OP AMP APPLICATIONS

IC in-amps are particularly well suited to meeting the combined needs of ratio matching and temperature tracking of the gain-setting resistors. While thin film resistors fabricated on silicon have an initial tolerance of up to ±20%, laser trimming during production allows the ratio error between the resistors to be reduced to 0.01% (100ppm). Furthermore, the tracking between the temperature coefficients of the thin film resistors is inherently low and is typically less than 3ppm/°C (0.0003%/°C).

When dual supplies are used, \( V_{\text{REF}} \) is normally connected directly to ground. In single supply applications, \( V_{\text{REF}} \) is usually connected to a low impedance voltage source equal to one-half the supply voltage. The gain from \( V_{\text{REF}} \) to node "A" is \( R1/R2 \), and the gain from node "A" to the output is \( R2'/R1' \). This makes the gain from \( V_{\text{REF}} \) to the output equal to unity, assuming perfect ratio matching. Note that it is critical that the source impedance seen by \( V_{\text{REF}} \) be low, otherwise CMR will be degraded.

![Diagram of op-amp in-amp configuration](image)

**Figure 2-8: Two op amp in-amp single-supply restrictions for \( V_s = +5V \), \( G = 2 \)**

One major disadvantage of the two op amp in-amp design is that common mode voltage input range must be traded off against gain. The amplifier A1 must amplify the signal at \( V_1 \) by \( 1 + R1/R2 \). If \( R1 >> R2 \) (a low gain example in Figure 2-7), A1 will saturate if the \( V_1 \) common mode signal is too high, leaving no A1 headroom to amplify the wanted differential signal. For high gains (\( R1 << R2 \)), there is correspondingly more headroom at node "A", allowing larger common mode input voltages.

The AC common mode rejection of this configuration is generally poor because the signal path from \( V_1 \) to \( V_{\text{OUT}} \) has the additional phase shift of A1. In addition, the two amplifiers are operating at different closed-loop gains (and thus at different bandwidths). The use of a small trim capacitor "C" as shown in Fig. 2-7 can improve the AC CMR somewhat.

A low gain (\( G = 2 \)) single supply two op amp in-amp configuration results when \( R_G \) is not used, and is shown above in Figure 2-8. The input common mode and differential signals must be limited to values which prevent saturation of either A1 or A2. In the example, the