

PS — 4256 / 4456

ABSOLUTE GRAY CODE ENCODER



PS-4456/4457 (NEMA 4X)



PS-4256/4257 (NEMA 12)

Easily Interfaced to PLCs Using Standard Digital DC Inputs
Or Directly to Gray Code Modules*

Features

- Absolute 8 Bit Output
- Rugged Construction
- 3/4" Shaft with Ball Bearings
- NEMA 12 or NEMA 4X

Applications

- Packaging Machines
- Pick and Place Operations
- Assembly Machines
- Food Processing Equipment
- Indexing Equipment

General Information

Sinking[†] or Sourcing[†] Output — The encoders are available with Sinking[†] or Sourcing[†] outputs. Be sure to order the type that is compatible with the control's input circuits. The use of fast response DC inputs is recommended to minimize missed fast pulsing encoder outputs.

NEMA 4X Option — The NEMA 4X version of the encoder includes a stainless steel enclosure and shaft, double sealed ball bearings, and conformal coating on both sides of the internal circuit board. This version should be ordered for applications which involve washdowns, high humidity or corrosive atmospheres.

* A-B 1771-DL or Similar type modules

[†] See page 7 for sinking/sourcing definitions

Why 8 Bit Gray Code?

When wiring an encoder to the PLC, the most important thing to remember is which output is the MSB (Most Significant Bit) and which is the LSB (Least Significant Bit). If the order is reversed, or the output wiring is out of order (transposed wires), the value that you create in the PLC register will not sequence properly.

MSB and LSB are digits of the binary number. An understanding of the different number systems used by logic controllers (binary, hex, decimal, etc.) is essential to know what these codes signify.

- Gray Code is a cyclic or reflected binary code, specifically designed for positioning information. In a Gray Code number only **one-digit** changes at a time. In a binary number, going from one number to the next may have **many of its digits** change.

The cyclic change is created by the relationship of the 8 pulse disks that turn the encoder OFF and ON. (See Figure 6, page 6.)

- **Most Significant Bit** refers to the binary code (Gray Code) digit that is on the far left when written out. This digit changes the **least** as the binary number goes from 0 to 255.
- **Least Significant Bit** refers to the binary code (Gray Code) digit that is on the far right when written out. This digit changes the **most** as the binary number goes from 0 to 255.

Absolute Position Decoding — The 8 Bit Gray Code signal always represents the current position of the encoder shaft. The PLC cannot get out of sync with the present encoder position — not even when the encoder shaft is turned while power is off to the controller.

8 Bit Resolution (256 increments) — The revolution of the encoder shaft is divided into 256 uniform increments. Each increment is 1.4 degrees wide, which allows any machine position to be known within ± 0.7 degrees. This is appropriate resolution for many applications, especially when PLC scan times are taken into account (@ 60 RPM, a 10 mSec scan time equates to 3.6 degrees of motion between scans).

Error Free Decoding — Only one of the bits changes state when the encoder shaft rotates, eliminating the need for sophisticated latching and/or handshaking circuitry between the encoder and the PLC. Standard DC input cards are used to interface with the encoder. The only special programming needed is 8 exclusive-ORed (XOR) ladder rungs.

RPM / Response Considerations

The operating speed and resolution required of the application must be considered when interfacing the Gray Code encoder directly to a PLC or other control device. The scan speed and/or hardware response will cause delays that can reduce the overall system response and resolution. **Where full 8 bit resolution is required at higher speeds, the use of an Electro Cam PL μ S (Programmable Limit Switch) is recommended.**

Values might not be true for certain fast response PLC inputs. Faster response times are dependent on hardware.

When machine speed rises above a certain level, several factors need to be considered:

- What is the scan time of the PLC program?
- What is the response time of the input module?
- What is the integer value that is being used, and is it dependent on several of the least significant bits?

