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Power Handling Test Report

TT9 Series Attenuators
Power Simulation and Testing

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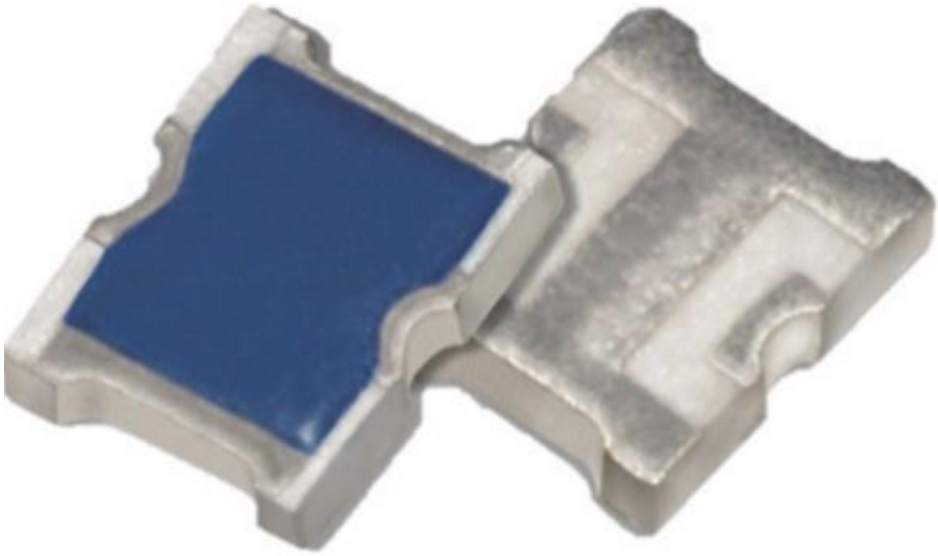
August 28th, 2019



1. Scope

The purpose of this report is qualify the power handling capability of the TT9 product line. This report describes the test procedure and presents test results to support qualification. The power is supplied using DC (Direct Current) power to provide maximum heat for the device's internal resistors on a destruct type Printed Circuit Board (PCB). Electrical tests are completed by measuring DC Resistance (DCR)and Calculating DC Attenuation (DCA). A batch of 4 different attenuation chips with 5 samples in each batch is studied. The Group A test is thermal shock, followed by an 168 hour burn-in of which at least half of the total burn-in time is at a temperature of 100 C. The change is DCA is recorded after each step. The cumulative change in DCA is analyzed to determine the part's power handling qualification.

Thermal Finite Element Analysis (FEA) simulations are performed to calculate the maximum power handling of the family of parts. The simulation model is validated by physical testing of the 1dB, 3dB, 6dB and 10 dB attenuators.

The motivation for this report came from Project DD-215756 to qualify the power handling capabilities of the TT9 product line. The previous data sheet specifies 500 mW power handling for all attenuation values. Real power handling of the attenuators is higher for all attenuation values and much higher for lower attenuation values

2. Specifications

The TT9 series is offered as a SMT. The series has attenuation values between 1 to 10 dB in 1 dB increments. Both a RoHS and non-RoHS version is offered.

	Attenuation Accuracy	
Attenuation (dB)	DC - 15 GHz	15 - 20 GHz
0 - 4	+/- 0.50	+/- 0.50
5 - 10	+/- 0.50	+/- 0.75

Table 1 – Specification: Attenuation Accuracy

VSWR	
DC - 20 GHz	10 - 20 GHz
1.40:1 Typical	1.70:1 Max

Table 2 – Specification: VSWR

Input Power CW	
Attenuation	Power
(dB)	(W)
0 - 1	4.00
2 - 3	1.50
4 - 6	1.25
7 - 10	1.00
Full Rated Power at 100 C. Power is derated linearly to 0 Watts at 150 C	

