Formulas

To Calculate:

Maximum container rate (MCR) on conveyor in containers per minute

Given: CP = container pitch (container-to-container spacing) in inches
RP = recommended sample pitch (distance resolution) in inches
SP = sampling period of sensor (cycle time) in seconds

Formula: $\frac{RP \times 60 \text{ seconds}}{CP \times SP}$ = MCR containers per minute

Example: CP = 4 inches
RP = 0.25 inch
SP = 0.003 seconds

Calculation: $\frac{0.25 \times 60 \text{ seconds}}{4 \times 0.003}$ = 1250 containers per minute

To Calculate:

Required sensor sample period (SP)

Given: CS = conveyor speed in inches per second
RP = recommended sample pitch (distance resolution) in inches

Formula: $\frac{RP}{CS}$ = SP seconds

Example: CS = 100 inches/sec.
RP = 0.25 inches

Calculation: $\frac{0.25}{100}$ = 0.0025 sec. (or 2.5ms)

To Calculate:

Sample pitch (SD) or distance between samples

Given: CS = conveyor speed in inches per second
SP = sensor sample period in seconds

Formula: CS x SP = SD inches

Example: CS = 100 inches/sec.
SP = .0005 seconds

Calculation: 100 x .0005 = .05 inches

To Calculate:

Window edge drift (WS) due to temperature change.
(SM600, SM607 only. SM606 is temperature compensated)

Given: The window edges will drift at the rate of 1.7% per 10°C
WE = window edge in question given as distance from sensor face in inches
TD = temperature shift in degrees Celsius

Formula: $\frac{0.017 \times TD \times WE}{10}$ = WS in inches

Example: WE = 2 inches
TD = 20°C

Calculation: $\frac{0.017 \times 20 \times 2}{10}$ = .068 inches

Note: The speed of sound increases as the temperature rises therefore the window edges will appear to move toward the sensor as the temperature increases.

To Calculate:

Object distance (D) from inner window edge using 0-10V analog sensor, indirect type.

Given: VOUT = output in volts
WW = window width in inches

Formula: $\frac{VOUT \times WW}{10}$ = D in inches

Example: VOUT = 3.3 volts
WW = 4.625 inches

Calculation: $\frac{3.3 \times 4.625}{10}$ = 1.526 inches from the inside window edge

Formulas, con't

To Calculate:

Object distance (D) from inner window edge using 4-20mA analog, indirect type sensor.

Given: IOUT = output in milli-Amps
WW = window width in inches

Formula: $\frac{(IOUT-4) \times WW}{16} = D$ in inches

Example: IOUT = 15mA
WW = 4.625 inches

Calculation: $\frac{(15-4) \times 4.625}{16} = 3.18$ inches from the inside window edge

To Calculate:

Sonic beam diameter (D)*

Given: L = distance of sensor in inches
BS = beam spread in degrees

Formula: $2 \times L \times \tan(BS/2) = D$ in inches

Example: L = 4 inches
BS = 7 degrees (SM600)

Calculation: $2 \times 4 \times \tan(7/2) = 0.489$ inch diameter

*NOTE: Since the beam spread in degrees changes with distance from the sensor, this calculation is approximate. For more accurate calculation, ask your distributor or Hyde Park for a beam plot.

To Calculate:

Minimum hole-size diameter (D) through which to detect*

Given: L = distance of hole from sensor in inches
BS = beam spread in degrees
S = safety factor

Formula: $S \times 2 \times L \times \tan(BS/2) = D$ in inches

Example: L = 4 inches
BS = 7 degrees (SM600)
S = 1.2 (20% safety factor)

Calculation: $1.2 \times 2 \times 4 \tan(7/2) = 0.587$ inch diameter

*NOTE: Since the beam spread in degrees changes with distance from the sensor, this calculation is approximate. For more accurate calculation, ask your distributor or Hyde Park for a beam plot.

Sensing Terms

absorbent materials

Object materials that absorb some or all of the transmitted ultrasonic energy rather than reflect it back to the sensor. For example, granular products, foam rubber materials, and certain textiles and papers may need a stronger transmitted signal for reliable detection. Detection of foam surfaces from soaps and similar products is also difficult and should be tested prior to installation.

accuracy

In ultrasonic analog sensing specifications, the relationship between output magnitude and actual object position, expressed in terms of the span. Using the Model SM506 analog sensor with a 4 to 20 mA output as an example: If the sensor is set up with a 20" span between the near and far limit and the sensor's output current reads 12 mA, the object is expected to be 10" from the near limit. The accuracy specification indicates a possible maximum object position error of ±0.50% of the span, or 0.1" (0.005 x 20). This means the distance at 12 mA can vary between 9.9" and 10.1" in that span.

acoustic interference

An intense acoustical noise generated near the sensor which may interfere with the sensor's operation. Offending noise sources are usually well above the range of hearing. Common sources of this type of acoustical interference may be: air nozzles, machine vibration, and sliding friction. Another source of acoustic interference, known as "cross talk," can result when an ultrasonic sensor responds to the signal from an adjacent ultrasonic sensor. While this can be eliminated by repositioning the sensors, the Hyde Park Model SM504 sensors are designed to operate adjacent to other SM504 sensors without cross talk interference.

air movement and densities

See *Sensing Considerations* section on 2-21.

air pressure

See *Sensing Considerations* section on 2-21.

ALARMS push-button

A push-button on the alarm models of the Hyde Park Model SM500 family of sensors is used to set two discrete alarm set points (near/far, high/low) anywhere within the sensing range where alarm outputs are required to protect equipment from potential damage. The Model SM502 dual-level series and SM506 analog series have this push-button.

ALARM set point

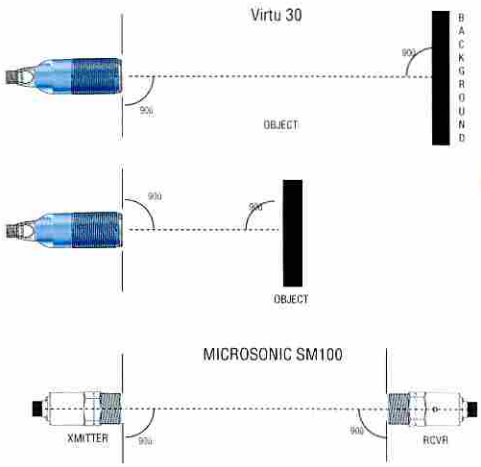
In using either the Hyde Park Model SM502/SM602/SM902 dual-level or SM506 analog series sensors, the point within the sensing range where an alarm output is generated by the unit.

