# 4-20mA VIBRATION MONITORING

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# 4-20 mA: An Overview

## How Does It Work?


The 4-20 mA product generates a current signal which is scaled to the minimum and maximum amplitudes. An output of 4 mA represents zero vibration (no load) and an output of 20 mA represents the maximum vibration (full load).

It is important to understand that the 4-20 mA signal output is proportional to the overall amplitude generated within a defined frequency band. Therefore, the signal does not include data from frequencies outside the frequency band, and includes all vibration (critical faults and non-critical) within that band.

## Historical

The measurement of temperature, pressure, flow, and speed of our industrial processes has always used some form of instrumentation as an aid. An early and simple measurement of temperature was accomplished with a thermometer and recorded manually on paper indicating not only the temperature, but also the time it was taken. Circular charts, pneumatic meters, and strip chart recorders became a standard means for process measurements, and evolved into an early form of process control that included amplitude and time dependent data that could be trended or analyzed. The instruments of yesterday have given way to the modern control schemes of today like the PLC, DCS, and SCADA systems integrating multiple Vibration Sensor/Transmitters, inputs, and outputs in operations centers.

Today's modern systems offer flexibility in Vibration Sensor/Transmitter selection, and use standard 4-20 mA current loops for most applications. Process control provides a wide variety of monitoring options, time based trending, and control applications to keep machines performing efficiently and running at their required capabilities. 4-20 mA current loops are inherently low in noise and signals can be transmitted over long distances making an ideal combination for industrial applications. Vibration Sensor/Transmitter outputs are proportional to current, with 4 mA representing a zero level, and 20 mA representing a maximum level over a given range.

## Process Scaling

In some cases a broader than normal scale may be desired where a significant increase in vibration above normal can be tolerated before alarm or shutdown would be required.

For example, your application might operate normally at 0.30 in/sec (7.66 mm/sec) and varying loads might make higher overall levels a normal occurrence that would not merit an alarm. Instead, alarms and shutdown might not be desired until 1.80 in/sec (45.7 mm/sec).

Normal = 0.30 in/sec = 7.6 mm/sec = 6.40 mA

Shutdown = 1.80 in/sec = 45.7 mm/sec = 18.40 mA

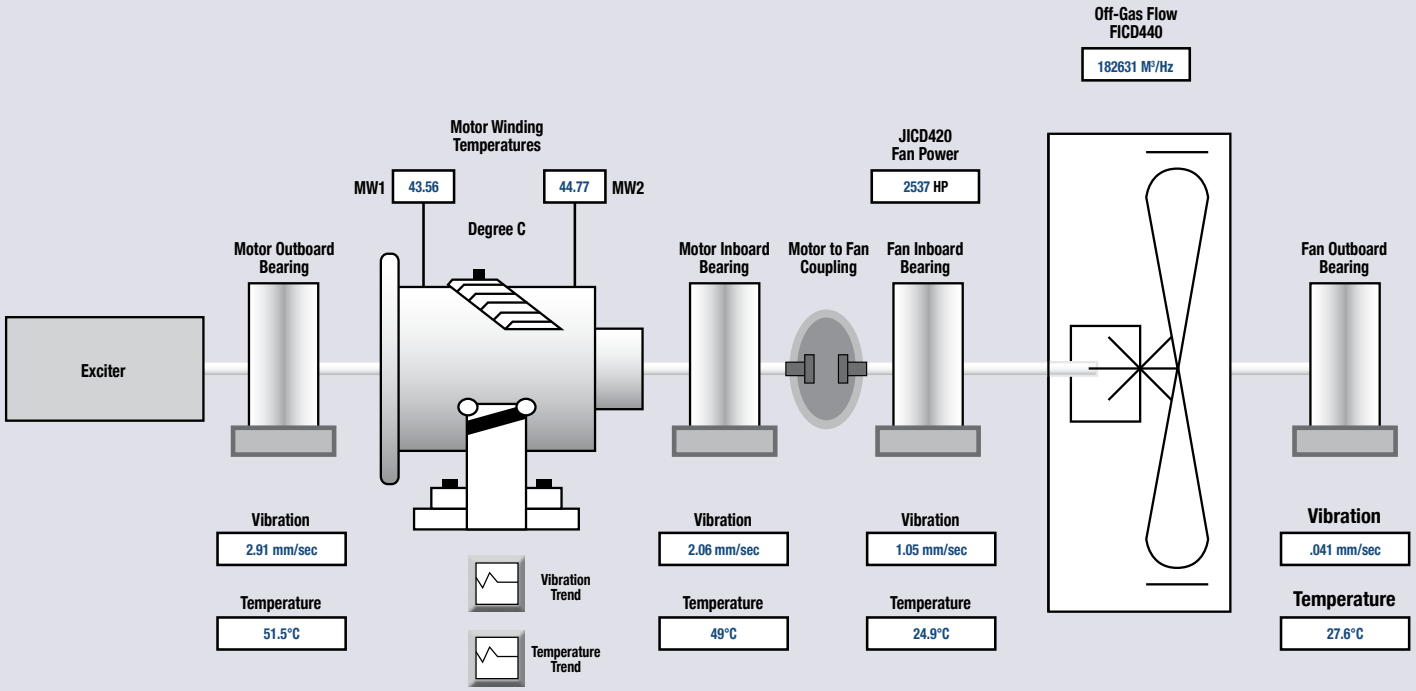
| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Input | in/sec | 0.00 | 0.25 | 0.50 | 0.75 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 |
| | mm/sec | 0.00 | 6.35 | 12.70 | 19.05 | 25.40 | 31.75 | 38.10 | 44.45 | 50.80 |
| Output | mA | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 |
| | | | Normal | | | | Alarm | | Shutdown | |

