A PASSIVE INTERMODULATION MESUREMENT SYSTEM WITH PLANER CONTACT SETUP

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1 Introduction

Passive intermodulation (PIM) generated by metallic contacts may cause serious interference in multi-frequency communication systems such as cellular base stations. Several works about PIM products generated by non-linear effects at the contacting faces has been reported. Bayrak and Benson employed a specially manufactured coaxial measuring device in that a variety type of test samples were located and axially pressured via small bellows by means of a pressure-control nut[1]. It required high manufacturing costs and great care during the assembly of the test bench to ensure that significant PIM were not present due to the system itself. To simplify the PIM evaluation of metallic junction or printed antenna, therefore, a setup without coaxial device is preferable.

In this paper, we propose a planer measurement setup using strip conductors with dielectric substrate and a flat electromagnetically connecting structure for evaluating PIM product at the metallic contact. The system performance verified by 2-tone test on 900MHz band is described, and several metallic contacts are evaluated in terms of surface roughness and plating condition including Sn, Au, Pd and Ag. It is shown that validity of the planer measurement device. It is also shown that excellent PIM characteristics of Au plated copper via amorphous nickel in the planer measurement setup.

2 Experimental Setup

Fig.1 shows a configuration of PIM measurement system using planer measurement setup. In the figure, (a) shows a block diagram of the experimental setup. Each carrier amplified with different frequency excites the DUT with PIM that is observed in a spectrum analyser. The spectrum analyser E4440A by Agilent Technology is used in this paper. A 70m-length open-circuited semi-flexible coaxial cable composed of a silver-plated copper wire as centre conductor and a tin soaked copper braid as outer conductor is employed as dummy load absorbing the power passed through the DUT. An isolator protecting the amplifier from over-reflection in open-circuited test is installed in a presence of the transmission power combiner. PIM may be caused in the transmitting power combiner, however it can be reduced by high isolation over 150dB of the duplexer with receiving bandpass filter.

The fig.2(a) shows a configuration of planer measurement setup. It contains the tri-plate DUT composed of two planer printed boards. Since the measurement device includes electromagnetic coupled junction between soldered substrate and the DUT substrate, it does not require any soldering in replacing the test sample. Fig2(c) shows the DUT substrate for planer metallic contact. It consists of a low-impedance microstrip line and a 50Ω microstrip line connected via λ/4 impedance transformer. The tri-plate DUT is composed of the low-impedance microstrip lines of which conductive strips are mated face-to-face. The strip line with the characteristic impedance of 16Ω(5mm width strip line on a 1.6mm thickness substrate, εr=2.6) is employed to obtain wide contact area. The electromagnetic junction is composed of two parasitic elements placed above and under the discontinuous microstrip line via dielectric layer as shown in fig.2(b). Since PIM generated at the junction between metal strip and dielectric substrate is quite small compared with one due to metallic junction, therefore it can be negligible. In this paper, dielectric substrate with ε_r=2.6 and conductor thickness of 0.035mm is commonly employed. The substrate with the thickness of 1.6 and 0.8mm are chosen for the microstrip line and the parasitic elements, respectively.

3 Experimental Results

Fig.3 shows input characteristics of the planer measurement setup including the EM-junctions. Low insertion loss S_{21} less than 1dB and small reflection S_{11}<–15dB are obtained at operating frequencies such as 862, 891 and 920MHz. In the EM-junction and the DUT, each substrate are pressured by screwed bolt, however, input characteristics of the whole setup are not sensitive to the pressure between substrates. Same results are also obtained when the substrates are pressured by a solid weight such as 2Kg or 3Kg.

Fig.4 shows residual PIM characteristics of the measurement system itself. In experiment, the 3rd order PIM at 920MHz is measured for two frequencies with 862 and 891MHz. Operating power is chosen as $41dB_m$ for each carrier. Firstly, the system noise without DUT and dummy load is evaluated by the open-circuited test at the EM-junction. The PIM is sampled at every second during 300 seconds. The maximum residual noise of $–122dB_m$ is obtained in this time. On the other hand, residual noise of the system is also measured when the long semi-rigid cable is used as dummy load. The PIM of –123dBm is also observed in this case.

Fig.5 shows PIM characteristics of planer contacts with different degrees of surface roughness. In the experiment, we employ 5 samples with fine-, middle-fine- and -coarse mesh on the strip surface in addition to polished-sample and unpolished raw sample. All the samples excluding coarse meshed one produce relatively stable PIM, which indicates that surface roughness of DUT affects the stability of PIM generation. Therefore, dispersion of PIM level due to surface roughness is estimated within 15dB. The polished sample generates relatively low PIM characteristics, while it is degraded over 10dB compared with the system residual PIM because of the shorting of contact pressure making complete surface contact. These phenomena are not affected by contact pressure very much.