alignment

The positioning of a sensor so that the maximum amount of the emitted sound energy reaches the receiving sensor. For pulse-echo types of sensors in object and background mode, the transmitted beam of the sensor should be perpendicular to the object or background target, respectively. For thru-beam types of sensors, alignment refers to the extent to which a line, perpendicular to the face of both transmitter and receiver, passes through the center of each face. In some situations, perfect alignment is not desirable and better results are obtained if the receiver is tilted about 10 degrees out of alignment.

alternating current (AC)

An electric current that periodically reverses direction of electron flow. The rate at which a full cycle occurs in a given unit of time (usually a second) is called the frequency of the current. A sinusoidal current rated at a given frequency, usually 50 Hz or 60 Hz.



ambient

The environmental conditions in and around the sensing area (e.g., humidity, light intensity, temperature, air speed).

ambient acoustical noise

See *Sensing Considerations* section 2-21.

ambient temperature

The temperature (in Celsius or Fahrenheit) of the environment in which the sensor is operating.

ampere (Amp)

A standard unit of current. It is defined as the amount of current that flows when one volt of emf (electromotive force) is applied across one Ohm of resistance. An Ampere of current is produced by one Coulomb of charge passing a point in one second.

analog

A representation of data by continuously variable quantities, e.g., voltage or current.

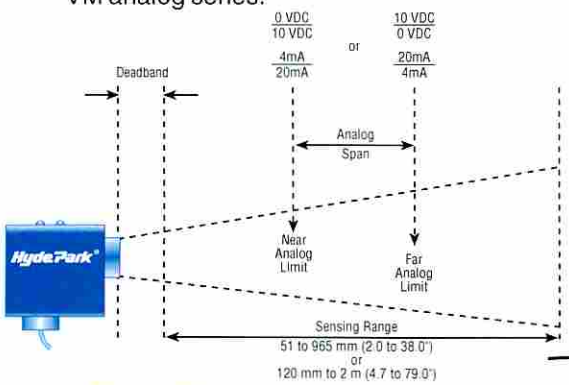
analog limits

In Hyde Park's analog sensors, the near and far boundaries that are set with the LIMITS push-button, within which the object detection and control take place. In the SUPERPROX® Model SM506 series, these limits are identified by the analog output selected: 0 to 10 VDC or 4-20 mA. The position of maximum output is determined by the configuration Switch 1 position. In the DIR position, the maximum analog output occurs at the limit (Near) closest to the sensor. In the INV position, the maximum analog output occurs at the limit (Far) farthest from the sensor.

analog response

The speed at which the continuously variable quantity (output voltage or current) follows the object position. Two methods are typically used to measure this: step response and frequency response. Step response is the time (typically

in ms) required for the voltage or current to change to a certain percent of the final value. Frequency response is another way to measure analog response. Imagine a SUPERPROX® analog sensor monitoring a rotating cam. As the cam rotates faster and faster, the unit becomes less accurate in its measurement. The frequency where the measured value of the difference between minimum and maximum is one-half the true difference is often used as a measure of frequency response. In Hyde Park's analog sensors, it is the change in analog output relative to the change in position of an object sensed within the near and far span limits of the Model SM506, SM606, SM906, and VM analog series.



attenuation

The lessening of sensing energy caused by environmental elements such as dirt, dust, moisture, or other contaminants in the sensing area. Attenuation is measured as a ratio or as the logarithm of a ratio (decibel).

background sensing mode

For Hyde Park's SUPERPROX® ultrasonic sensors, this sensing mode is recommended when detecting objects with round or irregular shapes and non-perpendicular pro-files. The background mode, using a unique secondary echo lock-out function, enables the sensor, with a fixed, background target, to operate as a universal, all-materials-type, break-beam detector.

After setting the window limits on the fixed target (See Figure 1 below), make sure the ultrasonic transmission path between the sensor and the target is clear of obstructions.

Once set, the sensor accepts only the first (primary) ultrasonic pulse echo received from the target within the window limits as shown in Figures 1 and 2. In this mode, the echo is received and detected as an object not present. Object presence is detected when the object interrupts the sonic pulse transmission path between the sensor and the fixed target, as shown in Figures 2 , 4, and 5.

As a result of the secondary lock-out function, the sensor is permitted to receive only the primary echo after each sonic pulse. All subsequent secondary echoes are "locked out". If the first echo received from the object travels a lesser distance than the first echo from the fixed target window, that object is detected as being present.

As shown, if the echo off an object is not received (Object #1, Figure 4), or if the first echo is received off an object that is outside the window limits (Object #2, Figure 5). the object is detected as being present.

background suppression

An ultrasonic sensor's capability to disregard any or all pulse-echo returns from objects located outside or beyond where the far sensing window limit is set.

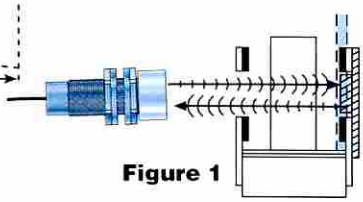


Figure 1

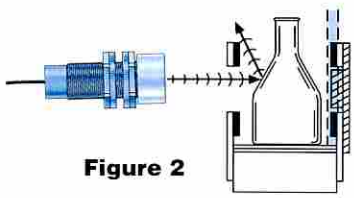


Figure 2

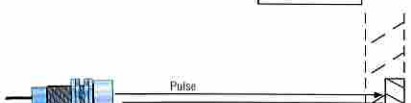


Figure 3

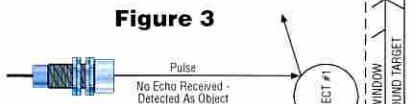


Figure 4

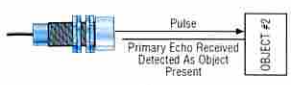
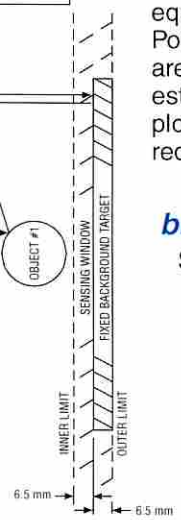


Figure 5



backup detection

An application in which the sensor is used to detect either the presence of objects (e.g., containers, that have accumulated at a particular point in the conveyor line) or when the movement of back-to-back containers is such that a backup condition is determined.

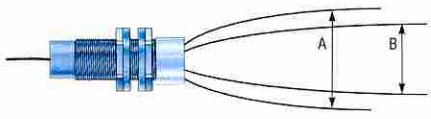
beam

Ultrasonic waves emitted from the sensor's transmitter. The waves diverge, approximating a cone shape until environmental attenuation "pinches off" the cone. The beam cone angle is included in the sensor's specification.

beam angle

The angle at which the pulses of sound energy expand from the transmitter, thus defining the cone of the sonic beam. Illustrated below are angle A of 20° for the Hyde Park Model SM900 2 meter range series and angle B of 10° for the SM500 1 meter range series.

