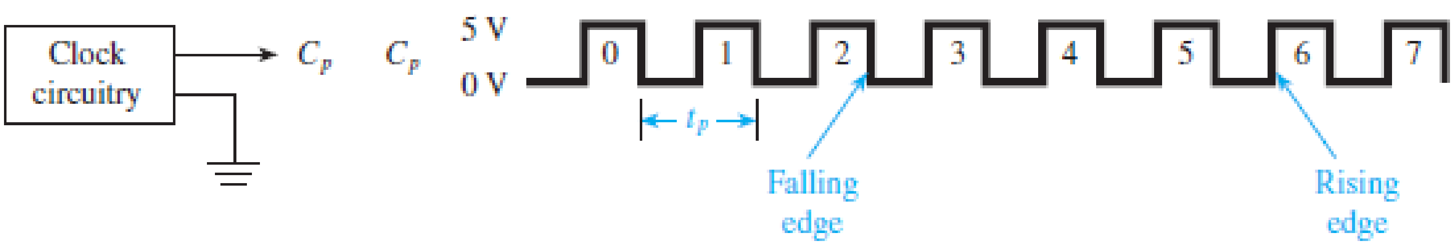


Figure 4-2: Periodic clock waveform as seen on the oscilloscope.

Clock Waveform Timing Cont'd

- ✓ It follows that frequency and period are respectively given by

$$f = \frac{1}{t_p} \quad \text{and} \quad t_P = \frac{1}{f}$$

Example 4-2

- ✓ A PC manufacturer specifies a microprocessor speed of 4 GHz (Gigahertz). What is the period of the microprocessor's waveform?
- ✓ ***Solution:***

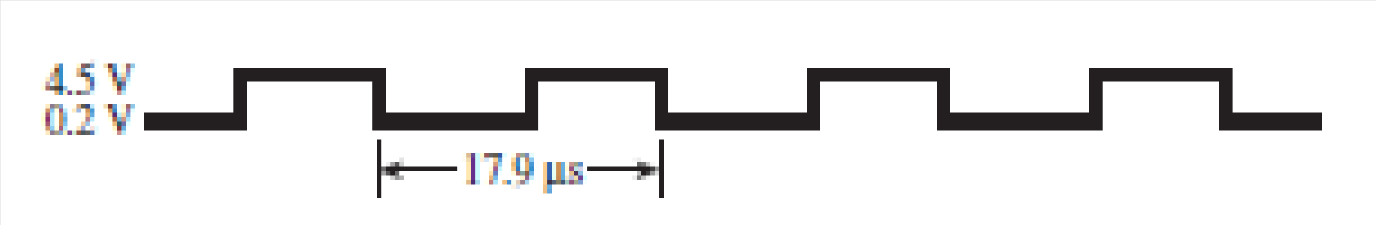
$$t_P = \frac{1}{f} = \frac{1}{4\,\text{GHz}} = 250\ ps$$

Clock Waveform Timing Cont'd

Example 4-3

- ✓ Sketch and label the time, *t* and voltage, *v* axis representing a 56 kbps (kilobits per second) clock waveform transmitted between a PC and a peripheral device. (Assume that the voltage levels were measured on an oscilloscope at LOW = 0.2 V and HIGH = 4.5 V.)
- ✓ ***Solution:***

$$t_P = \frac{1}{f} = \frac{1}{56\,\text{kbps}} = 17.9\,\mu\text{s}$$



Serial Representation

- ✓ Binary information to be transmitted from one location to another will be either **serial** or **parallel** form.
- ✓ The serial format uses a single electrical conductor (and a common ground) for the data to travel on. The serial format is inexpensive but slow because it can only transmit 1 bit for each clock period.
- ✓ Serial communication can be sped up by using extremely high-speed clock signals.
- ✓ Several standards have been developed for high-speed serial communications, the most notable which are V.90, ISDN, T1, T2, T3, Universal Serial Bus (USB), Ethernet, 10baseT, 100baseT, 1000base T, cable, and DSL.

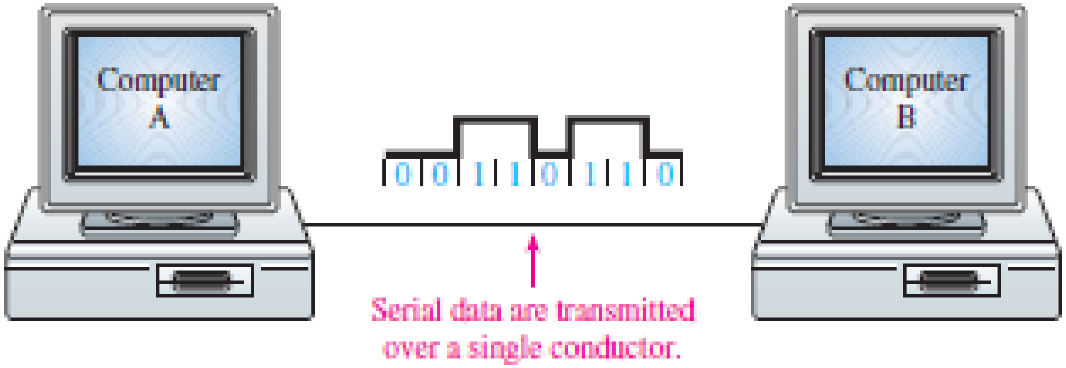


Figure 4-3: Serial communication between computers.

