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# Power Handling Test Report

## TS06XXF Series Attenuators
## Power, Simulation and Testing

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## 1. Scope

The purpose of this report is qualify the power handling capability of the TS06XX 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 4 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. Then the same chip goes to a Group B test consisting of a Short Term Overload (STOL). 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, 10dB and 20 dB attenuators.

The motivation for this report came from Project DD-215755 to qualify the power handling capabilities of the TS06XX product line. The previous data sheet specifies 200 mW power handling or attenuation values. Real power handling of the attenuators is much higher or lower attenuation values.

## 2. Specifications

The TS06XX series is offered as a planar, single wrap, triple wrap or wire bondable version. The series has attenuation values between 1 to 12 dB in 1 dB increments, 15 dB and 20 dB. Both a RoHS and non-RoHS version is offered.

| | **Attenuation Accuracy** | | **VSWR ( x:1 Typical )** | |
|---|---|---|---|---|
| Attenuation ( dB ) | DC - 10 GHz | 10 - 20 GHz | DC - 10 GHz | 10 - 20 GHz |
| 0 | CONTINUITY ONLY | | CONTINUITY ONLY | |
| 1 - 9 | +/- 0.50 | +/- 0.50 | 1.25:1 | 1.35:1 |
| 10 - 20 | +/- 0.75 | +/- 1.00 | 1.25:1 | 1.35:1 |

*Table 1 – Attenuation Accuracy and VSWR*

| **Input Power CW** | |
|---|---|
| Attenuation | Power |
| ( dB ) | ( W ) |
| 0 - 1 | 3.00 |
| 2 - 3 | 1.20 |
| 4 - 10 | 0.60 |
| 11 - 20 | 0.50 |
| Full Rated Power at 100 C. Power is derated linearly to 0 Watts at 150 C | |

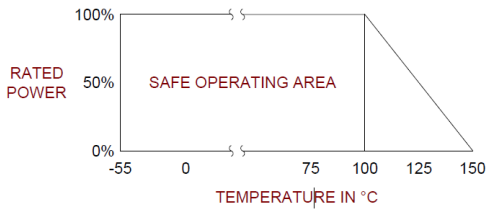



*Table 2 - Input Power CW and Power Derating at Temperature*

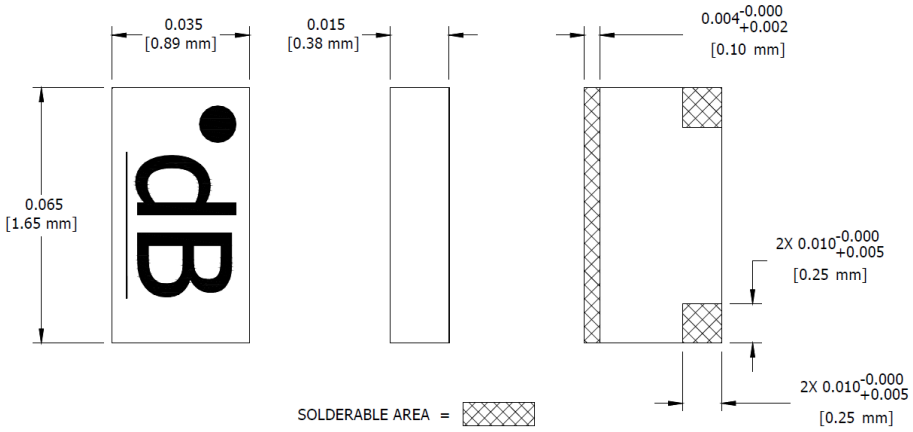
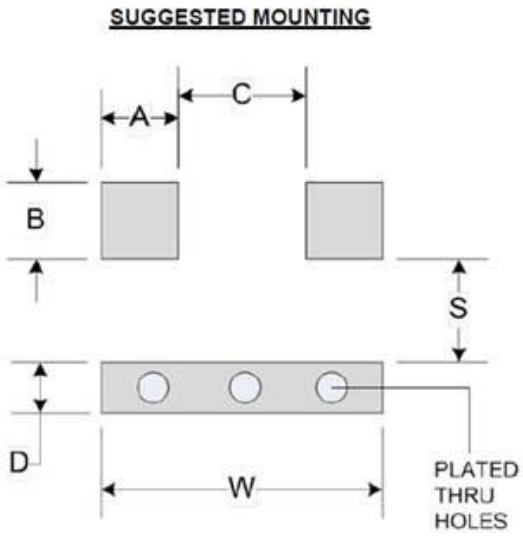