The stated included angle of the Hyde Park sensors' sonic beams ranges from 7° to 20° depending upon the model and is only an approximation. The beam plot (below) of a particular sensor model provides more accurate information.

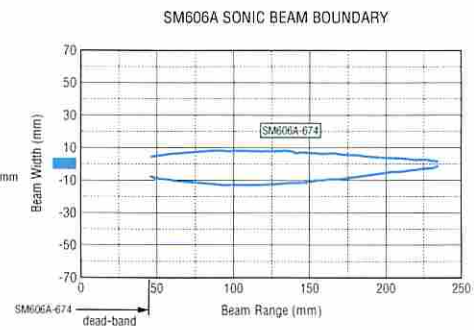


beam plot

Developed from data collected at 20° C and zero air flow, the points defining the boundaries and shape of the Hyde Park sonic beam. Shown above is the beam plot for the SM606 analog sensor. The boundaries were established using a 10 cm x 10 cm (3.94" x 3.94") object "target" positioned parallel to the sensor face. The plot is valid for targets equal to or larger than 10 cm x 10 cm. Points defining the boundaries of the plot are represented by the target edge closest to the beam axis. These and other plots are available from the SCC upon request.

break-beam sensing

See thru-beam sensing on 2-19.



"CE" mark

The CE mark on Hyde Park sensor products indicates a guarantee of conformity to entry requirements for products sold in the European market.

chemical compatibility

The capability of a sensor to avoid damage to its components caused by chemicals. Hyde Park's SUPERPROX®, MICROSONIC®, and VIRTU® ultrasonic sensors will resist most chemicals including most food/beverage products. An optional fluorosilicone rubber face is available on some models to resist petroleum-based hydrocarbons and a variety of other chemicals.

coincidental secondary echo condition

This is a condition associated with using the Hyde Park ultrasonic proximity sensors in the object mode (Figure 1).

When an object is properly positioned between the sensor and the window (See Figures 2 and 3), the ultrasonic pulse from the sensor will reflect repeatedly between the sensor and the object, thus creating a series of secondary echoes. A coincidental secondary echo condition exists when the distance traveled by the primary echo of an object at or within the window limits is a multiple of (most likely twice) the distance traveled by a secondary echo off the foreground object. As shown in Figure 3, Object #3 is properly positioned halfway between the sensor and the inner window limit and is mistakenly detected as if it were Object #1. Exercise caution when considering a SUPERPROX® application to avoid this "false echo" condition.

common

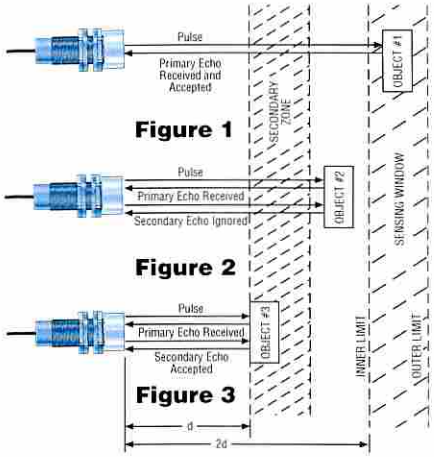
A circuit ground, the return path of charge to a power supply. Frequently, this point has the same potential (voltage) as a true earth ground, but this is not guaranteed.

cone diameter

The diameter of the sonic beam cross section at a specific distance out from the sensor and beyond the dead band.

configuration switches

A set of dip switches, located in the control compartment of the SM500 SUPERPROX® ultrasonic sensors, used to set up the sensor for its intended application. See the Product Information section.



connector

A device used to join or break two circuits quickly and easily when required. This Hyde Park sensor connection style provides a quick connect and disconnect service for the user.

continuous load current

The flow of charge from an output to an external unit.

continuous wave

The type of ultrasonic sensing used in Hyde Park's thru-beam sensors, MICROSONIC® , in which a separate transmitter generates ultrasonic energy continuously with very short interruptions of the transmitter beam easily detected by a separate and properly aligned receiver. See *thru-beam (or break-beam) sensing* on page 2-19.

control compartment

The area in the back of the SUPERPROX® Model SM500 family sensors, behind the square cover, that contains a variety of configuration switches, push-buttons, and a potentiometer used to set up the sensor for a given application. See Product Information section.

coupler

The silicone or glass epoxy material, which when attached to the piezoelectric crystal in the Hyde Park sensor, serves as the face of the sensor and is used to amplify the sound wave signal and "push" it through the air. This coupler provides a link that transports the sound energy or signal from the crystal to the outside air. This is necessary because air presents a resistance that would greatly inhibit the sensing range were it not for the boost provided by the coupler.

crosstalk

See *acoustic interference* on 2-11.

crystal

An electronic device made of quartz and having crystalline piezoelectric properties. In ultrasonic terminology, crystal refers to the piezo element, a ceramic made of lead, zirconium, and titanate which is used as part of the basic element of the transducer.

current consumption

Amount of flow required from the power supply by the unit in order to operate properly.

current loop or signal current loop (4-20 mA)

A type of analog sensor output that impresses a current across the connected load. The impressed current ranges from 4-20 mA. This type of output is less susceptible to electrical noise.

current pulse

A burst of electrical energy. A rapid increase in the flow of charge followed by a return to the original rate of flow.

current sinking output

See *NPN current sinking output* on 2-16.

current sourcing output

See PNP current sourcing output on 2-17.

cycle time

See response time on 2-18.

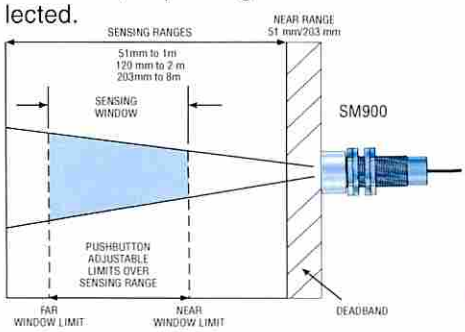
Dairy 3A Sanitary Standards

A set of voluntary standards formulated by joint government, supplier, and consumer effort to ensure that all dairy equipment can be thoroughly cleaned to prevent unsanitary conditions. Sensor housings, made of NORYL® plastic meet these standards for Hyde Park sensors and are available in gray to distinguish them from the standard blue ULTEM® housing.

deadband

The minimum allowable distance out from the sensor for reliable object detection. It is determined by a time period beginning when the transducer is energized, producing a sound wave, and when the resulting oscillations from that sound wave diminish to the point where it is possible for the transducer to accurately receive its echo. This space or "blind zone" in front of the sensor is not reliable for object detection. For Hyde Park ultrasonic sensors, the deadband can extend

from 14 mm (0.75") to 203 mm (8") from the sensor, depending on the model selected.



delay on/off control

The output of a sensor may be delayed until a fixed time after the event occurred that triggered the output. Generally, the state of the sensor must stay constant or the timer will restart. Delay on refers to the time interval between when the sensor detects the object and when the output changes state. Delay off refers to the time interval between when the sensing ceases and when the output changes state.

