Thin Film Technology Corp.

Effects of PCB and Manufacturing Design on CPA 0612 Precision Current Sense Resistor Tolerances

Thin Film Technology Corp's CPA 0612 series is a low ohm foil current sense resistor. The resistor features a 4-terminal design with Kelvin connections to minimize the effects of contact resistance and achieve tighter tolerances. Although the resistors are manufactured within specifications, variations in resistance can be observed for a given part under different test conditions and printed circuit board (PCB) designs. As a result, a study was carried out to investigate the factors that may contribute to variations in the CPA's resistance. Factors that are considered are excitation location of current flow, resistor overhang, and PCB copper thickness.

The excitation location of current flow refers to the point at which current is applied and voltage is measured on a test board. Figure 1 below illustrates the CPA resistor mounted on a test board with three excitation locations, denoted as low probing, middle probing, and high probing excitation. The arrows in Figure 1 represent the flow of current for a given excitation location.

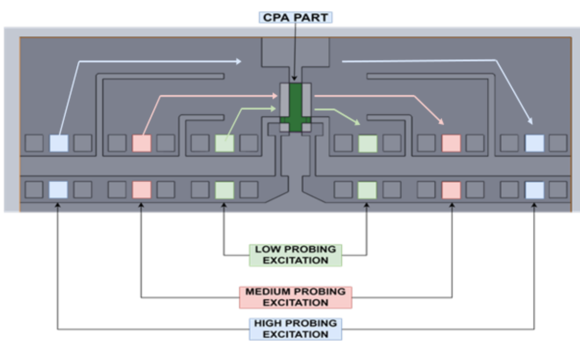


Figure 1. CPA Part on Test Board with Excitation Locations

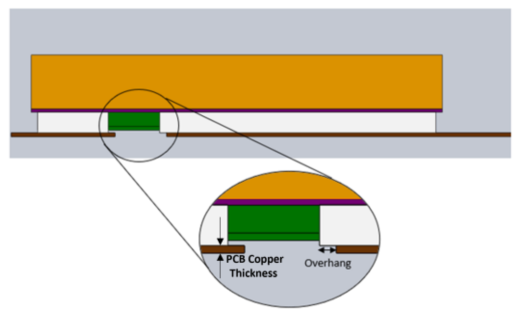


Figure 2. Overhang Condition

Figure 2 above depicts the resistor overhang condition, which refers to the length of misalignment when resistor's electrodes are soldered to the PCB land pattern. This misalignment results in an uneven contact surface between the PCB and the part, potentially creating unwanted concentration of current that can cause the resistance value to drift.

The PCB copper thickness, shown in Figure 2, could also impact the CPA's resistance variation. The copper thickness directly correlates to the long side axis of the current electrode, potentially skewing the expected resistance of the part.

Various experiments and simulations considering the possible combinations of effects previously described were conducted for the CPA part as well as Thin-Film's WRL resistor as a basis of comparison. A slight variation in resistance was observed when using low probing excitation versus high probing excitation as well as when the overhang condition was present. The PCB copper thickness was observed to have a direct correlation to resistance variation which decreases when copper thickness is increased. Table 1 and Table 2 depict the variation in resistance between high and low excitation and variation due to the overhang condition (50 micrometers verses no overhang) when the copper thickness is increased for the CPA and the WRL resistor, respectively.