Serial Representation Cont'd

- ✓ Figure 4-4 illustrates the serial representation of the binary number 01101100.
- ✓ Serial representation (S_o) is shown with respect to some clock waveform (C_p) , and it LSB is drawn first.
- ✓ Each bit from the original binary number occupies a separate clock period, with the change from one bit to the next ocuring at each falling edge of C_p .

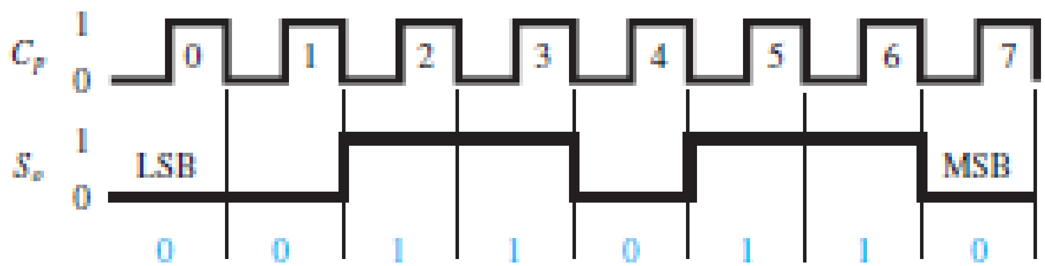


Figure 4-4: Serial representation of the binary number.

Parallel Representation

- ✓ The parallel format uses a separate electrical conductor for each bit to be transmitted (and a common ground).
- ✓ If the digital system is using 8-bit numbers, eight lines are required.
- ✓ This tends to be expensive, but the entire 8-bit number can be transmitted in one clock period, rendering it faster.

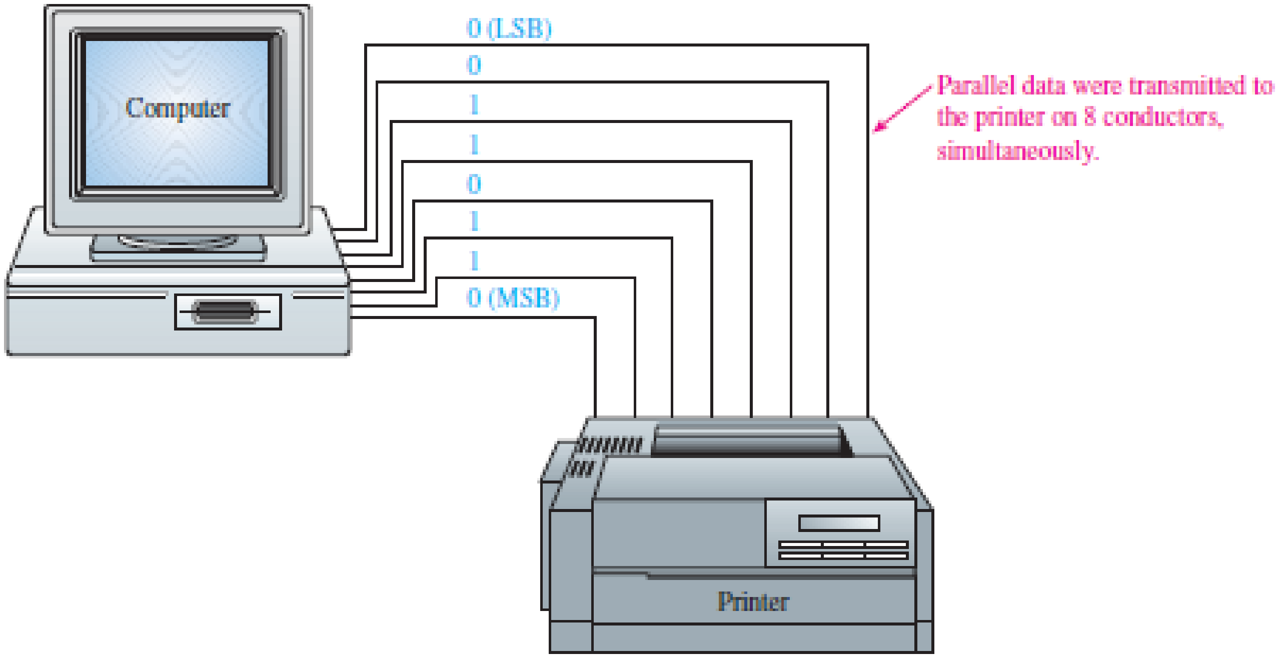


Figure 4-5: Parallel communication btn a PC and printer .

