Vishay Thin Film Engineering Test Report

PTN - THETA J MEASUREMENTS

1. Background

Managing thermal energy in passive devices is a challenge in today circuit assemblies. The demand to reduce the size of electronic assemblies, coupled with the need to increase power levels, has resulted in the need to clearly understand the thermal characteristics of devices. A typical way of quantifying the thermal characteristics of devices is by examining the temperature difference between the highest temperature region of the component and the surrounding areas such as the case or termination and the board or substrate on which it is mounted for testing. Knowing these temperature values, we can calculate the thermal resistance properties which are expressed as Theta J values in °C/W.

The typical formulas for these Theta J calculations are as follows:

Theta $J_C = (T_J - T_C)/P$
Theta $J_B = (T_J - T_B)/P$
Theta $J_A = (T_J - T_A)/P$

Where:

Theta J_C = Junction to Case (Termination) Thermal Resistance
Theta J_B = Junction to Board Thermal Resistance
Theta J_A = Junction to Ambient Thermal Resistance

and:

T_J = Junction temperature or in this case the highest temperature region of the film area on the device under test
T_C = Case temperature or in this case temperature of the termination on the device under test
T_B = Board temperature or in this case, the temperature of the test cards used for the thermal analysis
T_A = Ambient temperature of the test lab where the analysis was performed
P = Power applied to the device under test

2. Experimental Methods

Thermal imaging for this testing was conducted on a range of samples by mounting one device per 2.25" x 4" test card. The test cards were constructed with a 2.5 mil copper metallization on both surfaces. Thermal vias on 120 mil centers provided heat transfer between surfaces of the test card. This test card design, shown in figure 1 below, essentially creates and infinite heatsink for the purpose of this testing. The list of samples tested is shown in table 1 below.

TABLE 1 - SAMPLE DETAILS

CASE SIZE	RESISTANCE VALUE		
	LOW	CRITICAL	HIGH
0603	10 Ω	25.2 kΩ	80 kΩ
1206	10 Ω	40.2 kΩ	90.9 kΩ
2512	10 Ω	40.2 kΩ	65.5 kΩ

Thermal measurements were taken on the device under test using a FLIR SC645 camera equipped with a 50 µm close-up IR lens in the arrangement shown in figure 2 . In order to obtain a range of Theta J values, the devices under test were powered at 1x, 2x, and 3x their rated power. At the time the initial power was applied and during the change in applied power between levels, a video capture of the device under test was made for duration of 3 minutes.

During the data analysis, temperature values were obtained one minute into the recording which was determined to be the time for the device to reach a steady state temperature. The location of the temperature readings is shown in figure 1.

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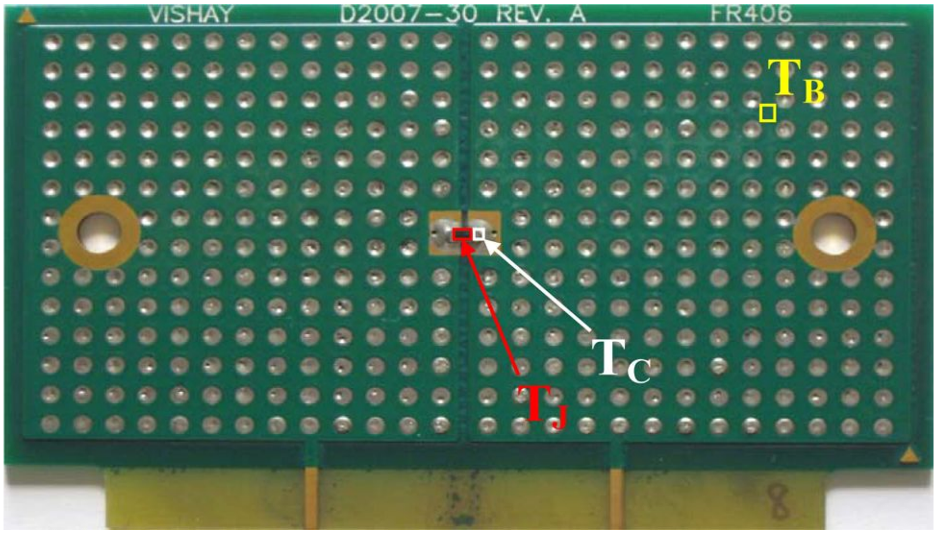

