

# ENCODER - GLOSSARY OF TERMS

## **A**

### **115/230 VAC**

The standard line voltages available in the US and some other countries. It is alternating current used to power devices.

### **50/60 Hz**

The frequency of alternations of current flow in the line. The US uses 60 Hz; Europe and some other countries use 50Hz.

### **5PY**

A type of DC tachometer that has a specific bolt pattern

### **ABS PLASTIC**

A terpolymer made from three monomers; acrylonitrile, butadiene, and styrene.

### **ABSOLUTE ENCODER**

An absolute encoder provides information in the form of unique digital or sine/cosine output that indicates position based on a multi-channel code for every resolvable movement of motion or shaft rotation. This type of encoder would require no reference since each discrete position has an independent code.

### **ACCURACY**

Related to the incremental encoding disk is a measure of how close the output is to where it should be. It is the difference between the theoretical position of one increment or bit edge and the actual position of the edge. It is usually expressed in units of distance, such as  $\pm 30$  arc seconds or  $\pm 0.0001$  inch. If it's expressed as a percent, make sure to state whether it's a percent of full scale (not usually meaningful with a rotary encoder) or a percent of nominal resolution.

### **ACCELERATION**

The rate of change in velocity of a moving object expressed in units of distance per second squared or in radians per second squared.

### **AD CONVERTER**

A device that converts a sampled analog signal to a digital code that represents the amplitude of the original sample

### **AMBIENT TEMPERATURE**

The average or mean temperature of the surrounding air which comes in contact with the equipment and instruments under test.

### **ANGULAR MISALIGNMENT**

is the maximum deviation in perpendicularity between the encoder shaft and the face of the mounting surface. It is the total of shaft misalignment, shaft runout and mounting face runout.

### **ASCII**

This most common code is the American Standard Code for Information Interchange; it is seven or eight bit code consisting of ones and zeros that represent letters, numbers and control characters. Seven bits allow for the encoding of 128 possible values.

#### **AXIAL END PLAY**

The variation in shaft end surface position with reference to the motor mounting surface with a specified axial load applied in each direction.

#### **AXIAL LOADING**

The force applied to a shaft end surface directed along the axis of rotation.

#### **AXIAL LOAD (MAXIMUM)**

Maximum axial load is the maximum force that may be applied to the shaft without reducing the rated operating life or causing deviation from the rated performance.

#### **AWG**

A rated standard of American Wire Gauge that indicates the diameter of the wire or groups of wires.

### **B**

#### **BAUD RATE**

The rate at which each bit is transferred to and from a device.

#### **BC42**

A type of DC tachometer that has a specific bolt pattern

#### **BC46**

A type of DC tachometer that has a specific bolt pattern

#### **BCD**

Binary Coded Decimal: a number representation system in which each decimal digit is identified by a unique arrangement of binary digits.

#### **BEARING**

Part of an encoder that supports the rotational movement of another part.

#### **BI-DIRECTIONAL**

Bi-directional refers to an encoder output code format from which direction of travel can be determined. This applied to quadrature encoders.

#### **BINARY**

Refers to the number 2 or a system with a radix of 2 (base 2); e.g. the function of a switch (on/off) can be represented by ones and zeros.

#### **BIT**

is an abbreviation for BInary digiT; it refers to the smallest element of RESOLUTION. (See QUANTUM)

## C

### **CE (EUROPEAN COMPLIANCE)**

Sets essential electromagnetic compatibility, within the European markets, for all electrical and electronic equipment that may interfere with other equipment, or that may be interfered with other equipment

### **CHANNEL**

Each channel is a unique incremental output of the encoder also referred to as an information path.

### **CODE**

A system of representation for a finite number of values in a particular sequence.

### **COLLIMATED**

A means of using lenses to direct waves of light in a parallel path.

### **COMPLEMENTARY**

Complementary is the term for two identical periodic signals where one signal is electrically inverted from the other. Example of single channel electrically inverted. Complementary signals are typically generated by inversion of the electrical output from a single channel.