Parallel Representation cont'd

✓ Figure 4-6 illustrates the parallel representation of the binary number 01101100.

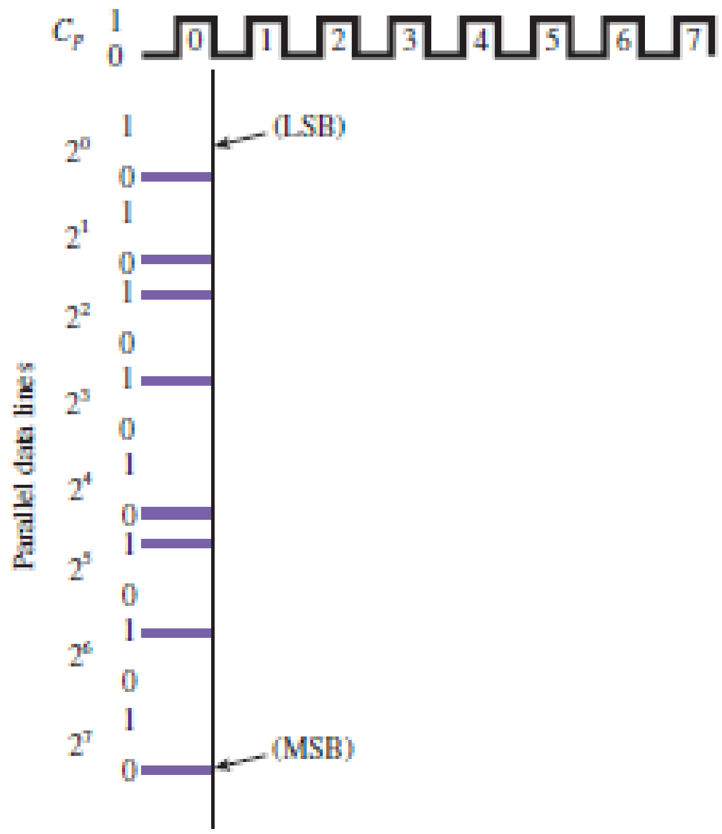


Figure 4-6: Parallel representation of the binary number.

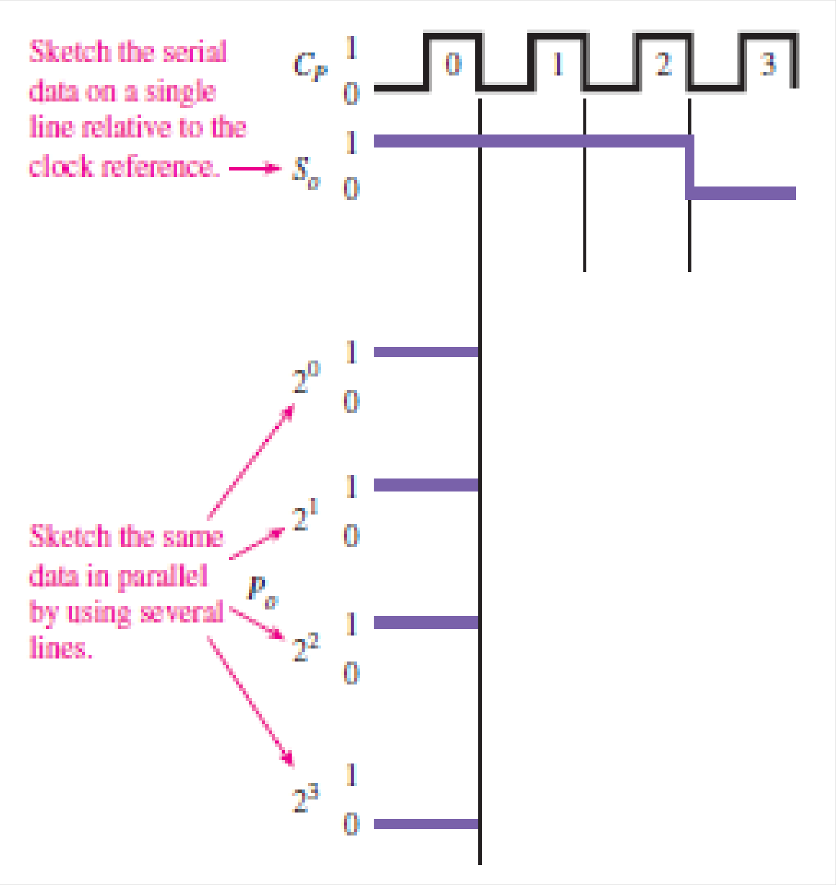
Example 4-4

- ✓ Sketch the serial and parallel representations of the 4-bit number 0111. If the clock frequency is 5 MHz, find the time to transmit using each method.
- ✓ ***Solution:***

$$t_P = \frac{1}{f} = \frac{1}{5\,\text{MHz}} = 0.2\,\mu\text{s}\,,$$

$$t_{\text{serial}} = 4 \times 0.2\,\mu\text{s} = 0.8\,\mu s$$

$$t_{\text{parallel}} = 1 \times 0.2\,\mu\text{s} = 0.2\,\mu s$$



Serial Transmission Simulation

- ✓ Figure 4-7 shows a MultiSIM simulation of the transmission of three ASCII characters MP3 from a transmitting device (Word Generator) to a receiving device (the Logic Analyzer).

