Glossary for the encoder (and drives) world

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First of all, what is the correct name?
There is no such thing as a correct name. When you talk to a prospect about a Sensor Bearing or an Encoder, she might just as well start talking about Rotary Pulse Generators or Digital Tachogenerators or even Speed Transducers. In fact, it is difficult to locate any encoder manufacturers on the Hannover Industriemesse CD. But you can find Rotary Encoders and Rotary Pulse Generators or Angular Encoders. It all depends. And it usually is the same thing.
So, there is no correct name for a device that outputs square pulses with a speed proportional frequency. But it seems that the SKF terminology shall be Encoder or Sensor Bearing. But remember; the customer is always right!

And now. The Glossary. It has been compiled from different lectures that I have been delivering over the last twenty, or so, years. The audience has mostly been from the automation, drives, pulp & paper, manufacturing and steel mill side. Very little textile, mining or food industry and I guess that the contents reflect this. Please add to the glossary! We are – quite a few of us – entering a new world, the world of industrial electronics, where nothing is as simple as it might look and sometimes simpler. Let's at least avoid confusion in words. So, do share your knowledge. Mail contributions and suggestions to me at gke@swipnet.se

A channel
See *Channels*

Ampere
Unit for current intensity. Symbol: I, unit: A
Some common current levels: an ordinary incandescent lamp (60 W) consumes a quarter of an ampere (0,25 A) in Europe and half an ampere (0,5) in USA. Starting a car engine takes 200 or 300 amps out of the battery and your wrist-watch consumes five or ten millionths of an ampere (5 – 10 μA). In electrical accidents, it is always the current that kills or lights fires. A low voltage can be as dangerous as a high one if allowed to put enough current through its victim. Be careful.

Absolute encoder
There are two fundamentally different encoder types; incremental and absolute. The absolute encoder contains a disk with several tracks which carry patterns with increasing resolution in such a way that every position is unique. The tracks are read with the aid of an optical system that converts the pattern into a combination of electrical signals, which can be used as is (i.e. in parallel form) or converted to some standard code for transmission over a serial line.

Adapter ring
Very few motors are built to accept the mounting of an encoder directly. To be able to use an encoder or a tacho generator a suitable mounting surface has to be created. The (almost always) circular surface sits on one end of the adapter ring and the other end of the adapter ring is machined to suit the end bell of the motor. Adapter rings and couplings add to the cost and complexity of externally mounted encoders.

Alignment
Two rotating machines must be well aligned for several reasons. The obvious reason is that bearing life degrades if the alignment is bad. More subtle phenomena are that a badly aligned encoder produces output pulses that are frequency modulated with the shaft speed. This often leads to "EIO" (Encoder Induced Oscillations) at certain speeds. A Sensor Bearing avoids these problems. It is hard to get better alignment than one already has inside the motor or bearing box.

ASCII
American Standard Code for Information Interchange. Originally a 7 bit code, nowadays there are variations with 8 bits, notably the "IBM ASCII"

ASM
Asynchronous Motor, which see.

Asynchronous
Not synchronous. Either not locked to an external clock (asynchronous transmission) or not exactly synchronous with a rotating field (as in asynchronous motor).

Asynchronous motor
A motor where the *rotor* is driven by a rotating magnetic field (produced by windings in the *stator*) and where there is a *slip* between the rotating field and the rotor. The slip is often in the 1 – 5 % order. A full-load speed of 1450 RPM is common for a four-pole motor (synchronous speed 1500 RPM)[1]. The most common motor in industrial applications. Also known as an *Induction Motor* or even a *Squirrel Cage Motor*.

B channel
See *Channels*

Back Up
Anything that is used when the primary function fails. A Back Up copy of a data base, for instance. Also a battery that takes over when ordinary power supply fails. Multiturn Encoders often use Back Up batteries to keep track of their position when power is removed. A back Up battery in your computer makes the RTC tick and keeps settings from getting lost when power is turned off.

Bit parallel, resolution
Where the information signals travel side by side. Each signal (bit) has its own wire and there are as many wires as there are bits (plus one signal ground wire). The bits are often binary weighted, i.e. the first bit has value 1, the second one is worth 2 and the fourth one 4. The value doubles all the time. This scheme makes it possible to express large numbers with relatively few bits. Eight bits makes any number between 0 and 255 possible, while 16 bits go all the way to 65535. For moderate resolutions – say in the 0,1 % range – one needs one thousand combinations to choose from and since 12 bits will make 1024 combinations possible it is also a very popular resolution in higher class everyday encoders. Many customers think that they need 1024 or better, but precision can be obtained in other ways than increasing the resolution. See Reciprocal Speed Measurement. *RSM*.

