Absolute Encoder Output Codes

Photocraft absolute encoders generate a binary code word indicating the angular position of the shaft. Each equal sized segment of one shaft rotation is indicated by a unique value. For example, an 8-bit absolute encoder divides a 360° rotation into 256 equal size segments of about 1.4° each.

A conventional absolute encoder uses a code disk containing the binary code words for each segment (see figure 1). The code disk uses a cyclic binary code known as gray code (GC) that is precisely imprinted as opaque and transparent segments on concentric tracks, one track per bit of resolution. A radial line of photo-sensors (8 sensors for the 8-bit example) are used to read the disk pattern and directly outputs the code word. Gray code is used because only one bit value changes as the shaft moves from one position to the next. This eliminates problems of ambiguous outputs if there were multiple bits changing simultaneously.

Unfortunately, computers and PLCs typically use natural binary (NB), not gray code. Therefore, the gray code generated by the encoder must be converted. Photocraft encoders optionally include a conversion circuit based on a micro controller that can convert the gray code to any other useful code, such as natural binary.

As an alternative the computer or PLC can perform the gray code to natural binary conversion using the following algorithm:

1. The most significant bit remains unchanged.
2. Each other natural binary bit is determined by exclusive OR-ing the corresponding gray code bit and all other gray code bits to the left.

The following example converts gray code (10010) to natural binary (11100):

$$\underline{NB} \leftarrow \underline{GC}$$
$$1 \leftarrow 1$$
$$1 \leftarrow 1 \oplus 0$$
$$1 \leftarrow 1 \oplus 0 \oplus 0$$
$$0 \leftarrow 1 \oplus 0 \oplus 0 \oplus 1$$
$$0 \leftarrow 1 \oplus 0 \oplus 0 \oplus 1 \oplus 0$$

For codes that are not a power of 2, the next power of 2 minus the positions per revolution must be subtracted from the result of the exclusive OR for the upper ½ revolution. For example to convert 360 GC to NB:

$NB \leftarrow (\ldots \oplus \ldots)$ for positions 0-179

$NB \leftarrow (\ldots \oplus \ldots) - (512-360)$ for positions 180-359

Decimal	Natural Binary	Gray Code
0	00000	00000
1	00001	00001
2	00010	00011
3	00011	00010
4	00100	00110
5	00101	00111
6	00110	00101
7	00111	00100
8	01000	01100
9	01001	01101
10	01010	01111
11	01011	01110
12	01100	01010
13	01101	01011
14	01110	01001
15	01111	01000
16	10000	11000
17	10001	11001
18	10010	11011
19	10011	11010
20	10100	11110
21	10101	11111
22	10110	11101
23	10111	11100
24	11000	10100
25	11001	10101
26	11010	10111
27	11011	10110
28	11100	10010
29	11101	10011
30	11110	10001
31	11111	10000

Table 1: Comparison of decimal, natural binary, and gray code

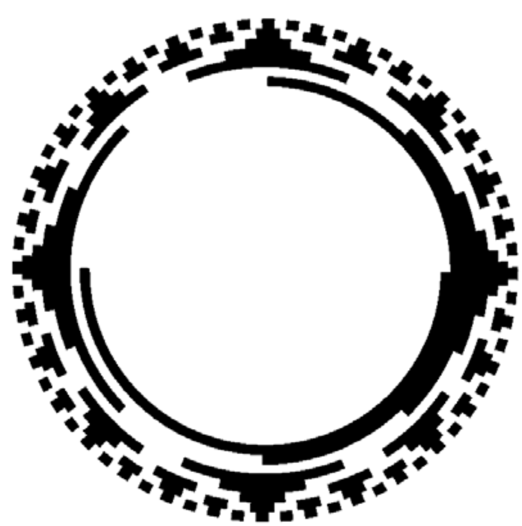

Figure 1: 256 position gray code disk

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