Technical Note 102

Bridge-balance and Zero Controls in Amplifiers

Bridge Balance

When a bridge circuit, such as the one shown in Figure 1, is in balance, the voltages at Points B and C are equal. Transducers, such as strain gages, load cells, accelerometers, RTD's, and pressure gages are often connected as one or more arms of a bridge. For example, R1 might be a strain-gage element and R2, R3, and R4 fixed resistors, or both R1 and R3 might be strain-gage elements and R2 and R4 fixed resistors and so forth. Points B and C are connected to the input terminals of an amplifier.

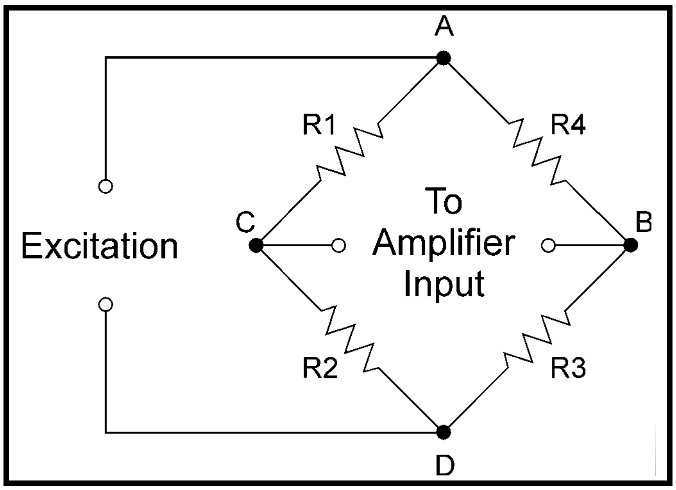

Figure 1

In the usual strain-gage system, it is desirable that the bridge be in balance (0 V input to amplifier) when no stress is applied to the strain gage. In a practical situation the strain-gage elements and fixed resistors may not always be the exact values for balance under this condition. A bridge-balance circuit can be added as is shown in Figure 2 to address this situation.

By adjusting the potentiometer R_{bal}, Point B may be made more positive or negative as required to balance the bridge. R_{lim} is a limiting resistor (limiting the range of control that the balance potentiometer has), and together with R_{bal}, acts as a shunt across R3 and R4. The balance circuit however does introduce some nonlinearity into the bridge-balance equation.

The bridge-balance circuit may be external or contained within the amplifier itself. The Ectron Model 352, Series 400 with Option M, and Model 563H all contain a multi-turn bridge-balance potentiometer as a front-panel control. In addition the Model 563H has internal terminals for bridge completion, calibration, and balance-limit resistors

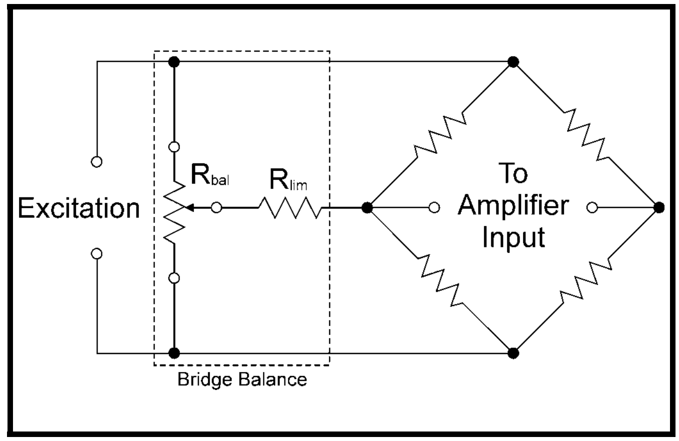

Figure 2

while Ectron enclosures such as the 408 Series provide these terminals externally to the amplifiers.

Offset and Zero

It is frequently desirable to maintain a point in a circuit at a fixed reference potential. Very often this potential is 0 V or "ground." The amount by which the point varies from the reference potential is called the "offset" or "offset voltage." The offset may be positive or negative and may occur anywhere in a circuit. In an amplifier, the offset at the output and the offset at the input are important parameters and are usually adjustable by controls that may be internal or on the front panel.

