DESIGN NOTES

Closed Loop Control with Data Acquisition Systems

Design Note 13

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Introduction

The use of microprocessors in process control loops is quite common. A processor based control loop requires special design considerations as compared to traditional analog loops. Often a single centrally located processor will be used to control several remotely located processes. The outputs of the remote process sensors can be digitized at the sensor location and then be transmitted to the central processor. Unfortunately, transmitting digital signals typically requires one wire for each bit of resolution and requires expensive cabling. Alternatively, the sensor output can be transmitted as an analog signal to the central processor area for digitization. However, transmitting analog signals over distances can introduce errors because of noise and voltage drops in the wires.

The solution to these control loop problems can be found in the LTC®1090 series of data acquisition systems. As can be seen in the schematic of Figure 2, ten bits of data can be digitized remotely and sent to the processor with only three wires plus ground. The single supply capability and the low DC current drain (1mA typ.) also simplify remote location. The LTC1090 series provides the user with blocks of 1, 2, 6, or 8 10-bit channels which can be chosen according to how many sensors are located in each remote site.

The LTC1090 series is ideally suited for such process control loop applications as position control, temperature control, container filling and tension control.

Circuit Description

The circuit of Figure 2 is a container filling control loop which has a resolution of .03 pounds with a 30 pound full scale. It was designed to implement an automatic filling station for the model train shown in Figure 1. When S1 is closed the MC68HC05 processor reads the LTC1092. If the weight is below the preprogrammed limit in the processor then the motor drive line which controls the pump is turned on. The LTC1092 is continually read by the processor as the truck is filled, until the limit is reached. The motor drive line is then shut off. The limit may be derived in a number of ways. A fixed limit will result in filling to an absolute weight, while relative or tare weight filling can be implemented when the measured empty weight is used in the calculation of the limit. Code for this application is available upon request from Linear Technology Corporation

The NCI 3220 strain gauge used in this circuit has a linearity specification of .04% which makes it a good match for the .05% linearity of the LTC1092. However, the offset and full scale of the strain gauge are only guaranteed to 10% so trims are required. The circuit is run ratiometrically so an absolute reference is not required. The strain gauge output is amplified by one-half of an LT1013 with the other half being used to buffer the resistor divider that is used for the LTC1092's

