EXTENDING THE CAPABILITIES OF AD694 TRANSMITTER IN BRIDGE CONNECTED SENSOR APPLICATIONS

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The 4-20mA analog current interface has a wide application in industrial electronics because of high signal/noise ratio, especially in high noise environment. The interest in this interface doesn't decrease over the years. A proof of this is the development of new ICs such as AD693, AD694 and XTR101 as well as embedding extra digital communication capabilities (for example the HART protocol, some HONEYWELL solutions etc.).

This paper examines the subject of using the AD694 transmitter for converting the voltage of bridge connected sensor into current. It is proposed a three-wire interface scheme, which satisfies the requirements for higher measuring bridge supply current. A variety of suitable preamplifier schemes are presented for amplification of the bridge signal to the levels required by the AD694 transmitter.

The bridge measurement scheme power supply stabilisation is achieved by using the reference voltage source built into AD694. It provides a capability to supply the bridge sensor by stabilized voltage source or by current generator. Experimental data are collected and provided by powering a single strain gauge using each of these power supply methods.

The force sensors measure both stretching and pressure, and have bipolar readout. This puts the requirement to shift the zero line of the transmitter output current. In the proposed schematic solution this is achieved by applying the necessary signal shift in the preamplifier stage. A suitable method is proposed to derive the reference voltage, for the zero line shift, from the internal reference source. This is achieved in current generator mode as well as in voltage source mode.

A temperature range measurements is foreseen for the schematic proposed.

Keywords – transmitter AD694, bridge measurement schematics

1. INTRODUCTION

The choice of proper interface between the sensing devices and the readout device has significant impact on system performance.

Modern electronics relay on digital transmission and sophisticated protocols. Besides the well-known benefits this approach has some drawbacks when applied to a system with a low count of sensors. There are almost no savings due to sensor wiring, still the higher price intelligent sensors are used and some processing power is lost to communication protocols handling.

Analogous signaling has to deal with noise induced over the wiring. A choice between voltage and current signaling has to be made. In general industrial electronics rely on current signaling because of its better noise immunity.

The 4-20mA current interface has a wide application in industrial electronics because of high signal/noise ratio, especially in high noise environment. It has become a widespread standard is commonly found in many designs that focus on process monitoring and control and in data acquisition systems.

2. PROBLEM STATEMENT

The concept behind the 4-20 mA interface is to power the sensor using 4mA of current over the two-wire interface line. When using bridges we wish to apply higher current or voltage in order to achieve better sensitivity. In order to avoid the 4mA constraint a separate power line can be used, increasing the number of wires to three.

Fig. 1 shows the internal structure of the AD694 monolithic current transmitter. It

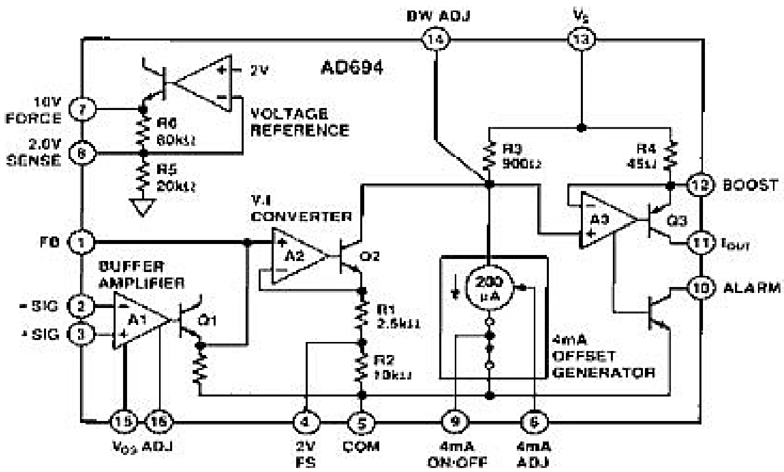

Fig. 1

contains a stabilized power supply source (2V/10V), a buffer amplifier stage, a V-I converter, precalibrated for 0-2V and 0-10V input ranges, and an output stage, featuring output current adjustment and open loop alarm. The IC allows for single or dual supply operation – 4.5V to 36V.

The internal reference source can only supply as much as 5mA.