Bit serial
Where the information signals travel one after another. Like pearls on a string. The coding can be straight binary or ASCII or anything that sender and receiver has agreed on.

BCD
Binary Coded Decimal. An (obsolete) coding scheme. Used with Thumb-Wheel Switches.

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[1] At 50 Hz mains frequency. A 60 Hz mains would make the motor run at 1740 RPM (synchronous speed 1800 RPM)

BNC
Bayonet Navy Connector. A cylindrical connector with one inner pole and an outer shield. Used to connect oscilloscope probes and such things to the oscilloscope. A very common connector in other applications as well.

Byte
A set of eight bits. A byte can be interpreted as a Character, a Number or as a set of individual status bits. BPC (Before PC) a byte could be any set of bits. There were six bit bytes and ten bit bytes. Even nine bit bytes. But that has changed. Today, a byte is always a set of eight bits. A byte can be represented in several ways. The following representations all mean decimal 65, hexadecimal 41 or "A" or a set of bits where bit number 0 and 6 are set:

- 065D
- 041H
- "A"
- 01000001 ; equivalent expressions

Bits in a byte are always numbered from right to left with bit 0 being the rightmost bit.

C channel
See *Channels*

CCW
See Rotation

Channels (signals)
The simplest incremental encoder outputs a signal on channel A and that's it. This signal can be used for speed measurements, but it is not possible to tell in which direction the shaft rotates. *CW* and *CCW* rotation both give the same output signal.
To be able to discriminate CW/CCW one needs two channels: A and B in Quadrature (i.e. with a quarter period – or 90 degrees – phase shift between them). With an A and a B channel it is possible to measure speed and count pulses in both directions. And that is fine, as long as one does not need to know the exact position (angle) of the shaft. To be able to synchronise the measurements with some mechanical feature in the machinery it is necessary to introduce a synchronising pulse, which is either called the C channel or the Z channel. Or the Index.
So far, we have three types of encoder outputs:

- the A-channel type for pure speed measurements
- the AB-channel type for speed measurements with direction discrimination
- the ABC (or ABZ) channel type for speed and position measurement with precise synchronisation

Then, there are inverted signals available in many encoders. By using inverted (*complementary*) signals it is possible to operate encoders in a lot noisier environment than with single ended outputs. An encoder with A and B channels will have four wires coming out of it (positive supply, A and B signals and the ground – or 0 volts – wire) while an ABC encoder with complementary outputs will have eight wires (positive supply, A, /A, B, /B, C and /C signals and the ground – or 0 volts – wire).

Complementary signals
A square wave is said to be complementary to another if the level changes in opposite directions. If the original signal A is low, then the complementary signal /A is high, and vice versa. The bar before the /A is often placed above the A. Many encoders have complementary output signals since it improves the EMI immunity. The Sensor Bearing has Open Collector outputs. See also *Channels*.

Coupling
A coupling has to be used when one wants to couple an encoder to the motor shaft. The coupling is very often a weak link in the motor/encoder chain and is a constant source of failures. Since the alignment between motor shaft and encoder shaft is less than perfect, a flexible coupling is needed to avoid forces on the encoder bearings. A flexible coupling is an expensive and delicate piece of machinery and can be avoided by using he Space Inside concept.

cps
Cycles per second. Early unit for frequency. Obsolete. Use Hertz [Hz] as a unit for frequency.

CW
See Rotation

Disc
The translucent round disc in an optical encoder is either made of glass or a stable plastic. In some cases, there are also metal discs with slits in them or with a reflecting pattern that mirrors light back to the phototransistor. The disc (and the slit plate, if there is one) is the one element in an optical encoder that causes most problems. Common failure modes are cracks, dirt, abrasion, skew or simply that it spins loose from the shaft during a fast acceleration or a quick stop. Accidents like these do not happen in a Sensor Bearing.

DOL
Direct On Line. To connect a motor DOL means that is is started and run without any special devices like Soft-Starters or Frequency Inverters. Most ASMs are DOL today.

D-sub
This rather clumsy connector (you can see at least two of them on the back of a computer) were considered smaller than miniature i.e. "subminiature" back in the sixties. And since the connector is D-shaped, the name just got there. They come in 9, 15, 25, 37 and 50 poles. Connector type is indicated with S (sleeve/female) and P (pin/male).