Scan Time / Maximum RPM / Degrees Per Scan

Scan Time	Max RPM	Deg / Scan @ 30 RPM	Deg / Scan @ 100 RPM	Scan Time	Max RPM	Deg / Scan @ 30 RPM	Deg / Scan @ 100 RPM
1 mSec	234	0.18	0.60	20 mSec	11	3.6	12.0
5 mSec	46	0.9	3.0	25 mSec	9	4.5	15.0
10 mSec	23	1.8	6.0	30 mSec	7	5.4	18.0
15 mSec	15	2.7	9.0	40 mSec	5	7.2	24.0

The table above indicates the maximum RPM that the encoder can be turning for all 256 positions to be decoded each revolution for the corresponding scan time. Exceeding the indicated RPM will result in encoder shaft positions being skipped by the control. It is acceptable to skip encoder positions when 8 bit resolution is not required. Worst case output response = 2 Scans + Hardware response.

Figure 1

Refer to the above chart to compare machine RPM to the values listed on the chart. If speed exceeds the value, the PLC will not "see" certain Gray Code values. Miscalculation of the output value will occur.

If a bit is on for 30 μ Sec, and the scan time is 10 mSec, the

processor will not see that bit (or combination of bits). If the input module's response time is longer than the bit, or bits on time, the module will not react to the input. All of these factors show up as non-sequencing position values, or outputs that are not performing properly.

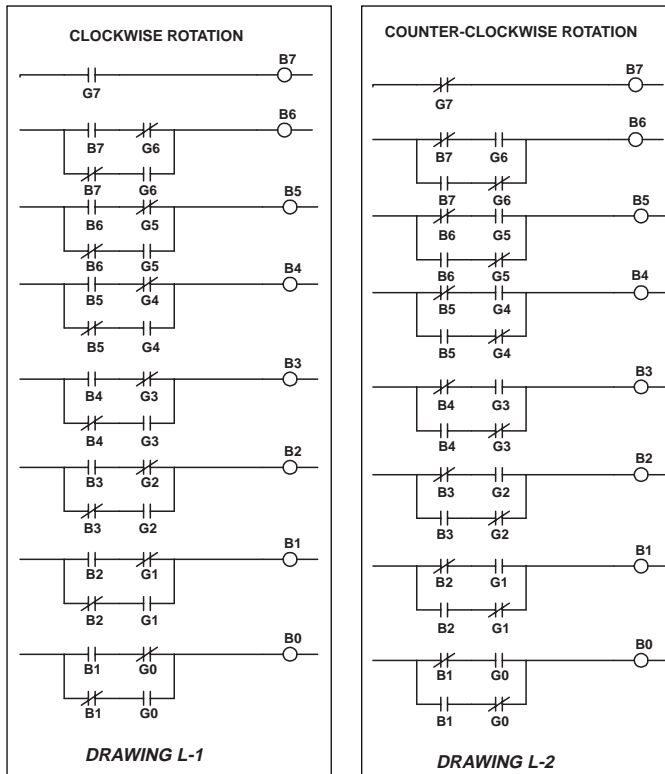
Decoding Gray Code?

The Ladder Programming examples shown below apply for all Gray Code Encoder models. The examples show how to convert the 8 Bit Gray Code output signal (G0-G7) of the encoder to a binary number (B0-B7) during each scan of the PLC. The value of the Binary result will always be in the range of 0 - 255 because the 8 bit encoder divides each revolution into 256 uniform increments. Ladder rungs which follow the conversion can compare the rotary position value to known positions for control of machine devices that must operate at specific positions within the overall machine cycle. The rotary position of

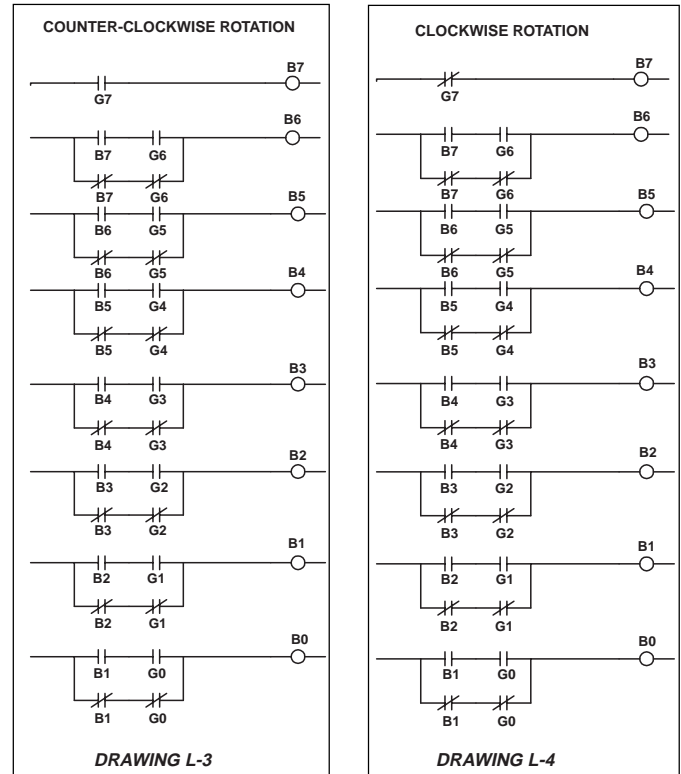
the machine cycle can also be used to gate input sensors and shift register functions.

