

The output of the quantizer encoders for a block $\mathbf{f}_b^{(2)}$ are given by

$$\mathcal{E}(\mathbf{f}_b^{(2)}) = \begin{bmatrix} 30 & 12 & -2 \\ 8 & -6 & 0 \\ 2 & 0 & 0 \end{bmatrix}$$

We assign codewords according to the zigzag scan order 30, 12, 8, ..., using Golomb codes as follows:

$$\begin{bmatrix} G_8 & G_4 & G_4 \\ G_4 & G_4 & G_2 \\ G_4 & G_2 & G_2 \end{bmatrix}$$

where G_m is a Golomb code with parameter m . **Show the sequence of bits obtained for this block. Show separators between codewords for clarity. How many bits per input symbol are used for this particular block.** (Recall that if $m = 2^k$, the Golomb codeword for $n = mq + r$ is given by q zeros, a one, and a k -bit natural binary code for r .)

The following table gives the estimated frequency of occurrence of letters, characters and numerals in English based on some selection of texts. The symbols have been encoded with a Golomb-Rice code with parameter $m = 2^k = 8 = 2^3$ by assigning a codeword to the ordinal number n associated with each character in the table. **Decode the following bitstream to get the set of ordinal numbers n and the corresponding text. Explain what you are doing.** Two codeword boundaries are inserted to help you check if you are on track. Recall that the Golomb-Rice codeword for $n = mq + r$ is given by q zeros, a one, and a k -bit natural binary code for r .

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00111110100100110111001001000111001001 | 0100010100100110
01001010110101010 | 1001000001011000011110000110100001101
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n	Character: frequency: percent	n	Character: frequency: percent
1	: 72327800 (18.74%)	28	-: 1000071 (0.26%)
2	E: 37047647 (9.60%)	29	?: 469889 (0.12%)
3	T: 27083970 (7.02%)	30	X: 454572 (0.12%)
4	A: 23944887 (6.21%)	31	J: 448397 (0.12%)
5	O: 22536157 (5.84%)	32	;;: 311385 (0.08%)
6	I: 20133224 (5.22%)	33	!: 300580 (0.08%)
7	N: 20088720 (5.21%)	34	Q: 275136 (0.07%)
8	H: 18774883 (4.87%)	35	Z: 268771 (0.07%)
9	S: 18415648 (4.77%)	36	:: 96752 (0.03%)
10	R: 17103717 (4.43%)	37	1: 63148 (0.02%)
11	D: 13580739 (3.52%)	38	—: 57781 (0.01%)
12	L: 12350767 (3.20%)	39	0: 40105 (0.01%)
13	U: 8682289 (2.25%)	40): 38729 (0.01%)
14	M: 7496355 (1.94%)	41	*: 38475 (0.01%)
15	C: 7248810 (1.88%)	42	(: 38220 (0.01%)
16	W: 7022120 (1.82%)	43	2: 36981 (0.01%)
17	G: 6396495 (1.66%)	44	': 36692 (0.01%)
18	F: 6262477 (1.62%)	45	`: 36256 (0.01%)
19	Y: 6005496 (1.56%)	46	": 31829 (0.01%)
20	P: 5065887 (1.31%)	47	": 30629 (0.01%)
21	,: 4784859 (1.24%)	48	3: 25790 (0.01%)
22	.: 4680323 (1.21%)	49	9: 24985 (0.01%)
23	B: 4594147 (1.19%)	50	5: 21865 (0.01%)
24	K: 2853307 (0.74%)	51	4: 21181 (0.01%)
25	V: 2745322 (0.71%)	52	8: 18853 (0.00%)
26	": 2566376 (0.67%)	53	7: 17124 (0.00%)
27	': 1699273 (0.44%)	54	6: 17007 (0.00%)

Table . Frequency of occurrence of characters in a set of English texts.