*Figure 1 – 2D Drawing TS06XXF Mechanical Footprint*




| | Inches | | | | | | mm | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Part Number | A | B | C | D | S | W | A | B | C | D | S | W |
| TS06xxF | 0.018 | 0.018 | 0.033 | 0.020 | 0.016 | 0.068 | 0.46 | 0.46 | 0.84 | 0.51 | 0.41 | 1.73 |

*Figure 2 – 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 12 dB in 1 dB increments, 15 dB and 20 dB.

The simulations model includes the attenuator PCB, fixture board 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 film temperature of 150 C is chosen as 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 and change in attenuation.

The results of the simulation show that the TS06 attenuators should be capable of handling power levels at 2.5 to 15 times higher than the rated spec. The physical testing will **test 4 attenuation value: 1, 3, 10 and 20 at power levels of 3, 1.2, 0.6, and 0.5 Watts, respectively.**

- Materials:
  - TS06 Substrate: Alumina 99.5% ( k = 29 W/mK )
  - PCB: Rogers R06035T at 0.010" thick with 1oz Copper on both sides
  - Base: Aluminum 6061 0.25" thick
  - Heatsink: Copper Plate 1" 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

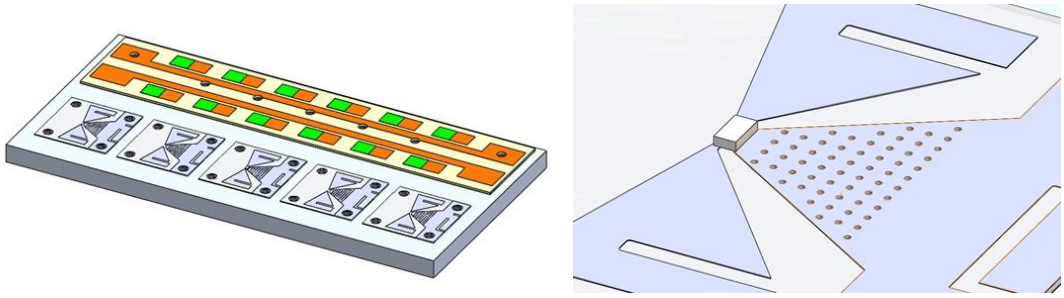


*Figure 3 – 3D Model of Test Setup Assembly and Individual Test Board*

| TS06XXF - Attenuator Power Dissipation | | | | | |
|---|---|---|---|---|---|
| Attenuation ( db ) | Input Power ( W ) | R1 (Input ) ( W ) | R2 ( Output ) ( W ) | R3 ( Ground ) ( W ) | Total Power ( W ) |
| 1 | 3.679 | 0.2134 | 0.1692 | 0.3789 | 0.7616 |
| 2 | 1.656 | 0.1904 | 0.1209 | 0.3014 | 0.6127 |
| 3 | 1.406 | 0.2404 | 0.1209 | 0.3403 | 0.7016 |
| 4 | 1.172 | 0.2649 | 0.1067 | 0.3340 | 0.7055 |
| 5 | 1.018 | 0.2850 | 0.0906 | 0.3207 | 0.6963 |
| 6 | 0.889 | 0.2951 | 0.0747 | 0.2960 | 0.6659 |
| 8 | 0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 9 | 0.824 | 0.3922 | 0.0494 | 0.2785 | 0.7202 |
| 10 | 0.791 | 0.4105 | 0.0411 | 0.2602 | 0.7119 |
| 11 | 0.751 | 0.4194 | 0.0338 | 0.2366 | 0.6898 |
| 12 | 0.745 | 0.4455 | 0.0283 | 0.2242 | 0.6981 |
| 15 | 0.641 | 0.4465 | 0.0144 | 0.1590 | 0.6198 |
| 20 | 0.587 | 0.4802 | 0.0047 | 0.0963 | 0.5811 |