Fig. 1

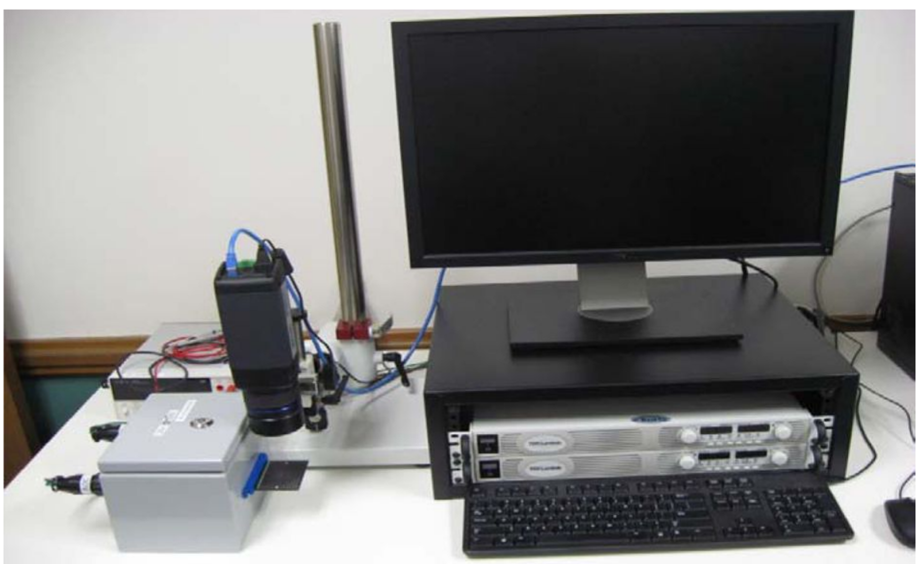

Fig. 2

Using these temperature readings, and the ambient temperature of the test lab, the Theta J values were calculated using the formulas defined in the background section above.

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3. Results and Discussion

Table 2 below, is a summary of Theta J test results. As the data shows, there is good agreement between resistance values, within each case size chip. This data is also represented graphically in figures 3 through 11 of Appendix A.

TABLE 2 - THETA J VALUE SUMMARY TEST RESULTS SUMMARY

CASE SIZE	DEVICE WEIGHT (g)	RESISTANCE VALUE (Ω)	RATED POWER (mW)	APPLIED POWER (mW)	T_J MAX. (°C)	THETA J_C (°C/W)	THETA J_B (°C/W)	THETA J_A (°C/W)
0603	0.003	10	150	150	32.03	32.00	48.41	55.14
				300	40.07	34.70	49.04	54.66
				450	48.58	35.25	49.28	54.50
		25 200		150	31.88	31.50	51.36	61.10
				300	39.47	31.98	49.35	57.07
				450	47.87	30.38	46.24	53.09
		80 000		150	32.13	23.64	40.52	49.43
				300	42.65	27.14	45.42	53.32
				450	46.25	26.82	42.59	48.50
1206	0.009	10	400	400	40.44	21.08	30.84	35.88
				800	58.72	21.89	31.78	37.46
				1200	78.03	22.55	32.52	37.70
		40 200		400	39.46	18.76	30.47	38.40
				800	54.83	20.17	31.16	37.86
				1200	70.79	20.63	32.08	38.16
		90 900		400	38.35	15.27	27.11	34.82
				800	53.54	15.94	27.82	34.53
				1200	67.01	16.36	28.32	34.61
2512	0.033	10	1000	1000	50.93	15.52	19.97	25.41
				2000	77.48	15.63	19.96	24.43
				3000	104.69	15.98	20.14	24.50
		40 200		1000	65.98	16.06	19.70	24.39
				2000	112.98	16.81	20.18	24.17
				3000	164.07	17.16	20.84	24.94
		65 500		1000	51.82	11.70	16.27	23.74
				2000	82.70	15.49	20.66	25.68
				3000	114.96	16.06	21.14	25.88

4. Conclusion

The results of this testing provide designers with critical thermal resistance information necessary to the design on high density circuit assemblies. The Theta J values we observed are somewhat better than those reported by other manufacturers based on comparable test conditions.