### **CURRENT SINKING OUTPUT**

A logic form that requires current flow out of the input of the PLC or counter and back to the output of the encoder. The encoder sink this current, which is sourced by the input circuitry. This is the most common output circuit configuration. It uses an NPN output transistor in the encoder.

### **CURRENT SOURCING OUTPUT**

A logic form that requires current flow from the output of the encoder to the input of the counter or PLC. The encoder sources the current and the input circuitry of the counter or PLC sinks this current. This output circuit is seldom used. It usually requires a PNP output transistor in the encoder.

### **COUNTS PER REVOLUTION (CPR)**

The number of increments on the disk of an incremental encoder. A one thousand increment encoder has a CPR of 1000. Can mean either cycles per revolution or counts per revolution. To avoid confusion, this term should not be used. (see Understanding Quadrature)

### **CYCLE ERROR**

The difference between the actual cycle width and the theoretically correct cycle width which is nominally  $1/\text{resolution}$  and expressed in electrical degrees or in percent of cycle width.

## D

### **DA CONVERTER**

Digital or Analog converter; a circuit that accepts digital input signals and converts them to analog output signals.

### **DIFFERENTIAL LINE DRIVER**

An output circuit that increases the current and allows the signal greater noise immunity due to using the difference signal between two lines.

### **DIFFERENTIAL OUTPUT**

Refers to the complementary outputs from a feedback device when the signals are excited by a line driver. Best performance occurs when the receiver input impedance is matched to the line driver output.

### **DIRECTION OF ROTATION**

In a bi-directional incremental encoder, Channel A will lead Channel B for one direction of rotation. If the direction of the rotation is reversed, Channel B will lead Channel A.

### **DISK**

Typically made of glass, metal or plastic with precise position incremental lines. These lines are also known as increments. The number of increments determines the resolution or CPR of the encoder.

### **DUAL CHANNEL**

A dual-channel encoder produces two incremental outputs. These two outputs are generally in quadrature (90° phase separation) relationship to each other. They are typically referred to as Channel A and Channel B.

### **DUTY CYCLE**

The total time to complete one on/off cycle

## **E**

### **EDGE SEPARATION**

The separation between a transition in the output of Channel A and the neighboring transition in the output of Channel B. There are four states per cycle, each nominally 90 electrical degrees apart for quadrature output.

### **ELECTRICAL DEGREE**

An electrical degree is 1/360 of a cycle and is related to mechanical degree through resolution. It is mathematically expressed as follows:

$\text{Resolution} \times 360 \text{ electrical degrees} = 360 \text{ mechanical degrees.}$

### **EMI**

Electromagnetic Interference

### **ENCODE**

To express given information by means of a code.

### **ENCODER (SHAFT TYPE)**

An encoder is an electro-mechanical device that translates mechanical motion (such as position, velocity, acceleration, speed, direction) into electrical signals.

### **END PLAY**

Amount of shaft axial movement with maximum axial load.

**ERROR**

is the algebraic difference between the indicated value and the true value of the input.

**EXCITATION**

The external electrical energy applied to a transducer for its proper operation.

**E****FEEDBACK**

Returning a portion of the energy from the output of a system to its input. Positive feedback reinforces and is called regeneration while negative feedback reduces energy and is called de-generation.

**FREQUENCY MODULATION**

In encoders, this is the deviation from a theoretically correct frequency when the shaft is rotated at a constant velocity.

**FREQUENCY RESPONSE**

Frequency response for an incremental encoder is the encoder's electronic speed limit or the maximum frequency of the output signal expressed in kilohertz (1 kHz = 1000 Hz = 1000 cycles/sec). For calculations, rotational speed must be in rev/sec (rps = rpm/60); linear speed must be either in/sec or mm/sec, depending on the scale line count.  $(\text{cycles/rev}) \times (\text{rev/sec})/1000 = \text{kHz}$

**G****GATED INDEX**

A type of circuit that causes the marker pulse to arrive coincidentally with the same pulse width as Channel B.