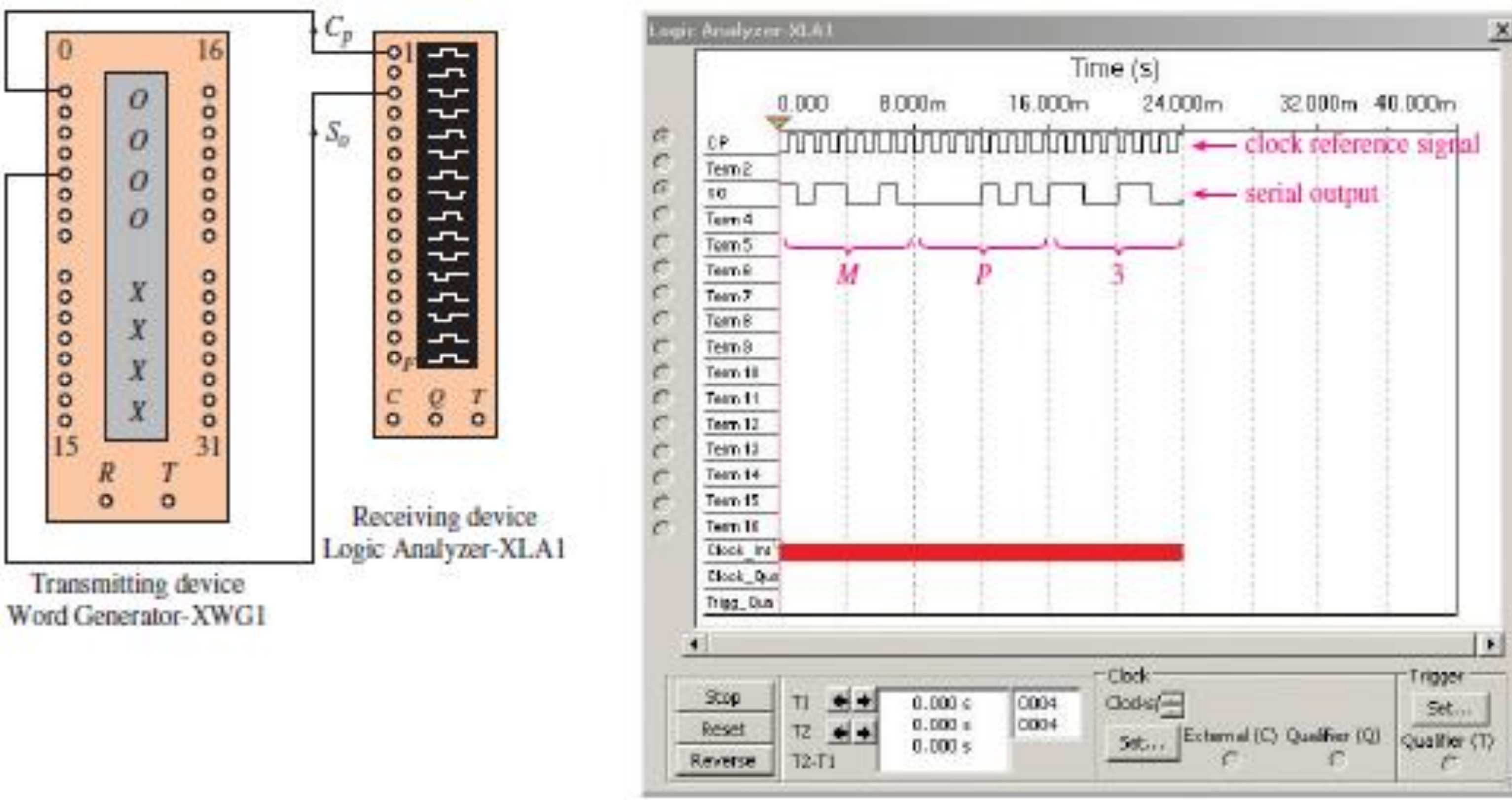


Figure 4-7: MultiSIM simulation of serial transmission.

Serial Transmission Simulation

- ✓ Figure 4-8 shows a MultiSIM simulation of the transmission of three parallel ASCII characters Y2K from a transmitting device (Word Generator) to a receiving device (the Logic Analyzer).