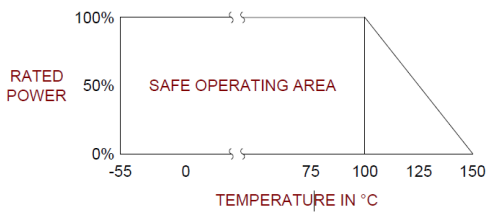


Table 3 - Input Power CW and Power Derating at Temperature

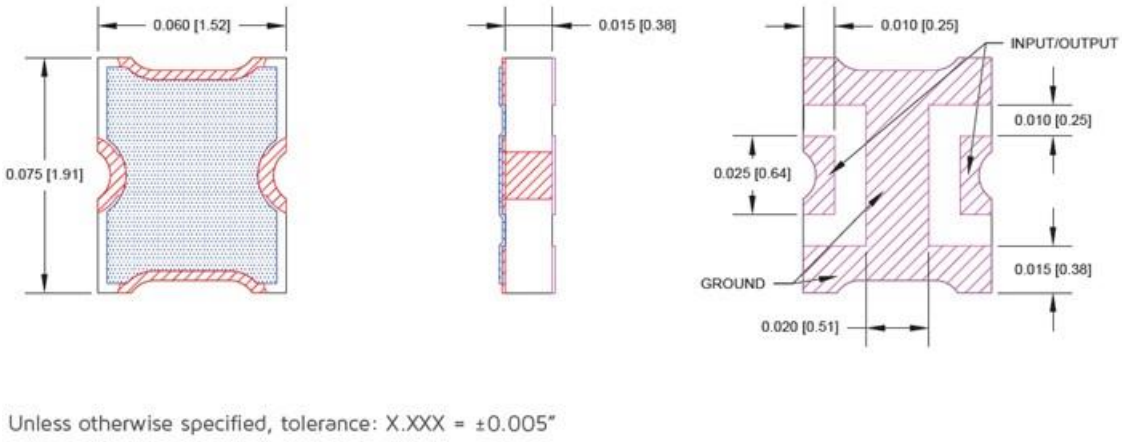


Figure 1 – 2D Drawing TT9 Mechanical Footprint

	Inches						MM					
Part Number	A	B	C	D	S	W	A	B	C	D	S	W
TT9XXSMT	0.025	0.015	0.016	0.049	0.018	0.070	0.64	0.38	0.41	1.24	0.46	1.78

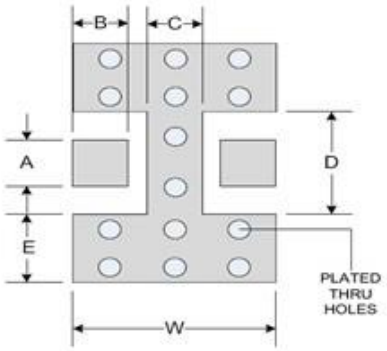


Figure 2 – Suggested Mounting Footprint

3. Thermal FEA Simulation

Thermal Finite Element Analysis (FEA) simulations are performed to calculate the maximum power handling of the family of parts. The simulations are calculated for chips with attenuation values from 1 to 10 dB in 1 dB increments.

The simulations model includes the attenuator, PCB and the heatsink. The simulation takes into account conduction heat transfer into the heat sink and free convection transfer into the ambient surroundings. The base of the heatsink is set to an isothermal boundary at 100 C. The results show the amount of power required to heat any point on the film to 150 C. The temperature of 150 C is a conservative design point to avoid resistance drift due to thermal coefficient of resistivity (TCR). Significantly higher film temperature can lead to a drift in resistance, change in attenuation, reduced operating life or part failure.

The results of the simulation show that the TT9 attenuators should be capable of handling power levels at 2 to 8 times higher than the previously rated spec of 500 mW. The physical testing will test 4 attenuation value: 1 dB, 3 dB, 6 dB and 10 dB at power levels of 4.00 W, 1.50 W, 1.25 W, and 1.00 W, respectively.