DELAYS push-button

A push-button on the Model SM503 series sensors used to set on and off delay times.

DeviceNet Capability

Hyde Park's SM600FP flat-profile and SM900 sensors are available with a DeviceNet interface. DeviceNet is a 4-wire, which all draw their operating power from the bus. A master device, usually a PLC, coordinates communication activities on the bus: polling sensors and controlling actuators. The benefits of this type of interconnect scheme include: alpha-numeric-based information exchange between Hyde Park sensors and the DeviceNet network, universal sensor hardware for a multitude of applications, and improved error/fault reporting capability.

differential height inspection

A sensing application in which an array of Hyde Park Model SM504 series sensors are programmed to simultaneously detect various specific heights and produce an output when a specific height is not detected.

digital output

A discrete output that is always in one of two stable states.

diode

A two-layer semiconductor that allows current to flow in only one direction - from anode to cathode.

dip switch

One or more switches housed in a "dual in-line package" and soldered into a circuit board, thus providing a small and economical switch. In Hyde Park ultrasonic sensors, these are tiny switches in the control compartment of the Model SM5XX series sensors used to configure the sensor for a given application. See Product Information section.

direct current (DC)

Electrical current in which electrons flow in one direction only. It may be constant or pulsating as long as its movement is in the same direction.

direct/inverse output

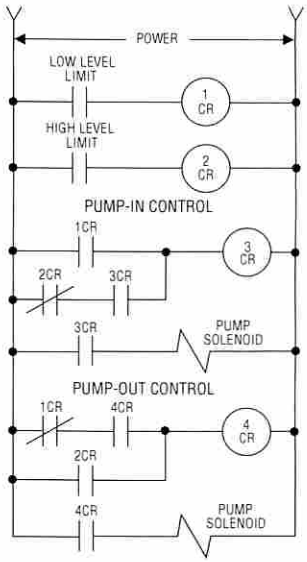
Refers to the polarity of the analog output. "Direct" output means that the voltage or current decreases as an object moves away from the sensor. "Inverse" output means that the voltage or current increases as an object moves away from the sensor.

dual-level on/off latch

A logic function in which an input signal to the latch module causes the module's output to turn on. The output remains on until a signal is applied to a second input to reset the latch. The "latch" function is usually implemented in a hardware module or PLC software. The on-board microprocessor in the Model SM502/SM602/SM902, and VM Virtu series dual-level control sensor models performs a stand-alone on/off logic latch control with respect to a preset high and low limit switch point. This eliminates the need for any external control relay or programmable controller program logic to perform either a pump-in or a pump-out level control application. In the pump-in mode, the sensor output latches on when the level drops to the low level limit and latches off when the level rises to the high level limit. In the pump-out mode, the sensor output latches on when the level rises to the high level limit and latches off when the level drops to the low level limit. The preceding diagram illustrates the on/off relay latch control logic emulated by a dual-level control sensor.

dual-level sensing

One of several sensing techniques within the capabilities of Hyde Park ultrasonic sensors, where the user sets two limits, a high level and a low level, within which the level of a product is to be controlled through a discrete on/off output. See information on the Model SM502/ SM602/SM902, and VM Virtu



series sensors for a full explanation of the three versions available.

echo

The ultrasonic energy which reflects off an object and returns to the detector.

electrostatic

Refers to motionless electrical charges. Charges exert mechanical forces on each other which can be used to generate ultrasonic waves.

environmental compatibility

Hyde Park sensors are capable of operating in a variety of environments and conditions, including selected acids, bases, salts, hydrocarbons, oils, solvents and food products among others.

ESD (electrostatic discharge)

The sudden discharge of electrical charge. The charge is commonly built up as a result of sliding friction between dissimilar materials (shoes and carpet). The potentials may reach 50 kilovolts (kv) in dry environments. This phenomenon may cause destruction of electrical equipment that is not protected.

ETL safety label

The label which guarantees that advertised Hyde Park AC-powered sensors have been approved by a nationally recognized laboratory and they comply with federal law.

false echo

See Coincidental Secondary Echo Condition on 2-13.

far (low) limit

The boundary of the sensing "window" farthest from the Hyde Park sensor.

fixed sensing window (width)

A defined space in front of the sensor within which object detection takes

place. The Hyde Park Model SM300/660 family of proximity sensors have fixed sensing window widths.

fluorosilicone rubber

An elastomer that is resistant to all food products and several chemicals, including many solvents and petroleum-based products found in industry. Many of Hyde Park's sensors use this material as an ultrasonic coupling material (see *coupler* on 2-13).

foreground suppression

An ultrasonic sensor's capability to disregard any or all pulse-echo returns from objects located between the sensor and where the near sensing window limit is set.

frequency

The number of times a periodic action occurs in a unit of time. The number of hertz (Hz, the unit of frequency, one cycle per second) that an electric current completes in one second.

frequency drift

A percent of deviation from a specific number of cycles per second (Hz) for a given sonic or ultrasonic waveform.

gain adjustment

Determines the degree of sensitivity for a sensor.

gain setting

The amount of amplification of the input signal. Several sensor models are capable of operating at high or low gain. Higher gain can overcome signal loss due to poor reflective surfaces, high environmental temperature, etc while low gain is used if stray echo or secondary echo problems occur.

gap detection

Sensing for either voids or spaces between containers on a conveyor line system. Upon sensing a gap, the sensor can be used to automatically start, stop, or modulate speed of associated in-line conveyors and machinery.

gate-controlled sensing

A unique feature of the Model SM504 series sensors in which they perform periodic sensing of multiple objects or locations. Depending on the application, one or more of these sensors is triggered with a switching device to prevent possible false sensor outputs due to changing foreground object conditions.

ground

Referring to earth ground, used as a return for electric currents and as an arbitrary zero of potential. It is important at high power levels mainly for safety reasons. It also refers to the electronic chassis or enclosure ground or to DC common (voltage reference to the negative side of a DC power supply).

hermetic seal

An air-tight seal. All Hyde Park sensors are hermetically sealed to withstand harsh environments.

hertz (Hz)

The international unit of frequency, equal to one cycle per second. Hyde Park sensors operate at a frequency of 75 kHz, 180 kHz, 200 kHz, 300 KHz and 500 kHz.

hysteresis

Means "to lag behind". An electronic design consideration for ultrasonic sensors such that the point at which the sonic echo is received by the sensor is different than the release point of the output. This differential prevents the output of a sensor from oscillating near switching points. It is also a function of the number of echoes that must come from either inside or outside the window to switch the sensor's output.

impedance

Measured in Ohms. This is the total opposition a circuit, cable, or component offers to alternating current (AC) at a given fre-quency. Impedance includes resistance, inductive reactance, and capacitive reactance.

input

The signal (voltage or current) applied to a circuit to cause the output of that circuit to change state. It includes the terminal, jack, or receptacle provided for reception of the input signal.

input voltage

The power source required by an electric or electronic device (e.g., a self-contained sensor) in order for the device to operate properly.

intrinsic safety

A design technique applied to electrical equipment (e.g., sensors and switches) and wiring for hazardous locations. The technique involves limiting electrical and thermal energy to a level below that required to ignite a specific hazardous atmosphere. Intrinsic safety design often eliminates the requirement for expensive and awkward explosion-proof enclosures.