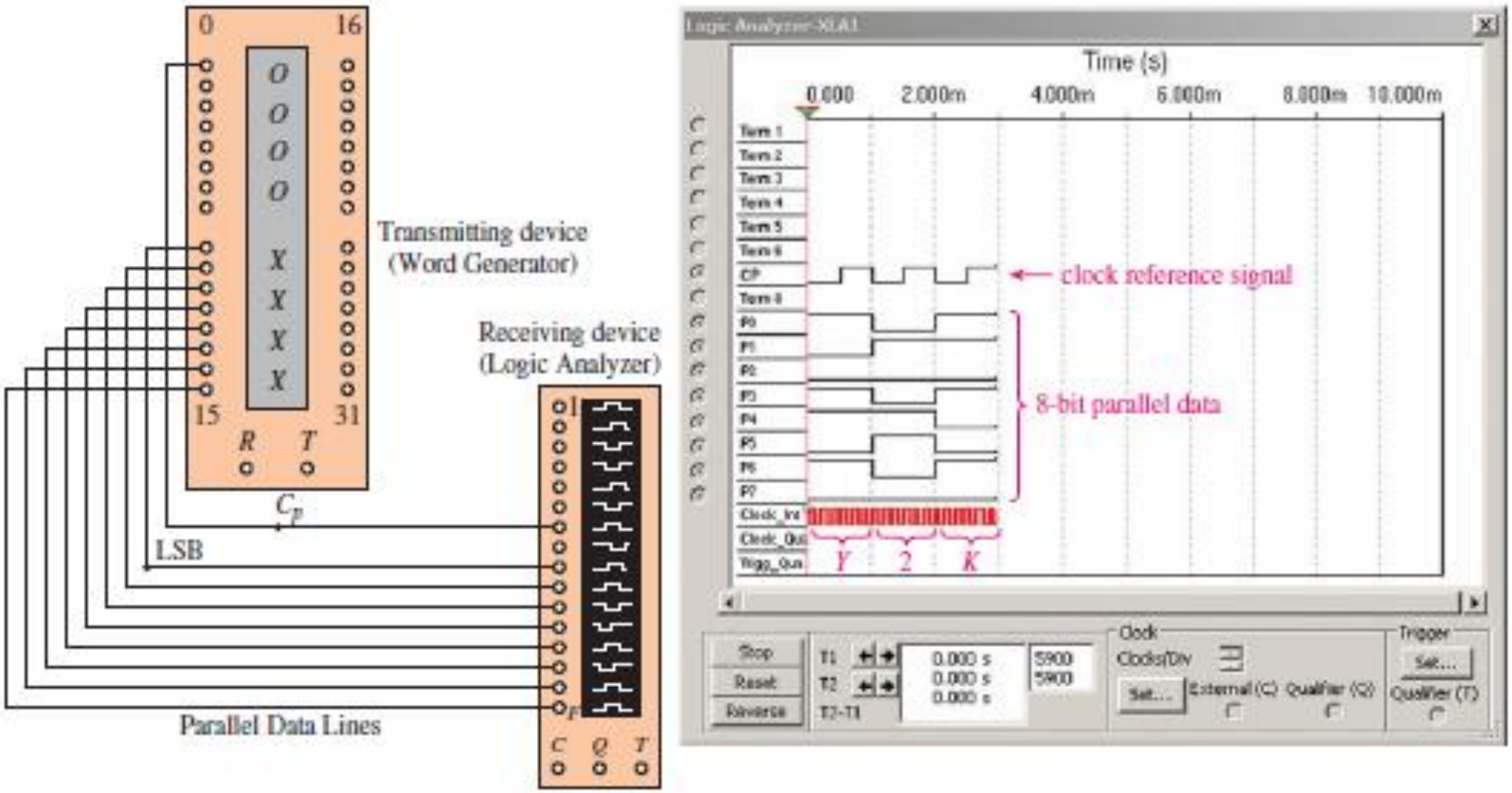


Figure 4-8: MultiSIM simulation of parallel transmission.

Switches in Electronic Circuits

- ✓ The transitions between 0 and 1 digital levels are caused by switching for one voltage level to another (usually 0 V to +5 V).
- ✓ One way that this is accomplished is to make and break a connection between two electrical conductors by way of a manual switch or an electromechanical relay.
- ✓ Another way to switch digital levels is by use of semiconductor devices such as diodes and transistors.