- Materials:
  - TT Substrate: Alumina 96% (k = 20 W/mK)
  - PCB: Rogers R06035T at 0.010" thick with 1oz Copper on both sides
  - Base: Aluminum 6061 0.25" thick
- Thermal Contacts:
  - PCB to Aluminum Base: Thermal Grease Wakefield-120 = 3.46e-5 Km^2/W
    - Thickness = 0.001"; K = 0.735 W/mK
  - Solder: Sn62 with 30% porosity = 1.45e-6 Km^2/W
    - Thickness = 0.002"; K = 50 W/mK x 30% porosity = 35 W/mK

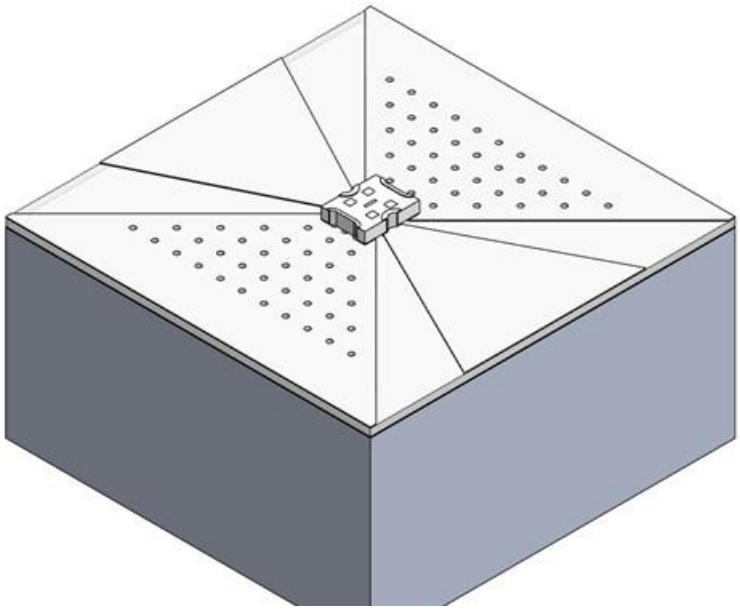


Figure 3 – 3D Model of Simulation

TT9 - Attenuator Power Dissipation					
Attenuation (db)	Input Power (W)	R1 (Input) (W)	R2 (Output) (W)	R3 (Ground) (W)	Total Power (W)
1	4.08	0.2366	0.1877	0.4202	0.8446
2	2.68	0.3082	0.1956	0.4878	0.9916
3	1.71	0.2924	0.1471	0.4138	0.8533
4	1.7	0.3842	0.1547	0.4845	1.0234
5	1.5625	0.4375	0.1391	0.4922	1.0688
6	1.225	0.4067	0.1029	0.4079	0.9175
7	1.412	0.5394	0.1073	0.4829	1.1296
8	1.39	0.5991	0.0945	0.4754	1.1690
9	1.37	0.6521	0.0822	0.4631	1.1974
10	1.185	0.6150	0.0616	0.3899	1.0665

Table 4 – Attenuator Power Dissipation

TT9 - Power Rating		
Attenuation (db)	Simulated Power Handling (W)	Power for Burn-In Test (W)
1	4.08	4.00
2	2.68	-
3	1.71	1.50
4	1.7	-
5	1.5625	-
6	1.225	1.25
7	1.412	-
8	1.39	-
9	1.37	-
10	1.185	1.00

Table 5 – Power Rating

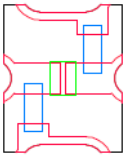
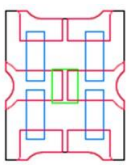
Attenuation Values	Resistor Layout
1 to 4 dB	
5 to 10 dB	