We aim to achieve the following goals:

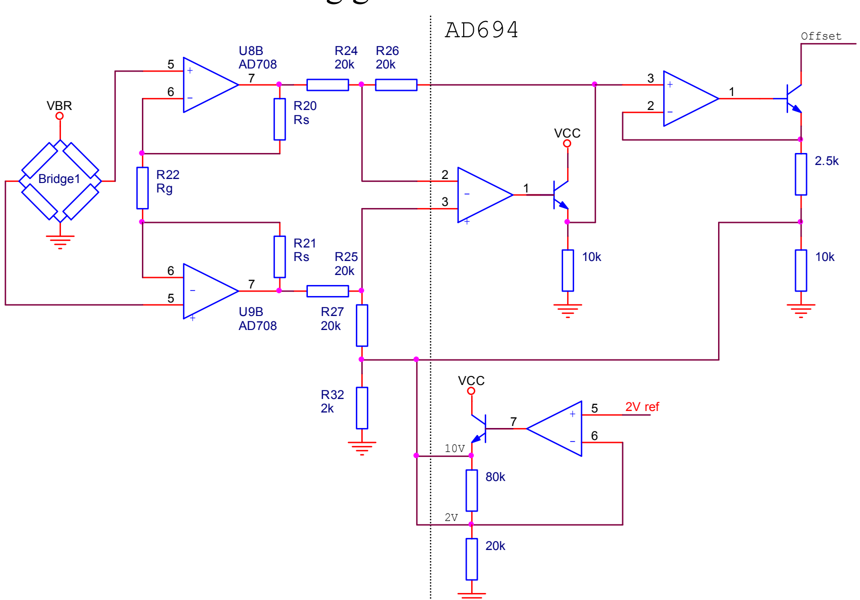

Fig. 2

- higher supply current
- provide the means to supply the bridge sensor by constant current
- simple preamplifier circuit that will allow for proper input signal amplification.
- extend the input to accept "bipolar" signals

There is a reference design in [1], named "low cost sensor transmitter", that discusses similar problems.

Fig. 2 shows the proposed schematic. It requires external power supply for the bridge and transmits only positive input signals.

In order to use the internal voltage reference to power the sensing bridge the schematic, shown on fig. 3, was proposed.

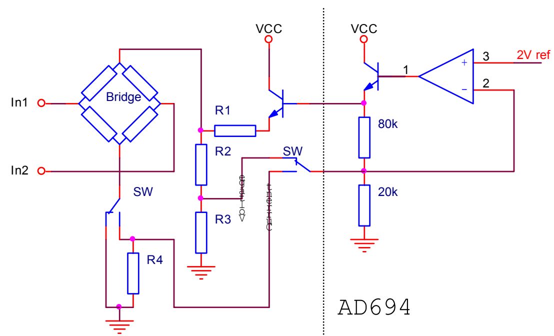

Fig. 3

It is capable to feed larger currents into the bridge, thru the external transistor.

The external feedback circuit allows to manually choose the supply voltage (R_2/R_3), or current (R_4) applied to the bridge.

In order to amplify and transmit "bipolar" signals, the "zero" output signal has to be lifted up to half the output scale. The offset voltage is applied at the V0 point (fig. 4). Although the circuit works particularly well with high input signal it has problems with low signal processing. Because of the current flowing thru R_9 and the internal pull-down resistor the amplifier is unable to pull the V-I input down to 0V.

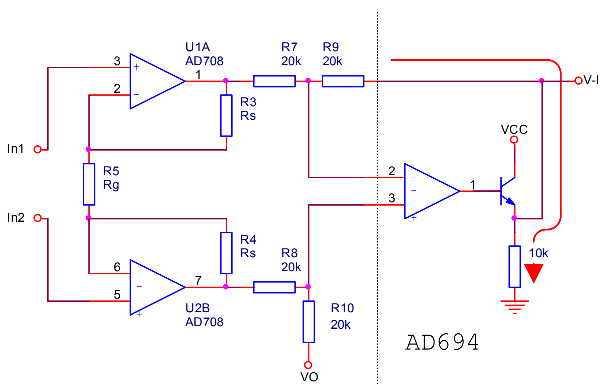

Fig. 4

An alternative circuit is proposed and tested, shown on fig. 5. Its transfer function is calculated as:

