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# Exponential-Golomb coding

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An **exponential-Golomb code** (or just **Exp-Golomb code**) is a type of **universal code**. To encode any **nonnegative integer** *x* using the exp-Golomb code:

- Write down *x*+1 in binary
- Count the bits written, subtract one, and write that number of starting zero bits preceding the previous bit string.

The first few values of the code are:

```
0 ⇒ 1 ⇒ 1
1 ⇒ 10 ⇒ 010
2 ⇒ 11 ⇒ 011
3 ⇒ 100 ⇒ 00100
4 ⇒ 101 ⇒ 00101
5 ⇒ 110 ⇒ 00110
6 ⇒ 111 ⇒ 00111
7 ⇒ 1000 ⇒ 0001000
8 ⇒ 1001 ⇒ 0001001
...[1]
```

This is identical to the **Elias gamma code** of *x*+1, allowing it to encode 0.<sup>[2]</sup>

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## Extension to negative numbers <sup>[edit]</sup>

Exp-Golomb coding for *k* = 0 is used in the **H.264/MPEG-4 AVC** and H.265 **High Efficiency Video Coding** video compression standards, in which there is also a variation for the coding of signed numbers by assigning the value 0 to the binary codeword '0' and assigning subsequent codewords to input values of increasing magnitude (and alternating sign, if the field can contain a negative number):

```
0 ⇒ 0 ⇒ 1 ⇒ 1
1 ⇒ 1 ⇒ 10 ⇒ 010
-1 ⇒ 2 ⇒ 11 ⇒ 011
2 ⇒ 3 ⇒ 100 ⇒ 00100
-2 ⇒ 4 ⇒ 101 ⇒ 00101
3 ⇒ 5 ⇒ 110 ⇒ 00110
-3 ⇒ 6 ⇒ 111 ⇒ 00111
4 ⇒ 7 ⇒ 1000 ⇒ 0001000
-4 ⇒ 8 ⇒ 1001 ⇒ 0001001
...[1]
```

In other words, a non-positive integer *x*≤0 is mapped to an even integer −2*x*, while a positive integer *x*>0 is mapped to an odd integer 2*x*−1.

Exp-Golomb coding is also used in the **Dirac video codec**.<sup>[3]</sup>

## Generalization to order *k* <sup>[edit]</sup>

To encode larger numbers in fewer bits (at the expense of using more bits to encode smaller numbers), this can be generalized using a **nonnegative integer** parameter *k*. To encode a nonnegative integer *x* in an order-*k* exp-Golomb code:

- Encode ⌊*x*2<sup>*k*</sup>⌋ using order-0 exp-Golomb code described above, then
- Encode *x* mod 2<sup>*k*</sup> in binary

An equivalent way of expressing this is:

- Encode *x*+2<sup>*k*</sup>−1 using the order-0 exp-Golomb code (i.e. encode *x*+2<sup>*k*</sup>) using the Elias gamma code), then
- Delete *k* leading zero bits from the encoding result

Exp-Golomb-*k* coding examples

<i>x</i>	<i>k</i> =0	<i>k</i> =1	<i>k</i> =2	<i>k</i> =3	<i>x</i>	<i>k</i> =0	<i>k</i> =1	<i>k</i> =2	<i>k</i> =3	<i>x</i>	<i>k</i> =0	<i>k</i> =1	<i>k</i> =2	<i>k</i> =3
0	1	10	100	1000	10	0001011	001100	01110	010010	20	000010101	00010110	0011000	011100
1	010	11	101	1001	11	0001100	001101	01111	010011	21	000010110	00010111	0011001	011101
2	011	0100	110	1010	12	0001101	001110	0010000	010100	22	000010111	00011000	0011010	011110
3	00100	0101	111	1011	13	0001110	001111	0010001	010101	23	000011000	00011001	0011011	011111
4	00101	0110	01000	1100	14	0001111	00010000	0010010	010110	24	000011001	00011010	0011100	00100000
5	00110	0111	01001	1101	15	000010000	00010001	0010011	010111	25	000011010	00011011	0011101	00100001
6	00111	001000	01010	1110	16	000010001	00010010	0010100	011000	26	000011011	00011100	0011110	00100010
7	0001000	001001	01011	1111	17	000010010	00010011	0010101	011001	27	000011100	00011101	0011111	00100011

8	0001001	001010	01100	010000	18	000010011	00010100	0010110	011010	28	000011101	00011110	000100000	00100100
9	0001010	001011	01101	010001	19	000010100	00010101	0010111	011011	29	000011110	00011111	000100001	00100101

See also [edit]

- Elias gamma coding
- Elias delta coding
- Elias omega coding
- Universal code

References [edit]

- ↑ <sup>*a*</sup> <sup>*b*</sup> Richardson, Iain (2010). *The H.264 Advanced Video Compression Standard* . Wiley. pp. 208,221. ISBN 978-0-470-51692-8.
- ↑ Rupp, Markus (2009). *Video and Multimedia Transmissions over Cellular Networks: Analysis, Modelling and Optimization in Live 3G Mobile Networks* . Wiley. p. 149.
- ↑ "Dirac Specification"  (PDF). BBC. Retrieved 9 March 2011.

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	Dictionary type	Byte pair encoding · DEFLATE · Lempel–Ziv (LZ77 / LZ78 (LZ1 / LZ2) · LZJB · LZMA · LZO · LZRW · LZS · LZSS · LZW · LZWL · LZX · LZ4 · Statistical)	
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