Control and Motor Drive Testing on a Bascule-type Railroad Drawbridge

Application Note

Data Logging Case Study

Measuring tools: Fluke 180 Series DMM with FlukeView® Forms

Operator: Electrical engineer

Features used: Data logging and analysis

Situation

When a major railroad requested help in appraising the operational safety of an electrically powered, 100 year-old railroad drawbridge, technician Paul Visocky faced an unusual challenge.

The bridge in question spans a busy waterway. As part of their predictive maintenance program, railroad management wanted to confirm the baseline performance parameters of the bridge operating mechanism.

The word bascule stems from the French word for seesaw, and refers to a structure in which one end is counterbalanced by other structure or weights. In this case, the weight of the bridge is counterbalanced by a pivoting concrete counterweight attached to the bridge structure with two long steel arms.

The bridge is lifted and lowered by two 480-volt, 50-horsepower electric motors controlled by a programmable logic controller (PLC) located in an equipment shack high in the bridge structure beside the waterway. The motors operate through a gearbox to turn a six-inch steel shaft approximately 20 feet long. Pinion gears at both ends of the shaft mesh with rack gears on booms attached to the bridge structure. As these booms are drawn back or driven forward, they raise or lower the bridge, aided by the counterweight. (see figure 1)

For Visocky, electrician with Everett Engineering in Everett, Wash., the project posed some significant questions:

- How could he measure the performance of the electrical and mechanical drive components through a complete operating cycle and full range of motion?
- How could he accurately compare the electrical and mechanical loads, and determine whether the drive system was operating within safe limits?

Paul Visocky of Everett Engineering and Chuck Newcombe of Fluke. Downloading data from three Fluke 189 DMMs and a Fluke 123 ScopeMeter into the laptop for comparison and analysis in FlukeView® Forms.
Note: Shaft with strain guage and FM transmitter in foreground.

Scope of work

Visocky set up tests to monitor and record multiple operating parameters as the bridge was run several times through its operating cycle. These measurement parameters included:

- One phase of motor current for each motor.
- One phase of voltage applied to motors.
- Torque applied to the driveshaft.

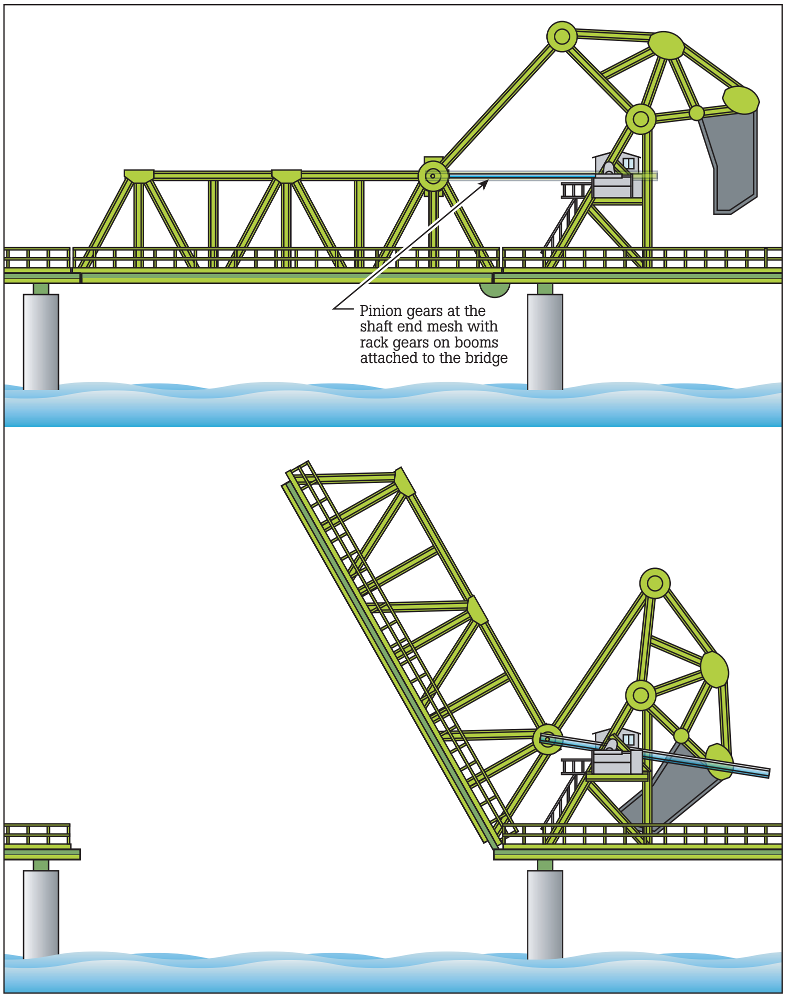

Figure 1. Bascule bridge example.