Converting Gray Code to Binary involves a sequence of "Exclusive OR" operations. It is simple to program this same conversion logic in other programming languages besides ladder logic. In addition to decoding the rotary position of the encoder, controls with arithmetic capability can be programmed to perform direction reversal, position offset and re-zero functions, as well as convert the position value to degrees for ease of monitoring and setup.

Models DDN & DDP



Model DDH



Use a **limit** test function to program a pulse in the PLC. The limit test uses a test reference (in this case the integer register that the Gray Code is going into), and compares it to see if it is between a **lower limit** and an **upper limit**. If the integer value is between the lower limit (ON setpoint), and the upper limit (OFF setpoint), the rung is **true** and an output is turned on. If the integer value does not fall between the upper and lower limits, the rung is false, and nothing happens.

For every output pulse to occur, a different limit test must be programmed with the appropriate limits. **Reminder:** The limit values are position values, not degrees.



Gray Code — Error Free Decoding

The Gray Code chart below (*Figure 2*) shows the bit patterns that are used to represent all 256 encoder positions. It can be seen on this chart that from any position to any adjacent position, only 1 bit changes state. This ensures that the encoder inputs can be read by the control at any point in time (even during a transition) without error.

Consider the following comparison to Binary Code:

INC	DEG	GRAY CODE	BINARY
127	178.6	01000000	01111111
128	180.0	11000000	10000000

When Gray Code advances from increment 127 to 128, only 1 of the 8 bits changes state — bit 8. When Binary Code advances from increment 127 to 128, all 8 bits change states. Sampling the Binary bits during this transition could result in a very large decoding error. Sampling the Gray Code bits during this transition would yield either 127 or 128, depending only on bit 8.

Refer to the table below to understand the relationship between the **increment** (integer), **degrees** and **binary numbers**. Use this table as a guide for setup and troubleshooting your Gray Code system.

- INC (increment) column represents the integer value to which the Gray Code is equal. The increments are 0 to 255 (256 total) that repeat or cycle. (At 255, the next number change is 0, increment to 255, then repeat the cycle over again).
- DEG (degree) column represents the actual degree position that the Gray Code is indicating.
- Gray Code column shows the Gray Code value for that particular position. This Gray Code binary number is the same as the Gray Code inputs status, 1 = ON and 0 = OFF.

Because the Gray Code value is also a graphic representation of the input status, it is an invaluable tool in checking the position or troubleshooting.