## Vibration Monitoring

The same 4-20 mA technology used to measure temperature, pressure, flow, and speed can also be extended to measure the overall vibration of rotating machines. Adding a Vibration Sensor/Transmitter to the machine provides a critical measure of the machines health, and can be used to identify changes in balance, alignment, gears, bearings, and many other potential faults that may not be currently detected. Monitoring machine vibrations can prevent undetected catastrophic failures from occurring, and at the same time require minimal human interaction to provide continuous machine protection.

There are multiple options to add vibration monitoring to an already familiar 4-20 mA interface connecting to the PLC, DCS, or SCADA systems.

### Example as Seen on DCS, PLC & SCADA Systems

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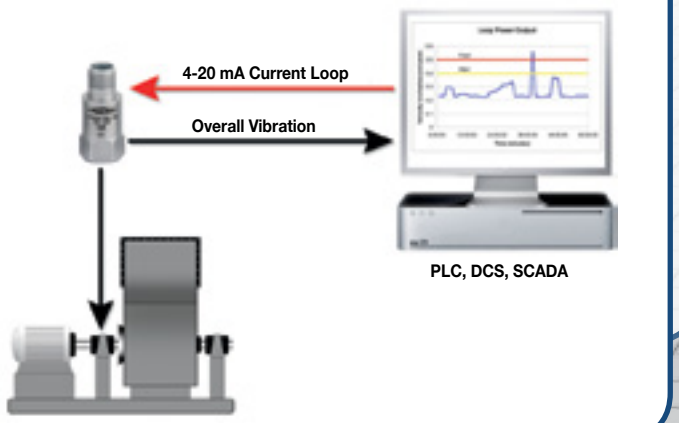
# Overall Vibration

## LP200 & LP300 Series

### Loop Power Sensors, 4-20 mA Output

- Peak & RMS outputs available
- 4-20 mA output proportional to velocity
- 4-20 mA output proportional to acceleration

A Loop Power Vibration Sensor/Transmitter like the LP200 Series (4-20 mA proportional to vibration measured in velocity) or LP300 Series (4-20 mA proportional to vibration measured in acceleration) can be mounted on the machine and added to the control loop. As the overall vibration of the machine changes, the 4-20 mA output will vary proportionally.

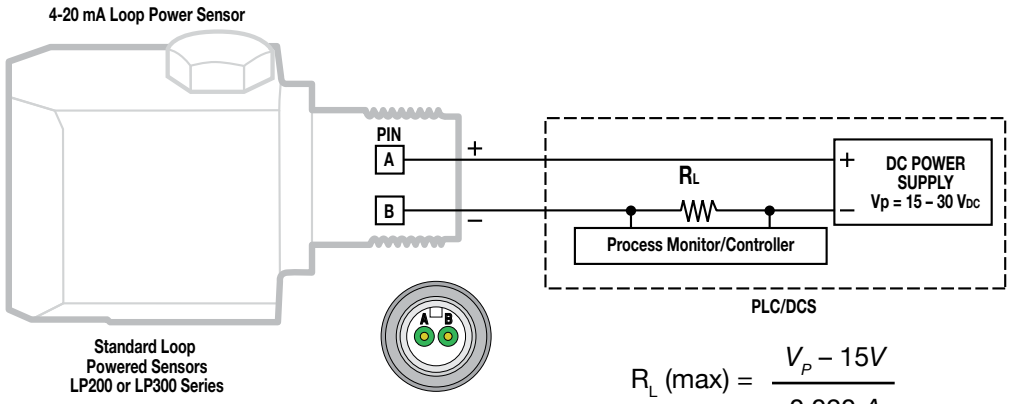




**Figure #1** – Loop Power Circuit (Two Wire Transmitter)

# Wiring 4 - 20 mA Loop Power Sensors

Relative to **Figure #1**, for a two wire Loop Power Sensor, the positive wire would be connected to Pin A, and the negative wire would be connected to Pin B. The measurement device ($R_L$) will be placed in series with the negative wire between the Loop Power Sensor and the negative terminal of the power supply. In this configuration, the Process Monitor or Controller can measure the 4-20 mA current flowing in the current loop.