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Appendix A

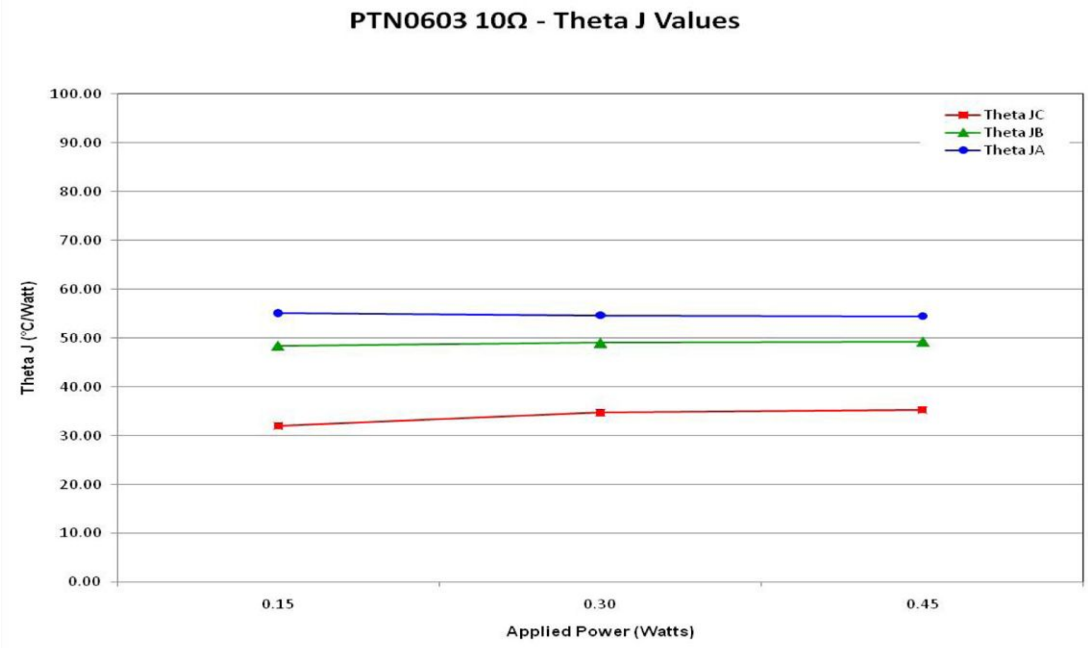

Fig. 3