8 Bit Gray Code Table

INC	DEG	GRAYCODE	INC	DEG	GRAYCODE	INC	DEG	GRAYCODE	INC	DEG	GRAYCODE	INC	DEG	GRAYCODE	INC	DEG	GRAYCODE
0	0.0	00000000	45	63.3	00111011	90	126.6	01110111	135	189.8	11000100	180	253.1	11101110	225	316.4	10010001
1	1.4	00000001	46	64.7	00111001	91	128.0	01110110	136	191.3	11001100	181	254.5	11101111	226	317.8	10010011
2	2.8	00000011	47	66.1	00111000	92	129.4	01110010	137	192.7	11001101	182	255.9	11101101	227	319.2	10010010
3	4.2	00000010	48	67.5	00101000	93	130.8	01110011	138	194.1	11001111	183	257.3	11101100	228	320.6	10010110
4	5.6	00000110	49	68.9	00101001	94	132.2	01110001	139	195.5	11001110	184	258.8	11100100	229	322.0	10010111
5	7.0	00000111	50	70.3	00101011	95	133.6	01110000	140	196.9	11001010	185	260.2	11100101	230	323.4	10010101
6	8.4	00000101	51	71.7	00101010	96	135.0	01010000	141	198.3	11001011	186	261.6	11100111	231	324.8	10010100
7	9.8	00000100	52	73.1	00101110	97	136.4	01010001	142	199.7	11001001	187	263.0	11100110	232	326.3	10011100
8	11.3	00001100	53	74.5	00101111	98	137.8	01010011	143	201.1	11001000	188	264.4	11100010	233	327.7	10011101
9	12.7	00001101	54	75.9	00101101	99	139.2	01010010	144	202.5	11011000	189	265.8	11100011	234	329.1	10011111
10	14.1	00001111	55	77.3	00101100	100	140.6	01010110	145	203.9	11011001	190	267.2	11100001	235	330.5	10011110
11	15.5	00001110	56	78.8	00100100	101	142.0	01010111	146	205.3	11011011	191	268.6	11100000	236	331.9	10011010
12	16.9	00001010	57	80.2	00100101	102	143.4	01010101	147	206.7	11011010	192	270.0	10100000	237	333.3	10011011
13	18.3	00001011	58	81.6	00100111	103	144.8	01010100	148	208.1	11011110	193	271.4	10100001	238	334.7	10011001
14	19.7	00001001	59	83.0	00100110	104	146.3	01011100	149	209.5	11011111	194	272.8	10100011	239	336.1	10011000
15	21.1	00001000	60	84.4	00100010	105	147.7	01011101	150	210.9	11011101	195	274.2	10100010	240	337.5	10001000
16	22.5	00001000	61	85.8	00100011	106	149.1	01011111	151	212.3	11011100	196	275.6	10100110	241	338.9	10001001
17	23.9	00001001	62	87.2	00100001	107	150.5	01011110	152	213.8	11010100	197	277.0	10100111	242	340.3	10001011
18	25.3	00001011	63	88.6	00100000	108	151.9	01011010	153	215.2	11010101	198	278.4	10100101	243	341.7	10001010
19	26.7	00001100	64	90.0	00100000	109	153.3	01011011	154	216.6	11010111	199	279.8	10100100	244	343.1	10001110
20	28.1	00011110	65	91.4	01100001	110	154.7	01011001	155	218.0	11010110	200	281.3	10101100	245	344.5	10001111