*Table 3 – Attenuator Power Dissipation*

| TS06XXF - Power Rating | | |
|---|---|---|
| Attenuation ( db ) | Simulated Power Handling ( W ) | Power for Burn-In Test ( W ) |
| 1 | 3.679 | 3 |
| 2 | 1.656 | - |
| 3 | 1.406 | 1.2 |
| 4 | 1.172 | - |
| 5 | 1.018 | - |
| 6 | 0.889 | - |
| 8 | 0 | - |
| 9 | 0.824 | - |
| 10 | 0.791 | 0.6 |
| 11 | 0.751 | - |
| 12 | 0.745 | - |
| 15 | 0.641 | - |
| 20 | 0.587 | 0.5 |

*Table 4 – Power Rating*

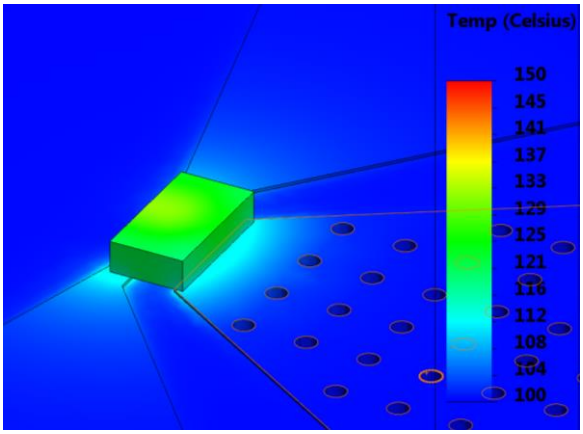
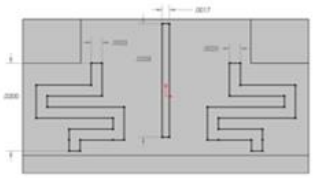
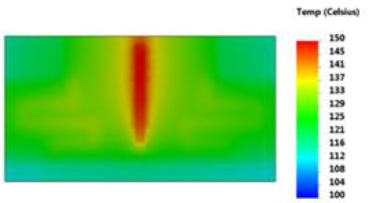
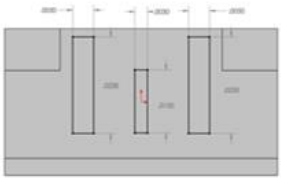
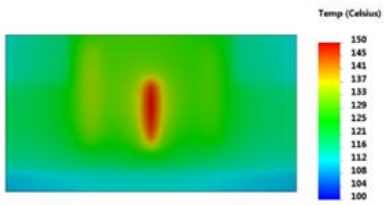
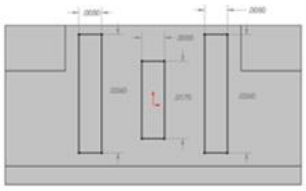
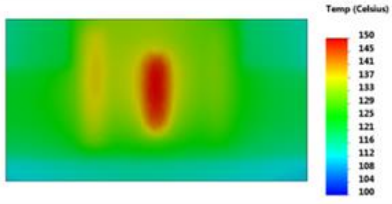
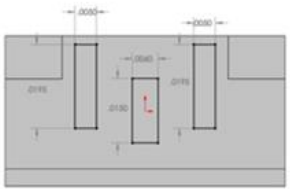
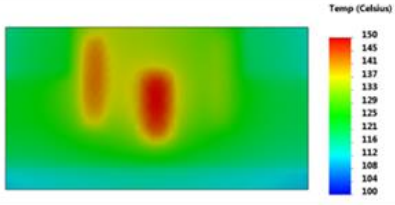
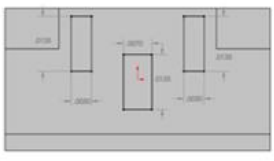
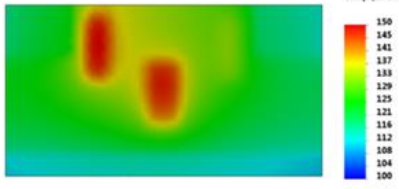