Duty Cycle
The quotient between ON time and period time in a pulse train or when specifying how much work a motor or machine is doing. Often expressed in percents. A motor that works two minutes and idles three minutes is said to have a 40 % Duty Cycle in a five minutes work cycle.

CMOS
Complementary Metal Oxide Semiconductor. The prevailing IC technology today. Characterised by low power consumption and high speed. Used in micro processors and memory chips. Has push-pull output.

Decoupling
Electronic circuits are reliable and dependable – as long as they are properly fed. The supply voltage is important. It shall be within prescribed limits and it shall be free from fast variations aka ripple, noise and transients. A common way of removing the fast, high frequency noise and transients is to install a decoupling capacitor across the supply rails. It acts like a shock-absorber and makes life a lot easier for the electronic circuitry. It is often impossible to run a system without properly dimensioned decoupling capacitors. Especially where fast micro processors are involved.

DOL
Direct On-Line. A way of starting and running asynchronous motors (ASM) where no frequency inverters or soft-starters are used. Most ASMs are still running DOL.

DSP
Digital Signal Processor. A micro processor which has been designed for especially efficient execution of code for applications like FFT, filters, echo cancellation, pattern recognition and other applications that require massive computing power at low cost and a small, power efficient package. Typical application areas are VFDs (Variable Frequency Drives) and Cellular Phones. Large suppliers are Texas Instruments, Analog Devices, Motorola, Hitachi and several other manufacturers.

DTC
Direct Torque Control. A technique that produces a very good sensorless VFD (which see), but not perfect. A speed error in the 1 – 2 percent range can be expected over the rated speed and load range. More if the temperature varies. DTC requires a powerful *DSP* and is seldom seen in small drives – a few kW – or *FHP* drives.

E series
A set of numbers that are used for resistors and other electronic components. There are several E-series, the more common is E12, which contains the numbers 10 12 15 18 22 27 33 39 47 56 68 82. This is why resistor values are so "off" normal numbers. The recommended Pull-Up resistors for the Sensor Bearing are taken from the E12 series. There are several E series. The E192 series is the highest in use and contains 192 numbers between 100 and 988. A part of the E192 looks like this: ... 619 626 634 642 ...

EMC
Electro Magnetic Compatibility. A good thing. A device is Electro Magnetically Compatible with its environment if it can function properly in it and if it does not disturb its neighbours. There are standards for EMC. And there is an EU directive about EMC. Offenders risk jail or have already paid hefty fines (the Cardiff case).

Embedded Control
A micro processor application where the micro processor is "hidden" from the user and where the program resides in fixed memory like ROM or EPROM. An embedded controller is part and parcel of the application it controls, be it a bath room ventilator, a micro-wave oven or a sewing machine or a Variable Frequency Drive. Mass fabrication makes prices in the semi-dollar range possible and capabilities are still – after thirty years of development – growing at a steady rate. A prime candidate for inclusion in future Sensor Bearings.

EMI
Electro Magnetic Interference. A bad thing. Disturbs signal transmission and measurements. Sensor bearing is quite immune to EMI, but the cables pick up the interference and can influence the pulses. Screened cables necessary when the signals shall travel more than a few meters in noisy environments.
Small valves and relay coils that lack EMI suppression are among the worst EMI generators. Large motors are usually not a problem – this is contrary to popular belief, but still a fact. VFDs with modern semiconductors are also terrible to have near a signal cable. There are not many VFDs that comply with the EMC directive. Bear that in mind.

ESD
Electro Static Discharge. The phenomenon that you experience when you leave the car on a cold and dry winter day. A short flash with a sharp sound and an unpleasant pain in the hand or finger. Also when walking on a wall-to-wall carpet and touching a metal object. What you have is a little lightning with the thunder-bolt going from – or to, depending on what carpet and what shoes are involved – your finger. The voltages involved are in the 3 000 to 20 000 volt range. This miniature thunder-bolt destroys electronic components and one must be aware of the risk involved when one is handling computer boards, transducers and electronic components. The Sensor Bearing is no exception. Avoid handling it in a way that might expose it to ESD[2].

Frequency
How often something happens. More specifically; how many times it happens in one second. The unit is hertz [Hz] or "cps", which was very common in the US only ten or twenty years ago. In Germany, you often see s^{-1}, which is a formal way of saying "per second".
Angular frequency is often used in electronics. It is the number of radians per second. The symbol is ω (greek omega). One Hz equals 2π radians/second.

