INEXPENSIVE MIXERS FOR HI-REL COMMERCIAL MARKETS

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Abstract: Cellular and PCN markets are challenging manufacturers to reduce cost and improve reliability at the same time. To address these requirements an all weld, shielded metal case mixer was developed. Internal components were redesigned for manufacturability and improved reliability. The resultant product is lower in cost than a conventional mixer. Life tests indicate that the reliability goal (5 years) has been well exceeded.

Volume markets such as cellular and PCN are challenging manufactures to reduce cost and increase reliability. This paper examines a design approach used to achieve these objectives for a double balanced mixer and describes the test methodology and test results.

Double balanced mixers are available in a variety of packages from different vendors. Plug-in shielded metal case is a popular package widely used in the industry. For frequencies below 4 GHz, lumped element design is widely used, as it provides multi decade bandwidth in a very compact size. Manufacturing methods of these units are fairly well established. Leaded quads and toroidal or binocular cores are used and interconnection to the package and devices are made by soldering.

During soldering, the diode quad is stressed thermally. This could result in epoxy encapsulation softening, lead movement and diode quad chip movement. Also the soldering process leaves finite flux residue even after best cleaning. All these factors reduce reliability of the mixer. In addition, cleaning with present day chemicals are environmentally harmful.

In the improved design all connections are done by welding. To facilitate welding, the header and quad packages are redesigned. The quad is built on a small ceramic board and weld pads are brought out for connection. Pins are redesigned to have nail heads to accomplish welding. All parts are bonded to the header with epoxy. The package itself is welded.

Resulting units are being subjected to life tests to evaluate the reliability.

i) 17 units are being cyclically thermally shocked -55° to 100°C. 2470 cycles have been completed without any failure.

ii) 20 units are in a burn-in chamber at 100°C. 7 dBm and -15 dBm of LO and RF power respectively are applied to each device. After 14,880 hours of burn-in (34 device years) no failure has occurred.

iii) 50 devices were subjected to mechanical shock and vibration per MIL-STD-202. No failures occured.

iv) One variation of this mixer has gull wing leads for surface mount. Thermal compatibility of the mixer to the mother board such as woven teflon is important. 10 units were soldered on teflon glass boards and cyclically thermally shocked -55° to 100°C. After 350 cycles no failure has been reported.

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The new process increases reliability and lowers the manufacturing cost of the mixers. Another major benefit of the new design is the improved sigma performance factor SP defined as below:

$$SP = \frac{| \text{Spec Limit} - \bar{x} |}{\sigma}$$

Due to the inherent assembly repeatability because of the exact component layout and short wire lengths from the transformers, the performance variation from unit to unit is quite small, "skinny sigma". Thus the sigma performance factor is high (the distance from the statistical average, x, to the specification limit). As the value of sigma decreases, the unit to unit repeatability increases. Fig. 1 shows the SP data for a mixer manufactured using the above process. Observe L-R and L-I at 32 MHz. High numbers of SP indicate that weld process preserved the natural balance of the quad. Isolation at high frequencies is a function of parasitics and are very difficult to control. An SP of 4 or better is achieved for these parameters. Note also excellent values of SP on conversion loss. An SP of 4.5 is achieved for critical parameters.

Welding process lends itself to automation and reduced labor cost. This along with repeatability (or less number of rejects) results in less scrap, testing and lower cost.

These new assembly and design concepts enable components to be manufactured with greater quality and consistency of performance (measured by SP). RF and microwave industry is not used to the concept of consistency of performance as means of achieving it were not explored. Benefits of consistency are enormous. Assemblies will have higher throughput as there will be less rejects, faster test times or sampling. It also makes these parts an ideal candidate for automated assemblies for faster production and manufacturers can respond to quick increase in manufacturing capacity.

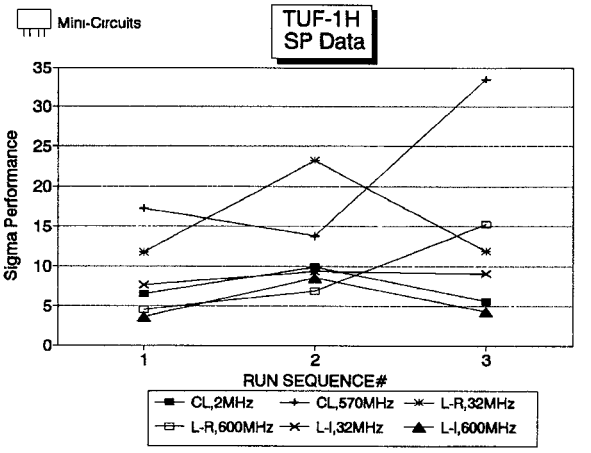

Fig. 1: SP performance