Appendix 3: RS Trim analysis

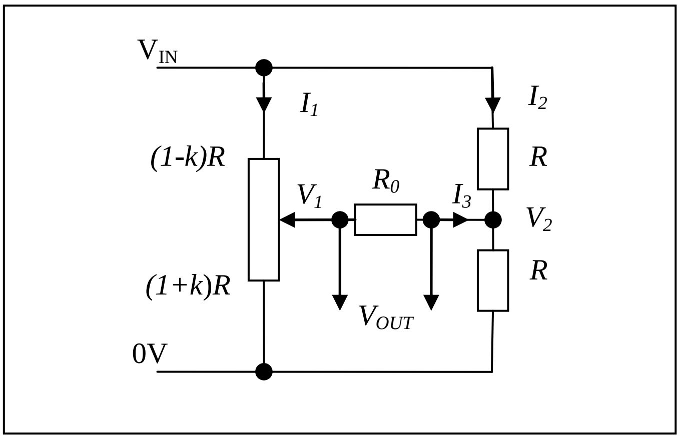

Fig.1 RS trim circuit

The parameter, k, describes the setting of the (ten-turn) potentiometer ($-1 < k < +1$).

For the left side, according to Ohm's and Kirchhoff's laws: -

$$V_1 = (I_1 - I_3)(1+k)R \quad \text{and} \quad I_1 = \frac{(V_{IN} - V_1)}{(1-k)R} \quad \Rightarrow \quad V_1 = \frac{(1+k)}{(1-k)}V_{IN} - \frac{(1+k)}{(1-k)}V_1 - I_3(1+k)R$$

$$\Rightarrow \quad V_1\left(1 + \frac{(1+k)}{(1-k)}\right) = \frac{(1+k)}{(1-k)}V_{IN} - I_3(1+k)R \quad \Rightarrow \quad 2V_1 = (1+k)V_{IN} - I_3(1-k)(1+k)R$$

Similarly, for the right side: -

$$V_2 = (I_2 + I_3)R \quad \text{and} \quad I_2 = \frac{(V_{IN} - V_2)}{R} \quad \Rightarrow \quad V_2 = V_{IN} - V_2 + I_3 R$$

$$\Rightarrow \quad 2V_2 = V_{IN} + I_3 R$$

From which one can deduce I_3: -

$$2(V_1 - V_2) = 2I_3R_0 = (1+k)V_{IN} - I_3(1-k)(1+k)R - V_{IN} - I_3R$$

$$\Rightarrow \quad I_3(2R_0 + (1-k)(1+k)R + R) = kV_{IN} \quad \Rightarrow \quad I_3 = \frac{kV_{IN}}{(2R_0 + (1-k)(1+k)R + R)}$$

Introduce the dimensionless ratio $\alpha = \frac{R_0}{R}$ so that the ratio of the output to the input is: -

$$\frac{V_{OUT}}{V_{IN}} = \frac{I_3 R_0}{V_{IN}} = \frac{\alpha k}{(2\alpha + 2 - k^2)}$$

For the F17 (and F700) the input is from a single turn on the ratio transformer $(V_{IN} = 10^{-2} V_S)$ and $\alpha = 10^{-2}$ so that, to a good approximation, the effect, in terms of bridge ratio is: -

$$\frac{V_{OUT}}{V_S} = \frac{10^{-4} k}{(2 - k^2)}$$

The full-scale range is, therefore, $\pm 10^{-4}$ or ±100ppm.

ASL F17 and F700 circuits

The setting of the potentiometer is not quite linear.

The characteristic curve is: $$f(k) = \frac{k}{(2-k^2)}$$

The slope of the curve is: $$\frac{df}{dk} = \frac{1}{(2-k^2)} - \frac{k(-2k)}{(2-k^2)^2} = \frac{2+k^2}{(2-k^2)^2}$$

$$k = 0 \quad \Rightarrow \quad \frac{df}{dk} = \frac{1}{2} \qquad \text{and} \qquad k = \pm 1 \Rightarrow \quad \frac{df}{dk} = 3$$

The sensitivity of the potentiometer thus varies over a range of 6 to 1.

The ten-turn potentiometer has a resolution of the order 10-3 so that at the centre setting (k = 0) the resolution, in terms of bridge ratio is: -

$$\delta\left(\frac{V_{OUT}}{V_S}\right) = \alpha\left(\frac{df}{dk}\right)\delta k$$

$$k = 0 \quad \text{and} \quad dk = 10^{-3} \quad \Rightarrow \quad \delta\left(\frac{V_{OUT}}{V_S}\right) = \alpha\left(\frac{df}{dk}\right)\delta k = 0.5\times 10^{-7}$$

Similarly: $$k = 1 \quad \Rightarrow \quad \delta\left(\frac{V_{OUT}}{V_S}\right) = 3\times 10^{-7}$$