Since one of the functions of these controls is to adjust any offset to 0 V, they are frequently called "zero controls." However, they may also be used to produce an

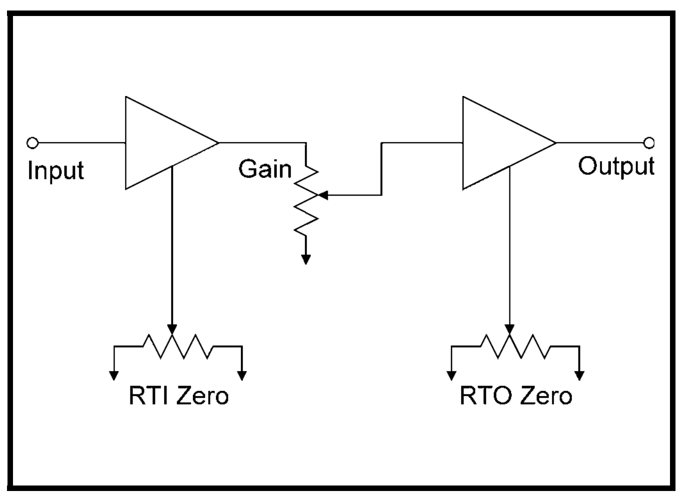

Figure 3

offset which is not zero, and are therefore sometimes called "offset" or "zero suppression" controls. In product manuals, Ectron refers to them as zero controls.

Depending on their place in the amplifier circuit, that is, where they introduce the compensating voltage, these controls are called RTO (referred-to-output) zero controls, or RTI (referred-to-input) zero controls. Figure 3 represents a typical amplifier arrangement.

The RTO zero control is shown in the signal path after the gain control. Consequently the voltage level produced by this control at the output is independent of the gain. A typical zero-control specification such as 200 mV RTO means that the amplifier dc output voltage may be adjusted over a range of 200 mV with respect to zero and that the amount of offset so introduced will remain the same no matter what the gain is.

By contrast, since the RTI zero control is ahead of the gain control, its effect is equivalent to a change in the amplifier input and consequently is multiplied by the gain setting. For example, if the RTI zero control is set to produce a +10 mV output at a gain of 1, changing the gain to 100 will produce an output of +1 V. Generally a much greater variation in output voltage results from an RTI zero control than from an RTO zero control. Furthermore, a well-designed RTI zero control such as that found in Ectron amplifiers does not affect the input isolation or common-mode-rejection capability of the amplifier. An amplifier may have both RTI and RTO zero controls. One of the most frequent uses of the RTI zero control is to compensate for a static (no-signal) offset voltage from a transducer. For example, a weighing system may indicate the weight of both the container and its contents when only the net weight is wanted. In this case, the container alone may be weighed, the resulting dc voltage from the load cell considered as an offset voltage at the amplifier input and "zeroed out" (offset) by the amplifier RTI zero control.

