Agilent MGA-53543 Improving IP3 using Current Stabilization

Application Note 5113

The following App Note describes a method by which the IP3 performance of the MGA-53543 may be improved over its operating temperature range using current stabilization.

Introduction

While the MGA-53543 offers exceptional IP3 performance, especially considering its typical current consumption (54mA OIP3 +39dBm), this performance can be affected by temperature variations.

Extreme operating temperatures result in IP3 performance being degraded both at –40 and +80 Celsius. One of the reasons for this change is the variation in Ids away from the optimized 54mA (5V) point. Ids tending to fall with increase in temperature. However , IP3 is not simply a function of Ids. At lower temperatures Ids tends to increase but IP3 still tends to be degraded. The proposed solution therefore, is to maintain Ids at a fixed value.

Figure 1 details one possible method for achieving this current regulation.

Resistor R1 is used to provide a voltage drop to determine Ids. A resistive divider formed by R2 and R3 sets the current point.

With a normal 5V supply and Ids of 54mA, device dissipation is 5 x 0.054 = 270mW. Because the use of a resistor in the drain supply causes a small voltage drop, a higher Ids was chosen to maintain the same power dissipation. In this case a current of 57mA. Through 4.7R this gives a drain voltage of 5-(0.057 x 4.7) = 4.732V. 4.73V x 0.057A gives the required device dissipation of 270mW.

To get this operating point, the potential divider is set to giv e the same voltage on the op-amp non inverting input as the voltage (V1) on the device side of R1 e.g. 4.732V. In this case a value of 680R for R2 and 12k for R3 gives a voltage of :-

(12/12.68) x 5 = 4.732V

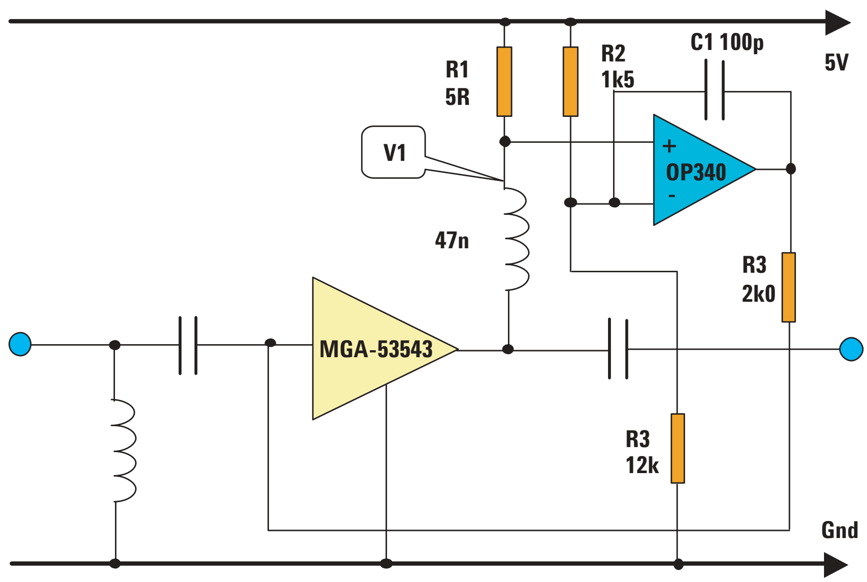

Figure 1. Simplified Schematic of Constant Current Bias arrangement.

Note: An TI OP-340 was used due to its ability to swing rail to rail (also because we had an existing stock!) but, any general purpose op-amp with rail to rail output capability will suffice.

To control the current, the output of the op-amp is fed into the input pin of the MGA-53543. This injects the additional current required to increase Ids and also acts as a current sink when Ids needs to be reduced.

Typically the output of the op-amp will hover around 700mV depending on the device and the operating temperature. The 2k resistor whilst acting as a load, is also of sufficiently high value to have no significant effect on the RF input path. If a lower resistor value is used a series inductor would be required. Capacitor C1 is included across the op-amp to limit its frequency response.

So in this way the current of the device will remain constant across temperature dependant upon the resistive divider formed by R2 and R3. Of course this assumes a constant regulated 5V supply and relatively stable resistors. Experiments have shown, though, that standard thick film resistors are more than adequate for the task.

Results

Figure 2 shows typical result for Ids v Temperature.

Clearly the graph shows the effect of temperature on Ids and the ability of the regulator design to maintain it at a constant level over temperature.

IP3 Measurements

The test circuit used to measure IP3 was the 1.9GHz design detailed in figure 3.

Due to the fact that the DC characteristics of the MGA-53543 vary slightly between samples, the improvement gained from using the above circuit will also vary between samples. However, there will always be an overall improvement where IP3 is falling off either at high or low operating temperatures.