In many cases, $R_L$ will be a 250Ω resistor. In this scenario, Ohm's Law ($E = IR$) will provide:

- a zero value of 1 VDC ($E = 0.004\ A \times 250\Omega$)
- a maximum value of 5 VDC ($E = 0.020\ A \times 250\Omega$)
- When $R_L = 250\Omega$, and Vp ≤ 24 VDC, then $R_L$ should be ½ watt
- When $R_L = 250\Omega$, and Vp > 24 VDC, but ≤ 30 VDC, then $R_L$ should be 1 watt

# Overall & Dynamic Vibration

## LP401, LP402 & LP404 Series

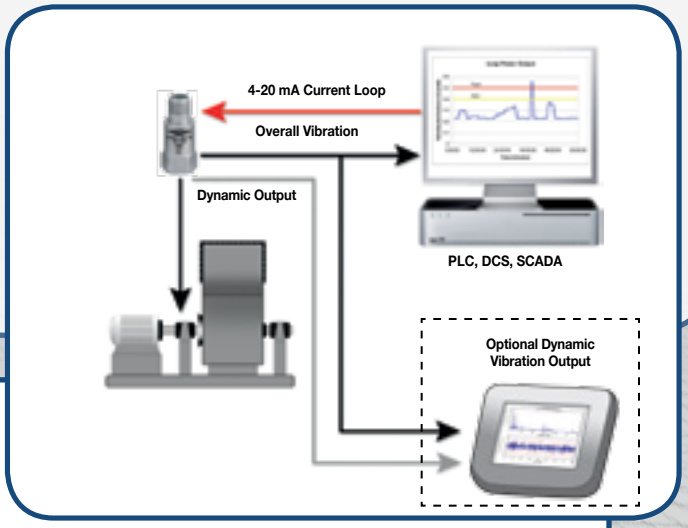
### Dual Output, Loop Power Sensors

- 4-20 mA Output & Dynamic Vibration Outputs
- Outputs to PLC, DCS, SCADA

Dual Output Loop Power Sensors also provide a secondary output of dynamic vibration. These secondary outputs could be acceleration or velocity and are combined in three different loop power sensor configurations:

1. LP401 Series – Overall Velocity (4-20 mA), and Dynamic Velocity (100 mV/in/sec)
2. LP402 Series – Overall Velocity (4-20 mA), and Dynamic Acceleration (100 mV/g)
3. LP404 Series – Overall Acceleration (4-20 mA), and Dynamic Acceleration (100 mV/g)

**Dual Output 4-20 mA Loop Power Sensors are a three wire technology where Pin A is the positive 4-20 mA power, Pin B is a shared common, and Pin C is a positive dynamic vibration.** Please reference **Figure #2**.



