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Bulletin No. PRA2-B
Drawing No. LP0540
Released 7/07

MODEL PRA2 - PULSE RATE TO ANALOG CONVERTER

- *DELIVERS ANALOG OUTPUT PROPORTIONAL TO INPUT PULSE-RATE (Frequency)*
- *ACCEPTS VARIABLE PULSE-RATE INPUTS FROM A WIDE VARIETY OF SENSORS*
- *DUAL SIGNAL OUTPUT, 0 to 10 VDC PLUS SELECTABLE SIGNAL CURRENT OUTPUT OF 0 to 1 mA OR 4 to 20 mA*
- *SELECTABLE FREQUENCY RANGE RATINGS FROM 30 Hz to 10 KHz*
- *ACCURACY (Linearity) 0.25%*
- *SWITCH SELECTABLE FOR 115 OR 230 VAC*

DESCRIPTION

The Model PRA2 is a convenient plug-in module that provides voltage and current analog output signals proportional to the pulse-rate *(frequency)* of the input signal. In typical applications the PRA2 input is supplied by a machine mounted sensor that generates a signal which has a frequency proportional to machine or process speed. The PRA2 converts the frequency content of this signal to analog form for operating chart recorders, supplying speed control signals, or driving other controls and indicators that require analog input.

The PRA2 develops an internal *"constant-area"* pulse from the *negative going* edge of each input pulse or wave form cycle. These *"Constant-area"* pulses are fixed in voltage amplitude and time duration. The PRA2 then takes the average of a train of these pulses to generate an output voltage level proportional to the frequency. Another circuit within the PRA2 monitors the voltage output and produces a current output signal that will deliver either 0 to 1 or 4 to 20 mA, as determined by a set-up switch.

This unit is available with five overlapping adjustable range ratings, each rating providing a calibration adjustment to deliver maximum output over an input frequency range of approximately 3.3:1. Since the PRA2 develops an output by averaging pulses, an inherent response time is involved *(See response table, next page)*. The minimum response time is fixed for each range rating. It is longest for the lowest range rating and decreases as the frequency range rating increases. Response time must be considered, when using the PRA2 to provide closed-loop speed feedback signals, to avoid stability problems. For speed feedback applications it is usually advisable to select a high frequency range coupled with an appropriate sensor arrangement that delivers a high pulse rate.

The internal output filtering supplied for averaging purposes is kept to a minimum to provide the fastest practical response time for each range rating. Extra external capacitance can be added to provide more filtering if required.

The plug-in module mates with a heavy duty, CSA approved base mounting socket with pressure clamp screw terminals that accept stripped wires without lugs.