Frequency Inverter
The core of a *VFD*. The frequency inverter does two things: First, it takes AC power[3] from the mains and turns it into DC power by rectifying it. Then, it turns the DC into three-phase AC by chopping it into small pieces that are combined to produce a motor supply with the desired frequency and voltage. The rest of the VFD are control and communication equipment that makes the VFD safe and comfortable to use.

FHP
Fractional Horse Power. Small motors and drives. Usually in the 50 – 500 W range.

Gray code
A parallel code used in Absolute Encoders. Its main property is that only one bit changes at a time when the encoder is rotated. This technique improves security since the ambiguity, that might exist when several bits change at the same time – a so-called "major transition" – is eliminated.

GTO
Gate Turn Off thyristor. A silicon power device that – like an ordinary thyristor – can be triggered (turned on) by a positive pulse on its gate, and also – which is unique for the GTO – be switched off by a negative pulse on the gate. The GTO is still used for high power VFDs, but has largely been replaced by IGBTs, which are faster and easier to control.

Hall effect
A property with most metals, but very pronounced with certain semiconductors like bismuth and tellurium and others in groups III and V. The Hall effect generates a voltage when a thin conductor carries current and a magnetic flux is present perpendicular to the current direction. The voltage is proportional to the current and the magnetic flux, but is usually quite small – in the tens of millivolt region. The voltage is speed independent and a sensor based on the Hall effect and a magnetic code-wheel (like the SKF Sensor Bearing) can be used down to zero speed without loosing any information. The analogue nature of the Hall voltage makes it a suitable candidate for interpolation, which will make sensors with much higher resolution possible.

HTL
High Level Transistor Logic. A logic family that works with 12 or 15 V supply. Slowed down, EMI resistant. Sometimes used in VFDs.

Hz
Unit for *frequency*.

[2] Subject for a short seminar.
[3] Single-phase or Three-phase. Both are possible.

IC
Integrated Circuit. An electronic circuit that has been produced with photolithographic techniques on a chip of silicon. Often called “a chip”

IGBT
Insulated Gate Bipolar Transistor. A power transistor that combines the power handling capacity of an ordinary Bipolar Transistor with the good control properties of a Field Effect Transistor, which has an insulated gate and therefore draws no static control power. Fast. Turn-on and turn-off in 50 – 100 ns possible. Most medium to high power VFDs today use IGBTs.

Incremental
“In steps” An encoder is incremental when the pulses are the same no matter where on the disc or the scale they are produced. There is no way of telling what the angle or position is after a power outage (unless there is some kind of battery back-up). That is why most positions in construction and mining machines are measured with absolute encoders. It would be too time-consuming – sometimes even impossible – to run the machine through a “grid search” routine every time that power has been switched off.

Incremental encoder
See Incremental

Index Pulse
See Channels

Induction motor
Same as Asynchronous Motor, which see.

Interpolated resolution
The “native” signal in most encoders is a triangular or sinoid wave, with continuously varying level. In an ordinary (non-interpolated) encoder it is only the zero-crossings of the signal that is being used and converted to square pulses with steep edges. This is fine, drives and counters expect square signals with steep edges, but a lot of available information is thrown away in the process. In a robust and well designed encoder, the internal signals have a consistent amplitude and shape. Modern electronics can take advantage of this and interpolate a host of “in-between” positions from its knowledge about the signal and its actual value.

LED
The preferred light-source in an optical encoder. Long life, ruggedness and low current consumption are advantages over an ordinary incandescent bulb.

LPR
Lines Per Revolution.

LSB
Least Significant Byte. In a set of bytes – like a sixteen bit word – the LSB is the byte with the least “weight”, I.e. the byte that is placed at the end of the word, bits 7 – 0. See also MSB.

lsb
Least Significant Bit. The last (rightmost) bit in a word or a set of bits or binary signals. Very often also written LSB, where the context decides what the interpretation shall be. 0000 0001, word with lsb set. See also msb.

Major Transition
Binary numbers – as well as ordinary decimal numbers – increment and decrement in units. When a binary number has filled up all bit positions but the msb it will look like this: 0111 1111. The next increment changes all that: 1000 0000 so that all bit positions change state. This can lead to a problem if all bits do not change exactly simultaneously. The intermediate results can cause errors in a system and shall be avoided. The remedy is the Gray Code, which has been constructed so that only one bit position changes at a time, there are no Major Transitions in a Gray Code. Only Minor Transitions.