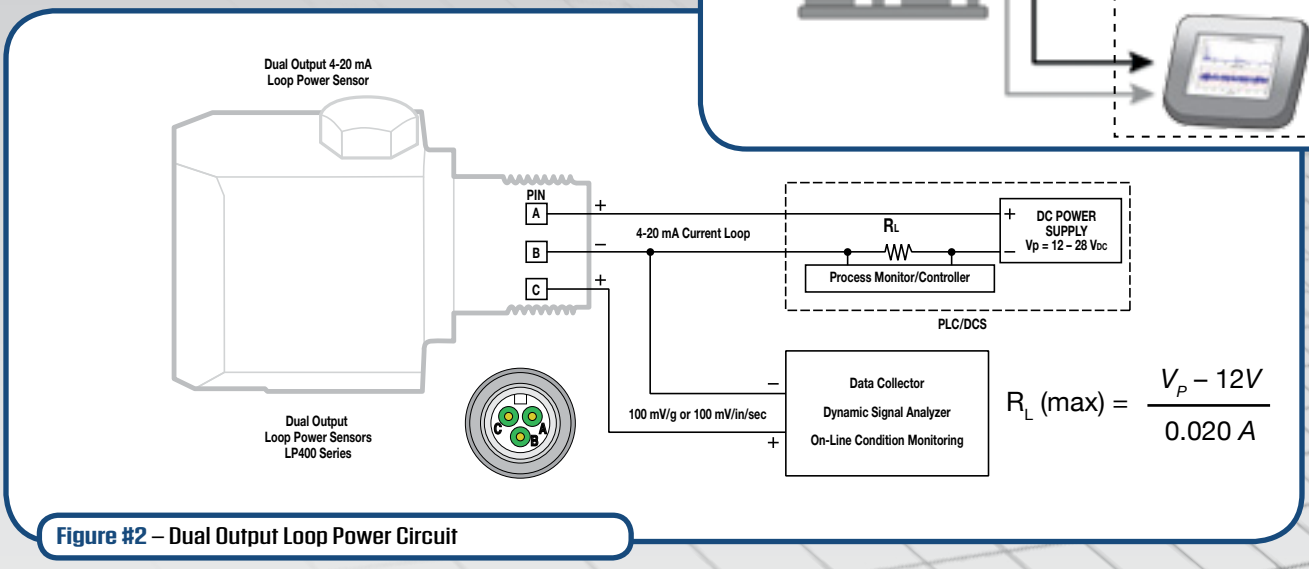




**Figure #2** – Dual Output Loop Power Circuit

# Wiring Dual Output 4 - 20 mA Loop Power Sensors

Relative to **Figure #2**, for a three wire Dual Output Loop Power Sensor, the positive 4-20 mA wire would be connected to Pin A, the negative wire would be a shared common connected to Pin B, and the positive Dynamic Vibration wire would be connected to Pin C. The 4-20 mA measurement device ($R_L$) will be placed in series with the negative wire between the Loop Power Sensor and the negative terminal of the power supply. In this configuration, the Process Monitor or Controller can measure the 4-20 mA current flowing in the current loop. The Data Collector, Dynamic Signal Analyzer, or On-line Condition Monitoring System will measure the Dynamic Vibration (100 mV/g or 100 mV/in/sec) across Pin C (+) and Pin B (-). **The 4-20 mA loop power provides all of the power for the sensor, including the Dynamic Vibration.**

# Overall Vibration and Temperature

## LP232, LP234, LP332 & LP334 Series

### Dual Output, Loop Power Sensors

- 4-20 mA Vibration Output
- **Temperature Output:** 10mV/°C (VDC)
- Outputs to PLC, DCS, SCADA

The Dual Output 4-20 mA Vibration and Temperature Sensor is available with an acceleration or velocity output in combination with a 10 mV/°C temperature output. Power is supplied by the 4-20 mA current loop. The overall vibration is proportional to 4-20 mA and can be used with a PLC, DCS, or SCADA for monitoring the vibration amplitude. The DC voltage output is proportional to temperature from -40°C (0.10 VDC) to +85°C (1.35 VDC) or -40°F (0.10 VDC) to + 185°F (1.35 VDC). This output can be trended in voltage to monitor the change in temperature of the machine. The temperature table displays the output in volts DC for the measurement range of the sensor.

| Temperature Output | | | |
|---|---|---|---|
| | 10 mV/°C | | 5.556 mV/°F |
| Degrees C | Output Volts DC | Degrees F | Output Volts DC |
| -40 | 0.10 | -40 | 0.1 |
| -30 | 0.20 | -20 | 0.21 |
| -20 | 0.30 | 0 | 0.32 |
| -10 | 0.40 | +20 | 0.43 |
| 0 | 0.50 | +40 | 0.54 |
| +10 | 0.60 | +60 | 0.66 |
| +20 | 0.70 | +80 | 0.77 |
| +30 | 0.80 | +100 | 0.88 |
| +40 | 0.90 | +120 | 0.99 |
| +50 | 1.00 | +140 | 1.10 |
| +60 | 1.10 | +160 | 1.21 |
| +70 | 1.20 | +180 | 1.32 |
| +80 | 1.30 | +185 | 1.35 |
| +85 | 1.35 | | |

An electrical wiring diagram **(Figure #3)** is shown below. The positive loop power would be connected to Pin A, the negative loop power would be connected to Pin B, and the temperature would be measured from Pin C (positive) to Pin B (negative).