$$K = 1 + \frac{R2}{R1} + 2\frac{R2}{R3} \quad (1)$$

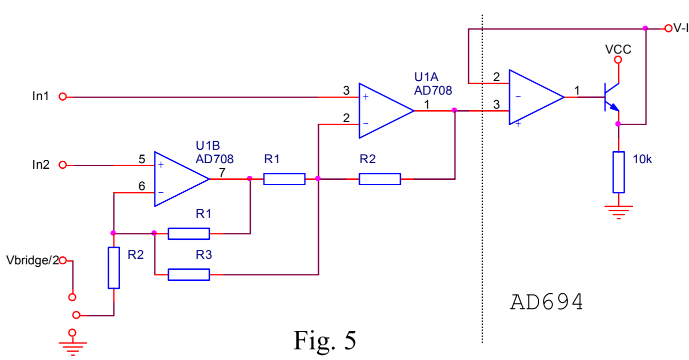

Fig. 5

It has the extra capability to shift the zero line up to the value of Vbridge/2. Nevertheless it uses fewer components than the circuit on fig. 4 and does not introduce voltage dependant error on the output value.

3. RESULTS

The experimental results are obtained using a full-bridge strain gauge, used as a weight sensor. Fig. 6 shows the calculated weight as a function of the output current and the error relative to the full scale. Fig. 7 shows the absolute error distribution. Dashed line marks the voltage mode and solid line the current supply mode.

The calculations show the scale to be mostly linear (R^2=0.9997 in voltage supply mode and R^2=0.99993 in current supply mode). The error trend lines show that the current supply helps to increase the accuracy (±0.5%). The error distribution charts confirm the current supply mode to be superior to voltage supply.