Micro processor
The heart of any, but the most specialised, computer today. The Processor used to fill big cabinets, but when Ted Hoff and his friends at Intel built their first Processor in 1971 on a silicon chip it was so extremely tiny that it was instantly named a Micro-Processor. And so it has remained.

MSB
Most Significant Byte. In a set of bytes – like a sixteen bit word – the MSB is the byte with the most “weight”, I.e. the byte that is placed at the beginning of the word, bits 15 – 8 in a sixteen bit word. See also LSB.

msb
Most Significant Bit. The first (leftmost) bit in a word or a set of bits or binary signals. Very often also written MSB, where the context decides what the interpretation shall be. 1000 0000, word with msb set. See also msb.

Multi-Turn
The ability to recognise more than one turn. If one needs to know not only the angle of a shaft, but also how many turns it has rotated, one definitely needs a Multiturn Encoder. Multi Turn encoders are often produced with two encoders, where the “coarse” encoder counts the turns and the “fine” encoder keeps track of the angle within one turn. A suitable gear is needed where the ratio is the same as the resolution of the fine encoder so that one full turn of the fine encoder results in one increment in the coarse encoder. The gearing makes Multi-Turn encoders delicate and difficult to use at high speeds and high accelerations. There are fully static (no gear) Multi-Turn encoders on the market today. They need to keep track of shaft position even when the power is switched off, which makes them dependent on an internal power source. Usually a Lithium battery.

Nibble
A set of four bits, or half a byte. The first micro processor, the 4004, was a nibble machine with a 0 – 15 number range. The expression is seldom seen today, even if the majority of all micro processors produced still are nibble machines (timers, door locks, thermostats, remotes etc).

NTC
Negative Temperature Coefficient resistor. A resistor that has a high resistance when it is cold and a low resistance when it is hot. Used mainly for temperature measurement and control in less demanding applications. Accuracy seldom better than one or two degrees C.

Open Collector
An output configuration in logic circuits. The output transistor shorts the output to signal ground when the circuit outputs a logic zero and stays open (not shorting) when the circuit outputs a logic one. This is of no use since the output voltage doesn’t change much. A *Pull-Up* Resistor is needed to “pull” the output voltage high (for a logic one). The output voltage is pulled low when the transistor conducts (logic zero). This type of output is being used with the Sensor Bearing. The values of the Pull-Up resistors are given in the sheet in the box. Se also *Push-Pull* and *Totem-Pole* output.

Passive magnetic pick up coil
A simple arrangement where a moving magnet induces a voltage in a pick-up coil. The induced voltage is speed-dependent and increases with speed. Under a certain speed, the voltage will be too low to be detected by the

associated electronics and information will be lost. This is why passive pick-up coils cannot be used in positioning devices, but are excellent as over-speed detectors.

Photo Transistor
The light sensitive element in an optical encoder. Receives light from the LED. The light is modulated by the interaction between lines on the encoder disc and lines on the *Slit Plate*. The variations in light intensity are translated into electric signals that are either interpolated or sent directly to a Schmitt trigger where the edges are sharpened into a square signal and output via line drivers.

Pole
In an ASM. The piece of magnetic material that the stator winding is wound on. There are always at least two poles. Poles come in pairs, so the next possible number is four. And then there are six, eight and so on. The number of poles has a profound effect on the motor speed when it is run direct on line. A two-pole motor runs close to 1500 RPM on a 50 Hz mains and close to 1800 RPM on a 60 Hz mains. In a four pole motor, there are twice as many poles around the motor so the rotating flux in the motor has twice as many places to visit so it takes longer to get round the stator, and the speed goes down to 1500/1800 RPM. Six poles takes the speed down to 1000/1200 RPM and eight poles to 750/900 RPM. The speed we are talking about is the non-load speed, which is very close to the synchronous speed. The full-load speed will, of course, be between 1 and 5 % lower. See also *slip*.

Polarity Protection
Protective means that are built into an electronic device to protect it from destruction due to wrong polarity (wires mixed up). The SKF Sensor Bearing does not – in its present form – have any polarity protection so it is necessary to read the instructions carefully and also to make sure what voltages and what polarities there are in the supplying device. See Vcc.

Power MOSFET
An extremely fast power transistor that is used in high-performance VFDs and servo drives. Also in *UPS*s and *PSU*s.

PPR
Pulses Per Revolution.

PSU
Power Supply Unit. The unit that supplies an electronic equipment with rectified and stabilised electric power. Usually +5 V, +/-12 V and +24 V.