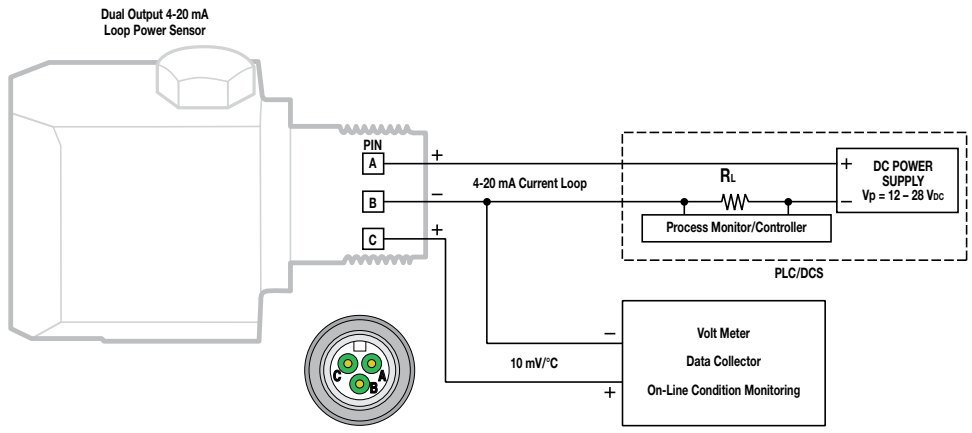
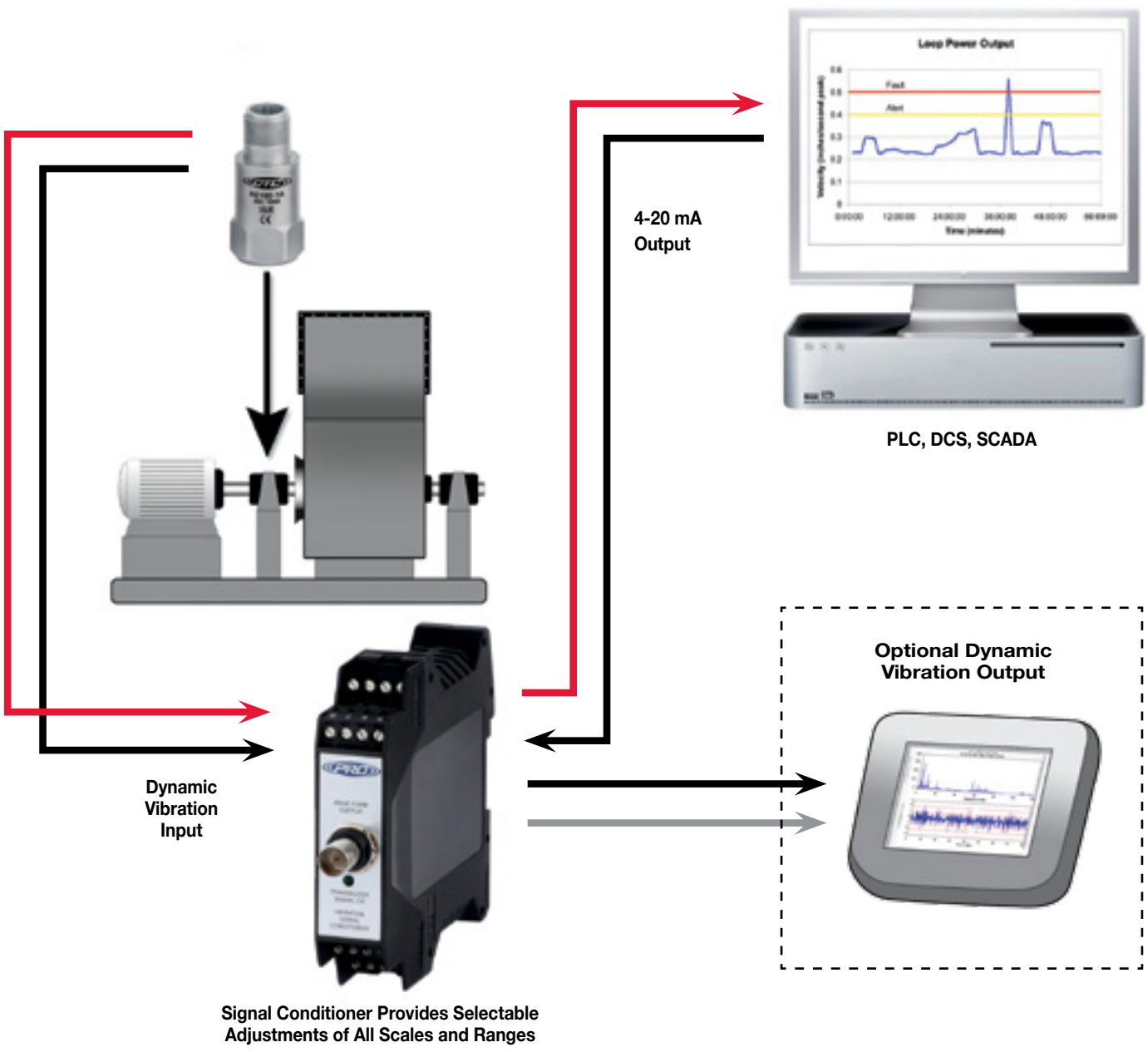