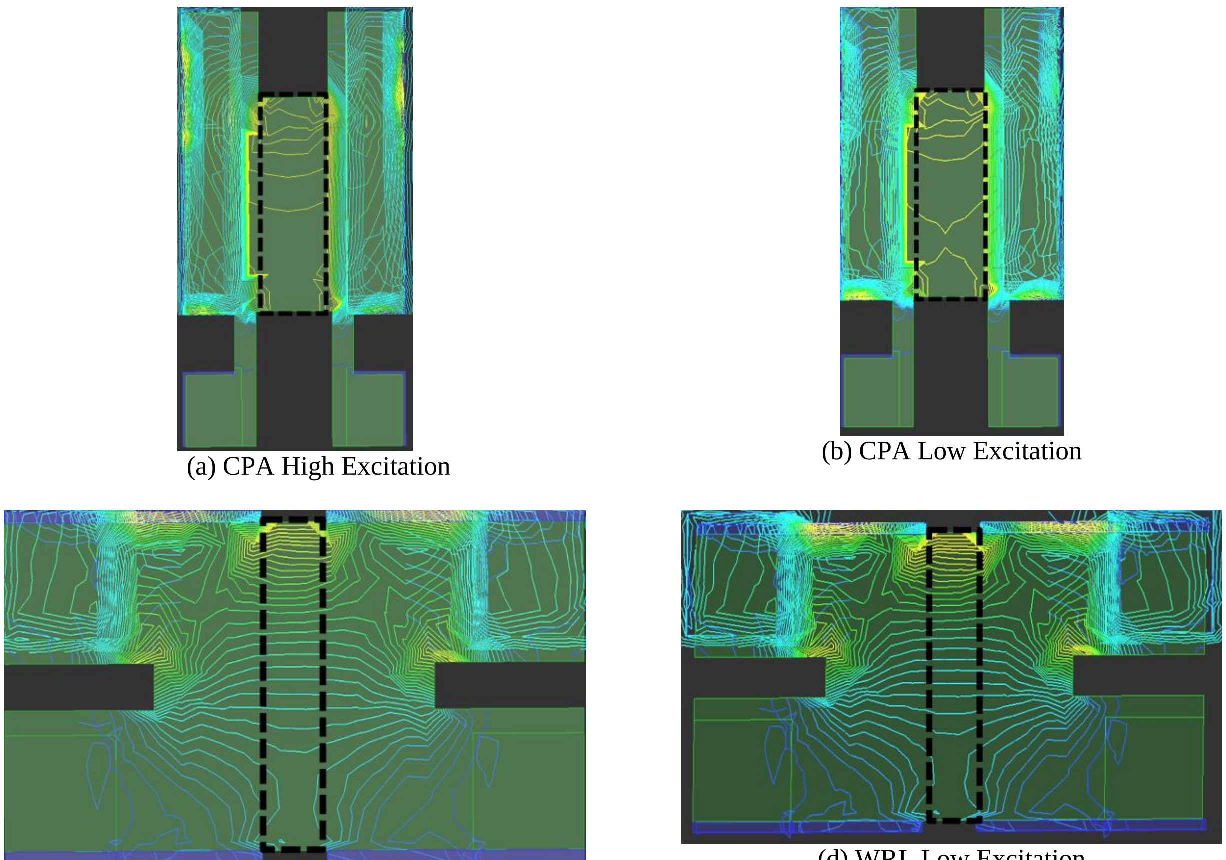
Table 1. Measured Resistance Variation in CPA Resistor for Different PCB Thicknesses

Copper Thickness [oz]	**Simulation**		**Experimentation**	
	Excitation Variation (High – Low)	Overhang Variation	Excitation Variation (High – Low)	Overhang Variation
0.5	5.3%	1.6%	4.7%	0.5%
1	3.4%	1.3%	3.2%	0.9%
2	1.8%	1.0%	2.3%	0.2%

Table 2. Measured Resistance Variation in WRL Resistor for Different PCB Thicknesses

Copper Thickness [oz]	Simulation		Experimentation	
	Excitation Variation (High – Low)	Overhang Variation	Excitation Variation (High – Low)	Overhang Variation
0.5	0.01%	0.6%	0.003%	0.124%
1	0.01%	0.6%	0.004%	0.044%
2	0.01%	0.6%	0.004%	0.044%

It can be observed that the WRL resistance does not experience notable variation when subject to the same conditions. In other words, the performance of the CPA resistor is more susceptible to the condition in which it is used rather than the condition in which it is made. This could be because the CPA resistor may experience more current crowding, or current unevenly passing through the resistor. Figure 3 below shows current contour lines from both the CPA and the WRL simulation results.



(a) CPA High Excitation

(b) CPA Low Excitation

(c) WRL High Excitation

(d) WRL Low Excitation

Figure 3. CPA and WRL Current Density Simulations

Under the same excitation probing, the distribution of current contour lines is evenly spread in the WRL part compared to the CPA part. This shows that the CPA part does experience current crowding. The CPA's tendency to experience current crowding may explain why the resistance varies under different test conditions.

In conclusion, it is observed that different test conditions and PCB designs affect the resistance measured for a CPA current sensor. A WRL resistor was analyzed along with the CPA resistor for a basis of comparison, and the WRL resistor was not as susceptible to errors in PCB design. Comparing the two parts simulations, the variation in the CPA’s resistance could be a result of current crowding. A more thorough simulation can be conducted to further investigate the effects of current crowding.