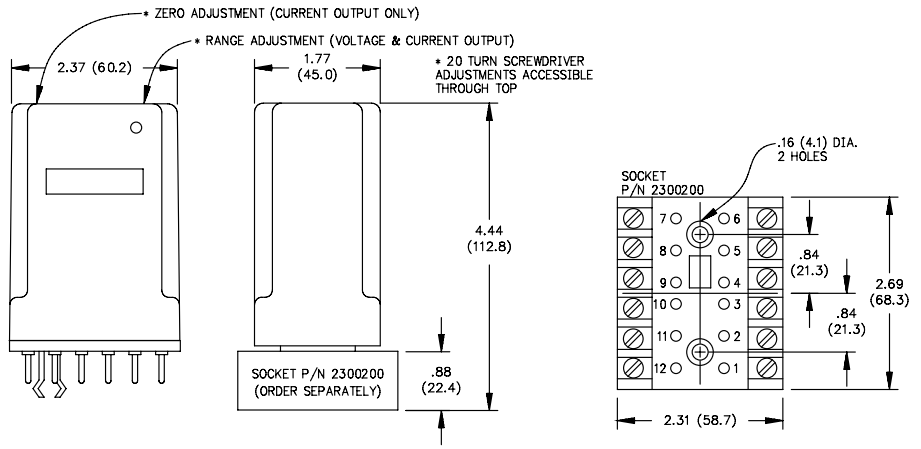
SPECIFICATIONS

1. **PRIMARY SUPPLY VOLTAGE:** Switch selectable for 115 or 230 VAC ±10%, 50/60 Hz; 8 VA
2. **SENSOR OUTPUT POWER:** +12 VDC ±5% regulated, 60 mA max.
3. **SIGNAL INPUT CHARACTERISTICS:** See *"Input & Output Switch Set-up"* section.
4. **MAX. FREQUENCY ADJUSTMENT:** 30 Hz to 10 KHz
5. **SIGNAL VOLTAGE OUTPUT:** 0 to 10 VDC @ 10 mA max.
6. **SIGNAL CURRENT OUTPUT (Selectable):**
   0 to 1 mA into load resistance range 0 to 4 KΩ.
   4 to 20 mA into load resistance range 0 to 250 Ω.
7. **LINEARITY:** ±0.25% of full range setting.
8. **VOLTAGE/CURRENT OUTPUT TRACKING:** Current Signals follow voltage signals within ±3% of full range setting.
9. **RESPONSE TIME:** See table on next page.
10. **OPERATING TEMPERATURE RANGE:** 0 to 60°C.
    Note: If using a primary supply voltage of 123 - 127 VAC, 50 Hz - derate operating temperature to 40°C
11. **WEIGHT:** PRA2 - 8 oz *(226.8 g);* Mating 12-Pin Socket - 2 oz *(56.7 g).*

ORDERING INFORMATION

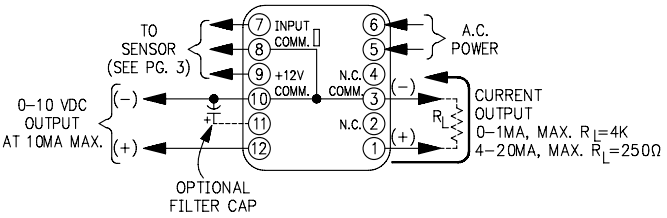
MODEL NO.	DESCRIPTION	PART NUMBERS
PRA2	Pulse Rate to Analog Converter	PRA20000
—	Socket, 12-Pin	2300200

DIMENSIONS In inches (mm)



APPLICATION CONSIDERATIONS

CONNECTIONS & SET-UP ADJUSTMENTS



VOLTAGE OUTPUT ADJUSTMENT:

Only the RANGE ADJUSTMENT is effective when voltage output is used. *(Zero Adjustment affects only current output.)*

PROCEDURE

1. Set AC power switch to proper position.
2. Connect voltmeter to Terminals 10 & 12.
3. Set the Range Switches for desired max. input frequency.
4. Apply the maximum input frequency and turn the *RANGE ADJUSTMENT to obtain the desired output voltage.

CURRENT OUTPUT ADJUSTMENTS:

When current output is used, the ZERO ADJUSTMENT must be set before RANGE ADJUSTMENT setting is attempted.

PROCEDURE

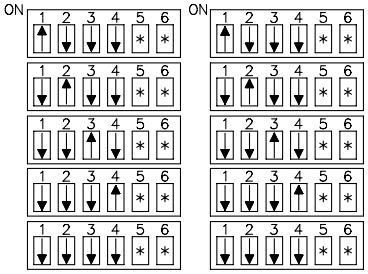
1. Set AC power switch to proper position.
2. Select current range with switch SW2-6 (OFF 0-1 mA / ON 4-20 mA) .
3. Connect a milliammeter in series with the current loop circuit from Term 1 to Term 3. CAUTION: DO **NOT** exceed maximum load resistance specified for the current range.
4. Set the Range Switches for desired max. input frequency.
5. Zero Adjustment:
   A) 0-1 mA Range - With input signal removed (zero frequency) turn ZERO ADJUST CW until positive current flow is indicated. Then, turn back CCW until the current flow just reaches zero. Stop turning the adjustment at that point.
   B) 4-20 mA Range - Set ZERO ADJUST until current is 4 mA.
6. *Range Adjustment: Apply maximum frequency input signal and set RANGE ADJUSTMENT to get desired output.

** RANGE ADJUSTMENT - Turning CW decreases output at a given frequency (increases range) and turning CCW increases output (decreases range).*

ADJUSTABLE RANGE RATINGS & OVER RANGE OPERATION

Frequency Range

RANGE	FULL SCALE ADJUSTMENT	SW1	SW2
1	30 Hz to 100 Hz		
2	100 Hz to 300 Hz		
3	300 Hz to 1 kHz		
4	1 kHz to 3 kHz		
5	3 kHz to 10 kHz		