PTC
A Positive Temperature Coefficient resistor. A resistor that has a low resistance at low temperatures and a high resistance at elevated temperatures. Often used as self-resetting fuses in short-circuit protection applications. A short circuit produces a high current, which heats the PTC so that it goes into high-resistance mode and reduces the current. When the short-circuit is removed, the PTC cools off and returns to low resistance.

Push-Pull output
An output configuration where a switch (transistor) is connected to the positive rail as well as to the negative (or ground) rail. A Push-Pull output has a low impedance in both high level state and low level state. This property makes it less sensitive to external disturbances. Se also *Open Collector*.

Pull-Up Resistor
A resistor that is added to a circuit in order to “pull” the output signal high. See *Open Collector*.

PWM
Pulse Width Modulation. Method to modulate the voltage to an ASM so that its mean value varies over time. The voltage (or rather its RMS value) is usually made to vary like a sine-wave so that the motor receives the same kind of voltage that it would if connected *DOL*. PWM modulation causes a lot of EMI that can make life difficult for other equipment in the vicinity. Most VFDs are terrible EMI polluters, but there are intrinsically EMI-free inverters on the market today. The original is NFO Sinus, Sweden. TechOnLine University has a short course on VFDs and EMI. (www.techonline.com)

Reciprocal speed measurement
Speed is usually measured by counting the number of pulses that an incremental encoder produces during a fixed time interval. The faster the shaft turns, the more pulses are produced during that time interval. But, there is a problem: The interval starts and stops regardless of the pulse train. So there is always an uncertainty at the beginning and at the end of the interval; did I just miss one pulse? Or did I get one too many? This is called “the +/- one error” and the only way to minimise it is to either increase the interval or the frequency. By doing so, the number of pulses increases so that the relative error introduced by “the +/- one error” is kept small enough for the purpose at hand.
But, there is another way, reciprocal measurement. It is – in fact – what one does when one measures the speed of a sprinter. The measurement taken is time and it is easy to calculate speed from time and known distance. There is no “+/- one error” any more and the resolution is not dependent of the number of pulses any more. The technique is being used in speed measurement equipment and it should be possible to use it in VFDs, too. But since there is a problem close to zero speed it is probably not universal enough to be widely used in drives. Not yet, anyhow.

Quadrature
When two signals are in “right angles” to each other. The angle shall be understood as electrical angle. One period equals 360 degrees and 90 degrees (right angle) corresponds to a quarter of one period. The A and B channels of a two-channel encoder are in quadrature. I.e. channel A is 90 degrees “ahead of” channel B when the encoder runs forwards. When it runs backwards, the B channel is ahead of A. Quadrature is necessary if one needs to know speed as well as direction of rotation. An added bebefit is that there are twice as many edges to evaluate in a “quad” encoder as in a single track encoder. A quad encoder with 64 PPR will give an effective resolution equal to 4 x 64 = 256 increments.

RPM
Rotations Per Minute. A common unit for rotational speed.

Resolver
An alternative to an Absolute Encoder. Similar to a little motor in construction, with windings in stator and rotor. Robust. Used by machine tool builders and the military. Practically infinite resolution due to its analogue character, but often poor speed accuracy – in the 1 % region. Needs more sophisticated electronics than an encoder.

Rotation, direction of
It is very important to avoid confusion when one is discussing in what direction a shaft rotates. There is some controversy about this issue and it is about how one shall define the direction and what terminology that applies. The controversy stems from the fact that there used to be two ways of looking at the shaft, but that changed about year 1960 and the valid definition shall be used now. The standard says that the direction shall be given when one is looking directly on the shaft end. If the shaft end rotates like the hands of a clock, then the shaft is rotating Clock

Wise (CW). If it rotates the other way round, then it rotates Counter Clock Wise (CCW). From this follows that if a shaft shall be driven Clock Wise, it needs a motor that runs Counter Clock Wise. This will probably present a slight problem when one is discussing Sensor Bearings, which don't come with a shaft.

RS 232C/D
Standard for serial asynchronous transmission of data. Moderate speeds and limited distance. Seldom faster than 115 kbit/s and seldom longer than 15 m. Same ting (for all practical purposes) as V24. Point-to-point. No multidrop possible.

RS422
Standard for serial asynchronous transmission of data. Balanced signals over double wires. One inverted signal and one non-inverted signals improve EMI immunity. Better speed and longer distances than RS232C/D. Multidrop capability. Up to 31 devices can co-exist on one RS422 line.

