TECHtips

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Electronics Manufacturing Insights from ACI Technologies, Inc.

SMT Component Reliability for RF Applications

ACI Technologies (ACI) characterized the reliability of surface mount RF components. The RF frequency band of interest was the X band (10.7 to 11.7GHz). A two pronged test for reliability of circuit card assemblies (CCA) was designed for both extreme thermal cycling and vibration. The rapid thermal cycling and extreme vibration testing simulates the total stress encountered by the assembly over the life of the product but accomplishes it in a relatively short period of time. In order to perform the reliability testing, a test vehicle consisting of a printed circuit board with test structures and components, was designed, fabricated, and assembled at ACI.

Surface mount technology (SMT) components were selected that are both commonly used and have operating ranges up to the X band of the RF spectrum. A digital attenuator in a quad flat pack, no lead (QFN) package was used with supporting chip components in 0402 and 0603 sizes. Two surface mount hybrid couplers with different leads were installed, one with L leads and one with castellated leads. Side launch SMA connectors with through-hole ground connections were installed to allow connection to the spectrum analyzer.

The frequency range of the attenuator is up to 13GHz while the other RF components are less than 4GHz based on their application in the actual circuit.

CCA Design and Assembly

The test vehicle was designed to simulate a proposed board stackup and allow the mounting of the SMT RF components. Each board has six RF paths that pass through the components (Figure 1). To observe any effects of vibration and thermal cycling on the laminated board, three RF paths were designed with no components to act as controls.

The component manufacturer's data sheets were used to define the shapes and sizes of both the pads on the CCA and the cutouts for the solder paste stencil. The stencil thickness was 0.005" to allow the proper solder volume on the 0402 and 0603 chip component ends. The larger, castellated lead coupler required a stencil having a "window pane" feature to reduce the volume of solder used to solder the large center ground to the ground plane.

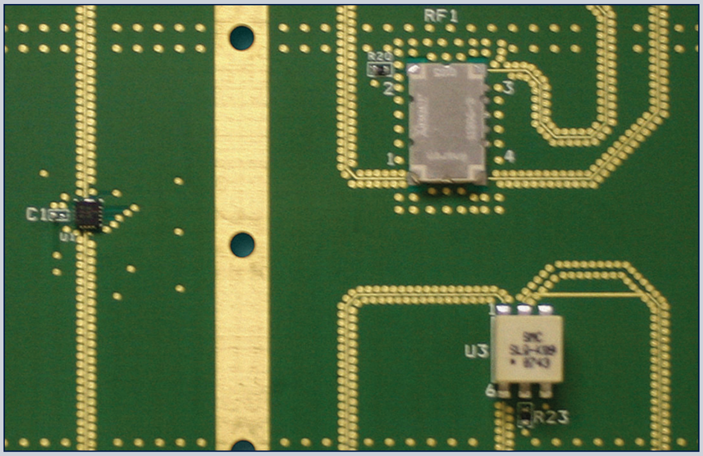

Figure 1: Section of test vehicle with digital attenuator and couplers.

The solder paste selected is the type typically used for military assemblies (63/37 tin-lead solder with a no clean flux and a J-STD-004 classification of ROL0). The board layout was programmed into an SMT pick and place machine so the QFN and 0402 components could be placed accurately. A double reflow process was used since the CCA has components on both sides. All flux residue was removed using an inline cleaner to meet IPC-A-610 Class 3 requirements for circuit card assemblies.

Accelerated Testing Plans

Component reliability was tested using accelerated temperature cycling based on JEDEC Standard JESD22-A104. The assemblies cycled between +85°C to -40°C for 1000 cycles of 91 minutes each. Breaks for RF testing occurred at 100, 200, 400, and 1000 cycles to allow more resolution into the possibility of early thermal failures.

Vibration testing was also performed to simulate the stresses of motion on the components over the life of the assembly. The three axes vibration testing was performed for two hours at frequencies from 4Hz to 50Hz per MIL-STD-167-1A (November 2005). The test vehicles were RF tested prior to being sent for vibration and then RF tested again on their return to ACI.