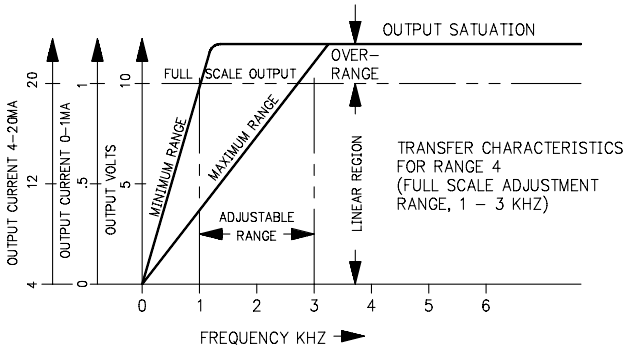


Frequency Curves

The Transfer Curve *(at right)* shows the frequency-input/voltage-output relationship for the PRA2, Range #4 for both Min. Range *(0-1 KHz)* and Max. Range *(0-3 KHz)* adjustment. These curves are typical and apply to all PRA2 ranges.

As shown by these curves, the PRA2 RANGE ADJUSTMENT allows the unit to be calibrated to deliver full scale output for any input frequency from the min. to max. range ratings. As long as the input frequency is equal-to or less-than the full-scale range setting, the PRA2 is operating in its linear region and the output voltage or current will be proportional to input frequency. If the input frequency exceeds the full-scale range setting *(over range)*, the output will flatten out and saturate at some level above 10 V at all higher frequencies.

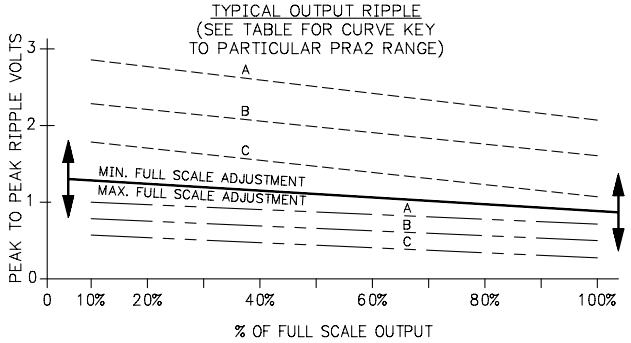
CAUTION: Maximum input frequency for PRA2 modules is 10 KHz. At input frequencies in excess of 10 KHz, the frequency roll-off characteristics of the input circuit will cause signal dropout and result in discontinuous operation.



OUTPUT RESPONSE & RIPPLE CHARACTERISTICS

PRA2 Modules are supplied with a minimum amount of output ripple filtering in order to avoid compromising response-time. The data presented below, permits a reasonable estimate of the amount of ripple and the response-time that will be experienced in a particular application. As shown by the curves below, the amount of output ripple depends on the range setting and the input frequency.

Ripple voltage can be reduced by adding external filter capacitance, but ripple-reduction is a trade-off against increased response times. This must be kept in mind, especially if the PRA2 is to be used to supply feedback control signals.



The values of capacitance given in the table are for reference only and do not imply a limit to the amount of capacitance that can be added. For example, an external filter capacitance may be 10 times the reference values shown for a very high degree of ripple reduction, provided that the resulting long response time is acceptable.

RANGE	FULL SCALE RANGE ADJUSTMENT		RESPONSE TIME	RIPPLE CURVE	EXT CAP (REF)
	MIN	MAX	[1]	[2]	[3]
1	30 Hz	100 Hz	250 msec	A	2.2 mfd
2	100 Hz	300 Hz	75 msec	A	0.56 mfd
3	0.3 KHz	1 KHz	25 msec	A	0.22 mfd
4	1 KHz	3 KHz	10 msec	B	0.1 mfd
5	3 KHz	10 KHz	8 msec	C	0.047 mfd

Note: If large capacitor values are required to achieve a high degree of ripple reduction, tantalum capacitors rated at 35 V or more are recommended. (Proper polarity must be observed. See Connection Drawing above.)

[1] RESPONSE TIME - Time required for the output to reach 90% of final value when the frequency is instantly changed from 0 to full-scale range frequency.
[2] See "Typical Output Ripple" Curves (at left).
[3] External Capacitance can be added between terminals 10 and 11 to decrease ripple. Reference values shown in MFD, will reduce ripple approximately 50% and will roughly double response times.

INPUT & OUTPUT SWITCH SET-UP

The Model PRA2 Pulse-Rate to Analog Converter uses the circuit shown on the right. The circuit uses a comparator amplifier connected as a Schmidt trigger circuit to convert the input wave form into the pulse form required for proper circuit operation. Three set-up switches are used to configure the input circuit to accept signals from a wide variety of sources, as follows:

SW1-5 - ON: Connects a 3.9 K pull-up resistor for sensors with current sinking output. (Maximum sensor current is 3 mA.)