**I****INCREMENTAL ENCODER**

An incremental encoder is a device that provides a series of periodic signals due to mechanical motion. The number of successive cycles (signals) corresponds to the resolvable mechanical increments of motion or position.

**INDEX REFERENCE/SIGNAL**

The index is a once-per-rev output used to establish a reference or return to a known starting position. It is a separate output generated by a special track which produces a single cycle (or transition change) at a unique position or positions such as center, home, zero, or reset point. Sometimes referred to as a marker pulse.

## **INTERPOLATION**

A mathematical process that estimates a missing functional value by taking a weighted average of known functional values at neighboring points. This involves an electronic technique for increasing the resolution from the number of optical cycles on the disc or scale to a higher number of quadrature square waves per revolution or per unit length. These square waves can then be QUADRATURE DECODED.

## **IP 50 PROTECTION RATING**

Protected against dust. Limited ingress (no harmful deposit).

## **IP 64 PROTECTION RATING**

Totally protected against dust. Protected against water sprayed from all directions. Limited ingress permitted.

## **IP 65 PROTECTION RATING**

Totally protected against dust. Protected against low pressure jets of water from all directions. Limited ingress permitted.

## **IP 66 PROTECTION RATING**

Totally protected against dust. Protected against strong jets of water. Limited ingress permitted.

## **J**

### **JITTER**

Phase jitter is the variation in the phase relationship between Channel A and Channel B over 360 degrees of rotation by the encoder disc. It is measured from the rising edge of Channel A with respect to the rising edge of Channel B.

## **K**

### **KILOHERTZ (KHZ)**

A measure of frequency

## **L**

### **LINE COUNT**

Line count is the number of equally spaced radial lines per 360 mechanical degrees on the incremental encoder code disk.

### **LINE DRIVER**

A circuit that provides error-free output pulses in electrically noisy environments or over long transmission lines when used with a line receiver.

### **LOGIC STATE WIDTH ERROR**

The deviation in electrical degrees of the state width from the ideal value. In a quadrature encoder, the ideal state width is 90 degrees.

## **M**

## **MAGNETO-RESISTIVE**

A technology where a highly sensitive bridge circuit reacts to the movement of the ferromagnetic gear teeth. The circuit imbalance is amplified to create the output signal; zero speed, high reliability and wide temperature range are its advantages.

## **MEASURING STEP**

is the smallest RESOLUTION element; it assumes QUADRATURE DECODE. (see also QUANTUM)

## **MEASURING WHEEL**

A wheel connected to an incremental encoder, thus changing linear distance to rotational movement.

## **N**

### **NEGATIVE GOING PULSE**

When activated, the pulse goes low (logic 0) or in a negative direction. Do not be confused by negative going, meaning the pulse goes negative in relationship to the signal common or reference level. These statements are for positive logic only. All shaft encoders are based on positive logic.

### **NEMA 4**

An enclosure rating intended for indoor or outdoor use primarily to provide a degree of protection against windblown dust and rain, splashing water, and hose directed water; undamaged by the formation of ice on the enclosure.

### **NEMA 13**

Enclosures are intended for indoor use primarily to provide a degree of protection against dust, spraying of water, oil and noncorrosive coolants.

### **NEMA 56C**

National Electrical Manufacturers Association Type 56C; A standard motor face whereby mounting to the motor requires a device with similar bolt hole dimensions, etc.

## **NOISE**

An undesirable electrical signal from an external source such as an AC power line, motors, generators, transformers, fluorescent lights, CRT displays, computers, radio transmitters, and others.

## **NPN**

A type of transistor with a P-type base sandwiched between an N-type emitter and an N-type collector.