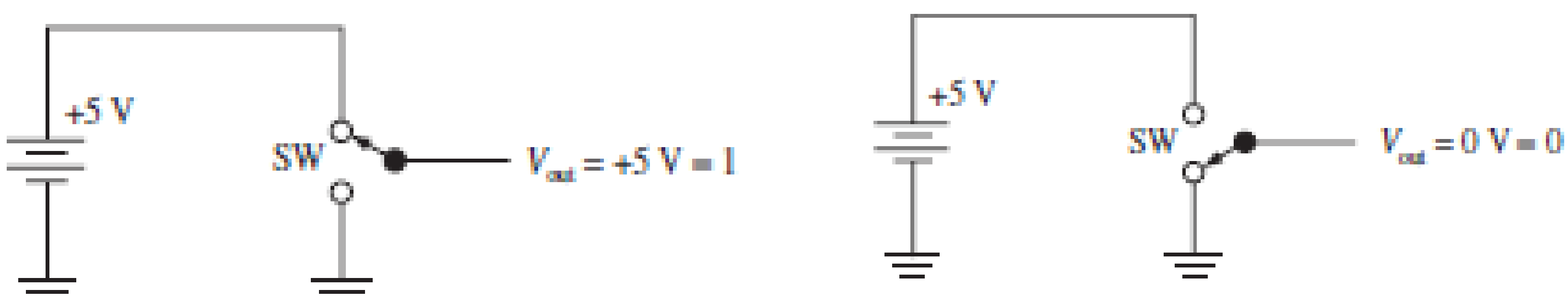


Figure 4-9: 1-Level output and 0-Level output.

A Relay as a Switch

- ✓ An electromechanical relay has contacts like a manual switch, but it is controlled by external voltage instead of being operated manually.
- ✓ They are often used to deliver HIGH/LOW digital levels to a high power load like a motor or a high-wattage lamp.

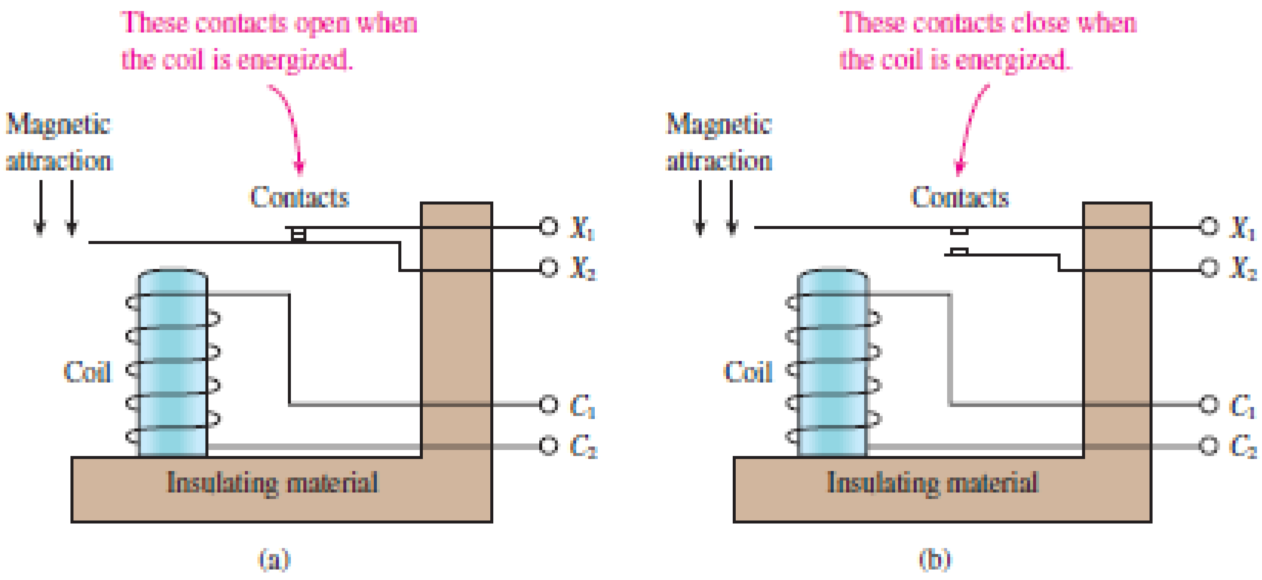


Figure 4-10: Physical representation of an electromechanical relay.

A Relay as a Switch cont'd

✓ Circuit involving a Normally Open (NO) relay.