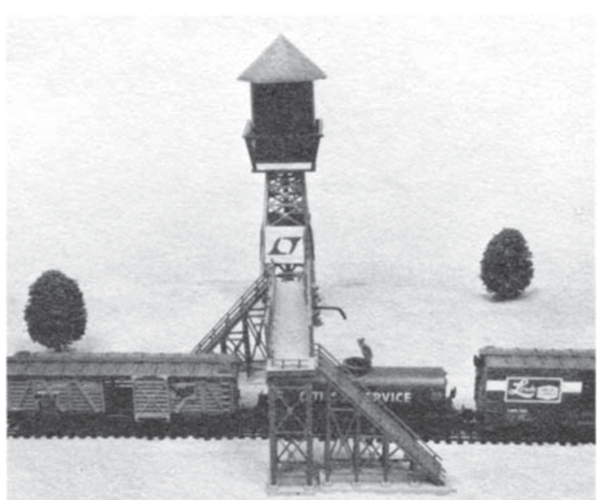

Figure 1. A Typical Application. Automatic Filling at a Railroad Siding

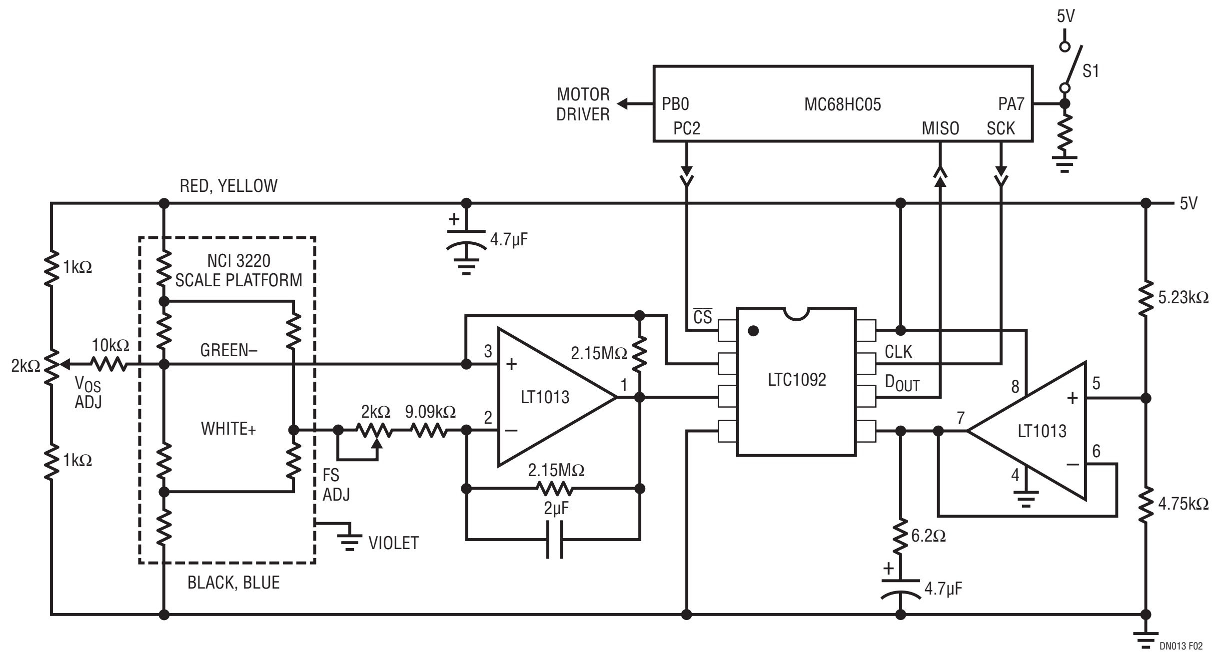

Figure 2. This Circuit Determines Small Weight Changes, Permitting Accurate Filling. Using the Appropriate Transducer, Containers May Range from Perfume Bottles to Railroad Cars

V_{REF} pin. Only one op amp is necessary to amplify the strain gauge output because of the differential inputs of the LTC1092. The 2.15MΩ resistor from pin 1 to 3 of the LT1013 is to balance the load on the strain gauge bridge. With the strain gauge zeroed, both inputs on the LTC1092 are at about 2.5V. As weight is added, the output of the LT1013 into the minus input of the LTC1092 swings toward ground. At the 30 pound full scale the output of the LT1013 is about 100mV above ground which results in a total swing of about 2.4V. The 2µF mylar capacitor filters the LT1013 output eliminating the effects of vibration caused by filling the train car. (As the train car nears the full point, vibration induced noise can cause the processor to stop the filling too soon.) It is important that the processor monitors the filling process in a timely fashion to prevent overflow. The setup shown relied on a slow fill rate to solve the last problem but with the processor in the loop it is possible to give the fill algorithm some intelligence so that it would run at a high speed to begin with and then run at a slower speed at some preset limit until the final limit is reached.

To calibrate the circuit, offset is first adjusted with no weight on the platform. Next, a known weight near full scale is used to adjust the gain. Once calibrated, variations in the supply voltage within the voltage limits of the LTC1092 should not cause additional errors.

Summary

The LTC1090 series is well suited for use in closed loop control systems. Their low supply current and serial interface make them easy to locate remotely. With a total unadjusted error of .05% over temperature the LTC1090 series is a good match to a wide variety of sensors. The differential inputs of the LTC1090 series can also simplify circuit design while a choice of 1, 2, 6 or 8 inputs gives the user just the level of complexity that is needed.

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