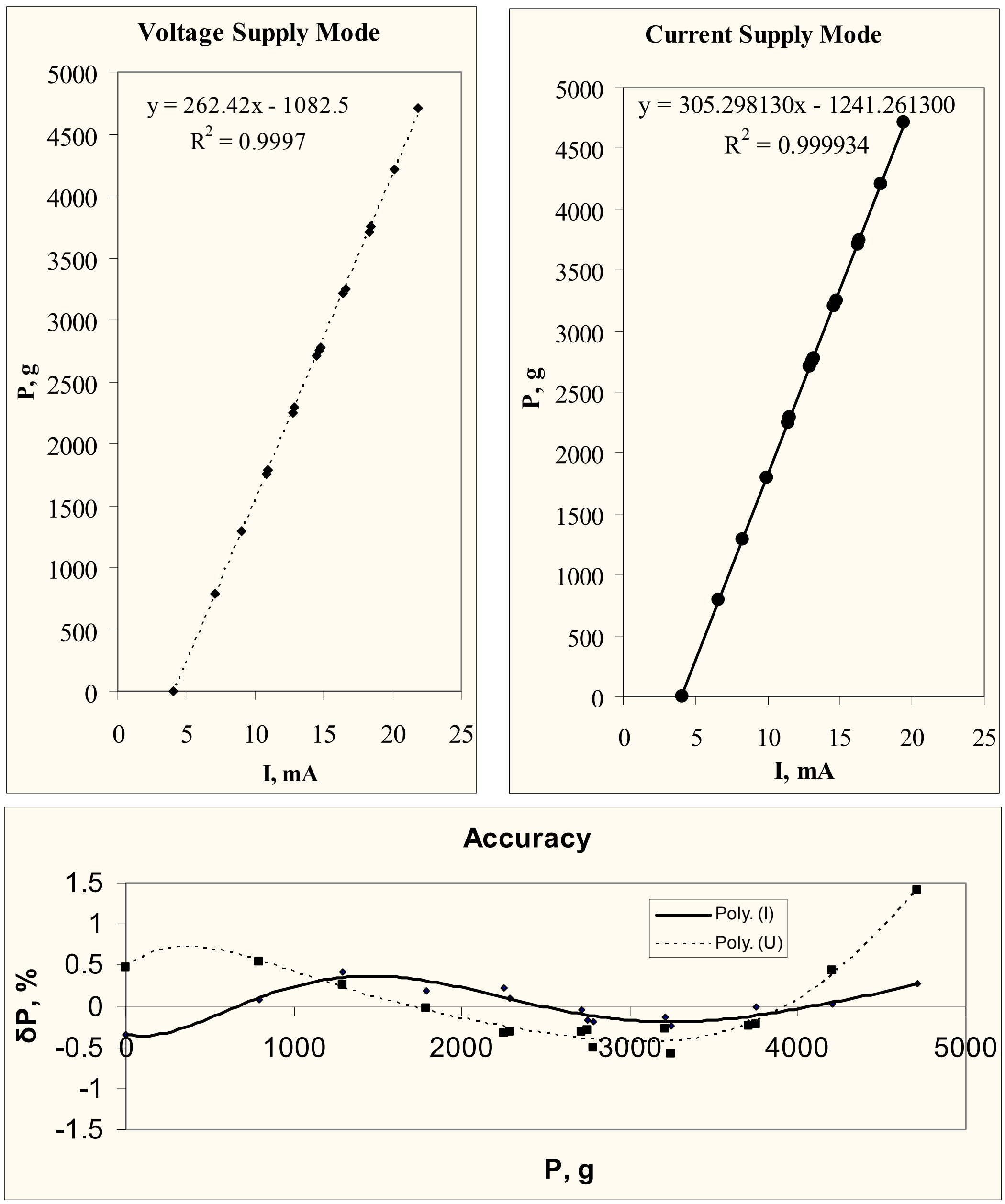

Fig. 6

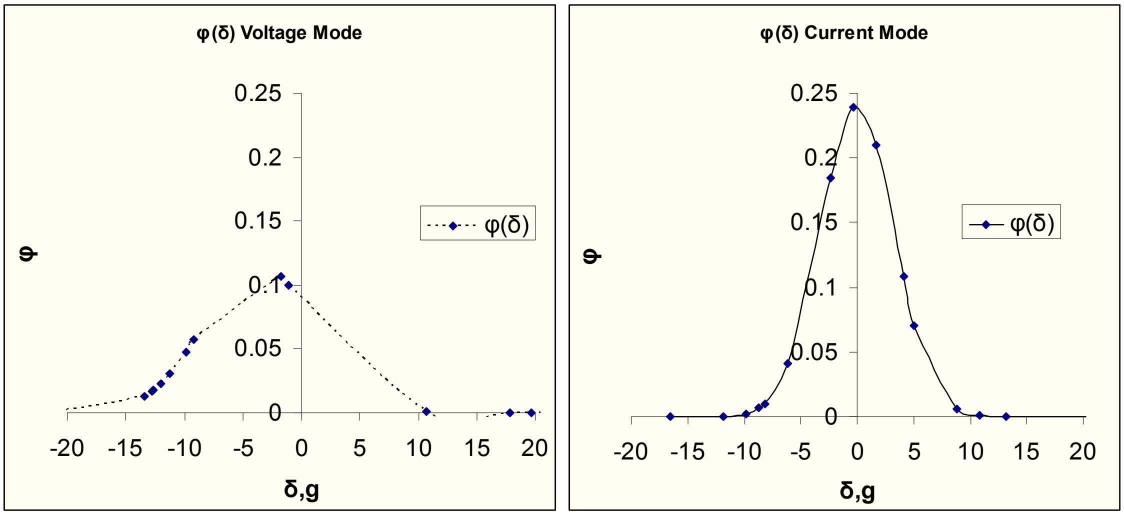

Fig. 7

4. Conclusions

The developed measuring system prototype shows excellent performance. The universal 4-20 mA interface allows for large scale integration measurements and control applications and easy upgrade of similar older sensors. The simple schematic makes possible for large quantity, low price manufacture of such precise measurement devices.

5. References

[1] AD694 – 4-20mA Monolithic Current Transmitter datasheet -
http://www.analog.com/UploadedFiles/Data_Sheets/390142776AD694_b.pdf
[2] XTR101 – Precision, Low Drift 4-20mA Two-Wire Transmitter –
http://www-s.ti.com/sc/ds/xtr101.pdf