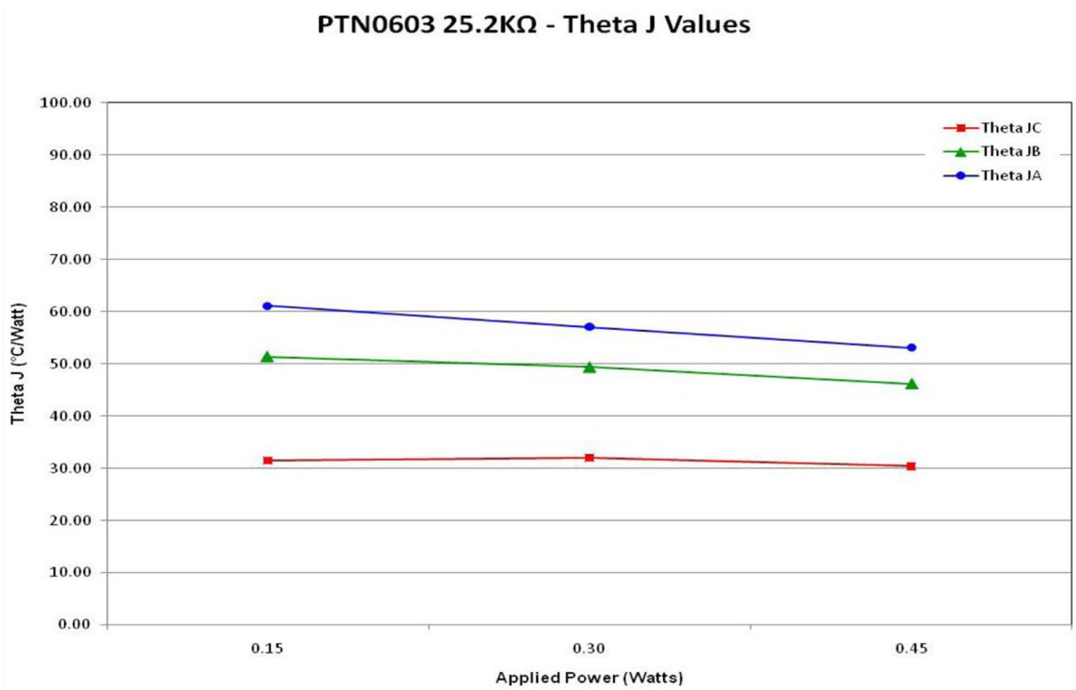

Fig. 4

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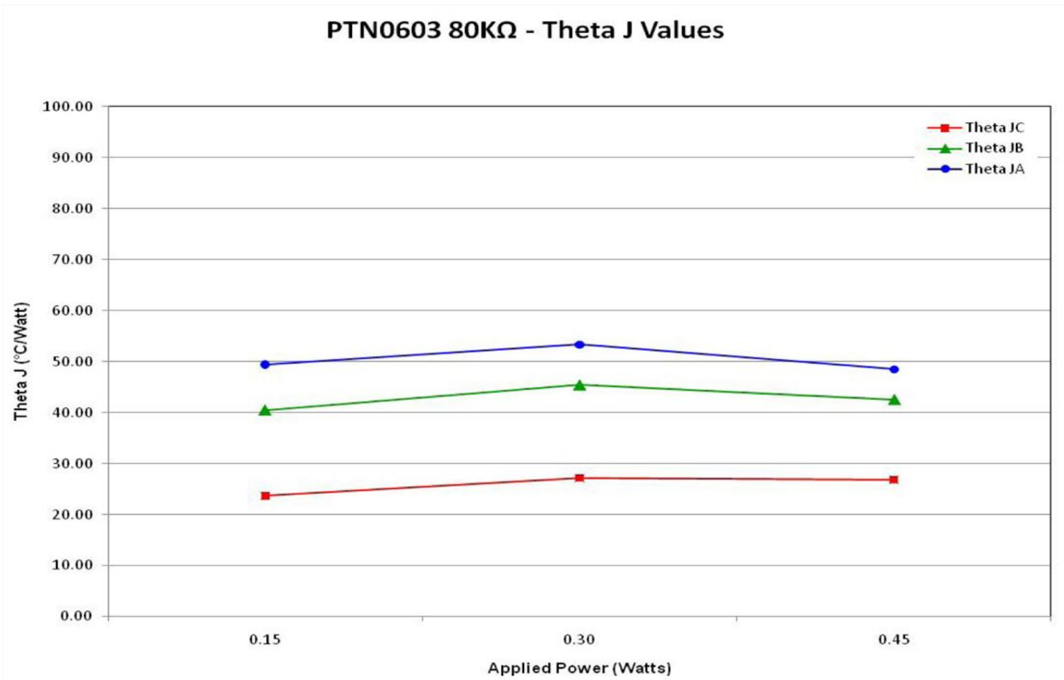