Figure 4 – Resistor Layout of TT9 Attenuator family

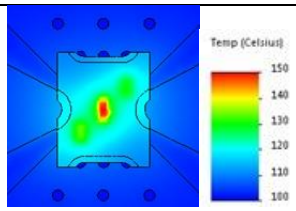
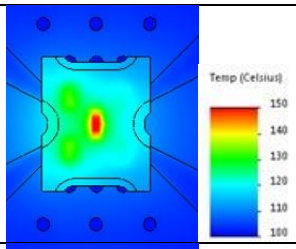
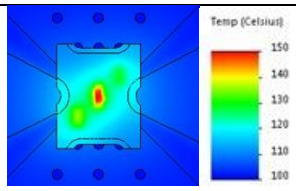
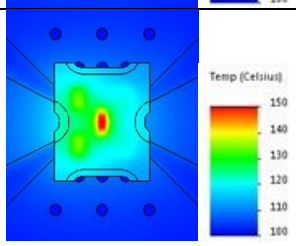
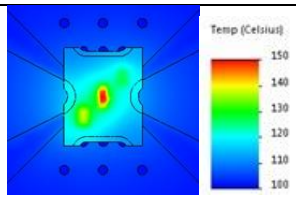
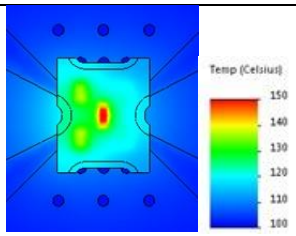
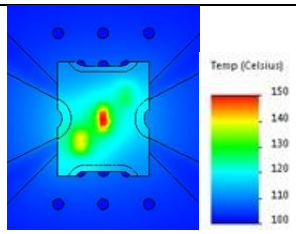
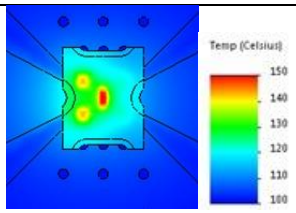
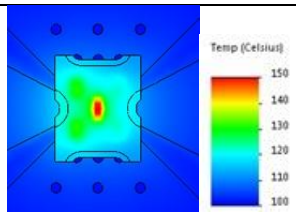
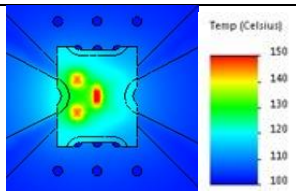
Attenuation Values	Thermal FEA Plot	Attenuation Values	Thermal FEA Plot
1 dB		6 dB	
2 dB		7 dB	
3 dB		8 dB	
4 dB		9 dB	
5 dB		10 dB	

Figure 5 – Thermal FEA Plots of TT9 Attenuator family

4. Testing

The attenuator family shall be divided into four (4) power handling test groups. Each power handling group will have one attenuation value tested to qualify the group. Attenuation values of 1dB, 3dB, 6dB & 10dB were tested. Attenuation values in each power group are noted in the Specifications section and also in the appropriate Specification Control Drawing (SCD) of the attenuator family. The Internal Qualification Inspection performed is listed in TP-9268.

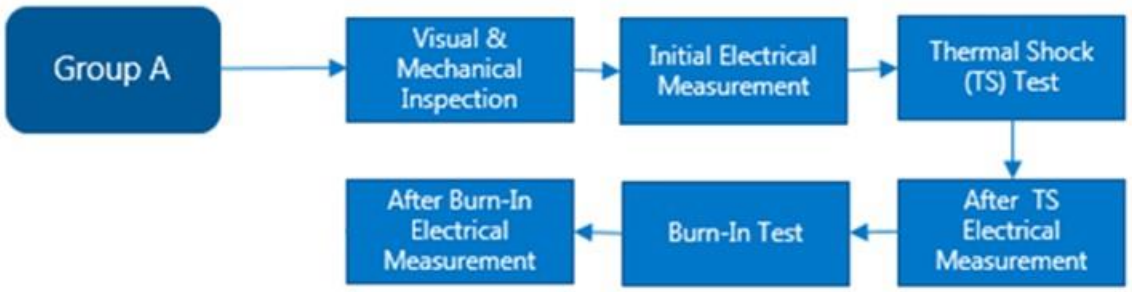


Figure 6 – Flowchart of Test Procedure

Group A: Each inspection lot shall be subjected to 100% Group A Inspection for all attenuation values. Devices must be mounted to a PCB prior to Electrical Inspection.

Visual / Mechanical Inspection: All devices Verify that materials, design, construction, physical dimensions, markings and workmanship are in accordance with applicable requirements per the appropriate SCD.