*Figure 4 – Thermal FEA Plot of Temperature Distribution on PCB and Backside of Chip*

| | | |
|---|---|---|
| 1 dB |  |  |
| 2 dB |  |  |
| 3 dB |  |  |
| 4 dB |  |  |
| 5 dB |  |  |

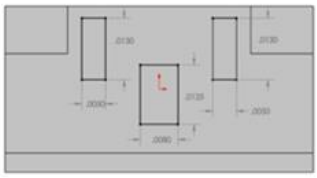
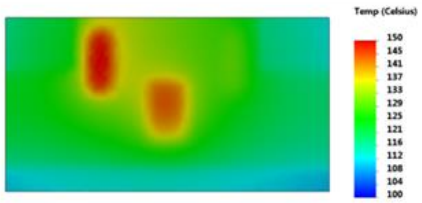
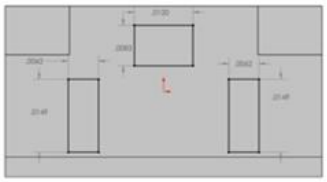
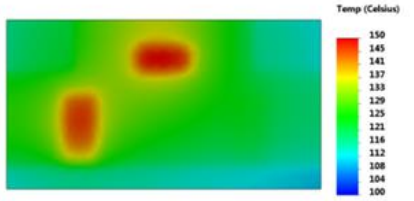
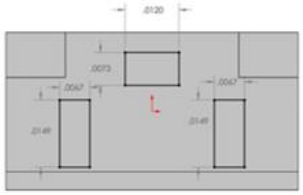
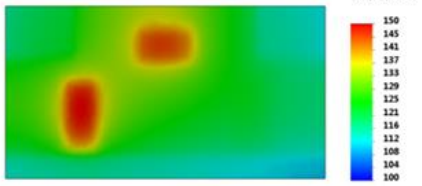
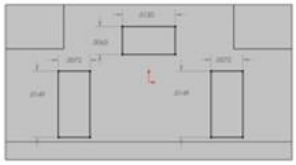
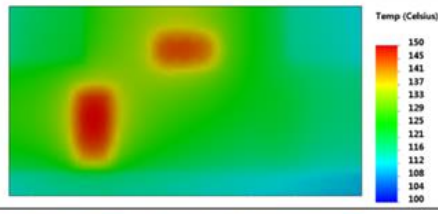
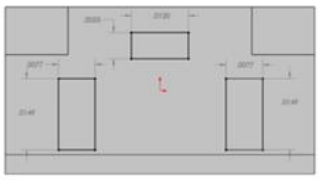
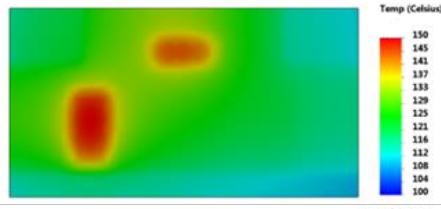
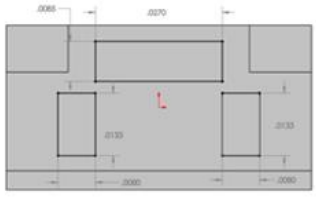
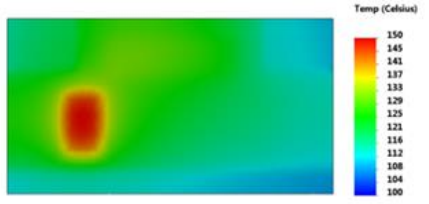
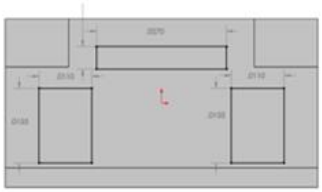
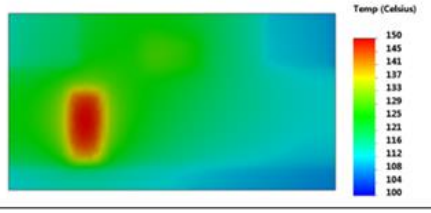
| | | |
|---|---|---|
| 6 dB |  |  |
| 9 dB |  |  |
| 10 dB |  |  |
| 11 dB |  |  |
| 12 dB |  |  |
| 15 dB |  |  |
| 20 dB |  |  |

*Figure 5 – Thermal FEA Plots of TS06 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-9251.