## **O**

### **OPEN COLLECTOR OUTPUT**

When the signal is taken directly off the collector element of the output transistor, no pull-up is used. This is the electronic equivalent of a mechanical switch closure to common. The input device of the PLC or counter is effectively placed in a series circuit that includes the output transistor and input device, which is often an optoisolator and the positive voltage supply. When the output transistor turns on, the circuit is completed and current will flow. The output signal can not be observed unless the circuit is completed externally.

## **OPERATING TEMPERATURE**

The temperature range over which a product will operate and maintain its specified performance criteria.

## **OUTPUT**

The quantity such as current, voltage or switching that a device delivers.

## **OUTPUT WAVEFORM**

The graphical representation of the output during one pulse interval.

## **P**

### **PARITY**

Addition of all the bits in a word is compared to the parity bit (even or odd). If they are both the same, the data is accepted. Otherwise, it is rejected.

### **PHASE**

Phase is electrical degrees of displacement between two encoder outputs, typically 90° in quadrature encoders.

### **PHASE ERROR**

The deviation in electrical degrees from a specified phase relationship between any two channels. This is nominally 90 degrees in a quadrature encoder.

### **POSITION ERROR**

Position error is the difference between the theoretically correct shaft position and its position as indicated by the encoder cycle count.

### **POSITIVE GOING PULSE**

In the low or logic 0 state, it is in the quiescent state. It goes high or logic 1 when activated. This is a transition in the positive going direction.

### **PULSES PER REVOLUTION (PPR)**

Number of pulses occurring in one revolution of the encoder shaft. Commonly (but mistakenly) used instead of cycles/rev when referring to QUADRATURE square wave output. (See the technical articles Square Waves and Pulses: A Clarification and Understanding Quadrature)

### **PULSE POLARITY**

Either positive going or negative going. A pulse has two logic states: activated or inactivated. These two states are opposite. When the pulse is in its quiescent state (high or low), it is at one particular logic level (1 or 0). When the pulse hits or is in the activated state, this logic level reverses itself for the duration of the pulse.

### **PULSE WIDTH**

The actual real time between identical points on the leading or trailing edge of a pulse to the next successive leading or trailing pulse edge. The pulse width of the output signal of most encoders is a 50% duty cycle on the clock outputs. Some models utilize a timed or "one shot" output. This



provides a constant pulse width irrespective of the pulse repetition rate or shaft speed. The factors to be considered when determining pulse width specifications are: (1.) What is the minimum pulse width requirement of the counter or PLC? This information is available in the counter or PLC specifications. (2.) Pulse repetition rate versus pulse width. With a constant pulse width, the individual pulses become closer together as the pulse repetition rate or shaft speed increases. At some point the pulses will overlap and the output signal as a series of well defined pulses ceases. The pulse repetition rate varies inversely with the pulse width and vice versa.

## **Q**

### **QUADRATURE**

A dual output encoder used for bi-directional motion control. One channel leads the other by 90 electrical degrees. By monitoring the phase shift of both channel A and B, direction can be determined. Another benefit of a quadrature encoder is count multiplication. With an appropriate counter, resolution can be multiplied up to four times. For instance, using this technique an encoder with CPR of 1000 can provide a resolution of up to 4000 pulses per shaft revolution. refers to the 90-electrical-degree phase relationship between the A and B channels of incremental encoder output. (See the technical article Understanding Quadrature)

### **QUADRATURE DECODE**

(or 4X Decode) refers to the common practice of counting all 4 quadrature states (or square wave transitions) per cycle of quadrature square waves. Thus, an encoder with 1000 cycles/rev, for example, has a resolution of 4000 counts/rev. (See the technical article Understanding Quadrature)

### **QUADRATURE ERROR**

Quadrature error is the phase error when the specified phase relationship between two channels is nominally 90 electrical degrees. It is inherent in all digital systems; it reflects the fact that you have no knowledge of how close you are to a transition. It is commonly accepted as being equal to  $\pm 1/2$  bit.