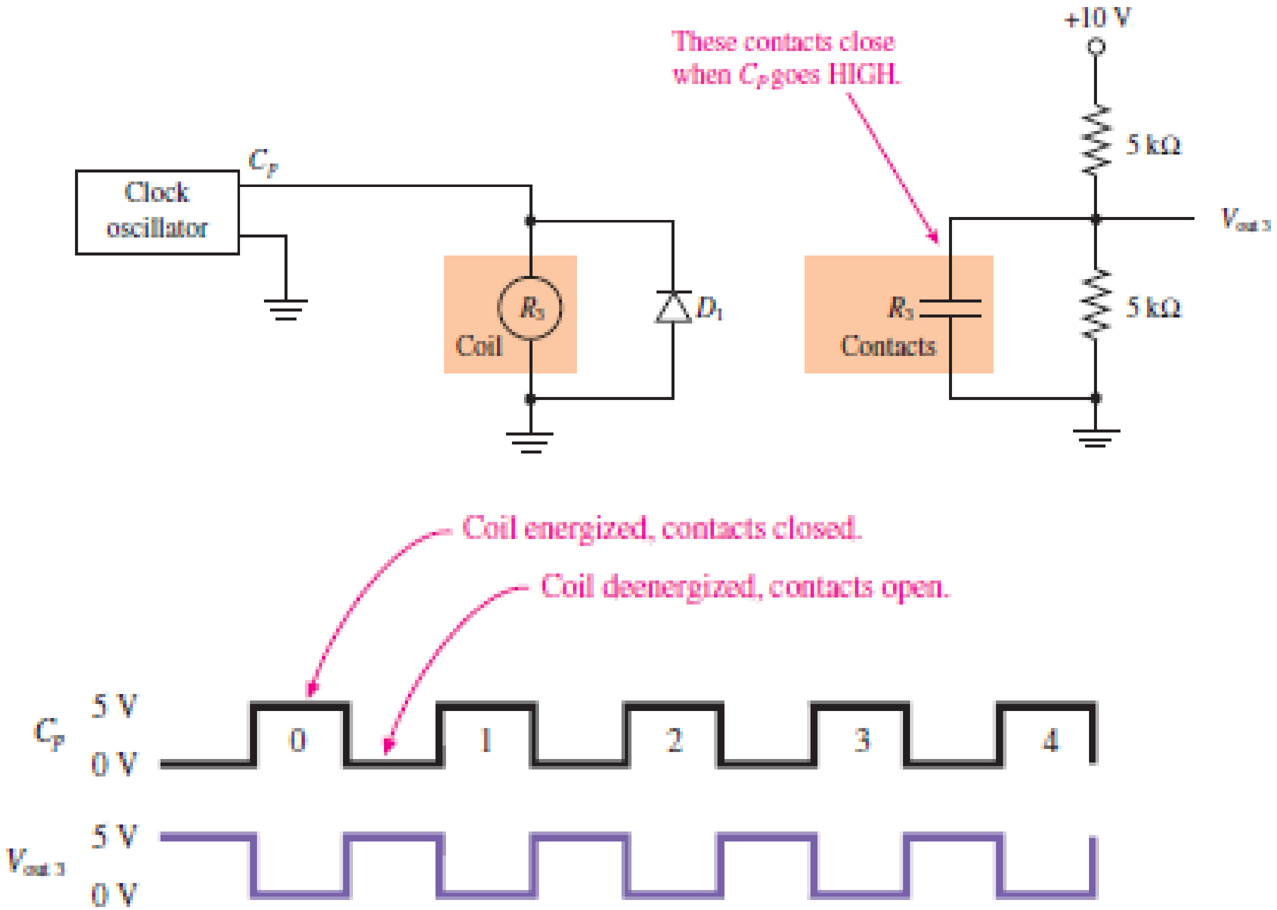


Figure 4-11: Relay used in a digital circuit and Timing diagram.

Example 4-5: A Transistor as a Switch

- ✓ Bipolar Junction Transistor is a commonly used switch in digital electronic ckts. Sketch the waveform at V_{out} in the circuit shown in Figure Ex. 4-5, given that the input signal C_p is +5 V when HIGH and 0 V when LOW.

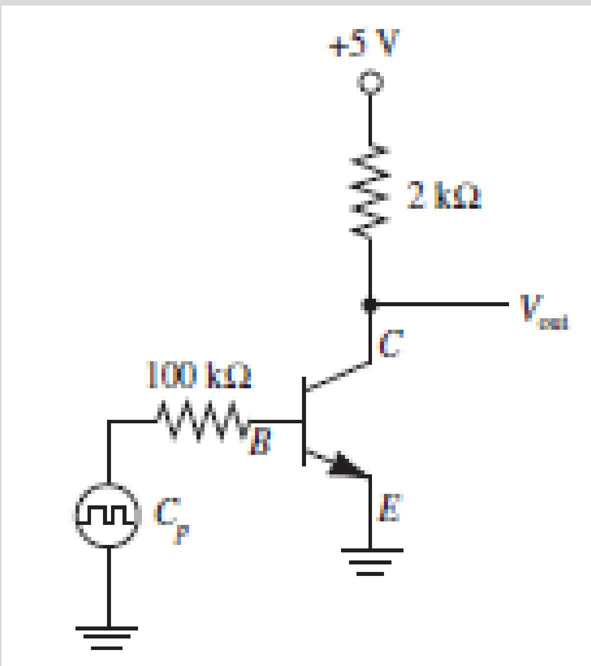


Figure Ex. 4-5-1:.

Solution:

- ✓ When $C_p = 0\,\text{V}$, the transistor is OFF and the equivalent circuit is shown in Fig. Ex. 4-5-3.