21	29.5	00011111	66	92.8	01100011	111	156.1	01011000	156	219.4	11010010	201	282.7	10101101	246	345.9	10001101
22	30.9	00011101	67	94.2	01100010	112	157.5	01001000	157	220.8	11010011	202	284.1	10101111	247	347.3	10001100
23	32.3	00011100	68	95.6	01100110	113	158.9	01001001	158	222.2	11010001	203	285.5	10101110	248	348.8	10000100
24	33.8	00010100	69	97.0	01100111	114	160.3	01001011	159	223.6	11010000	204	286.9	10101010	249	350.2	10000101
25	35.2	00010101	70	98.4	01100101	115	161.7	01001010	160	225.0	11110000	205	288.3	10101011	250	351.6	10000111
26	36.6	00010111	71	99.8	01100100	116	163.1	01001110	161	226.4	11110001	206	289.7	10101001	251	353.0	10000110
27	38.0	00010110	72	101.3	01101100	117	164.5	01001111	162	227.8	11110011	207	291.1	10101000	252	354.4	10000010
28	39.4	00010010	73	102.7	01101101	118	165.9	01001101	163	229.2	11110010	208	292.5	10111000	253	355.8	10000011
29	40.8	00010011	74	104.1	01101111	119	167.3	01001100	164	230.6	11110110	209	293.9	10111001	254	357.2	10000001
30	42.2	00010001	75	105.5	01101110	120	168.8	01000100	165	232.0	11110111	210	295.3	10111011	255	358.6	10000000
31	43.6	00010000	76	106.9	01101010	121	170.2	01000101	166	233.4	11110101	211	296.7	10111010			
32	45.0	00110000	77	108.3	01101011	122	171.6	01000111	167	234.8	11110100	212	298.1	10111110			
33	46.4	00110001	78	109.7	01101001	123	173.0	01000110	168	236.3	11111100	213	299.5	10111111			
34	47.8	00110011	79	111.1	01101000	124	174.4	01000010	169	237.7	11111101	214	300.9	10111101			
35	49.2	00110010	80	112.5	01111000	125	175.8	01000011	170	239.1	11111111	215	302.3	10111100			
36	50.6	00110110	81	113.9	01111001	126	177.2	01000001	171	240.5	11111110	216	303.8	10110100			
37	52.0	00110111	82	115.3	01111011	127	178.6	01000000	172	241.9	11111010	217	305.2	10110101			
38	53.4	00110101	83	116.7	01111010	128	180.0	11000000	173	243.3	11111011	218	306.6	10110111			
39	54.8	00110100	84	118.1	01111110	129	181.4	11000001	174	244.7	11111001	219	308.0	10110110			
40	56.3	00111100	85	119.5	01111111	130	182.8	11000011	175	246.1	11111000	220	309.4	10110010			
41	57.7	00111101	86	120.9	01111101	131	184.2	11000010	176	247.5	11101000	221	310.8	10110011			
42	59.1	00111111	87	122.3	01111100	132	185.6	11000010	177	248.9	11101001	222	312.2	10110001			
43	60.5	00111110	88	123.8	01110100	133	187.0	11000011	178	250.3	11101011	223	313.6	10110000			
44	61.9	00111010	89	125.2	01110101	134	188.4	11000010	179	251.7	11101010	224	315.0	10010000			