Fig.6 shows PIM characteristics of plated metallic contacts, in which the beryllium-copper sheets plated with Ag, Au, Sn, and Pd are employed, where magnetic Ni and amorphous non-magnetic Ni are employed as an undercoat of Au plating. The Au-plated copper junction with magnetic Ni-undercoat shows the worst PIM characteristics such as –60dBm, however, the Au-plated copper with the amorphous Ni-undercoat provide excellent PIM performance as small as Ag-plated beryllium copper.

4 Conclusion

Planer measurement setup was proposed for PIM evaluation of metallic junction. The metallic junction under the test was composed of strip-conductor pasted on dielectric substrate, and was excited via planer electromagnetic junction. System residual noise such as –125dBm was achieved for the open and the terminated tests. Presser on the planer metallic contact does not affect the evaluation very much when the weighs (1,2Kg) or plastic bolt-screw are used. PIM evaluation in terms of plated metallic junction such as Ag, Au, Sn, and Pd was carried out by the planer measurement setup. The results indicated that Au-plated copper via amorphous Ni-undercoat provide excellent PIM performance as small as Ag-plated copper.

References

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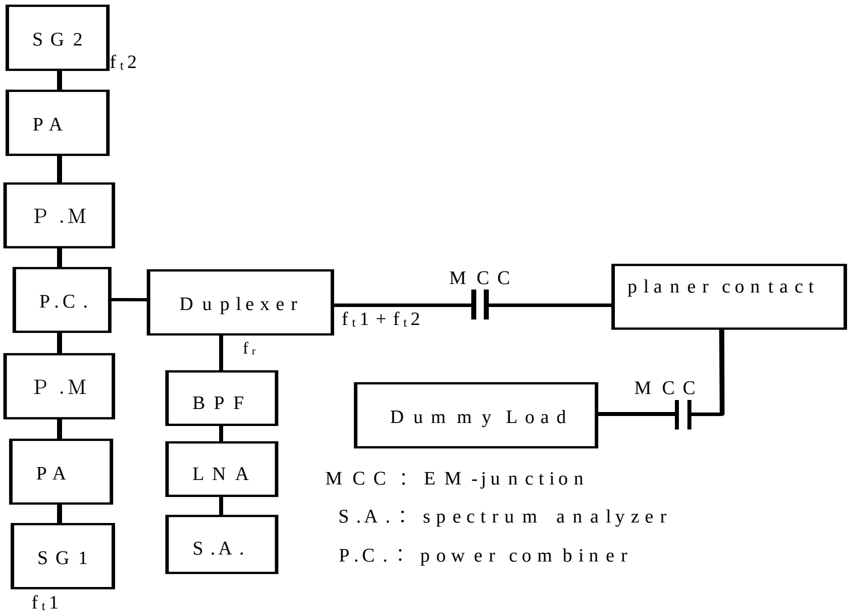
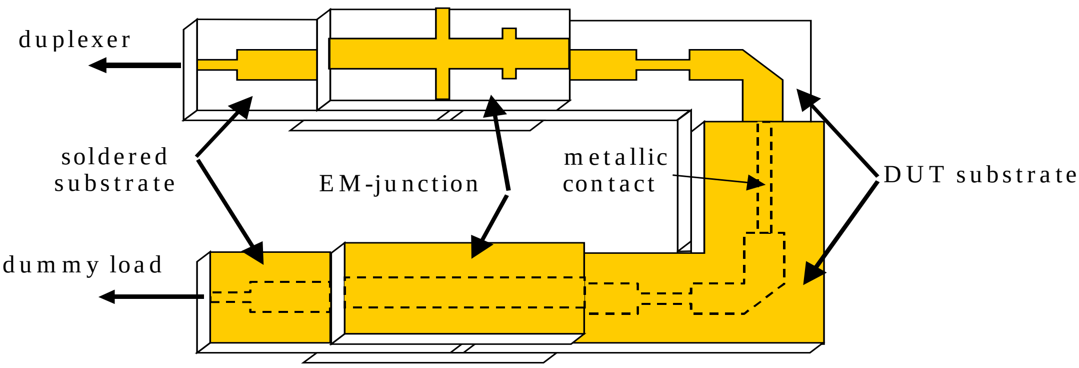
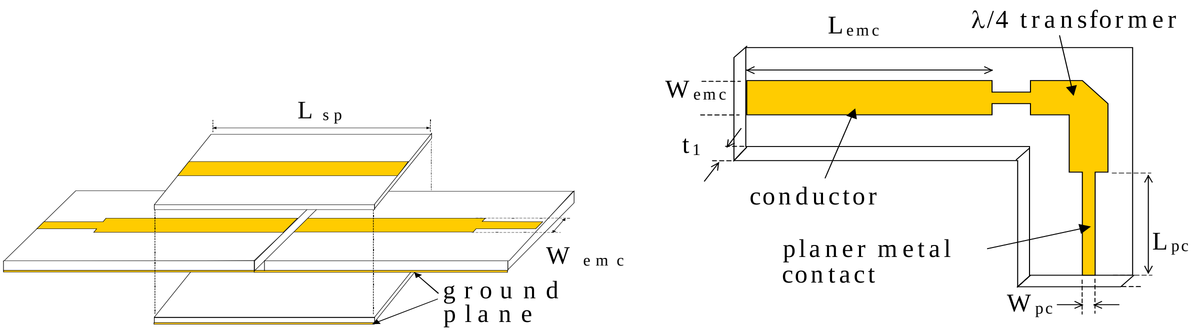