Fig. 5

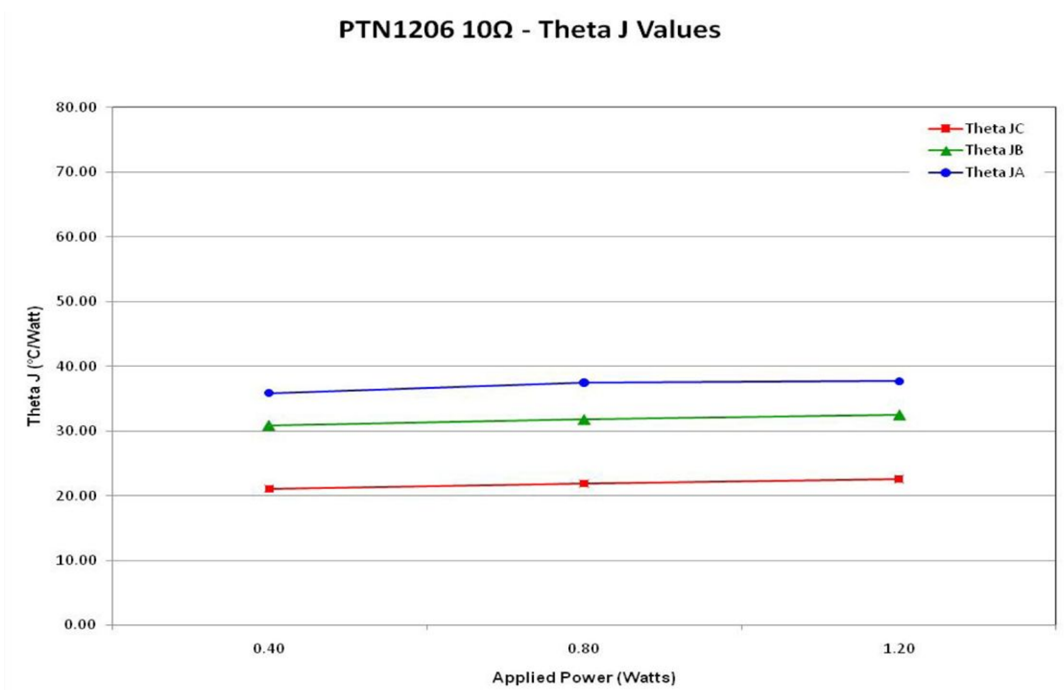

Fig. 6

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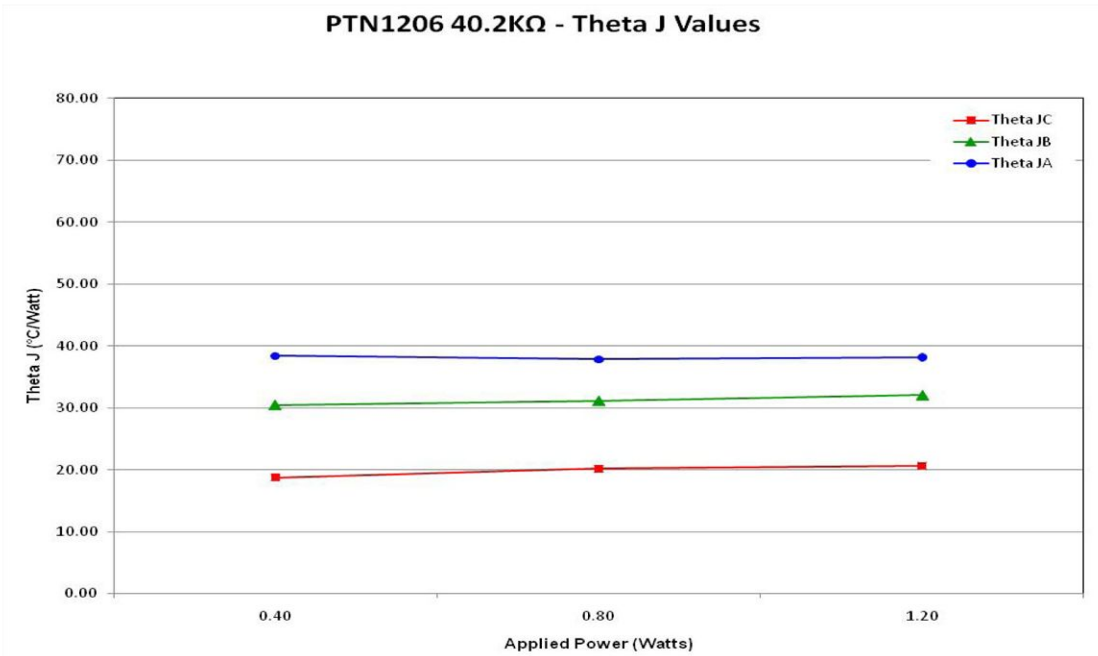