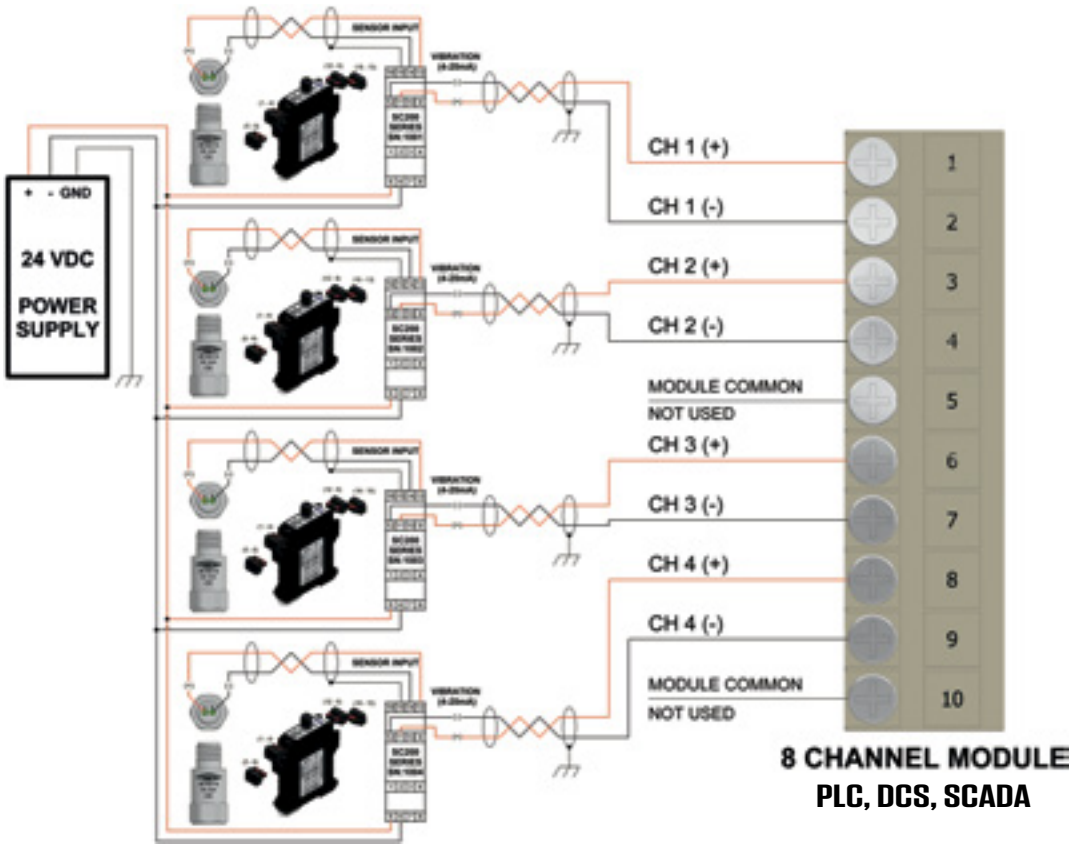

**Figure #3** – Dual Output Vibration/Temperature

# Signal Conditioner/Field Configurable

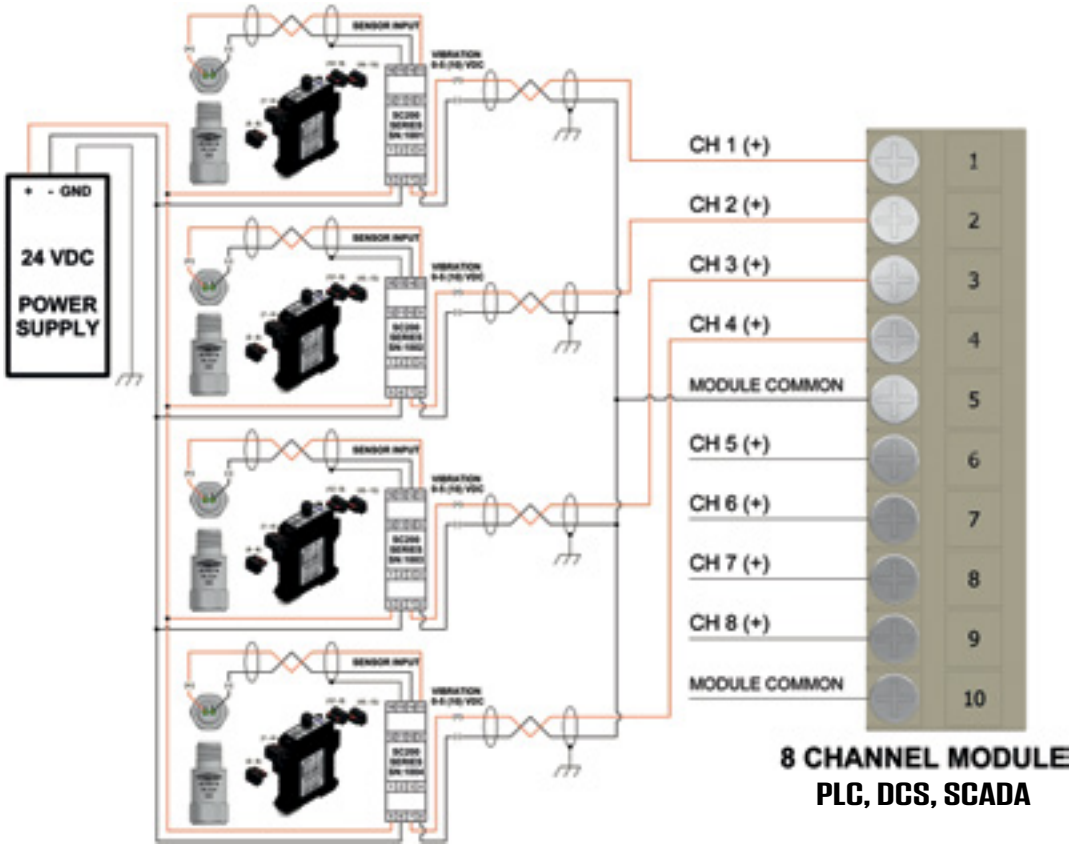
Signal Conditioners can also be used in conjunction with standard dynamic accelerometers, piezo velocity sensors, or displacement probes. The Signal Conditioner accepts the dynamic input and converts it to a proportional 4-20 mA output for the PLC, DCS or SCADA system. This type of application has many benefits. The Signal Conditioner can be adjusted in the field so that the scaling and filters match your application. The dynamic vibration signal is available from a standard BNC connection on the front of the Signal Conditioner, or as an optional output from the terminal block.



## 4 – 20 mA Current Output, Isolated Inputs




## 0 – 5 VDC or 0 – 10 VDC Output

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# Signal Conditioner – Configuration

The Signal Conditioner has a standard configuration, SC203-100A-002IR-010-01K-05, that uses a 100 mV/g acceleration input, has a full scale range of 0-2 inches/second rms., and is filtered from 10 Hz to 1000 Hz. Standard outputs are 4-20 mA and 0-5 VDC.

The Signal Conditioner can also be factory or field configured to meet the needs of almost any application. This allows for a wide range of applications and does not limit the settings after purchase. To assist with the configuration of the dip switches, there is an application at ***https://www.ctconline.com/_online_utilities.aspx***. As shown below, this application can be used to assist with the configuration of the signal conditioner in the field.

