

Solutions to Assignment 4

Question 1

The spreadsheet below shows the sum of the bytes, the sum modulo-256 and the checksum which is the additive complement (256 minus the sum modulo-256) which is 0xe4:

	A	B	C
1		hex	decimal
2		82	130
3		e8	232
4		5b	91
5		bd	189
6		17	23
7		16	22
8		b2	178
9		bb	187
10	sum		1052
11	sum mod 256		28
12	checksum	E4	228
13	check		0

for which the formulas are:

	A	B	C
9		bb	=HEX2DEC(B9)
10	sum		=SUM(C2:C9)
11	sum mod 256		=MOD(C10,256)
12	checksum	=DEC2HEX(C12)	=256-C11
13	check		=MOD(C10+C12,256)

Question 2

A block FEC code uses values from GF(4) with the 4 possible elements are represented using the letters A through D. The valid code words are:

element in	codeword out
A	ABC
B	DAB
C	CDA
D	BCD

- (a) The code rate is 1/3 because three elements are output per input element.
- (b) The minimum distance of this code is found by computing the Hamming distance between all pairs of different codewords as shown in the following table:

	ABC	DAB	CDA	BCD
ABC	0	3	3	3
DAB		0	3	3
CDA			0	3
BCD				0

The minimum distance is $d_{min} = 3$. Up to $d_{min} - 1 = 2$ errors can be detected and $\lfloor \frac{d_{min}-1}{2} \rfloor = 1$ error can be corrected.

- (c) The codeword ADA does not match any of the valid codewords so an error must have been introduced by the channel.

It's not possible to determine for certain whether the error can be corrected or not since the channel could have introduced any number of errors.

However, *if* the channel only introduced one error we can correct the error. The distance between the received codeword and the valid codewords is shown below:

codeword	received	distance
ABC	ADA	2
DAB	ADA	3
CDA	ADA	1
BCD	ADA	3

The closest valid codeword is CDA so the decoder would choose that codeword and assume the first element had been changed from C to A.

- (d) If the codeword AAA is received, the distances are:

codeword	received	distance
ABC	AAA	2
DAB	AAA	2
CDA	AAA	2
BCD	AAA	3

In this case the decoder can tell that there is an error but can't choose one closest codeword.

In practice the receiver would pick one of the three closest codewords at random. A CRC protecting the complete message would then determine if the guess had been successful or not.

- (b) If the puncturing pattern AB, A, AB is applied there are 3 input bits for every 5 output bits so the rate is 3/5.
- (c) The punctured encoder output would be 1, 1, 1, 0, 1.

Question 3

The rate-1/2 convolutional encoder shown in the lecture notes:

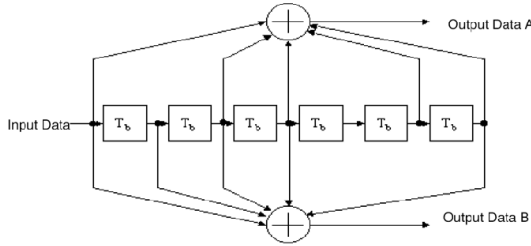


Figure 18-8—Convolutional encoder (k = 7)

is initialized so all the shift-register outputs are zero and the three bits 1, 1, 1 are input to it.

- (a) The values at the input and flip-flop outputs of the encoder as the bits are shifted in will be:

	FF outputs					
input	1	2	3	4	5	6
1	0	0	0	0	0	0
1	1	0	0	0	0	0
1	1	1	0	0	0	0
A=	+	+	+	+	+	+
B=	+	+	+	+	+	+

As shown in the schematic, the A output is the XOR of the input and the value of flip-flops 2, 3, 5 and 6. The B output is the XOR of the input and flip-flops 1, 2, 3 and 6.