Fig. 7

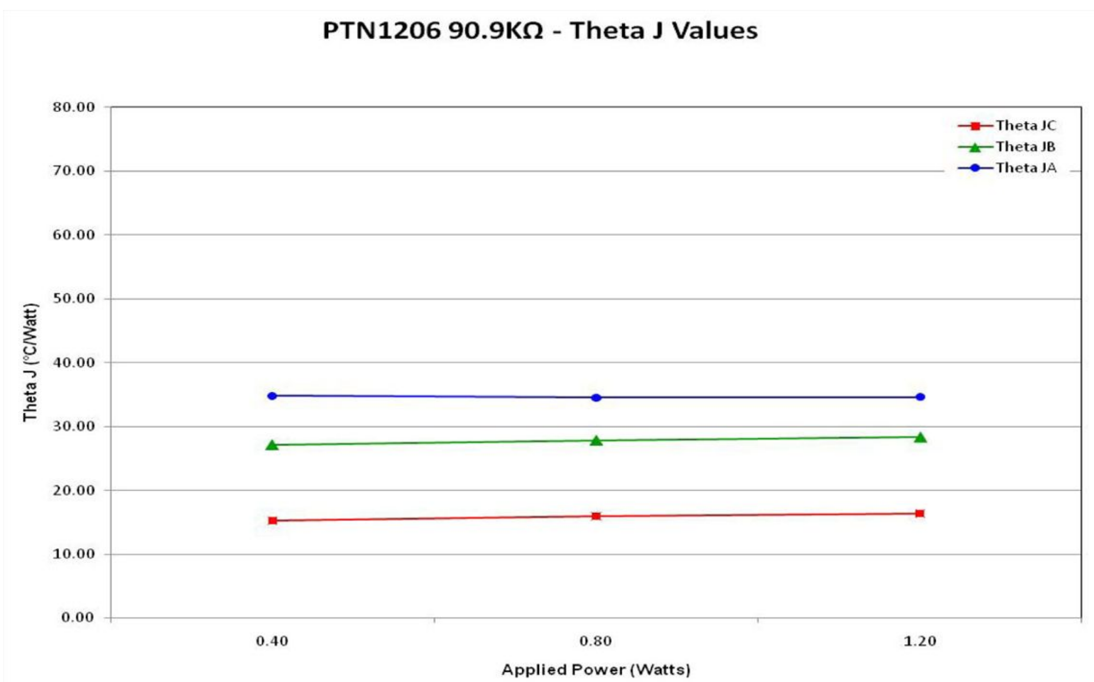

Fig. 8

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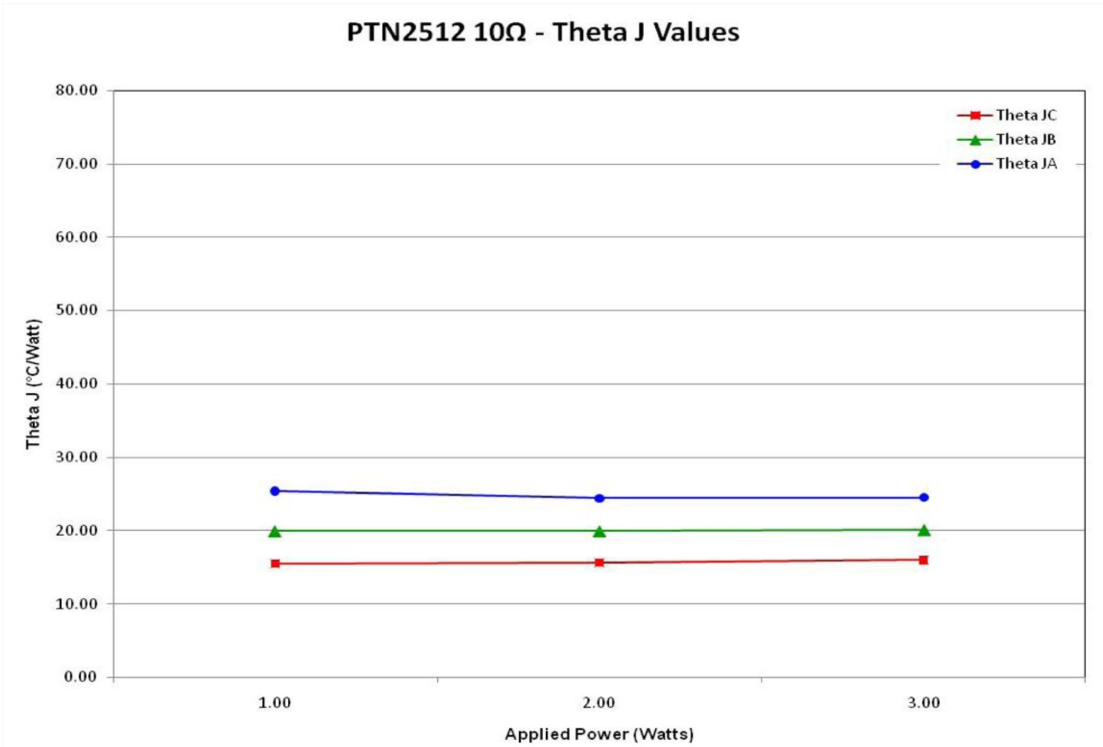