Test setup

Visocky used several Fluke measurement tools to log data during his tests, then displayed the collected data on a laptop computer using FlukeView® Forms software, release 3.0. He set up his tests as follows:

1. Lockout/tagout the supply panel.
2. Set up two Fluke 189 Logging Digital Multimeters (LDMMs) at the panel to collect and time-stamp current draw information for the two drive motors. Visocky used Fluke ToolPak™ magnetic hanging straps to temporarily attach the meters to the steel panel.
3. Connect a third Fluke 189 LDMM at the panel to log line voltage information. This data was collected only during the first round of tests.
4. Glue a Wheatstone Bridge-type solid state strain gauge transducer to the drive shaft. Inventor Charles Wheatstone popularized the Wheatstone four-arm bridge in 1843. Used as a strain gauge in this application, the device amplified changes in resistance that occurred as the surface of the steel pinion shaft underwent very small deformation when under torsion during bridge operation. These changes in voltage were then converted into torque readings.
5. Attach a battery to supply voltage to the strain gauge, and tape a low-power FM transmitter to the shaft. Attached to the strain gauge, the transmitter sent voltage readings to a nearby FM receiver connected to a Fluke 123 ScopeMeter® handheld oscilloscope, which was connected in turn to a laptop computer. Because the strain gauge turned with the shaft, a hardwired connection would be impossible.
6. Calibrate strain gauge output in terms of torque applied to the shaft. Temporarily attaching a lever arm to the pinion shaft, Visocky used a second strain gauge to measure the amount of pressure in pounds applied at the end of the lever as the shaft was placed under load. He then compared the readings of the two gauges and determined that .3 millivolts read through the torsion gauge was equal to 2.8 foot pounds of torque, and .0003535 volts represented 2828 foot-pounds of torque.
7. Re-activate panel and run tests.

Performing the tests

With measurement instruments in place, the test team raised and lowered the railroad bridge several times, while the Fluke instruments logged motor current, motor voltage and strain gauge voltage outputs.

Data logged on the Fluke 189 LDMMs during the first test sequence was downloaded to the FlukeView® Forms software on the laptop computer. Visocky then reset the units for a second test sequence. Strain gauge readings transmitted to the ScopeMeter® test tool were recorded directly on the laptop.

Data analysis

Returning to his office at Everett Engineering, Visocky prepared a FlukeView Forms graph displaying the test results. He used a new feature of FlukeView Forms version 3.0 that enabled him to display multiple inputs on a single graph. For these tests, he displayed current draw for the two motors on the bot-tom of the graph together with shaft torque in foot-pounds on the top. The graph showed torque loads of up to 14,000 foot-pounds during the operating cycle, and inrush current draw reached as high as 80 amps.

When data is logged using the Fluke 189 LDMM or Fluke 123 ScopeMeter test tool, the instruments time stamp the recorded data points. FlukeView Forms software automatically aligned these time stamps, making it easy for Visocky to compare the peak current readings from the motors at any instant with the level of torque applied to the pinion shaft at the same instant.

The FlukeView Forms combined graph (see Figure 2) shows clearly how power use and stresses change during bridge operation. The test sequence shows the Phase A current for one of the motors on the lower trace, with scale to the left, and the torque readings on the shaft on the upper trace, with the scale on the right, as the bridge was first raised and then lowered.

Simultaneous current and voltage logging at the control panel for two drive motors.

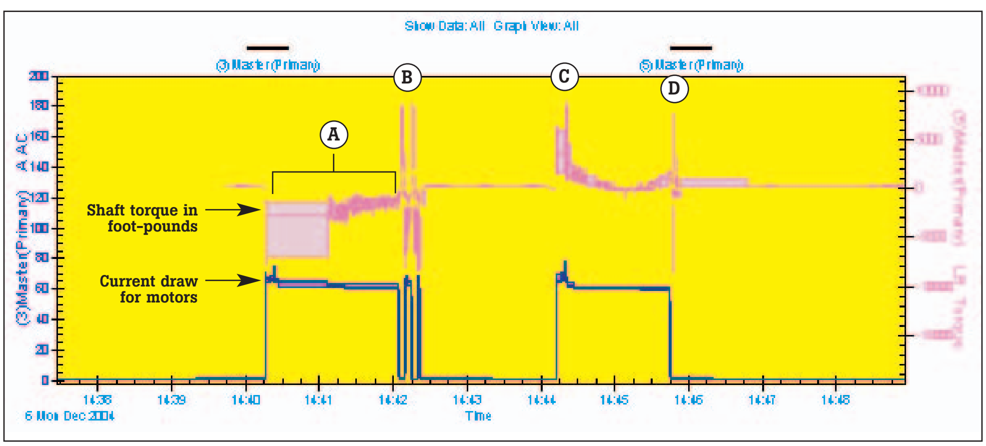

Figure 2. A–marks where the bridge began to raise. B–marks where the bridge is completely open and shaking. Note how the shakes cause the motor to turn on and off, as evidenced by the current draw. C–marks where the bridge begins to close. D–marks where it is settling into place.

Conclusion

Having observed how the bridge shook at its peak open position, the railroad was most concerned about operational safety. Through the torque and motor current analysis, Everett Engineering determined that the bridge was operating well within the limits, both for foot-pound torque stress on the shaft and for motor draw. The bridge was not in danger of failing.

The shaking was, however, having a marked effect on the motor, as evidenced in FlukeView Forms. Causing the motor to turn off and on so rapidly could eventually lead to circuit damage. The bridge operator could consider precise adjustments to the opening mechanism to smooth performance. Otherwise, during the regular predictive maintenance inspections, data for these same parameters could be collected, compared to the baseline and trended over time to track wear and predict the need for repairs.

To learn more about the Fluke 189 DMM and FlukeView Forms, visit **www.fluke.com/189kit**

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