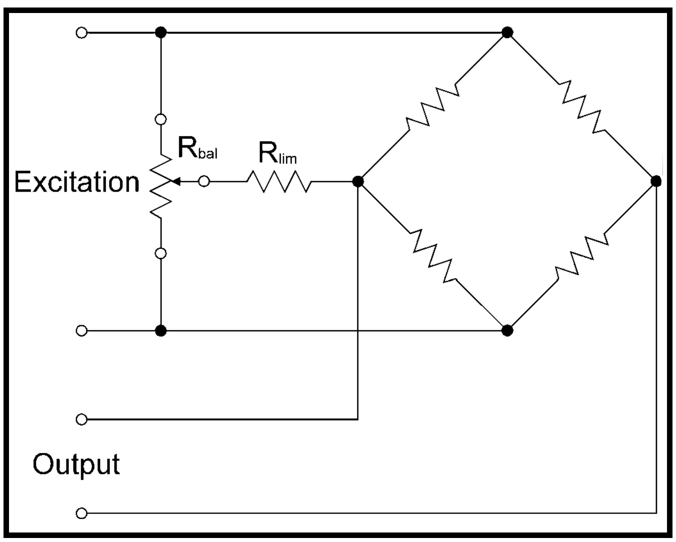

Figure 4

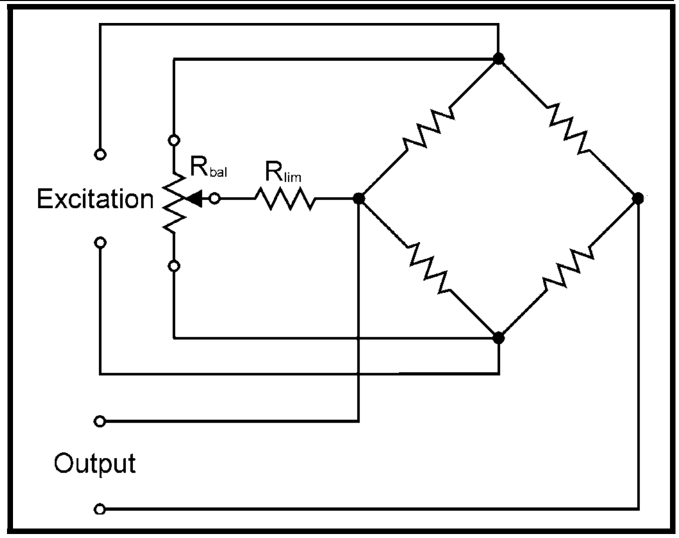

Figure 5

Once this is done, the system will indicate the desired net weight only. (This is an excellent application for autozero, described later.) A similar result can be achieved with a bridge transducer by rebalancing the bridge under the initial offset condition: that is, when the container alone is weighed. If the unbalance is considerable under this offset condition, however, the bridge may then be quite nonlinear, and serious errors may result. This nonlinearity is avoided by using the RTI zero control method.

Several uses for an offset control having the wide range provided by the Ectron 40mV RTI zero option (Model 428 and Option P in the 400 Series) can be seen. For example, the static physical zero (no-signal) condition for a transducer may result in a nonzero electrical signal to the amplifier as in the load cell example above. If the nonzero signal is amplified directly, the required amplification can result in saturation of the amplifier even before sufficient measurement sensitivity is reached. A wide-range RTI zero control allows the amplifier effectively to be zeroed despite the static nonzero input signal so that the amplifier gain can be high without saturation problems.

For example, assume that a strain-gage bridge with four active arms has a static load causing a +30 mV signal to the amplifier. If the required amplifier output is 0 V to +5 V for a +30 mV to +35 mV input change, a gain of 1000 is required. Without some means of zeroing the input, the amplifier output would attempt to vary from +30 V to +35 V, but would actually saturate at about + 13 V.

With the RTI zero control, however, the output may be simply adjusted to zero with the +30 mV static input. Then, as the input changes from 30 mV to 35mV, the output will give the required 0 V to 5 V output change.

Bridge-type transducers can be easily balanced by shunting one leg of the bridge as shown earlier. One might therefore ask why an offset control in the amplifier is needed. Two problems exist when shunt balancing a bridge transducer. First, the shunt resistor causes the bridge to become nonlinear as noted earlier, and second, errors are introduced unless the shunt resistor is connected to the bridge with separate wires.

Figure 4 shows a typical strain-gage bridge-balance circuit:Because of lead resistance in the cabling to the bridge, the simple four-wire hook-up shown adds inaccuracies in the bridge output. As a result, a seven-wire hookup is sometimes used, as is shown in Figure 5.

With an RTI zero control, the bridge-balance circuit is not needed. This feature therefore:

- Eliminates the need for bridge-balance control circuitry.
- Allows four-wire cabling to the bridge, a significant savings where long cables are needed or where weight is critical.
- Eliminates the nonlinearity of unbalanced bridges.

It is interesting to note that the RTI zero circuits in Ectron amplifiers do not involve the input circuit of the amplifier. Figure 6, shows the isolation between input and the rest of the amplifier, including the offset circuit.