Fig. 9

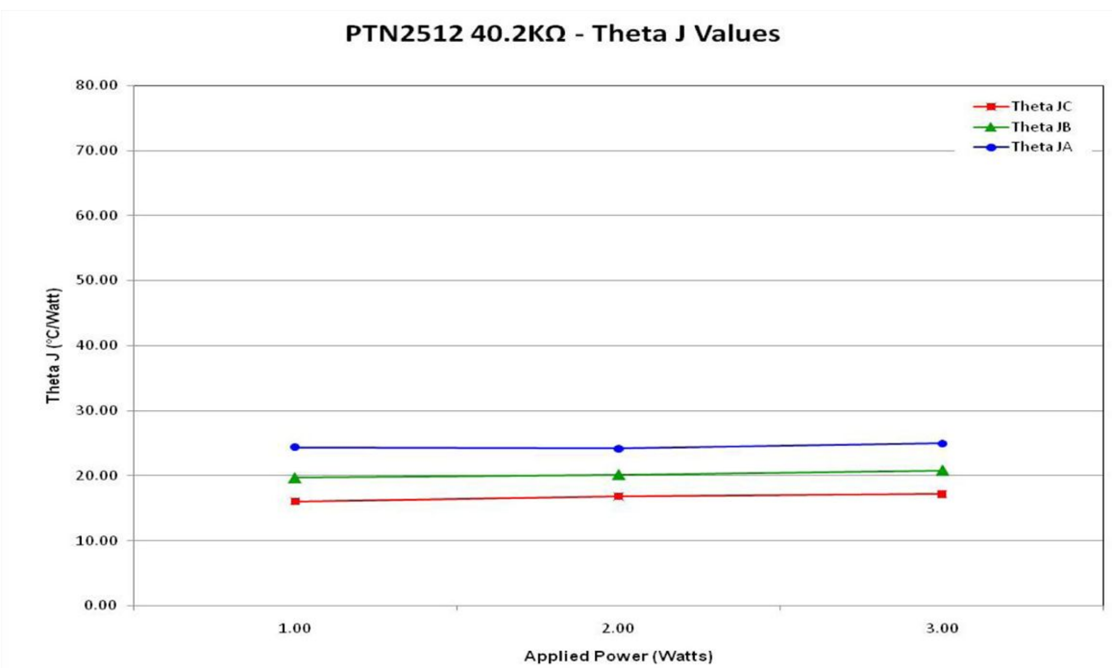

Fig. 10

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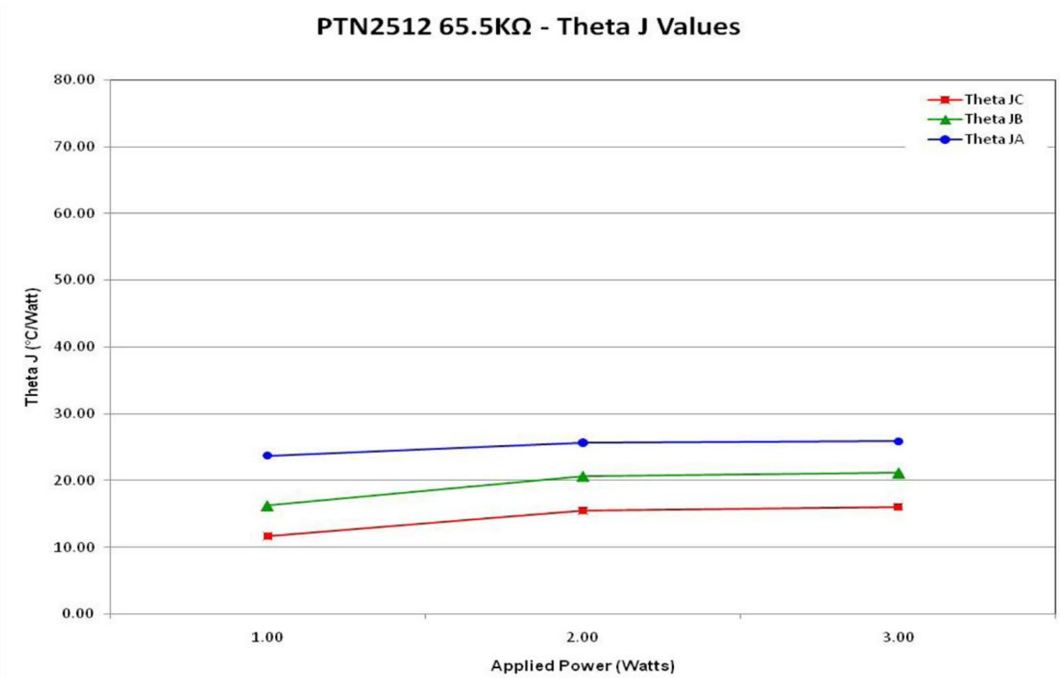

Fig. 11