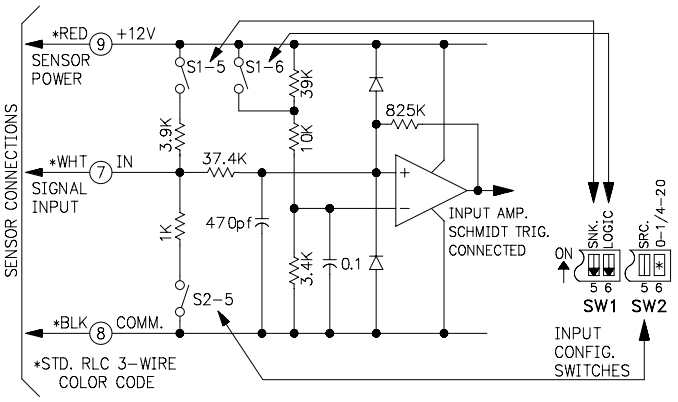
SW2-5 - ON: Connects a 1 K pull-down resistor for sensors with sourcing output. *(Maximum sensor output current is 12 mA @ 12 V output.)*

SW1-6 - ON: Sets bias of input to trigger at V_{IL} = 2.5 V, V_{IH} = 3.0 V; for logic level signals.

OFF: Sets the bias of input to trigger at V_{IL} = 0.25 V, V_{IH} = 0.75 V; for increased sensitivity when used with magnetic pickups.

SW2-6 - ON: 4-20 mA Output

OFF: 0-1 mA Output



OTHER CHARACTERISTICS & SPECIFICATIONS

Maximum Operating Frequency: 10 KHz with minimum pulse width ON and OFF times of 50 µsec.

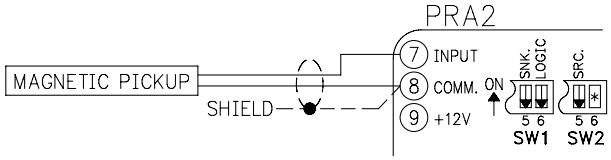
Maximum Input Voltage: Pin 7 *(Input)* may be driven from an external voltage up to ±90V provided SW2-5 and SW1-5 are "OFF" to disconnect internal load resistors. *(Maximum Input Voltage with SW2-5 "ON" is ±24 V)*

Input Impedance: With SW2-5 and SW1-5 "OFF", the resistive input impedance exceeds 1 Megohm, as long as Pin 7 voltage is greater than zero and less than +12 V.

Paralleling With a Counter and/or Rate Indicator Inputs: The PRA2 can be operated from a common sensor with current sinking output that is also used to drive the input of a Counter or Rate Indicator. Connect Pin 8 to the Common Terminal and Pin 7 to the Input Terminal of the Counter or Rate Indicator; set SW2-5 and SW1-5 "OFF" and SW1-6 "ON". DO NOT PARALLEL CONNECT THE +12V OUTPUT (Pin 9) OF PRA2 UNITS WITH THE +12V OUTPUTS OF COUNTERS, DITAKS, OR OTHER PRS1,PRA1, or PRA2 UNITS. These units have regulated supplies that will not load-share. Multiple inputs cannot be operated from sensing switches, 2-wire proximity sensors, or magnetic pickups.

CONNECTIONS & CONFIGURATION SWITCH SET-UP FOR VARIOUS SENSOR OUTPUTS

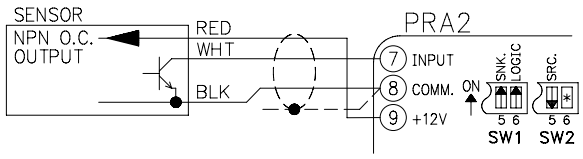
MAGNETIC PICKUPS



RECOMMENDED RULES FOR MAGNETIC PICKUP CONNECTIONS

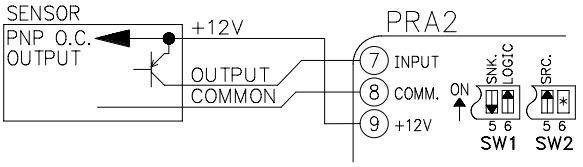
1. *Mount the PRA2 in a relatively "noise-free" environment, away from motor starters, control relays, or other sources of electrical interference.*
2. *Use 2-wire shielded cable for magnetic pickup signal leads.*
3. *Never run signal cable in conduit, troughs, or cable bundles with power carrying conductors.*
4. *Connect the shield to the common Terminal "8" at the input of the PRA2. DO NOT connect the shield at the pickup end, leave it "open" and insulate the exposed shield to prevent electrical contact with the frame or case. (Shielded cable, supplied on some RLC magnetic pickups, has open shield on pickup end.)*

SENSORS WITH CURRENT SINK OUTPUT (NPN O.C.)