## **R**

### **RADIAL LOAD**

The force applied at a specific point to the encoder shaft perpendicular to the axis of rotation. *Note:* It is important to note where the force is being applied along the shaft, due to the cantilever effect.

### **RADIAL PLAY**

The amount of shaft radial movement with the maximum radial load.

### **REFERENCE INPUT**

The input on the control device that takes in the reference position of the encoder.

### **RELUCTANCE TYPE ENCODER**

An encoder which uses ferromagnetic gear teeth to disturb the flux and cause a change in reluctance. A pulsed voltage proportional to the input generated. This type of encoder works well above 100 RPM.

### **REPEATABILITY**

is a measure of how close the output is this time to where it was last time, for input motion in the same direction. It's not usually specified explicitly, but it is included in the accuracy figure. (As a rule of thumb, the repeatability is generally around 1/10 the accuracy.)

### **RESOLUTION**

The number of increments on the encoder disk. For incremental encoders, resolution is defined as cycles per revolution. is the smallest movement detectable by the encoder. It can be expressed in either electrical terms per distance (e.g., 3600 counts/rev or 100 pulses/mm) or in units of distance (e.g., 0.1° or 0.01 mm).

### **RFI**

Radio Frequency Interference

### **RISE TIME**

The interval between the points that the instantaneous value rises from 10% to 90% of the specified upper limit.

### **RUNNING TORQUE**

Rotary force that is necessary to keep an encoder shaft turning. It is typically expressed in ounce inches.

## **S**

### **SHAFT LOADING**

Amount of force that can be applied to a shaft radially or axially; usually measured in pounds.

### **SHAFT RUNOUT**

Amount of shaft movement while spinning.

### **SHOCK**

A transient motion which is capable of exciting mechanical resonances.

### **SHORT CIRCUIT PROTECTION**

A feature that causes the solid state output to either withstand or turn off if exposed to a short circuit load condition.

### **SINGLE CHANNEL**

A single channel encoder produces one incremental output. They are often used for tachometry applications.

### **SOLDER TERMINALS**

For applications that require direct solder connections to the shaft encoder.

**SLEW SPEED**

is the maximum allowable speed from mechanical considerations. It is independent of the maximum speed dictated by FREQUENCY RESPONSE.

**SOLID STATE**

Any semiconductor device that controls electrons, electric fields or magnetic fields in a solid material.

**SQUAREWAVE**

A repetitive waveform (usually AC) whose shape is essentially square or rectangular (usually with an equal duty cycle)

**STABILITY**

Ability of an encoder to retain its performance characteristics over a long period of time.

**STARTING TORQUE**

The rotary force required to overcome friction and cause the encoder shaft to begin rotating. Also referred to as breakaway.

**STATE**

This usually refers to the logic level at a given instant

**STATE WIDTH**

Same as edge separation

**SYMMETRY**

Symmetry is the ratio of the ON time to the OFF time of the output signal for one channel. This ratio is optimally 50-50.

**I**

**TIR**

Total Indicator Reading

**TORQUE**

A twisting effect or movement exerted by force acting as a distance on a body equal to the force multiplied by the perpendicular distance between the line of action of the force and the center of rotation at which it is exerted.

**TORQUE (RUNNING)**

Running torque is the rotary force required to keep an encoder shaft turning. It is typically expressed in ounce-inches.

**TORQUE, STARTING (BREAKAWAY)**

Starting (breakaway) torque is the rotary force required to overcome static friction and cause the encoder shaft to begin rotating.

**TTL**

Transistor Transistor Logic

**U****UNIDIRECTIONAL**

Unidirectional refers to an encoder output code format from which direction of travel cannot be determined.

**V****VIBRATION**

Periodic change in displacement with respect to a fixed reference.

**Z****ZERO SPEED ENCODER**

An encoder which will give output signal down to zero speed

**ZERO INDEX**

An output signal from an encoder produced once in some specified displacement.