Fig. 1 block diagram of PIM measurement system



(a) planer measurement device



(b) EM-coupled junction (c) printed substrate with planer metallic contact

W_{pc}=4, L_{pc}=4, W_{emc}=10, L_{emc}=118, L_{sp}=156, ε_r=2.6, t_1=1.6, t_2=0.8

Fig. 2 an configuration of planer measurement setup

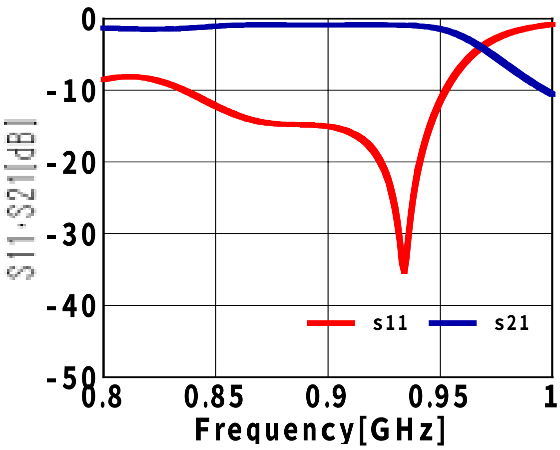


Fig.3 input characteristics of the planer measurement setup

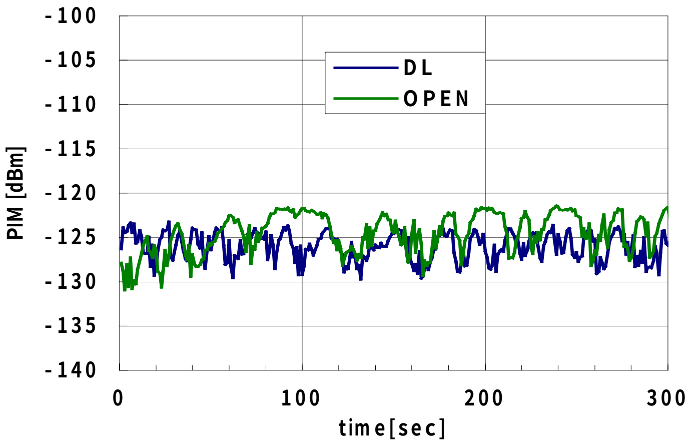


Fig.4 system residual noise for terminated and opened condition

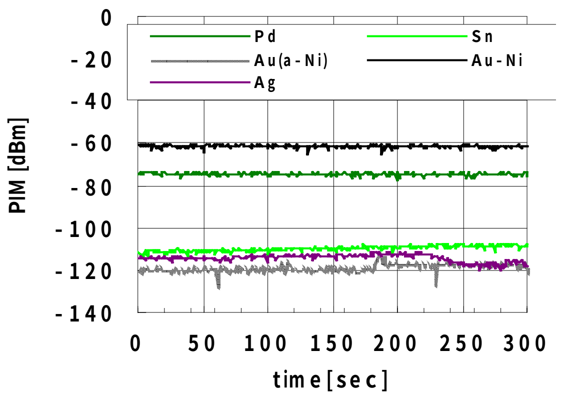


Fig.5 characteristics of planer contacts as a function of surface roughness

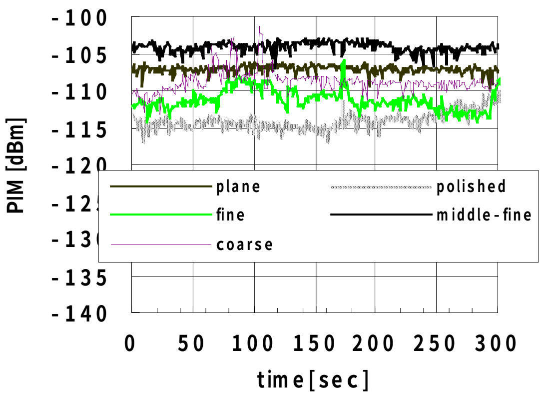


Fig. 6 PIM generated on the planer contacts with different metal plating