IP rating

A rating system which defines the suitability of sensor and sensor system enclosures for various environments. Similar to NEMA ratings for enclosures. Hyde Park ultrasonic sensors are rated IP66 and IP67 and carry the following protection levels:

IP66 - dust tight, strong jets of water (hose down)

IP67 - dust tight, submersion in water for up to 30 minutes at 1m

isolated output (or input)

A type of input or output that floats electrically from its host circuit. This type of circuit may be used to break ground loops.

jam detection

Sensing for a backup of containers on a conveyor line system due to either down-stream container jams or machinery stop conditions. Upon sensing a jam, the sensor can be used to automatically alert an operator or stop associated up-stream conveyors and machinery until the jam is clear.

kHz

Kilohertz, 1000 Hertz

latch (latching logic)

See dual-level on/off latch on 2-14.

LED (light emitting diode)

A semiconductor device that emits incoherent light formed by the P-N junction. Light intensity is roughly proportional to electrical current flow. LED's are used in Hyde Park sensors to indicate power on, object in view, output status, etc.

limit adjustment resolution

The smallest allowed distance that a limit can be changed.

LIMITS push-button

A push-button in the SUPERPROX® family of sensors used to set the position of limits, within which the detection of objects and levels takes place.

linearity

The deviation from a best-fit straight line representing the slope of an analog output. Using the Model SM906 with 4 to 20 mA output as an example, the linearity is ± 0.10% of the span. If the span is 30", the linearity is a ± 0.03" deviation above or below the best-fit straight line representing the slope of the output.

linear output

Characteristic of analog ultrasonic sensors such as the SM506, SM606, SM906, and VM Virtu, the output has a "straight-line" relationship to the sensing distance between the near and far sensing limits.

line transients

Voltage or current fluctuations on power conductors or input/output conductors. The transients are usually caused by noisy electrical equipment such as frequency-modulated motor drives or electro-mechanical relays. The noise may be conducted into the wires or induced magnetically or capacitively.

load

A device through which current flows producing, a voltage drop across it.

load resistance

Resistance is the ratio of voltage to current flow, V/I, measured in Ohms. Load resistance is that resistance seen by current from an output. Most sensors have a limit on how small resistance can be, since small resistance leads to excessive current flow and possible damage. Sensors with a 4-20 mA output have a limit on how large the load resistance can be since the sensor may not have enough voltage to impress a current.

logic/actuation

The capability of the sensor to make decisions and control actuation. Hyde Park's Model SM500/600/900 and VM families of "smart" sensors have this capability.

loss of echo

Occurs when the sensor does not receive echoes from an object within its sensing range for more than one second. When this occurs, the sensor's output automatically holds, switches off, or goes to a predetermined state for that model. When the sensor again receives echoes from the object it will either switch or remain in the same state depending on where the echoes are received relative to the control limits. Some models allow one or several cycles to pass before indicating a loss of echo.

mA

Abbreviation for milliAmpere. 1/1000 of an Ampere.

microprocessor-based intelligence

Noteworthy advance in ultrasonic technology which has given ultrasonics such features as error compensation, power, amplification, and timing adjustments, and computer interface capability that open the door to new control applications. For Hyde Park ultrasonic "smart" sensors, it is the capability to "learn" their surroundings, ignore non-target objects in the sensing range, make decisions, and control actuation consistently, operation after operation.

MICROSONIC®

The registered trademark of the Hyde Park line of ultrasonic thru-beam sensors.

motion detection

Sensing for a slowdown or stopping of back-to-back containers on a conveyor line system due to either downstream machinery slowdown or stop conditions. Upon sensing a slowdown or stop in motion, the sensor can be used to automatically alert an operator or stop associated up-stream conveyors and machinery until the back-to-back containers begin moving again.

multiplexing

A design in which an electronic control circuit interrogates each sensor of an array in sequence. Different functions share the same hardware, usually each function having exclusive use for a limited, but recurring time.

near (high) limit

The boundary of the sensing "window" nearest to the sensor.

NEMA (National Electrical Manufacturers Association) Enclosure Standards

A set of guidelines established by NEMA to determine levels of physical protection that an enclosure, like a sensor housing, needs for various environments. Such a surrounding case is constructed to provide a degree of protection to personnel against incidental contact with the enclosed equipment during specified environmental conditions.

A brief description of the NEMA enclosure standard types used in the manufacture of Hyde Park ultrasonic sensors follows:

NEMA 1 intended for indoor use primarily to provide a degree of protection against contact with the enclosed equipment.

NEMA 3 intended for outdoor use primarily to provide a degree of protection against windblown dust, rain, sleet, and external ice formation.

NEMA 4 intended for indoor or outdoor use primarily to provide a degree of protection against windblown dust and rain, splashing water, and hose-directed water.

NEMA 4X intended for indoor or outdoor use primarily to provide a degree of protection against corrosion, windblown dust and rain, splashing water, and hose-directed water.

normally closed (N.C.)

For a relay output, this implies the two contacts are connected, with connection broken only when the "sensing event" occurs. Other outputs are similar: NPN output at ground floats when event occurs. PNP output at voltage floats when event occurs.

normally open (N.O.)

Similar to normally closed (N.C.) except "not" connected.

NORYL®

Optional to the user, the plastic material used in the housing (case) of Hyde Park sensors which has been approved for USDA-Dairy 3A Sanitary Standards. Hyde Park sensor housings made of NORYL® are gray to distinguish them from the blue ULTEM® housings.

NPN

A type of transistor which requires a positive power supply. NPN refers to the structure of a transistor, i.e., excess hole (P) "sandwiched" between two excess electron (N) materials. This transistor has the characteristic that current injected into the base (P) allows current flow from collector to emitter as long as the base voltage is about 1/2 V higher than the emitter. In practice, NPN outputs are used to connect loads to ground.