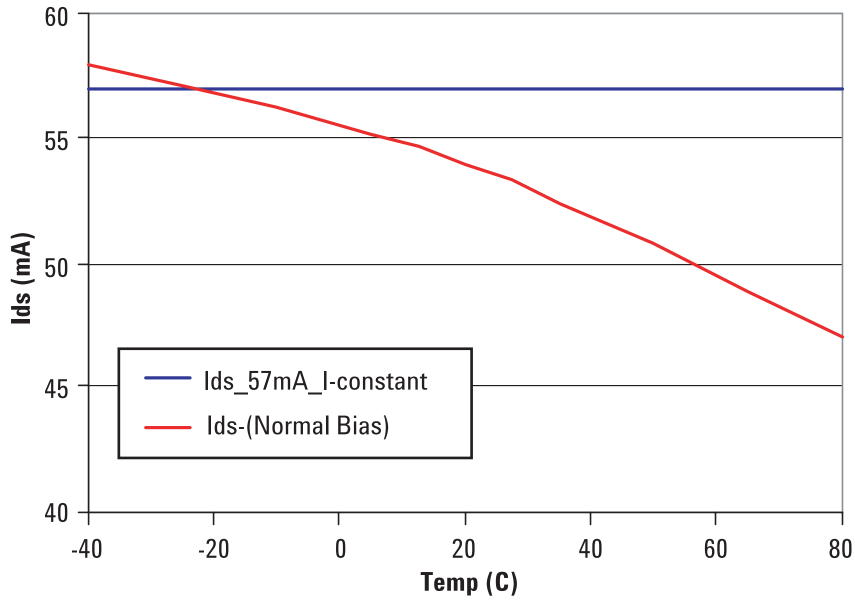

Figure 2. Ids v Temp (Active and normal Bias)

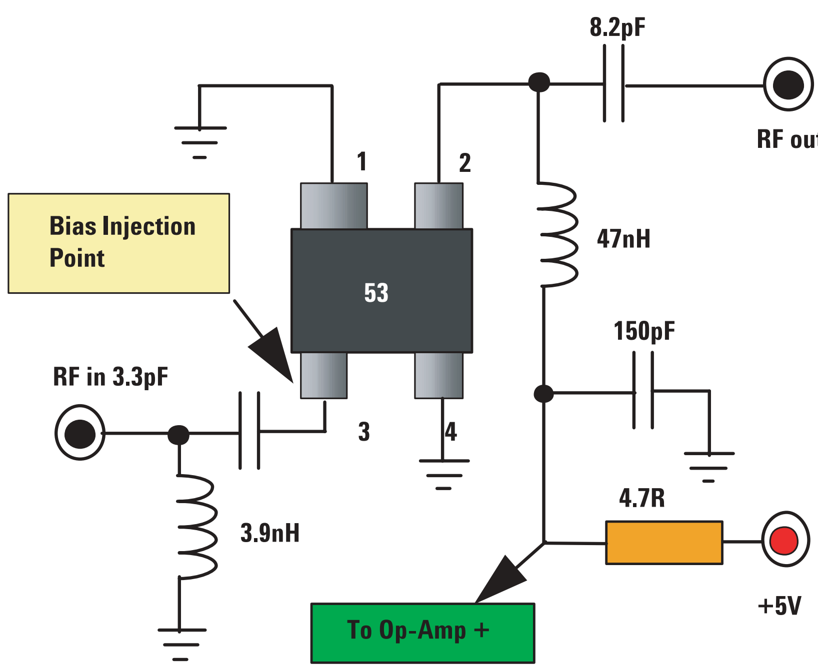

Figure 3. MGA-53543 1.9GHz Schematic

Figure 4 shows a typical graph of IP3 performance over temperature, with and without the current regulator circuit.

From the results above we can see that with the current fixed, the gradual fall off of IP3 with increase in temperature is reduced. With this sample the graph is also showing that this benefit reduces with temperature and can actually give a slight reduction in IP3 performance at very low temperatures. Overall though, a clear improvement can be seen. As previously mentioned, not all parts will give a graph similar to the one above. Some may show an improvement of IP3 at lower temperatures depending on the I-V characteristics of the part. Again though, making Ids constant will show an improvement at high temperatures with reduced benefits at very low temperatures.

Conclusion

Generally, the MGA-53543 may show reduced IP3 performance at temperatures other than ambient, mainly down to the DC operating point moving away from the optimal 54mA @ 5V Vds region. However, this effect can be reduced by fixing Ids using a simple Op-Amp circuit injecting /sinking current into/out of the RF input (pin 3) of the device. The improvement obtained being particularly significant at high temperatures.

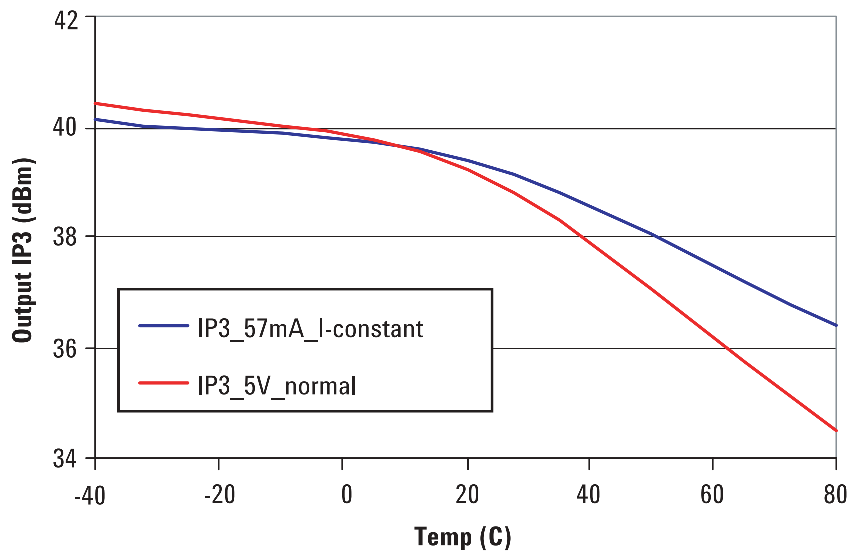

Figure 4. IP3 v Temp (57mA I-const and Normal bias) Vdd=5V

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