Figure 2

Wiring

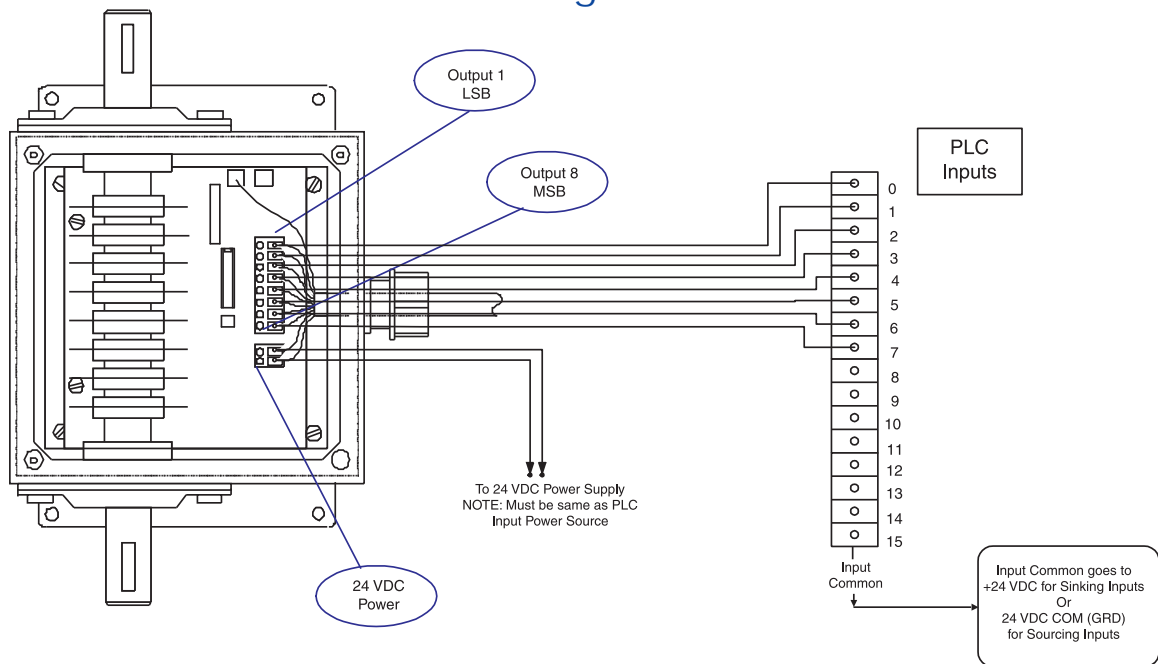


Figure 3

Dimensions

NEMA 12

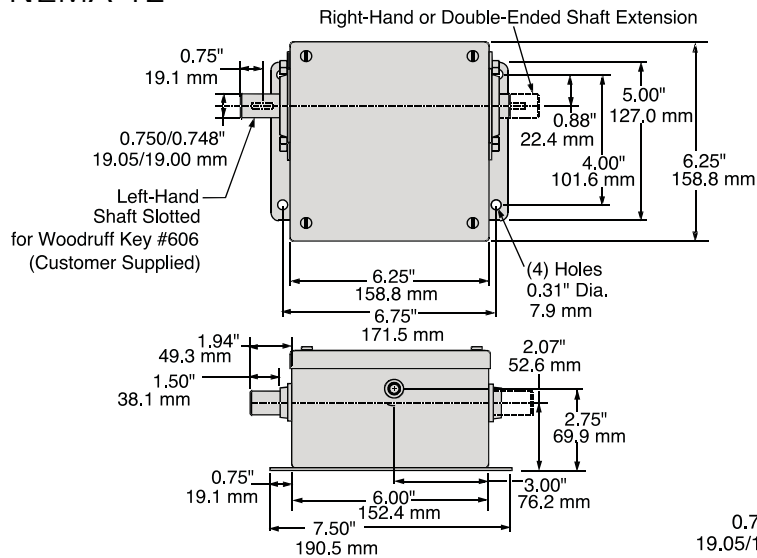


Figure 4

NEMA 4X

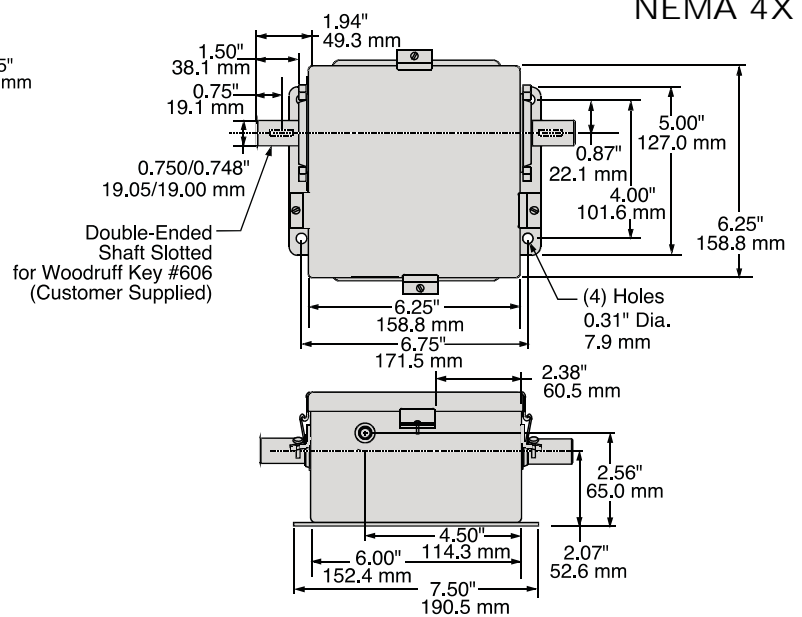


Figure 5

Specifications

General	NEMA 12	NEMA 4X
Ambient Temp.	0 - 60 Degrees C	0 - 60 Degrees C
Enclosure	JIC - 16 Ga Steel	JIC - 16 GA Stainless
Shaft Dia. / Material	3/4" Stainless Steel	3/4" Stainless Steel
Bearings	3/4" Sealed Ball Bearing	3/4" Double Sealed Ball
Conformal Coating	Component Side of PCB	Both Sides of PCB

Electrical	Sourcing [†]	Sinking [†]
Input Voltage	12 - 30 VDC	12 - 30 VDC
Output Voltage	12 - 30 VDC	3 - 30 VDC
Output Current (each bit)	50 mA	50 mA
Output Logic Type	High True	Low True or High True