Initial (INI) Electrical: Measure and record DC resistance between I/O path and from each I/O port to Ground paths in accordance with MIL-STD-202, Method 303. Calculate DC Attenuation. Acceptance limits shown in the specifications section or SCD.

Thermal Shock: Subject attenuators to 10 cycles of thermal shock, -55°C to +125°C in accordance with MIL-STD-202, Method 107. See Table 1:

Table 6 - Thermal Shock requirements listed in TP-9268

STEP	TEMPERATURE (°C)	TIME (MINUTES)
1	-55 (+0/-3)	15 min.
2	+25 (+10/-5)	5.0 max.
3	+125 (+3/-0)	15 min.
4	+25 (+10/-5)	5.0 max.

After Thermal Shock (ATS) Electrical: Measure and record DC resistance between I/O path and from each I/O port to Ground paths in accordance with MIL-STD-202, Method 303. Calculate DC Attenuation. Acceptance limits shown in the specifications section or SCD. All DCA measurements must be within ±.2dB of the INI DCA measurements.

Burn In: Burn-in properly mounted and terminated devices in increasing DC power and base temperature steps until the maximum power for each test group

(attenuation value) and 100°C base temp is achieved. The entire test duration must be 168 hours minimum with at least half of the test period at the maximum temperature and power specified in the SCD. Record and Report the power, temperature and duration for each step.

After Burn-In (ABI) Electrical: Measure and record DC resistance between I/O path and from each I/O port to Ground paths in accordance with MIL-STD-202, Method 303. Calculate DC Attenuation. Acceptance limits shown in the specifications section or SCD. All DCA measurements must be within ±.2dB of the INI DCA measurements.

5. Test Results

The change in attenuation was measured after each test step for 5 samples of 4 attenuation values. There are a total of 20 measurements. The acceptance limits of the test is a +/- 0.2 dB cumulative change in attenuation value.

The change is attenuation for each sample after each test is shown below in Table 9. A graphical representation showing average change in attenuation for a 5 unit sample size at each attenuation value is shown in Figure 6. The bar graph shows the average of each of the samples along with error bars showing one standard deviation. The upper and lower limits at +0.2 dB and -0.2 dB on the chart represent the acceptable limits of variation of attenuation for the qualification test.

The product passed the test. The worst performing test batch is the 20 dB. The average cumulative attenuation change is 0.008 dB with a standard deviation of 0.006 dB. A 99.7% confidence interval expects a maximum attenuation change of +/- 0.026 dB. This is 13% of the permissible +/- 0.2 dB change. The product passed the test. It is expected that the product may be able to handle slightly higher power if another round of testing was to be conducted.