NPN current sinking output

The output of a DC device that switches ground (DC common) to a load. The load is connected between the output of the device and the positive side of the power supply. The switching component is usually an open collector NPN transistor, with its emitter tied to the negative side of the supply voltage.

object (target)

The material, liquid, solid, transparent, moving or static that is being detected by the sensor in a given application.

object sensing mode

One of two operational modes (the other is background) in which the Model

SM300, 500, 600, 900, and Virtu VM sensors operate as a universal, all-materials type proximity sensor. Sensing in this mode is done by first setting the window limits as shown in the illustration and ensuring that the object surface is properly positioned in-line and parallel with the sensor face. In this mode, the sensor accepts all ultrasonic pulse echoes received off objects that are either at or within the window limits shown in blue. All other echoes, excluding coincidental secondary echoes received off objects outside the window limits, are ignored.

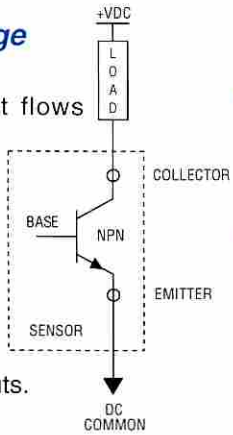
object surface area versus distance to sensor

See *Sensing Considerations* section on 2-21

off-delay time

Refers to the time delay between when the sensor stops sensing an object and when the output state switches inactive. The Hyde Park SUPERPROX ®Model series sensors provide both on- and off-delays.

off-state leakage current



The current that flows even when an output is off. For most transistors, this is in the µA range and is negligible. But solid state AC relays can allow µA to flow which sometimes causes problems with PLC inputs.

on-delay time

Refers to the time delay between when the sensor starts sensing an object and when the output state switches active. The Hyde Park SUPERPROX Model series sensors provide both on-and-off time delays.

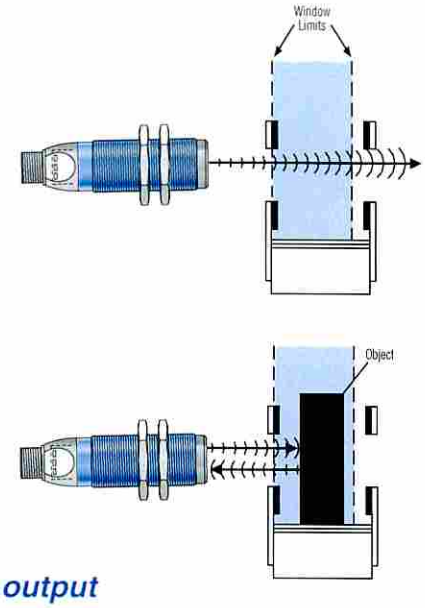
open collector

Open collector NPN describes a transistor output that sinks load current to common when the output is "on" (energized). When the output is "off", no current flows. A pull-up resistor or other type of load is usually provided by the user.

Open collector PNP describes a transistor output that sources current from the sensor supply when the output is "on". A pull-down resistor or other type of load is usually provided by the user.

oscillate

Change state in a regular, periodic fashion similar to, for example, a sine wave.



output

The useful power or signal delivered by a circuit or device.

output load range

The set of all values of impedance or resistance which can be connected to an output.

piezo

Literally, related to pressure. Used to refer to a material which exhibits the piezoelectric effect.

piezoelectric

The phenomenon of expansion along one axis when subjected to an electric field or production of an electric field when mechanically strained along an axis. Used to generate and sense ultrasound.

PNP

A type of transistor which sources current, PNP refers to the structure of a transistor, that is a thin layer of excess electron (N) semiconductor "sandwiched" between two layers of excess hole (P) semiconductor. This transistor has the characteristic that current injected into the base (N) allows current flow between the emitter and the collector (the two Players) as long as the base is about a 1/2 V lower than the emitter. In a sensor with a PNP output, this emitter is usually internally connected to the sensor power pin. In practice, PNP outputs are used to provide power to loads which are connected to ground. See the diagram under "PNP current sourcing output".

PNP current sourcing output

The output of a DC device that switches positive DC to a load. The load is connected between the output of the device and the ground (DC common) side of the power supply. The switching component is usually an open collector PNP transistor, with its emitter tied to the positive side of the supply voltage.

potentiometer

A variable resistor directly controlled by a dial, knob, or lever and used most commonly to produce a voltage proportional to a variable such as time delay, rate, etc. On the Hyde Park Model SM505 series motion sensor, the rate potentiometer sets the minimum threshold rate at which the sensor output switches either off or on, depending whether there is a decrease or an increase in the container motion rate. The "delay on" potentiometer on the same model series sets the minimum delay time before the output switches from off to on after container movement resumes at or above the setting of the rate potentiometer.

potting

Sealing by filling with a substance to exclude moisture. Hyde Park sensors are potted with an epoxy.

power/connection type

The second numerical digit in the Hyde Park sensor model number which indicates the AC or DC voltage range and the type of connection, connector, or cable style.

power consumption

The product of current and voltage(normally measured in watts) used by a device such as a Hyde Park sensor.

power supply

A device that provides the source of power (current and voltage). Regulated supplies are recommended for use with Hyde Park products.

proximity sensing

The technique used to determine whether an object has come close enough to a sensor to trigger an output. For Hyde Park sensors, it is the detection of object presence when the object is in front of the sensor and within the sensing range and sensing "window" of the sensor.

pull-up resistor

Load resistor connected between NPN open-collector (sinking) output and load voltage (usually supply voltage). This creates an output voltage. Lower values will help reduce electrical noise pick-up on the output cable.

pull-down resistor

Load resistor connected between PNP open-collector (sourcing) output and common. This creates an output voltage. Lower values will help reduce electrical noise pick-up on the output cable.

pulse

A current or voltage which changes abruptly from one value to another and then back to the original value in a finite length of time. It is used to describe one particular variation in a series of wave motions.

push-button configuration

The arrangement of push-buttons that are used to set up a Hyde Park ultrasonic sensor for a specific sensing application.