[†] See page 7 for sinking/sourcing definitions

The 8 Bit Gray Code Encoder Output Chart (*Figure 6*) shows the transitions of each of the 8 bits as the encoder rotates from 0 to 360 degrees. The output bits are phased so that only one bit changes state at each of the 256 increments. The pulse disc which operates bit 0 (least significant) has 64 uniformly spaced slots, bit 1 has 32 uniformly spaced slots, bit 2 has 16 uniformly spaced slots, and so on. The 8 bit output of the encoder is always one of the 256 bit patterns shown in the table on page 4 (*Figure 2*) and always represents the current position of the encoder shaft. For this reason, the control cannot get out of sync with the encoder. High speed count cards that use incremental encoders are NOT absolute and require marker pulses, or other reference signals, for position synchronization.

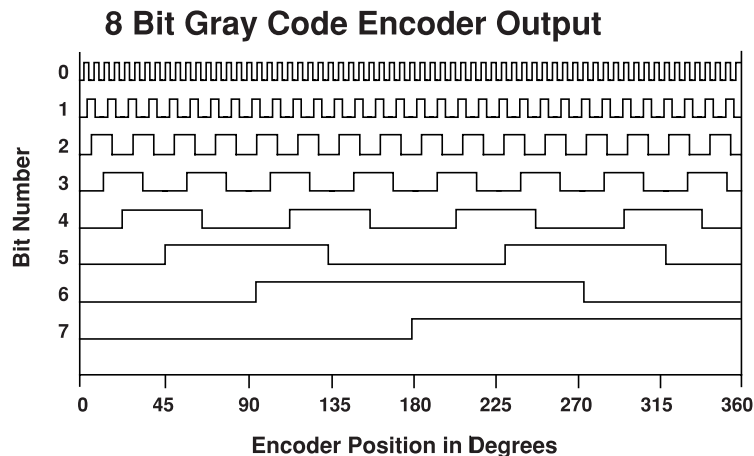


Figure 6

Encoder Part Numbers

1000 RPM MAX	2000 RPM MAX	Output Type	NEMA Rating
PS - 4256 - 12 - DDP	PS - 4257 - 12 - DDP	Sourcing [†]	12
PS - 4256 - 12 - DDN	PS - 4257 - 12 - DDN	Sinking [†] (Low True)*	12
PS - 4256 - 12 - DDH	PS - 4257 - 12 - DDH	Sinking [†] (High True)*	12
PS - 4456 - 12 - DDP	PS - 4457 - 12 - DDP	Sourcing [†]	4X
PS - 4456 - 12 - DDN	PS - 4457 - 12 - DDN	Sinking [†] (Low True)*	4X
PS - 4456 - 12 - DDH	PS - 4457 - 12 - DDH	Sinking [†] (High True)*	4X

***High True** = Current Flow

Low True = No Current Flow

Accessories

PS - 4300 - 03 - XXX (XXX = Length in Feet): 10 Conductor #22 gauge shielded (foil and braid) cable for use with encoders. Cut to specified length, stripped, tinned, connectors attached to shield.

EC - 8001 - XXX - XXX (X's for pitch and # of teeth): Sprocket disengagement clutch allows encoder to be rotated without turning the chain which drives the encoder. Call for more information.

†SINKING or SOURCING (as pertaining to Electro Cam Corp. products)

Sinking means that when the logic is true and the output (or input device) is ON, the output (or input device) is providing a DC common or ground to the connected device.

Sourcing means that when the logic is true and the output (or input device) is ON, the output (or input device) is providing a +DC voltage to the connected device.

This information is important when interfacing an Electro Cam Corp. product with another electronic device. If you are using an Electro Cam Corp. product input to an Allen-Bradley 1746-IN16 "sinking" input card* or similar A-B device, you have to supply a +DC voltage (Electro Cam Corp. **Sourcing** output) to this card, NOT a DC common or ground. In these cases, **Sinking** is what the card does with the input voltage; sinks it to common or ground.

* Other manufacturers include, but not limited to: Koyo (formerly GE Series 1, Texas Instruments, or Siemens SIMATIC PLS's) that use descriptions similar to Allen-Bradley.

Electro Cam Corp. is highly experienced in supplying automation solutions to a variety of industrial machinery.
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