RS485
Standard for serial asynchronous transmission of data. A modern and better version of RS 422. High data rates, but still not much more than 1 Mb/s, possible over decent distances. A couple of miles if speed is reduced.

RTC
Real Time Clock. A circuit or a function in a computer or embedded controller that keeps track of the time. It is usually able to count milliseconds, seconds, minutes and so on up to years. The well-known Y2k problem was to some extent a result of RTCs that were not aware of more than two year figures. There were also RTCs that did not know that year 2000 is a leap-year (an exception from the exception). Needs a continuous power supply or it will get lost. Back Up battery or capacitor necessary.

S-B
Sensor Bearing. A wonderfully robust, cost-effective and versatile SKF product.

SCR
Silicon Controlled Rectifier. Same thing as a *Thyristor*.

Serial interface
An interface for electric signals that operates with serial data. See *Bit Serial*, *RSxxx* and *ASCII*.

Servo flange
A mounting method, which is employed by many encoder manufacturers. The shaft end of the encoder has a flange with guides so that the encoder is well aligned to the motor. Clamps or screws for fastening.

Servo size
Denotes the diameter of a (cylindrical) servo component such as a resolver or an encoder. Servo size 8 means that the diameter is eight tenths of an inch. Size 11 is 1.1 inch.

Silicon
Many uses. In the encoders and drives world it is a semiconductor material that is used to fabricate all sorts of components like transistors, memories, micro-processors, thyristors, IGBTs and much more. Modern technology would not be possible without silicon.

Short Circuit
Or *short*. A highly undesirable condition where the impedance between two potentials goes to zero. The most common reason is that bare wire ends touch or that a mistake in the wiring has occurred. Will blow fuses or destroy circuits. Some devices have built-in short circuit protection, but don't rely on it.

Slit Plate
A part of an optical incremental encoder. The slit plate is stationary while the code disc rotates. The slit plate and the code disc have the same line pattern and this creates a moirée effect when the latter plate moves. The moirée pattern is easier to detect with a large area photo transistor than the light passing through a single slot would be. The slit plate replaces expensive and delicate lens arrangements and increases reliability.

Slip
The difference between synchronous speed and actual speed in an ASM. The slip is often given in percents. Slip = 100 x (synchronous – actual)/synchronous %.

Soft-Starter
A device that starts an ASM softly. Used to protect shafts, couplings and machinery driven by an asynchronous motor. Usually implemented as a stator control device with Triacs or Thyristors and associated control and protection circuitry built into a cabinet or other enclosure. Some soft starters can be used for Stator Voltage Control, which see, of fans and other Fluid Machinery with square law torque curves.

Space Inside
A concept that accurately describes some of the advantages with an SKF Sensor Bearing. Not to be confused with "Intel Inside".

Stator Voltage Control
A rather primitive method to control the speed of an asynchronous motor. Also known as Slip Speed Control. By lowering the stator voltage it is possible to increase the *slip* so that the motor speed goes down. The losses go up at the same time (it is like reducing the speed of a car by letting it slip on the clutch, which one should never do!). The method is simple, though, and is being used by ventilator manufacturers. This is because the torque goes down with the speed squared. A speed reduction to half speed reduces the torque to one quarter, so the slip losses are kept within reasonable limits (loss = slip times torque). These people could use a *S-B* to improve the performance of their products.

Synchronous
Following the same clock. A synchronous system always has a master clock (timing pulses) that all other events are locked to. In motor drives; synchronous means running with the same speed as the rotating field that exists within the motor frame. The rotational speed of the latter depends of the frequency of the voltage applied.

Synchronous motor
A motor that always runs with a speed that is an exact function of the applied frequency. A synchronous motor often has a rotor with permanent magnets that lock onto the rotating flux in the stator. The slip is 0 %. Synchronous motors often need position feed-back in order to stabilise it. Torsional oscillations might occur if there is no stabilising feed-back. A Sensor Bearing could provide a solution to this problem.

Thyristor
A "controllable diode". A power semiconductor that can switch high currents (kA) at elevated voltages (kV). Used in DC motor drives, electrolytic plating equipment, HVDC transmission systems and more.

Totem-Pole output
Similar to Push-Pull output, but a little less symmetrical. Specifically used in TTL circuits.