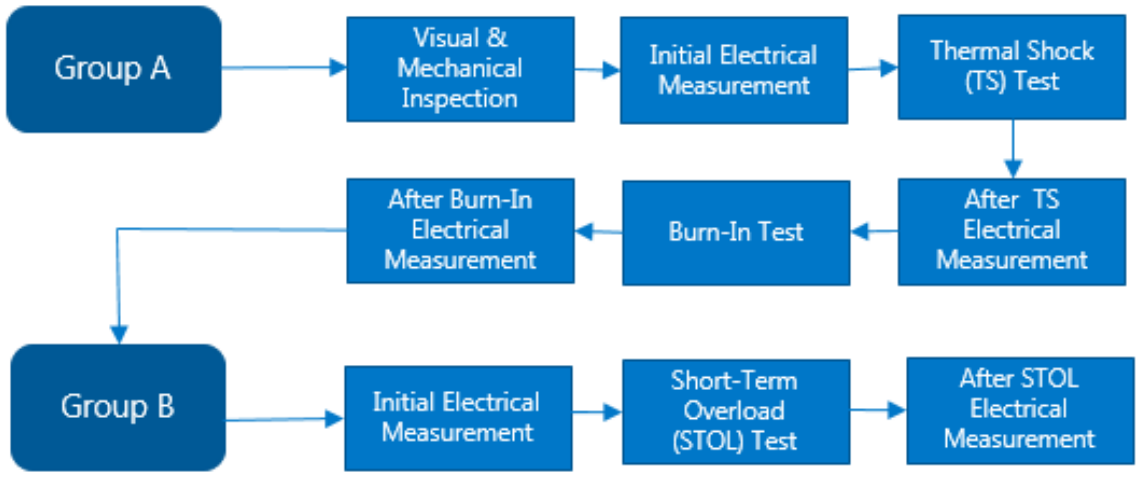



*Figure 6 – Flowchart of Test Procedure*

**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 5 - Thermal Shock requirements listed in TP-9251*

| STEP | TEMPERATURE (ºC) | 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.

**Group B:** Group B inspection shall be samples that have been subjected to Group A Inspection.

**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. Previous test final measurement results may be used.

**Short-Term Overload:** Apply 2.5 times the maximum working voltage (not to exceed twice the maximum rated voltage) for duration of five (5) seconds to devices mechanically mounted on a suitable heat sink. There shall be no evidence of arcing, burning, or charring.

**After Short-Term Overload (ASTOL) 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.

## 5. Test Results

The change in attenuation was measured after each test step for 5 samples at of 4 attenuation values. There are a total of 20 measurements. Historically, the Short Term Overload ( STOL ) test causes the most damage to resistive components. The Thermal Shock usually has negligible damage while the Burn-In test lays somewhere in between the Thermal Shock and STOL. 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 **Errore. L'origine riferimento non è stata trovata.**. A graphical representation showing average change in attenuation for a 5 unit sample size at each attenuation value is shown in Figure 7. 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.