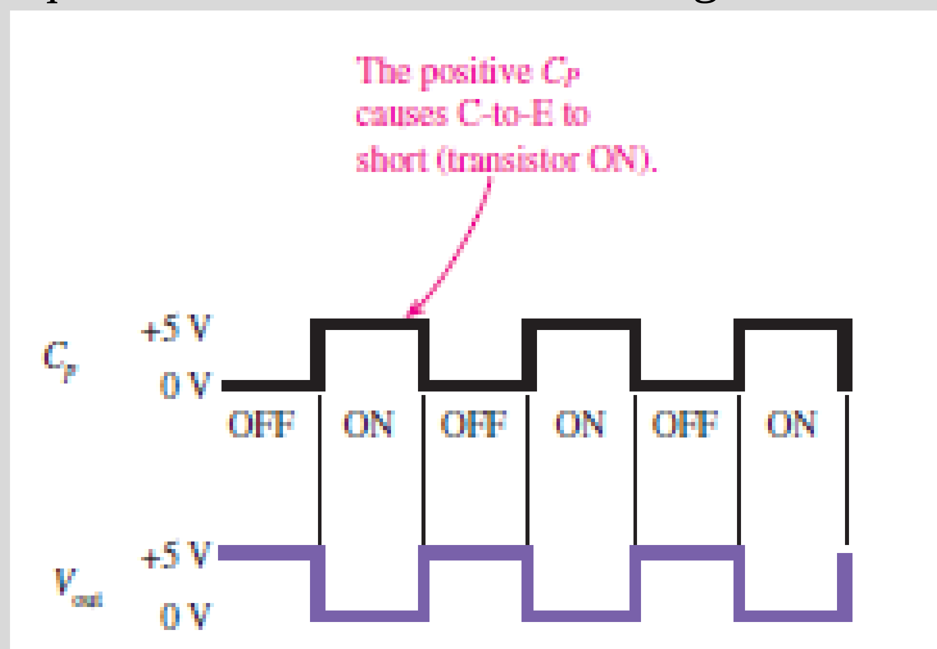


Figure Ex. 4-5-2:.

Example 4-5: A Transistor as a Switch cont'd

- ✓ Thus, $I_C = 0\,\text{A}$
- ✓ So that , $V_{out} = V_C = 5V - (0\,\text{A} \times 2\text{k}\Omega) = 5\ \text{V}$

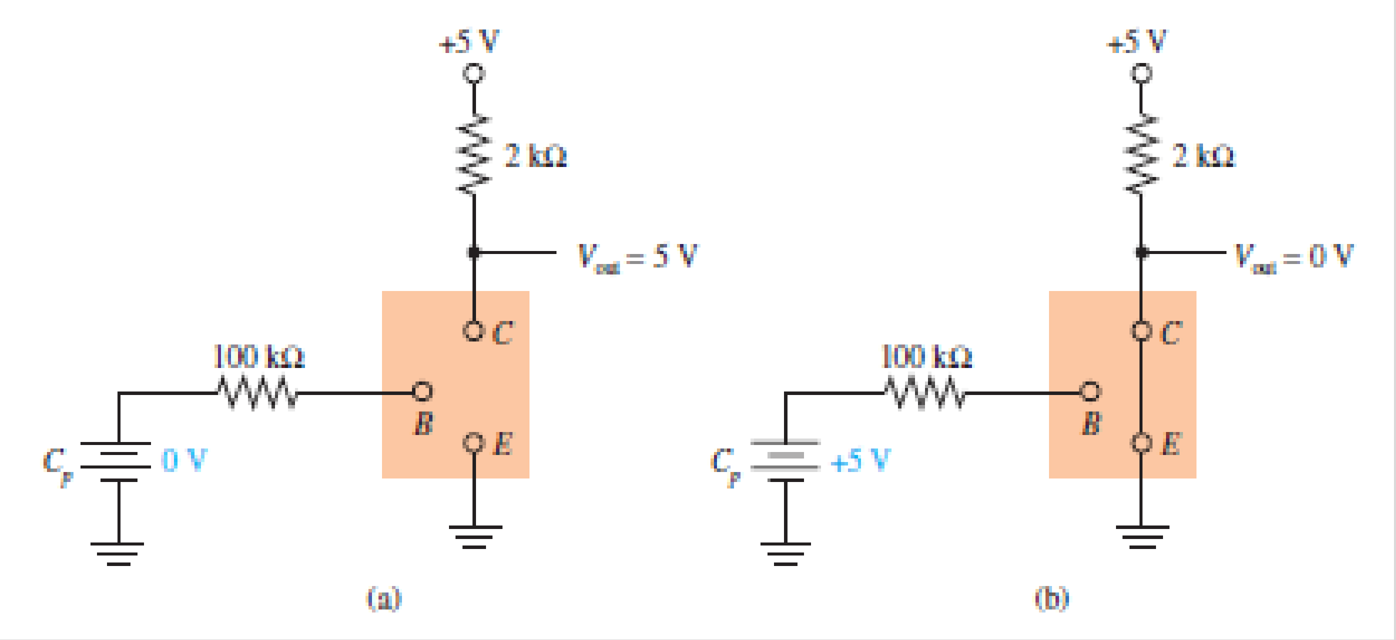


Figure Ex. 4-5-3:.

End of Lecture 4

Thank you for your attention!