Transducer
Any device that "transduces" i.e. changes a physical quantity into another. There is a multitude of transducers available. A few examples: A temperature transducer changes heat into an electric signal. An electro-acoustic transducer changes electrical power into sound (loudspeaker). A Speed Transducer changes speed into a proportional voltage. And a position transducer changes a position or an angle into a pulse stream (incremental encoder) or a set of parallel signals (absolute encoder). The word "transmitter" is often used, especially in the process control field, but Transducer is the correct terminology.

Transductor
Magnetic amplifier. Obsolete technology that was used during WW2 and after. Has found some new uses as a post-regulator in switching power supplies. Sometimes confused with Transducer. They are not the same thing.

Triac
Similar to a Thyristor, but can control current in both directions (the Thyristor can only conduct in one direction) and which is mostly used in dimmers, heat control and fan controls. Not available in high currents or high voltages. Typical data is 5 or 10 A and 400 – 600 V.

TTL
Transistor-Transistor Logic. The first IC family that "made it". Started the digital revolution. Still used in some applications, but CMOS has taken over. TTL in a supply voltage specification means that the supply voltage shall be +5 V +/-5 % and that there shall be adequate decoupling and low noise levels in the supply.

UPS
UnInterruptible Power Supply. A device that delivers electricity during a brown-out or a power outage. Works with accumulators and an inverter that converts the DC to AC. Many different types. Good protection against most mains voltage problems. Choose one without transfer switch if you need protection against transients and other EMI. Needs some expertise for best results.

V_{cc}[4]
The positive supply rail in a TTL or 74C system. Voltage is +5 volts with respect to ground (GND) and with a +/-5 % tolerance.

V_{dd}
The positive supply rail in a CMOS or NMOS system. Voltage is +3 -- 15 volts with respect to ground (GND) and with a rather large (often unspecified) tolerance.

V_{ee}
The "ground" in a TTL system. Defined as zero volts.

V_{ss}
The "ground" in a CMOS or MOS system. Defined as zero volts.

VFD
Variable Frequency Drive. The standard Asynchronous motor runs at a nearly constant speed when it is connected to a fixed frequency three-phase system. The only way of changing its speed (in an efficient manner) is to change the frequency and that is exactly what a variable frequency drive does.

The intricacies of a VFD make the technique hard to grasp, but it suffices to know that no VFD can ever produce a high precision speed without a sensor. Techniques like DTC and NFO come close, but if one needs better than one or two percent speed tolerance over speed, load and temperature range; an encoder is the only way to go. See also PWM.

VLSI
Very Large Scale Integrated circuits like micro-processors, memories, A/D converters, DSPs and many other electronic devices on a chip of silicon. See IC.

Volt
Unit for potential difference. Symbol: U or E, unit: V
Some common voltage levels: an ordinary incandescent lamp (60 W) runs on 230 V in Europe 110 V in USA[5]. Starting a car engine places 12 volts from the battery on your starter motor and the output from a microphone is in the micro-volt to millivolt range (millionth or thousandth volt). In electrical accidents, it is always the current that kills or lights fires. A low voltage can be as dangerous as a high one if allowed to put enough current through its victim. Be careful.

Wiegand transducer
Passive magnetic pick-up coils are simple and sturdy devices, but they have one drawback – they produce a voltage level that is speed dependent. This means that they cannot be used under a certain speed, the signal will simply not be strong enough. The Wiegand transducer overcomes this problem and can be used down to zero speed while still being a sturdy, passive device with a good temperature range. The Wiegand effect is a kind of a "snap effect" exhibited by some combinations of mild steel and hard magnetic material based on iron, cobalt and vanadium. The magnetic field in such a material does not change gradually as the external magnetic field is being changed, but snaps to the new polarity when a certain external field strength is exceeded. The snap is independent of speed so the Wiegand transducer can keep track of movements even if the are very slow.

Word
A set of 16, 32, 64 or 128 bits. The first PCs used 16 bit word, but 32 is common today. A 16-bit word can be composed of two bytes and there are two possible ways of doing it; either put the MSB before the LSB, or vice versa. The two semiconductor companies Intel and Motorola happened to chose different standards when it all started back in the seventies. So now we have two different standards. They are often referred to as "Little-Endian" and "Big-Endian" where the Little-Endian word has its Least Significant Byte (LSB) at the end.

Z channel
See *Channels*

[4] A word of caution: These symbols get mixed up. Always measure the voltage before you do anything foolish. Many electronic devices cannot stand being connected with the wrong polarity or to the wrong voltage. So, be careful. Or rather, leave the whole thing to the electronics guy.

[5] That's why the current consumption differs. See Ampere.