First order temperature independent resistors in analog and mixed signal IC design

In many applications of analog and mixed signal IC design, a temperature independent resistor may be required. This note describes a means to do this to a first order.

Figure 1.0 shows a series connection of two resistors which together will form the temperature independent resistor needed.

This configuration provides

\[ R_{\text{total}} = R_1 + R_2 \]  

(0)

Now let,

\[ R_1 = R_{01}(1+A_1\ast dt) \]  

(1)
\[ R_2 = R_{02}(1+A_2\ast dt) \]  

(2)
Where A1, A2 are the tempcos of the two resistors respectively and dt is the temperature differential across them.

Then the sum of the two resistors can be written:

\[ R_{total} = R_{01} + R_{02} + dt(R_{01}A1 + R_{02}A2) \]  \hspace{1cm} (3)

If,

\[ R_{01}A1 + R_{02}A2 = 0.0 \]  \hspace{1cm} (4)

Then R is temperature independent to a first order.

If A1 is a positive tempco and A2 is a negative tempco (a condition encountered commonly in practice) then we can write,

\[ \frac{R_{01}}{R_{02}} = \frac{A2}{A1} \]  \hspace{1cm} (5)

Equation 5 and equation 3 provide the design equations for the Temperature independent resistor design.

As an example assume that a 100 Ohm temperature independent resistor is required. Let's say that poly resistors are to be used. Then a typical tempco couple may be,

\[ A1 = 0.7E-3 \]
\[ A2 = -1.2E-3 \]

Using equation 5, we get:

\[ R_{01} = 1.71 \times R_{02} \]  \hspace{1cm} (6)

Thus the two equations lead to:

\[ R_{01} + R_{02} = 100 \]

Then,

\[ R_{02} = 100/2.71 \]  \hspace{1cm} (7)
Or,

\[
R02 = 36.9 \text{ Ohms} \quad (8)
\]
\[
R01 = 63.1 \text{ Ohms} \quad (9)
\]

To cross check the results we use equation 4,

\[
63.1 \times (0.7 \times 10^{-3}) - 36.9 \times (1.2 \times 10^{-3}) \approx 0.0
\]

If necessary, slight trimming could be done using the circuit simulator to get the final values.