Chapter 12

Symbology

12.1 Problems

Problem 12.1 (Credit card self-clocking waveform) *A credit card data stripe produces the self-clocking waveform shown in the top half of Figure 12.1 to encode the binary sequence 00000. What is the binary sequence encoded by the other waveform?*

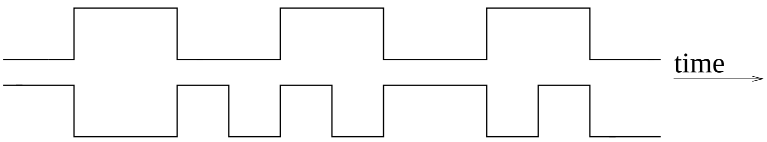


Figure 12.1: Self-clocking waveform in Problem 12.1.

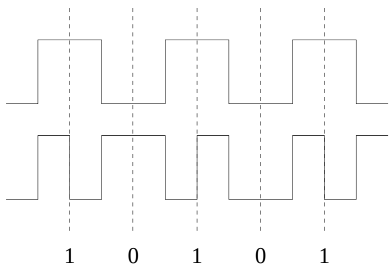
(ans:

0 1 1 0 1

)

Problem 12.2 (Generating a self-clocking waveform) *Sketch a self-clocking waveform that encodes the binary sequence 00000. Below this sketch, use the above transition times to sketch is the waveform that encodes binary sequence 10101.*

(ans:



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Problem 12.3 (Credit Card Code on Tracks 2 and 3) *The two-digit sequence 09 is very important. Encode these digits in a data block as they may appear on a credit card. Encode each code word on a separate line to form a data packet. Add the sentinel codes and terminate the data packet with a LRC code word.*

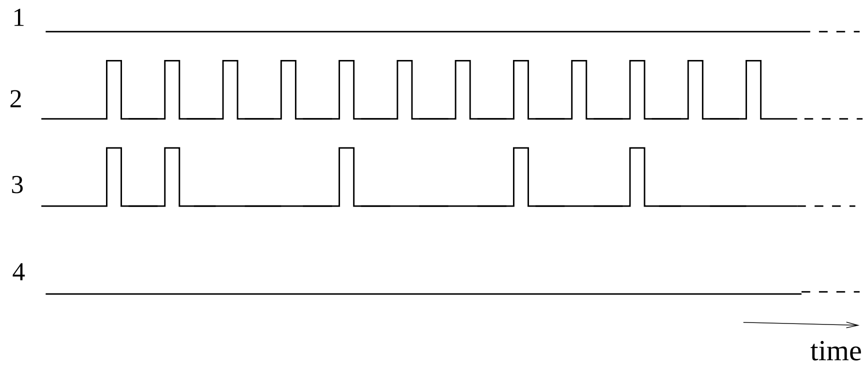
(ans:

	P				
start	0	1	0	1	1
0	1	0	0	0	0
9	1	1	0	0	1
end	1	1	1	1	1
LRC (op)	0	0	0	1	0

)

Problem 12.4 (Interpreting up-side-down USPS bar codes) *Decode as many digits as possible in the ZIP code from the waveforms shown in Figure 14.9.*

(ans:



Sensor 3 shows tall bars, so the bar code is up-side-down. The first tall bar is from the right side and the code is read backwards.

We ignore the first tall bar.

The first 5-segment code is 10010, read backwards is 01001, forming a 4.

The next 5-segment code is 01010, read backwards is 01010, forming a 5.

The next 0 forms the end of the next code, forming 3, 5, 6, 8, 9, or 0.

)

Problem 12.5 (USPS bar code check sum) *The ZIP code of Mountain View, CA is 94043. What is the check sum digit?*

(ans:

$$9 + 4 + 0 + 4 + 3 = 20 \quad \rightarrow \quad [20 + CSD]_{mod(10)} = 0 \quad \rightarrow \quad CSD = 0$$

)

Problem 12.6 (USPS error correction) *The bar code scanner in the U.S. Post Office produces an erroneous reading from a bar code. The reading is*

$$6\,0\,6\,1\,e\,8$$

where e represents the erroneous digit. What is the value of e?

(ans:

$$6+0+6+1+e+8=21+e \quad \rightarrow \quad [21+e]_{mod(10)}=0 \quad \rightarrow \quad e=9$$

)

Problem 12.7 (Pulse time for 60^o scan) *In Example 14.6, if the scan angle of the laser spot path is increased from 45^o to 60^o, what is the duration of the pulse produced by the first bar? Give answer in μs.*

(ans: The path through the black bar when the angle is 60^o is

$$\frac{1\,mm}{\cos(60^o)}=\frac{1\,mm}{0.5}=2\,mm$$

$$T_x=\frac{2\,mm}{100\,m/s}=\frac{2\times10^{-3}}{10^2\,m/s}=2\times10^{-5}s=20\,\mu s$$

)