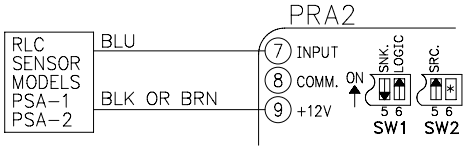


RLC SENSOR MODELS:
ASTC, LMPC, PSAC, LSC, RPGC, RPGB, RPGH, RPGQ, HESS, etc.

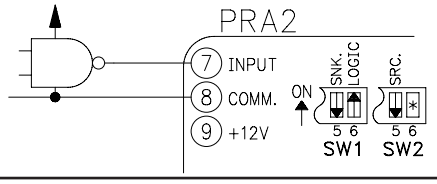
SENSORS WITH CURRENT SOURCE OUTPUT (PNP O.C.)



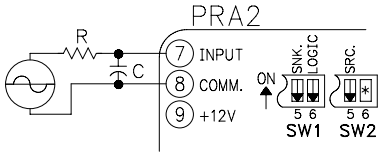
2-WIRE PROXIMITY SENSORS



INPUT FROM CMOS OR TTL



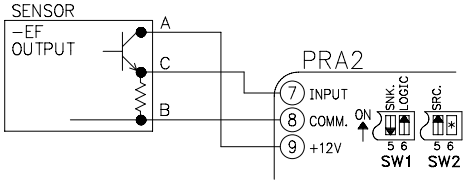
A.C. INPUTS FROM INVERTERS, A.C. TACHOMETERS GENERATORS, ETC.



R - Resistor to limit input current to 5 mA peak
C - Filter cap required when input A.C. has "ringing" characteristics as with inverters.

A.C. Power sources exceeding 50 V output should be coupled with an isolation transformer.

OLDER STYLE RLC SENSORS WITH -EF OUTPUT



RLC SENSOR MODEL: LMPEC

SENSOR & FREQUENCY RANGE SELECTION

The PRA2 Pulse-Rate to Analog Converter normally operates from a variable frequency signal supplied by a machine mounted sensor. The sensor signal varies in frequency in direct proportion to machine speed, and may be a sinusoidal, triangular, square, or pulse-type waveform. The sensor arrangement can take a variety of forms such as a Magnetic Pickup or Proximity Sensor detecting passing teeth on a sprocket or gear, a Photo-Electric Scanner viewing passing pulley spokes, a Rotary Pulse Generator coupled to a machine shaft, or a Length Sensor driven by a web or ribbon of material passing through the machine. (See Sensor Section of the catalog for more information on sensors.)

Since the PRA2 operates from the frequency content of the incoming signal, the response time of this device is also related to the signal frequency. This gives rise to the cardinal rule of selecting a sensor arrangement:

WHEN RESPONSE TIME IS IMPORTANT, SELECT A SENSOR ARRANGEMENT & LOCATION THAT WILL PROVIDE A HIGH FREQUENCY OUTPUT AT OPERATING SPEED.

When a PRA2 application is first contemplated, it seems to be natural to think in terms of applying the sensor to the low speed end of the power drive train. In some cases this may be the only practical location for the sensor, and if fast response is needed from the PRA2, a sensor arrangement capable of delivering a high number of cycles or pulses/revolution *(PPR)* will be required. In a great number of applications however, generating a higher frequency sensor signal is simply a matter of locating the sensor on a intermediate or high speed shaft such as directly on the drive motor shaft.

Another advantage of moving the sensor location up toward the high speed end of the drive train is that the shaft rotary motion is usually much smoother and more regular. Slow speed shafts will often rotate irregularly due to gear backlash, "slop" in couplings, or slack in chain drives.