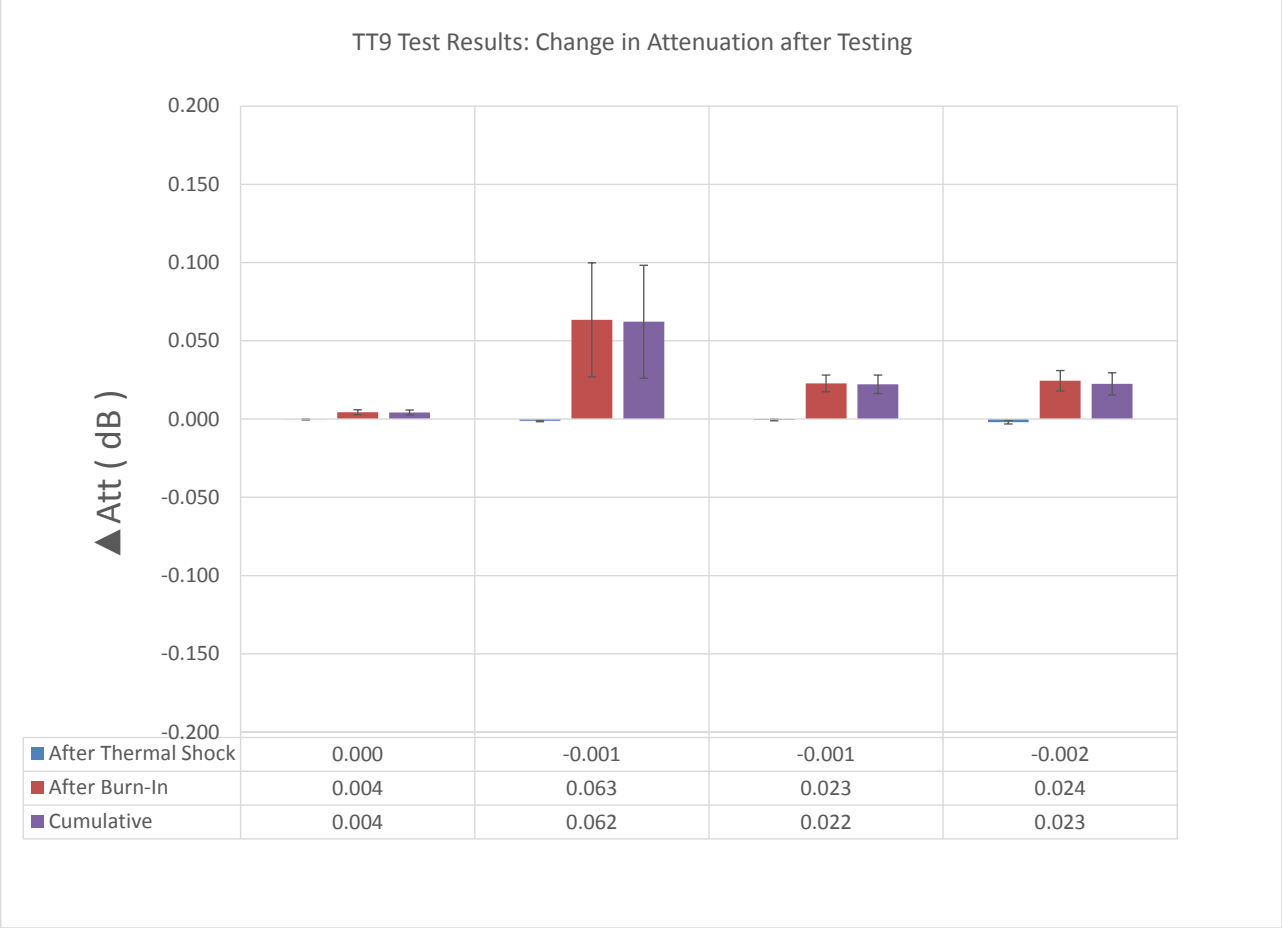


Figure 7 – Graphical Results of TT9 Test

Test Results - Change in Attenuation (dB)						
Attenuation	**After Thermal Shock**		**After Burn-In**		**Cumulative**	
(dB)	**AVG**	**STDEV**	**AVG**	**STDEV**	**AVG**	**STDEV**
1	0.000	0.000	0.004	0.002	0.004	0.002
3	-0.001	0.000	0.063	0.036	0.062	0.036
10	-0.001	0.001	0.023	0.005	0.022	0.006
20	-0.002	0.001	0.024	0.007	0.023	0.007

Table 7 – Test Results showing average and standard deviation of change in attenuation

6. Conclusion

The TT9 Attenuator product line will successfully meet the revised power rating. The previous power rating for all attenuation values was 500 mW.

The revised power rating for the 0 to 1 dB is 4.00 W, the 2 to 3 dB is 1.50 W, the 4 to 6 dB is 1.25 W and the 7 to 10 dB is 1.00 Watts. There have been no physical changes to the design geometry or materials used in constructing the TT9. Thermal simulation data was used to calculate the expected power handling. Physical testing verified the power handling capability. The product was subject to thermal shock and a 168 burn-in test. Statistical analysis of test results show a worst case attenuation change on the 3dB

attenuator. The worst case change of 0.17 dB within a 99.7% confidence interval. This value is close to the 0.2 dB permissible change in attenuation after testing.

The application environment and the efficiency of the heatsink will determine the power handling capabilities of the chip. The power rating of the High Reliability version of the TT9 remains at xxx mW.