Problem 12.8 (Data rate of a UPC symbol scanner) *A UPC symbol is scanned and the data is transmitted in 50 ms. What is the data rate of the scanner? (Ignore the time to scan the UPC symbol.)*

(ans: The UPC symbol encodes 12 digits, each with 7 bars, to give 84 bits. Each end bar has a 101 pattern, adding a total of 6 bits, and the center pattern is 01010, for an additional 5 bits, giving a total of 95 bits per UPC symbol.

$$\mathcal{D}_{UPC}=\frac{95\;bits}{50\times10^{-3}sec}=1.9\;kbps$$

)

Problem 12.9 (UPC check sum) *A product is designated by the UPC symbol number*

$$0\,7\,2\,3\,1\,0\,0\,0\,0\,4\,2$$

What is the value of the check sum digit?

(ans:

$$210-3\overbrace{(0+2+1+0+0+2)}^{=5}-\overbrace{(7+3+0+0+4)}^{14}=210-15-14=181$$

$$CSD=[181]_{mod(10)}=1$$

)

Problem 12.10 (UPC error correction) *The UPC symbol scanner in a store produces an erroneous reading from the UPC symbol. The reading is*

$$0\ 7\ 0\ 7\ 3\ e\ 0\ 5\ 3\ 3\ 5\ 9$$

where e represents the erroneous digit. What is the value of e?

(ans: The $CSD = 9$. The formula gives

$$210 - 3\overbrace{(0+0+3+0+3+5)}^{=11} - \overbrace{(7+7+e+5+3)}^{22+e} = 210 - 33 - 22 - e = 155 - e$$

$$CSD = [155 - e]_{mod(10)} = 9 \quad \rightarrow \quad e = 6$$

)

Problem 12.11 (Hacking an advanced CAPCHA) *Extend Example 14.10 to the case of upper and lower-case letters.*

(ans: Upper and lower-case letters extend the number of symbols to 52.

$$52^6 = 2 \times 10^{10}$$

The upper and lower-case letters are encoded with the same 8-bit ASCII code. Using the same 1 ms query time, the average time to guess a CAPCHA is

$$\frac{1}{2} \times 2 \times 10^{10} \textit{ queries} \times 10^{-3} \textit{ s/query} = 10^7 \textit{ s} = 2,778 \textit{ hrs}$$

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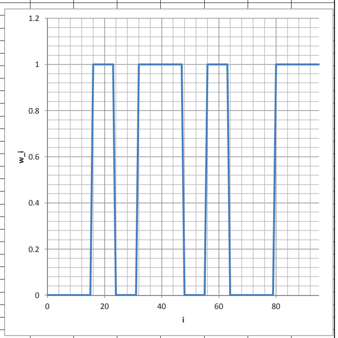
12.2 Excel Projects

Project 12.1 (Self-clock waveform design) *Following Example 13.56 compose a worksheet that uses* $T_p = 16$ *to generate and plot the credit card code waveform* w_i *that encodes the 4-bit sequence 1010 that starts and ends with 1 additional 0-valued bit, for a total of 6 bits. Let the first waveform value* $w_o = 1$.

(ans: The negative of the waveform shown also is correct.

	A	B	C
1	i	w_i	
2	0	0	
3	1	0	
4	2	0	
5	3	0	
6	4	0	
7	5	0	
8	6	0	
9	7	0	0
10	8	0	
11	9	0	
12	10	0	
13	11	0	
14	12	0	
15	13	0	
16	14	0	
17	15	0	
18	16	1	
19	17	1	
20	18	1	
21	19	1	
22	20	1	
23	21	1	
24	22	1	
25	23	1	1
26	24	0	
27	25	0	
28	26	0	
29	27	0	
30	28	0	
31	29	0	
32	30	0	
33	31	0	
34	32	1	
35	33	1	
36	34	1	
37	35	1	
38	36	1	
39	37	1	
40	38	1	
41	39	1	0
42	40	1	
43	41	1	
44	42	1	
45	43	1	
46	44	1	
47	45	1	
48	46	1	
49	47	1	
50	48	0	
51	49	0	
52	50	0	
53	51	0	
54	52	0	
55	53	0	
56	54	0	
57	55	0	1
58	56	1	
59	57	1	
60	58	1	
61	59	1	
62	60	1	
63	61	1	
64	62	1	
65	63	1	
66	64	0	
67	65	0	
68	66	0	
69	67	0	
70	68	0	
71	69	0	
72	70	0	
73	71	0	0
74	72	0	
75	73	0	
76	74	0	
77	75	0	
78	76	0	
79	77	0	
80	78	0	
81	79	0	
82	80	1	
83	81	1	
84	82	1	
85	83	1	
86	84	1	
87	85	1	
88	86	1	
89	87	1	0
90	88	1	
91	89	1	
92	90	1	
93	91	1	
94	92	1	
95	93	1	
96	94	1	
97	95	1	



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