Performance of the Model 428 and 400 Series amplifiers is degraded only very slightly by the addition of the RTI zero control circuit, even up to the full 40 mV. When the control is set for zero output, all characteristics remain as stated on the data sheet. When it is set to a nonzero value, the circuit adds to the dc drift; but because of the high stability, the added drift is small. For example, in the Model 428, the 40mV RTI zero control specification has a zero stability better than 1 µV RTI + 100 µV RTO + 0.005% of the RTI zero offset over a 200 hour period.

Autozero permits the heretofore manual operation of RTI zero to be performed electronically. By the activation of a switch, either manually or by remote control, circuits in the amplifier can be commanded to look at the output of the amplifier and automatically insert up to 40mV of the appropriate offset voltage at the input to bring the output to zero. This feature is standard in the Ectron 428 Series.

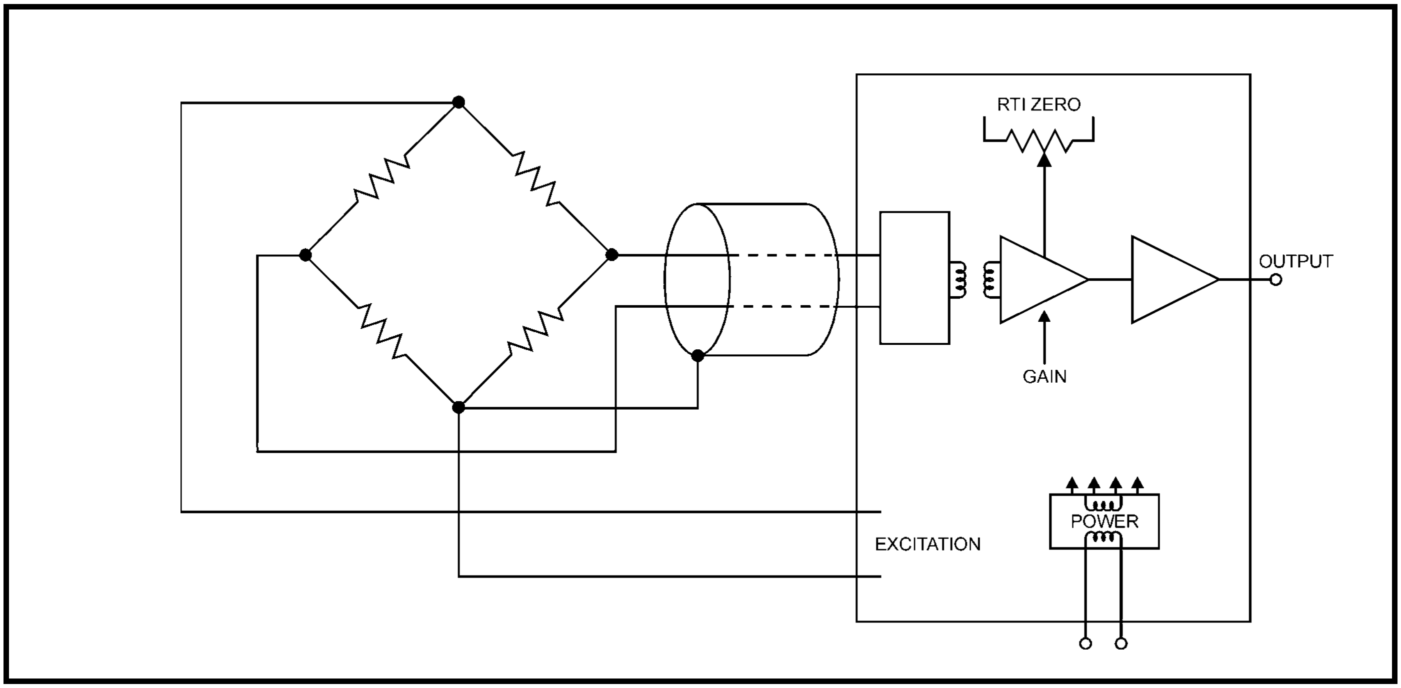

Figure 6

Ectron CORPORATION
8159 Engineer Road San Diego, CA 92111
(858) 278-0600 sales@ectron.com
www.ectron.com