

Combining Motion and Analog Measurements

Yokogawa Test & Measurement
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Moving parts have always required engineering expertise to make sure they perform reliably despite the shocks, vibrations, friction, and wear and tear of everyday life.

A high vibration amplitude might indicate a misaligned drive component or an unbalanced wheel in a vehicle. In this application note, we walk through integrating motor feedback encoder sensors with vibration channels in the Yokogawa ScopeCorder series of devices. The linear speed will be measured along with the vibration measured by an accelerometer. This is a common combination of sensor inputs, giving rise to the engineering adage “if it rotates, it vibrates.”

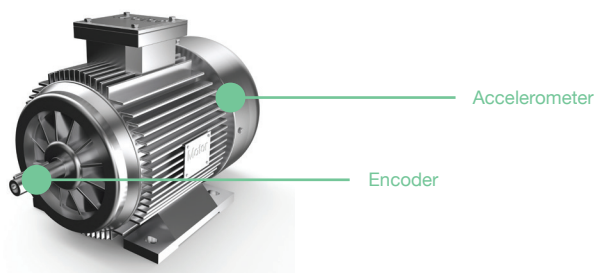


Figure 1 - Motor with encoder and accelerometer

One Input Module, Nine Measurements

The 720281 Input Module is known as the Frequency Module. This module not only measures frequency but makes a total of nine measurements common to motion sensing inputs. Compatible input sources can be configured using presets or custom settings:

- Encoder pulses (up to 42V)
- Electromagnetic pickup (direct input with 1:1 probes)
- Photo interrupters
- Mechanical contacts (with pullup resistor)

The nine available measurements are:

- Frequency
- Period
- RPM
- RPS (Rotations Per Second)
- Duty Cycle (%)
- Pulse Width
- Pulse Integration (available units of distance or flow volume)
- Velocity
- Power Supply Frequency

Resolvers, while not covered in this application note, can be connected to analog input modules and processed using the Real-Time Math option (/G3) on a DL850E ScopeCorder and choosing Resolver as the Math Operation.

Available advanced input signal conditioning settings on the 720281 include:

- Voltage range
- Bandwidth (four filters available)
- Chatter elimination (setting in milliseconds, similar to a de-bounce)
- Pull-up resistor (On/Off, pulled up to +5V for mechanical contacts)

Using one phase of a 5V A/B/Z encoder, the preset for logic 5V completes most of the needed settings.

Translating the Raw Data into Test Data

This encoder is connected to a motor demonstration setup. Four out of the nine 720281 test items settings are often related to motors: RPM, RPS, Pulse Integration (distance), Velocity.

Motion is continuous, but because pulses from encoders are discrete in nature, a stair-step waveform is displayed on the typical scope screen. The Yokogawa 720281 pre-processes this stair-step digital data with built-in digital signal processing. By enabling the Smoothing setting with an appropriate time constant, the waveform can more accurately represent constant velocity and provide more accurate cursor-based or post-processing measurements. Smoothing applies a moving average over a specified time window up to one second. Similarly, it may not make sense to update the distance measurement with each individual pulse incoming. The Pulse Average filter will reduce the update rate of the linear distance by waiting for N input pulses to occur, giving a much more stable and useable engineering value.

To measure distance, Pulse Integration counts the total pulses from a 0 point and multiplies this value by a distance-per-pulse value. This measurement mode would make it easy to find the location along a path (such as a railroad track) of an analog measurement made by another input module.

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Figure 2 - Velocity setup menu

To measure velocity directly, access the Velocity setup to input a time unit and a speed unit (default is meters per second). In this demonstration, the velocity will be increased while the vibration is simultaneously plotted. The effect of sudden decrease in the motor speed will be observed with the accelerometer. To measure the vibration, we use an ICP accelerometer.

Measuring Vibration with an Accelerometer

The 701275 accelerometer input module includes convenient features for easy connection and trending of accelerometers with built-in amplifiers. The two BNC inputs each provide 4 mA excitation current if needed, while the on-board anti-aliasing filter (AAF) reduces noise beyond the selected sampling rate using the option for automatic adjustment (cutoff frequency = 0.4 x sampling frequency in most use cases). In many cases, this means the accelerometer can be directly connected to the input module.

While accelerometers measure vibration, in most engineering scenarios the RMS amplitude of the vibration is more informative. Using the built-in measurement functions of the ScopeCorder the RMS measurement is selected and trended as a plot. In this demonstration we disabled RMS in order to observe the instantaneous response.

The results plotted below show the clear vibration response of the sudden slowdown of the motor.



Figure 3 - Velocity data (purple) and vibration data (yellow) showing vibration impulse corresponding to sudden slowdown

The 720281 also features built-in intelligence for detecting deceleration and full stop. When pulses are not detected, the module begins a deceleration model based on inverse proportional decay. After a user specified number of missing pulses, the module assumes a complete stop.

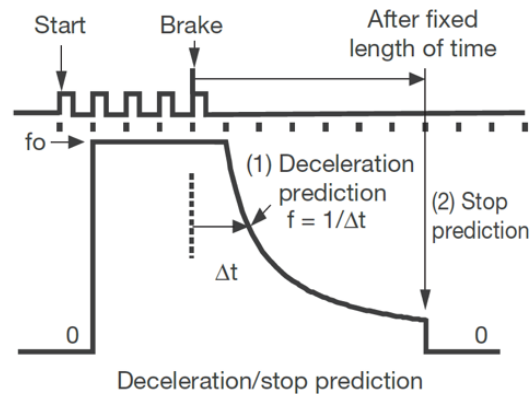


Figure 4 - If a pulse is not received, the optional deceleration and stop prediction algorithm provides modeled data

Yokogawa ScopeCorders and Input Modules provide many integrated features that can be configured quickly and easily – no programming required.

In this app note:

- DL350 or DL850E/EV ScopeCorder
- 720281 Frequency Input Module
- 701275 Accelerometer Input Module