SELECTING AN APPROPRIATE SENSOR ARRANGEMENT

There are no exact rules governing the selection of a sensor arrangement since machine geometry and conditions can vary widely from one application to the next. However, the following generalized criteria will prove useful as guidelines toward selecting the best sensor arrangement. *(See Sensor Section of the catalog for more information.)*

ULTRA-LOW SHAFT SPEEDS (10RPM or less) - Proximity Sensors, Photo-Electric Scanners, or Rotary Pulse Generators, are usually the best selections. In most ultra-low speed applications, it is advisable to provide as many pulses per revolution as possible *(high PPR)* to get acceptable response times.

LOW-SHAFT SPEEDS (10-100RPM) - LMPC (Super-Sensitive Magnetic Pickup), Proximity Sensors, Photo-Electric Scanners and RPG's can usually be applied in this speed range.

INTERMEDIATE SHAFT SPEEDS (10-1000RPM) - Magnetic Pickups, the LMPC, RPG's and some Proximity Sensors are appropriate at these speeds.

HIGH-SHAFT SPEEDS (1000RPM and up) - Magnetic Pickups, the LMPC and RPG's are usually the best choices.

FOR LINEAR SPEEDS ON PAPER WEBS, TEXTILE, RIBBON, STRIP AND WIRE - The LSC Length Sensor may prove desirable.

CAUTION: When selecting a sensor for operation at any speed, make sure the sensor is also capable of delivering an output for the entire speed range up through maximum machine speed.

DETERMINING SENSOR FREQUENCY OUTPUT & SELECTING THE PROPER FREQUENCY RANGE

Machine speeds are normally expressed in revolutions/minute *(RPM)* while the PRA2 has adjustable frequency ranges in cycles/second or Hz. In addition, sensor arrangements usually deliver a number of signal cycles or pulses for each shaft revolution. The following formula provides a convenient way to relate these variables:

$$\text{FRQ (CPS or Hz)} = \frac{\text{RPM x PPR}}{60}$$

WHERE:

RPM is the speed of the shaft where the sensor is located in revolutions per minute.

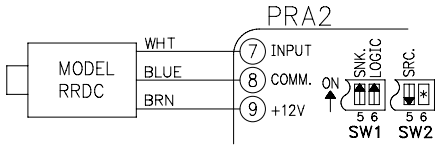
PPR is the number of pulses (or cycles) produced by the sensor for one shaft revolution.

EXAMPLE 1

A pulley with 6 spokes operates at 650 RPM maximum machine speed. The spokes are to be sensed with a Model RR Retro-Reflective Photo Sensor. The application requires a PRA2 to develop a 4-20 mA signal for a chart recorder *(20 mA output at max. speed)*. What is the frequency range to be used for the PRA2?

$$\text{FRQ @ max. speed} = \frac{\text{650 RPM x 6 PPR}}{60} = 65 \text{ Hz}$$

SELECT: Range 1 *(adjustable for max. output 30 to 100 Hz)*



EXAMPLE 2

The speed of a gravity-powered conveyor is restrained and controlled by a hydraulic brake *(pump)* which is coupled to a conveyor shaft. A PRA2 is to be used to supply a speed feed-back signal to the hydraulic control circuit, with 0-10 VDC corresponding to a speed range of 0-36 RPM on the conveyor shaft.

SOLUTION: Since the PRA2 is in the speed feed back control loop, fast response is important and a high PPR will be needed to minimize delay in output response. By using a 600 PPR Rotary Pulse Generator *(RPGB)* coupled by 3:1 speed-increasing instrument belt drive, the effective PPR of the conveyor shaft is 3 x 600 or 1800 PPR. The PRA2 input frequency then is:

$$\text{FRQ} = \frac{\text{36 RPM (max. speed) x 1800 PPR}}{60} = 1080 \text{ Hz}$$

SELECT: Range 4 *(adjustable for max. output, 1 to 3 KHz)*

Note: The smoothness of shaft motion can be a factor in this type of application. Direct coupling a high PPR Rotary Pulse Generator to a slow moving shaft that dithers or exhibits rotary oscillation can create false pulses reflected as an output that is erroneously high. A belt drive was chosen here to help dampen vibration effects. Adding some additional mass to the RPG shaft, such as a weighted drive pulley, will increase the inertia and dampen oscillation even further.

LIMITED WARRANTY

The Company warrants the products it manufactures against defects in materials and workmanship for a period limited to two years from the date of shipment, provided the products have been stored, handled, installed, and used under proper conditions. The Company's liability under this limited warranty shall extend only to the repair or replacement of a defective product, at The Company's option. The Company disclaims all liability for any affirmation, promise or representation with respect to the products.

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