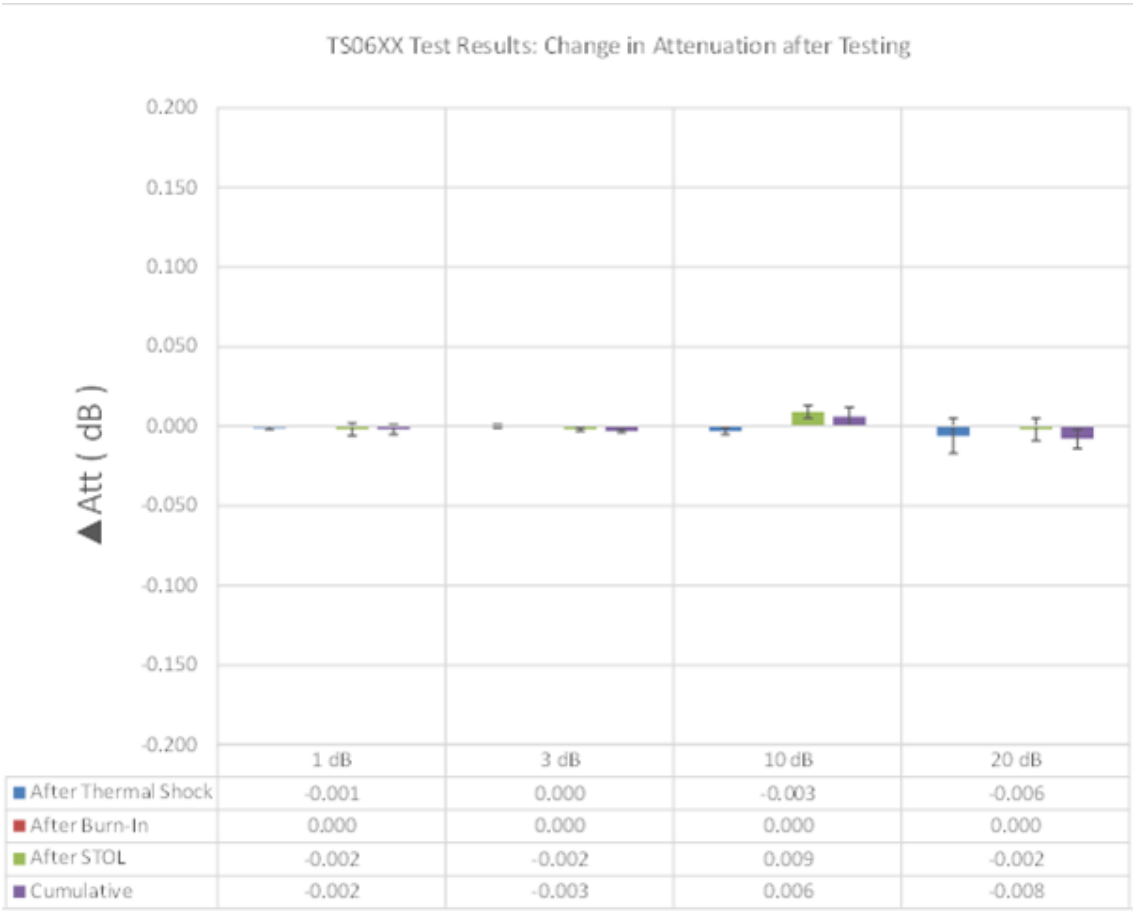



*Figure 7 – Graphical Results of TS05XX Test*

| Test Results - Change in Attenuation ( dB ) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Attenuation** | **After Thermal Shock** | | **After Burn-In** | | **After STOL** | | **Cumulative** | |
| **( dB )** | **AVG** | **STDEV** | **AVG** | **STDEV** | **AVG** | **STDEV** | **AVG** | **STDEV** |
| 1 | -0.001 | 0.001 | 0.000 | 0.000 | -0.002 | 0.004 | -0.002 | 0.003 |
| 3 | 0.000 | 0.001 | 0.000 | 0.000 | -0.002 | 0.001 | -0.003 | 0.001 |
| 10 | -0.003 | 0.002 | 0.000 | 0.000 | 0.009 | 0.004 | 0.006 | 0.006 |
| 20 | -0.006 | 0.011 | 0.000 | 0.000 | -0.002 | 0.007 | -0.008 | 0.006 |

*Table 6 – Test Results showing average and standard deviation of change in attenuation*

## 6. Conclusion

The TS06XX Attenuator product line will successfully meet the revised power rating. The previous power rating for all attenuation values was 200 mW. The revised power rating for the 0 to 1 dB is 3 W, the 2 to 3 dB is 1.20 W, the 4 to 10 dB is 0.60 W and the 11-20 dB is 0.50 Watts. There have been no physical changes to the design geometry or materials used in constructing the TS06. 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, a 168 burn-in test and a short term overload test. Statistical analysis of test results show a worst case attenuation change of 0.026 dB within a 99.7% confidence interval. This value is less than 20 % of the 0.2 dB permissible change in attenuation after testing.