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Thirty test vehicles were assembled using ACI's SMT equipment. Prior to thermal cycling and vibration testing, each of the RF paths on all of the CCAs were visually inspected and swept for Transmission Loss (S21) and Insertion Loss (S11) to gather baseline data. An Anritsu Spectrum Analyzer was used and data was gathered from 40MHz to 20GHz.

Fifteen CCAs were sent for thermal cycling and fifteen were sent for vibration testing. After vibration testing, there was no evidence of cracked solder joints or other evidence of stresses between the devices and the board. The RF paths on each of the fifteen CCAs were swept and data showed no significant degradation in the performance of the devices or paths. Figure 2 shows the data for the coupler direct path baseline versus post-vibration test.

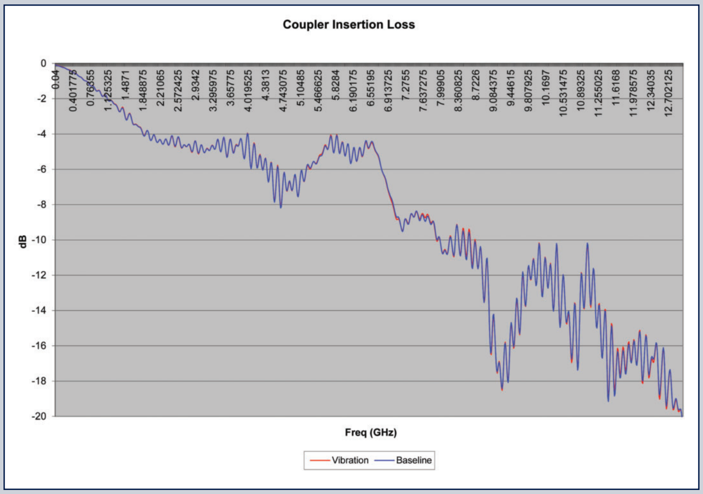

Figure 2: SMT Coupler X Band insertion loss before and after vibration testing.

Fifteen CCAs were run through 1000 thermal cycles with visual inspection and RF testing performed at established break points. Again, no evidence of damage was apparent on the visual inspections and no significant degradation in performance was apparent on any of the CCAs after RF testing. Figure 3 shows the performance before thermal cycling and at each of the break points for the coupler direct path.

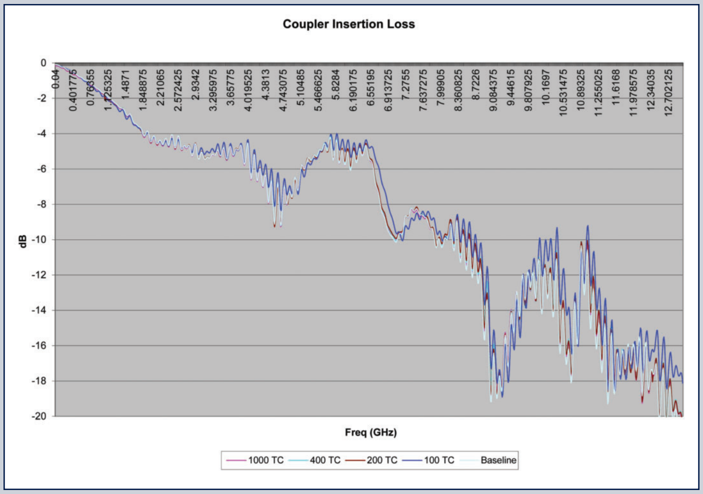

Figure 3: SMT Coupler X Band insertion loss before and after thermal cycling.

Report Summary

The analysis of SMT components in high reliability RF circuit card assemblies exposed to thermal cycling and vibration testing, showed no significant degradation of performance. Visual inspection of the components and the solder joints showed no physical damage and Figures 2 and 3 indicate that there is almost no degradation in performance through the accelerated life tests. Although the figures shown are for one specific device through the tests, all other SMT components performed as well.

Thermal cycling and vibration testing are among many of the analytical services offered at ACI, as well as component engineering and design services. For information and assistance with designing experiments to verify the integrity of electronic assemblies for military applications, contact the Helpline at 610.362.1320 or via email to helpline@aciusa.org.

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