File View Control Help

## SC200 Series Selection Guide and Configuration Setting Generator

V 8.0

**Instructions:** Follow the steps below to generate the SC (Signal Conditioner) Part Number, click on a listed option

| | 1. Select Input Source | | 2. Select FSRV | 3. Select FSU | | 4. Select High Pass Filter | 5. Select Low Pass Filter | 6. Select Output | 7. Powered |
|---|---|---|---|---|---|---|---|---|---|
| SC20 | 7 | – 5 0 0 A | – 0 0 5 | G | R | – 0 1 0 | – 1 0 0 | – 0 5 | – |

| Configuration | Input Source | Full Scale Range Values | Full Scale Units | | High Pass Filter | Low Pass Filter | | Output | Power |
|---|---|---|---|---|---|---|---|---|---|
| 3 = ISO (Standard)* | Accelerometers | 0X5 = 0 - 0.5 | I = IPS | P = Peak | 002 = 2 Hz | 050 = 50 Hz | 01K = 1000 Hz | 4 - 20 mA with | On |
| 7 = Factory configured per part number | 500A = 500 mV/g | 001 = 0 - 1 | M = mm/s | R = RMS | 005 = 5 Hz | 070 = 70 Hz | 02K = 2000 Hz | 05 = 0 - 5V | |
| | 100A = 100 mV/g | 002 = 0 - 2 | G = g's | T = Peak - Peak | 010 = 10 Hz | 100 = 100 Hz | 05K = 5000 Hz | 10 = 0 - 10V | |
| | 050A = 50 mV/g | 005 = 0 - 5 | D = mils | | 020 = 20 Hz | 200 = 200 Hz | 10K = 10000 Hz | | |
| | 010A = 10 mV/g | 010 = 0 - 10 | | | 050 = 50 Hz | 500 = 500 Hz | 15K = 15000 Hz | | |
| | Velocity Sensors | 020 = 0 - 20 | | | 100 = 100 Hz | | 20K = 20000 Hz | | |
| | 100V = 100 mV/IPS | 050 = 0 - 50 | | | 200 = 200 Hz | | | | |
| | 500V = 500 mV/IPS | 100 = 0 - 100 | | | 500 = 500 Hz | | | | |
| | Displacement Sensors | 200 = 0 - 200 | | | 01K = 1000 Hz | | | | |
| | 200D = 200 mV/mil | | | | | | | | N = Off |