PVC

Polyvinyl Chloride, a popular plastic used extensively in sanitary plumbing, automotive, and household applications. Hyde Park's sensor cable is jacketed with PVC and meets FDA requirements for intermittent contact with food.

rate potentiometer

A potentiometer whose position is proportional to a speed. A sensor on a can line might trigger when the speed exceeds a certain value set by the rate potentiometer.

reflector angle

The angle between the reflective surface of a target and the beam-axis of the sensor. The optimum angle for sensor performance is 90°.

remote type sensor

A sensor where the small piezo elements are far from the sensor. Hyde Park sensors with the remote sensing heads are typically used in extremely tight areas where it is impossible to mount and use a regular style sensor.

repeatability

Describes the error in reporting the position of an object (or the position of a window edge) as the object is removed to another location and then returned to exactly the same location.

resistance

In DC circuits, the opposition a material offers to current flow, measured in Ohms. In AC circuits, it is the real component of impedance, and may be higher than the value measured at DC. (Note that "real" is used in the mathematical sense of "not imaginary.")

resolution

The smallest change capable by an analog output. Resolution may appear in a specification in several ways: as inches of a set span or, depending upon the type of output, in volts or current of an analog output level. This specification does not indicate accuracy.

response potentiometer

A potentiometer whose setting is proportional to the delay and filtering applied to an output.

response time *(also called sensing rate or cycle time)*

In ultrasonic sensing, the elapsed time between the transmission of a pulse and the pulse echo reception. The response times for Hyde Park ultrasonic sensors vary from 0.5 milliseconds for the Model SM600 series to 200 milliseconds for the Model SM500 series. The faster the response time, the greater the sensor's capability of detecting a quickly changing object position and the shorter the sensing range. The Model SM606 analog sensor, with a response time of 0.5 ms, samples at the rate of 2,000 times every second within a fixed window of 1.5 to 2 inches from the sensor.

retroreflective

Energy which contacts an object and is reflected back toward the source.

reverse polarity

Interchanging the connections, usually power connections, so that what was connected to the higher voltage is now connected to the lower voltage.

RS-232

An ANSI standard for serial communication which defines voltages, signals, and connections. The most common "standard," iIt is used on most personal computers and is simple to implement. A Hyde Park sensor with the RS-232 feature means that the sensor can communicate with a terminal, laptop, or desktop computer.

sensing limits

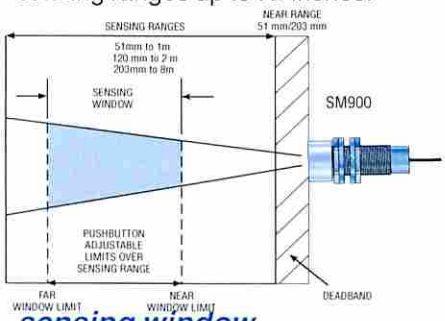
The boundaries, near and far, high level and low level, that define the sensing window. See "sensing window".

sensing mode

The arrangement of the Hyde Park sensors, through a simple dip switch, or microprocessor configuration,to function or operate in a particular manner. (See *object sensing mode* on 2-16 and *background sensing mode* on 2-12.)

sensing range

The total possible sensing capability of the sensor, beginning after the deadband, and extending out as far as the sensor is able to reach effectively. Hyde Park SUPERPROX® sensors have sensing ranges up to 315 inches. Hyde Park MICROSONIC® thru-beam sensors have sensing ranges up to 72 inches.



sensing window

The area of space in front of the sensor within which the object detection takes place. This space is defined two-dimensionally by two limits, near and far or high and low. Suitable objects that are present at or within these limits, and reflect sound energy back to the receiver, will cause the sensor's output to change (shortest and longest elapsed time for valid echo returns). Windows are fixed in standard SM300/600 sensors and adjustable in SM500/SM900, VM Virtu, and certain SM600 models.

sensor angle *(with respect to a smooth, flat surface)*

The angle created by the beam axis and its perpendicular, the latter represented by a smooth flat surface of an object. Hyde Park specifications call for this angle to be 90° ± 10°. If the flat-object surface is severely tilted away from the perpendicular of the beam axis, the echo is deflected away from the sensor, preventing the object from being detected.

sensor functionality

Refers to what the user wants the sensor to do. The five recognized functions are: presence/absence, positioning, inspection, condition measurement, or identification.

serial communications

A method of passing information sequentially, one bit at a time.

shape of the object

See *Sensing Considerations* section on 2-21.

shield

A conductive envelope around the primary conductors that provide an electronic barrier to electromagnetic interference. All Hyde Park sensors are shielded to limit the amount of RF energy emitted by the sensor, a requirement for CE approval. They are also shielded to prevent unwanted external noise from affecting sensor operation.

shielded cable

A cable that is protected against electrical and magnetic noise pickup. Cable may be shielded by a variety of methods and materials. Aluminum foil is most common but is less effective at lower frequencies than the braid-type of shield.

silicone rubber

An elastomer that is resistant to all food products and many chemicals found in industry. Many of Hyde Park's sensors use it as an ultrasonic coupling material (see "coupler" on 2-13). It's pliable yet damage-resistant nature makes it ideal for coupling ultrasonic energy to the air.

single file conveyor sensing mode

The setup configuration of a Hyde Park SUPERPROX® Model SM505/SM955 motion sensor to detect the movement of containers on single file conveyors.

sinking

Current flows into the connection. NPN transistors are usually current sinking outputs.

"smart" sensor

A sensor that uses the information or data it has detected and, through its microprocessor, actuates a specific outcome in a specific application setting. For example, Hyde Park's "smart" sensors use a discriminating microprocessor and push-button setup program to detect only the designated object within the sensing window while ignoring other foreground, lateral, and background objects. Another example is the Hyde Park dual-level sensor that detects the level at which a pump is to be turned on or off and outputs a signal causing the pump to turn either on or off. The same sensor can be configured to sound an alarm at a specific level.

sonic frequency

Frequency of the acoustic wave expressed in thousands of cycles-per-second (kHz). Generally, higher frequencies have higher attenuation rates in air. Ex:

SM900-8 m	75 kHz
SM100/700	180 kHz
SM500/900-1,2 m	200 kHz
VM Virtu	300 kHz
SM400/600/800	500 kHz

sourcing

Current flows out of the connection. PNP transistors are usually current sourcing outputs.

span

The distance between the set sensing limits (near and far) of a sensor with an analog output (e.g., Model SM506, SM606, SM906, and VM Virtu analog series.

step response

Refers to the time it takes a sensor output to respond to an instantaneous change in object position.

SUPERPROX®

The registered trademark of the Hyde Park line of ultrasonic proximity sensors.

Surface-to-beam angle

See *Sensing Considerations* section on 2-21.

surface reflection properties

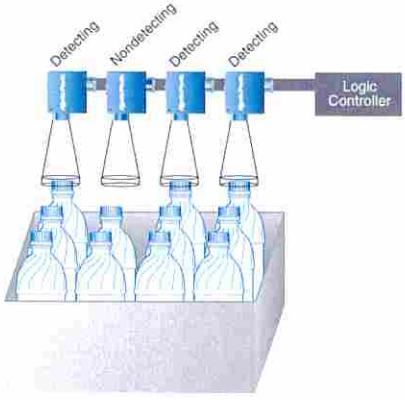
See *Sensing Considerations* section on 2-21.

switching rate

The frequency of a binary signal.

synchronized sensing

Coordinating the sampling time of one sensor to other events. It is frequently used with multiple sensors to eliminate interference occurring according to a common schedule. An example of synchronized sensing is the use of an array of SUPERPROX® Model SM504 series sensors to detect a full-case condition.



temperature

See *Sensing Considerations* section on 2-21.