The A outputs will be:

$$1 \oplus 0 \oplus 0 \oplus 0 \oplus 0 = 1$$

$$1 \oplus 0 \oplus 0 \oplus 0 \oplus 0 = 1$$

$$1 \oplus 1 \oplus 0 \oplus 0 \oplus 0 = 0$$

The B outputs will be:

$$1 \oplus 0 \oplus 0 \oplus 0 \oplus 0 = 1$$

$$1 \oplus 1 \oplus 0 \oplus 0 \oplus 0 = 0$$

$$1 \oplus 1 \oplus 1 \oplus 0 \oplus 0 = 1$$

So the first two outputs are 1,1 and the next two outputs are 1,0 and 0,1.

Question 4

We want to protect the message “1101” using a CRC generated using the generator polynomial $G(x) = x^4 + x^3 + 1$.

The generator polynomial order is 4 (5 terms) so the remainder will have 4 terms and we must append 4 zeros to the message. Then we divide the message by $G(x)$ to find the remainder:

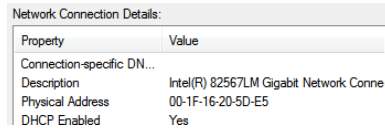
$$\begin{array}{r}
 \text{-----} \\
 11001 \mid 11010000 \\
 \underline{11001} \\
 00110 \\
 \underline{01100} \\
 11000 \\
 \underline{11001} \\
 \text{-----} \\
 0001
 \end{array}$$

The remainder of 0001 is the CRC that must be transmitted as the last 4 bits of the (protected) message. The transmitted bits are thus 11010001. As a check we can divide the message plus CRC by $G(x)$ to check that the remainder is zero:

$$\begin{array}{r}
 \text{-----} \\
 11001 \mid 11010001 \\
 \underline{11001} \\
 00110 \\
 \underline{01100} \\
 11001 \\
 \underline{11001} \\
 \text{-----} \\
 0000
 \end{array}$$

Question 5

- (a) As an example, for a computer running Windows 7 the MAC (or “physical”) address of a NIC can be found under Control Panel → Network and Internet → Network Connections. Right-clicking on an adapter and selecting Properties → Status shows the following:



The MAC address can also be found using the command `ipconfig /all` in a command prompt window;

```
Ethernet adapter Local Area Connection:
Connection-specific DNS Suffix . . . : 
Description . . . . . : Intel(R) 82567LM Gigabit Network Connection
Physical Address. . . . . : 00-1F-16-20-5D-E5
DHCP Enabled. . . . . : Yes
```

- (b) The MAC address is 00:1F:16:20:5D:E5 (using a colon separator between each byte in hexadecimal format).

The OUI is the first three bytes: 00:1F:16.

- (c) The [IEEE Standards Association's Registration Authority database](#) gives the following result for this OUI:

Assignment	Assignment Type	Company Name	Company Address
00-1F-16 (hex) 001F16	MA-L	Wistron Corporation	21F, 88, Sec.1, Hsin Tai Wu Rd., Hsichih, Taipei Hsien 221 TW

Question 6

For the following Ethernet packet:

```
00 1d 7e 2f b5 9b 00 24 1d 73 df ce 08 06 00 01
08 00 06 04 00 01 00 24 1d 73 df ce 0a 00 00 64
00 00 00 00 00 00 0a 00 00 01
```

- (a) The three Ethernet header fields are the destination and source addresses (6 bytes each) and the length/type field (2 bytes). The destination address is the first 6 bytes:

00 1d 7e 2f b5 9b, the source address is the next 6 bytes: 00 24 1d 73 df ce, and the length/type field is the next two bytes: 08 06.

- (b) Because the type/length field has value 0x806 (2054) which is larger than the maximum frame length (approximately 1500 bytes) it should be interpreted as a type field (“Ethertype”) rather than a length field. The Ethertype is 0x0806 which we can [look up](#)¹ to be ARP (Address Resolution Protocol). Thus the payload contents should be treated as containing an ARP packet.

- (c) The length of the payload is the total frame length (42 bytes in this case) minus the length of the Ethernet header (14 bytes) or $42 - 14 = 28$ bytes.

¹Although the IEEE publishes the Ethernet standard and is responsible for assigning Ethertypes, certain values such as this are de-facto standards.