* Note there is only one ISO part number clicking on this option will reset the grid to ISO Standard

Click Here To Generate or Print Dip-switch Combination (Useful for documentation purposes)

ON

SW1 SW2 SW3

1 2 3 4 5 6 7 8

Enlarge Dips

CLEAR

# Signal Conditioner – Temperature

It should also be noted that the Signal Conditioner is compatible with the TA102, TA104, TA131, TA133, TA135, and TA184 series dual output vibration and temperature sensors. The Signal Conditioner in combination with any one of these sensors will provide one 4-20 mA output proportional to vibration, and a second 4-20 mA output proportional to temperature.

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## Dynamic Output For Analysis

### XE150 Series

**1-8 Channel Signal Conditioner Enclosure**

- Provides 4-20 mA Signals & Dynamic Output
- Link to PLC / DCS Systems
- Available in Fiberglass or Stainless Steel

**For use with accelerometers, piezo velocity sensors & proximity probes**

## Stand Alone Displays & Relays


### PMX1000 Series

**1-2 Channel Process Control Enclosure with Display & Relay OR Display Only**

- Relays Trigger Alarm or Shutdown
- Displays IPS, g's, mils or Custom Scale
- 4-20 mA Output

## Dynamic Output & Display with Relay


### MVR1000 Series

**Four Channel Compact Vibration Monitoring System**

- Dynamic External Links
- Sunlight Viewable Display
- SPDT (Form C) 2 relays each

**For use with accelerometers, piezo velocity sensors & proximity probes**

### RXE150 Series

**Multi-Channel Vibration Switch**

- PLC, DCS, SCADA Connectivity
- 24/7 Monitoring with Shutdown Alarm
- Field Configurable, Multi-Channel
- Dynamic Outputs for Vibration Analysis

Component system allows for the accelerometer to be installed at the optimum measurement point, while the signal conditioner, relay and display can be adjusted for your application.

**NOTE: Cooling is required if internal temperature of RXE enclosure exceeds 140°F (60°C)**

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## Stand Alone Displays & Relays

### VP Series

#### ViPR Vibration Protection & Relay System

- Sunlight Viewable Display of Vibration Levels: IPS, g's, mils or Customized Scale
- Protect Critical Equipment with Relays to Trigger Alarms or Shutdowns
- 4-20 mA Retransmission for use with PLC, DCS, or SCADA Systems
- Pre-Wired for Turnkey Solution – Just Wire Sensors and Output Into Easily Accessible Screw Terminals

**Protect critical machinery & processes from excessive vibration & catastrophic failure.**

The VP Series Protection & Relay System from PRO will display the vibration level from a signal conditioner or a loop power sensor, with the capability to trigger alarms and shutdown machinery based on the amplitude of the overall vibration within a selected frequency range. Dual output versions display both vibration and temperature.

## Hazardous Area: Sensors and Signal Conditioners

The PRO Line offers a range of options for companies that require 4-20 mA solutions to protect against excessive vibration in explosive environments.

Our Sensors and Signal Conditioners have been certified by a variety of regulatory agencies so that you can protect your company's critical machinery application while ensuring plant safety almost anywhere in the world.

### CANADA & US:

Class I, Division 1 - Intrinsically Safe
Class I, Division 2 - Non-Arcing, Non-Sparking

### EUROPE:

Zone 0 - Intrinsically Safe
Zone 2 - Non-Arcing, Non-Sparking

### INTERNATIONALLY RECOGNIZED

**IECEx** Zone 0 - Intrinsically Safe


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A CTC DIVISION

PROTECTION & RELIABILITY INSTRUMENTS

# Lifetime Warranty on Materials & Workmanship

***PRO will repair or replace any of our products under warranty so long as the product was not subjected to misuse, neglect, natural disasters, improper installation or modification which caused the defect.***

***Authorized Distributor:***

MKT10167 rev E

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