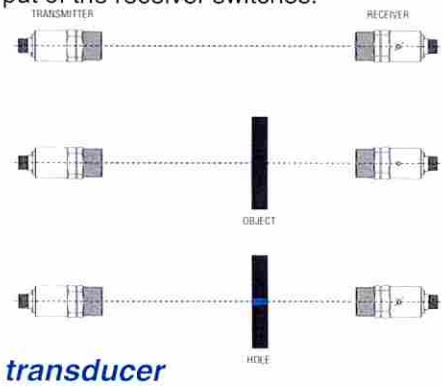
temperature dependence

A specification that indicates the amount of apparent position drift with respect to temperature drift. For example, if the span is set to 20" and the temperature drifts 8°C, then the sensor's output will drift and the apparent object position will shift by 0.0096" (0.006% of span/ °C or 0.00006 x 20" x 8). The Model SM5X6, SM6X6, 9X6, and VM Virtu analog sensor series have a temperature sensor embedded in the housing which compensates for changes in ambient temperature.

thru-beam (or break-beam) sensing

A sensing technique in which the object to be detected passes between an aligned transmitter and the receiver. The Hyde Park MICROSONIC® sensors, used in this technique, are defined as continuous-wave devices in which the transmitter emits a continuous ultrasonic beam which is picked up by the receiver. When an object passes between the transmitter and receiver and breaks the beam, object presence is detected and the output of the receiver switches.

Also, when a hole allows the beam to pass through to the receiver, the output of the receiver switches.



transducer

A device used to convert one form of energy into another form of energy. The transducer in the Hyde Park SUPERPROX® sensors converts electrical energy into transmitted sound energy and then, through its receiver, converts the reflected sound energy (echo) into electrical energy. The MICROSONIC® sensor transmitters convert electrical energy into sound energy and the receivers convert sound energy into electrical energy.

TRIAC

A solid state device used to switch AC currents. The SM52X, SM57X, and PM100 Python have an AC switch output.

Turbulence

Motion of air which rapidly fluctuates in direction and velocity (with reference to sensing, the unstable condition of the air in and around the sensing application). This condition can cause dispersion and deflection of the transmitted sound energy. The maximum sensing range is reduced by the weakened or diverted energy due to this condition and thus should be tested prior to operation.

ULTEM®

A trademark for a high temperature, high strength plastic (polyetherimide) manufactured by the General Electric Company and used in the housings of Hyde Park ultrasonic sensors.

ultrasonic operating principle

Ultrasonic sensors have an acoustic transducer which is vibrating at ultrasonic frequencies. The pulses are emitted in a cone-shaped beam and aimed at a target object. Pulses reflected by the target to the sensor are detected as echoes. The device measures the time delay between each emitted and echo pulse to accurately determine the sensor-to- target distance. The Hyde Park SUPERPROX® sensor determines this distance by measuring the elapsed time between the transmission of a pulse and the pulse echo reception. The transmitted pulse begins a time clock; the first returned pulse echo stops the clock.

Given the elapsed time, the sensor software calculates the distance traveled by the pulse from the sensor to the object, using the formula, D = TVs/2, where D = distance from the sensor to the object; T = elapsed time between transmission and reception of an energy pulse; and Vs = velocity of sound .... approximately 1100 feet per second. During operation, the calculated distance (D) between the sensor and the object is compared to the distance associated with the sensing window limits (see definition on 2-19). If D is at or within these limits, an output is generated. The output remains on until the echo either does not return or it returns from outside the window limits at which time it switches off.

ultrasonic sound

Pressure waves with a frequency that is above the range of human hearing, or above approximately 20,000 cycles per second (20 kHz). Ultrasonic technology uses electrical energy and a ceramic crystal (transducer) tuned to a specific frequency, to produce and to detect mechanical energy in the form of waves of energy. Hyde Park ultrasonic sensors use a piezoelectric-type crystal that is tuned to a specific, optimum frequency for the sensor model series:

- **75 kHz** for the Model SM900-8m series
- **180 kHz** for the Model SM100 / 700 series and Virtu VM30 / 80 series
- **200 kHz** for the Model SM500/900-1, 2 m series, and Model SM800 24-40" range thru-beam series
- **300 KHz** for VM1 and VM18 series
- **500 kHz** for the Model SM300 / SM600 proximity series and Model SM800 4-12 range thru-beam series

VAC

Voltage, alternating current

volt (v)

A unit of electrical pressure. One volt is the electrical pressure that will cause one Ampere of current to flow through one Ohm of resistance.

voltage

Electrical potential or electromotive force expressed in volts.

warranty

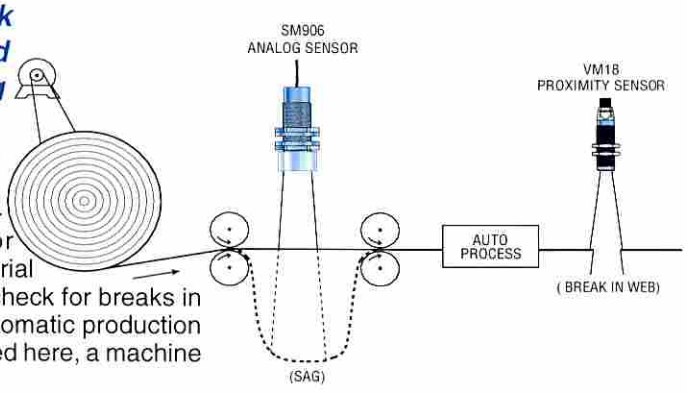
An assurance by the seller of property that the goods or property are as represented or will be as promised. See Hyde Park's Warranty information in the Warranty section of this catalog.

watt

A unit of electrical power. One watt is equivalent to the power represented by one Ampere of current with a pressure of one volt in a DC circuit.

Web break detection and material sag control

In this application, the manufacturer must constantly monitor and control material sag, as well as check for breaks in a web. In the automatic production process illustrated here, a machine draws material from the roll, processes it, then transfers it to the next stage. In the event of a process slowdown or machine jam, the material between the rollers will sag. Model SM506, 606, 906, and VM analog sensors with analog output detect the change in sheet-to-sensor distance and provide a linear and proportional output in mA or VDC. The output of the sensor instructs the variable speed drive controlling the feed roll to slow down. The SM500 proximity sensor monitors material as it exits the process, and detects breakage. When a break occurs, the process must stop and the roller be refed. By locating the sensor at the outlet side, a break can be stopped before the rollers downstream run themselves empty and have to be refed.



window

See *sensing window* on 2-18.

window-edge accuracy

Dimensional point of repeatability to detect an object at either near or far sensing window limit set points.