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# MULTI-PORT ELECTROMAGNETIC INTERFERENCE IMPROVEMENT USING HETEROGENEOUS PORTS

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# MULTI-PORT ELECTROMAGNETIC INTERFERENCE IMPROVEMENT USING HETEROGENEOUS PORTS

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## ABSTRACT

Techniques are provided herein for using different profiles on different ports for different radiation directions in multi-port projects. Because the superposition effect is weakened, the maximum radiation of a project is about 3dB smaller than those with uniform ports.

## DETAILED DESCRIPTION

The superposition of multi-port radiation rapidly worsens radiation performance. For multiple Small Form-Factor Pluggable (SFP) cages (e.g., 2x2, 2x4, 2x8, etc.), all ports have the same structure and profile. If every port is regarded as an antenna, each antenna may have the same main lobe direction (maximum radiation direction). The radiation in an electromagnetic compatibility (EMC) test is the superposition of all ports. Two ports increase radiation by about 3dB, theoretically. Four, eight, and sixteen ports increase radiation by about 6dB, 9dB, and 12dB, respectively. In general, more ports create bigger challenges for radiation tests of EMC compliance, as illustrated in Figure 1 below.

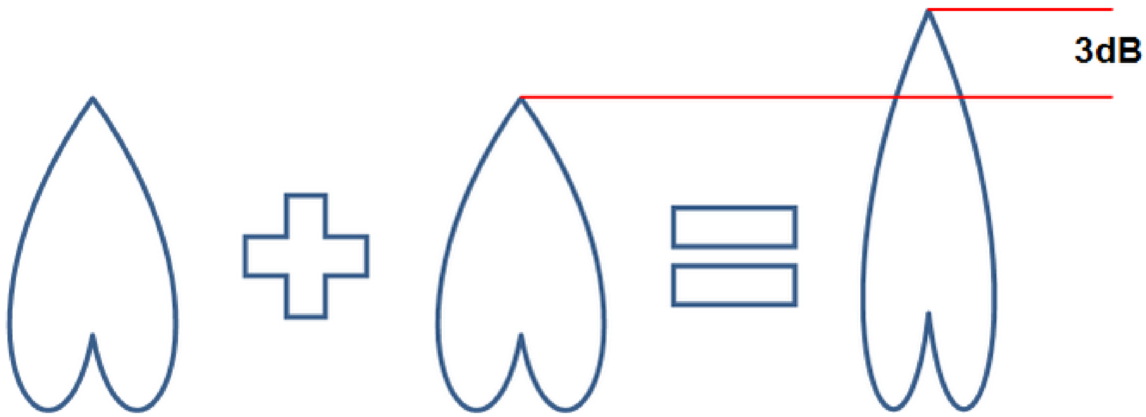


*Figure 1*

Figure 2 below illustrates a simulation model of a 2x8 cage. The Latches and Light Pipes are the openings. Because the Light Pipes are much smaller than the Latches, the Latches dominate the radiation level of whole model.

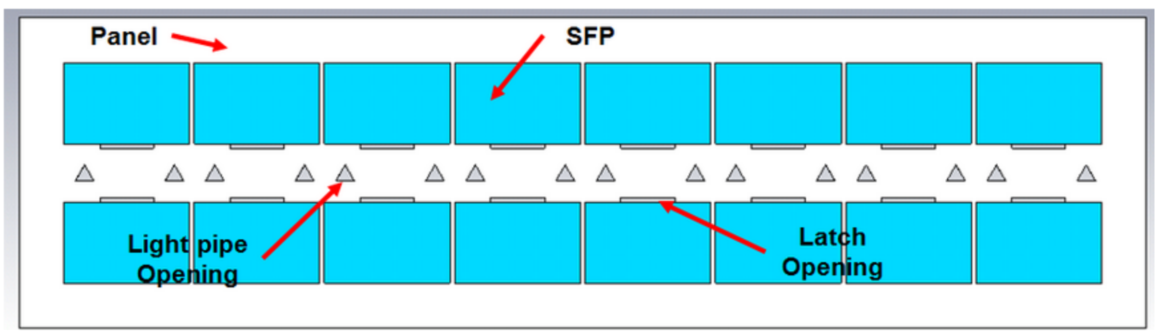


*Figure 2*

Figure 3 below illustrates 2x2, 2x4, and 2x8 port models.

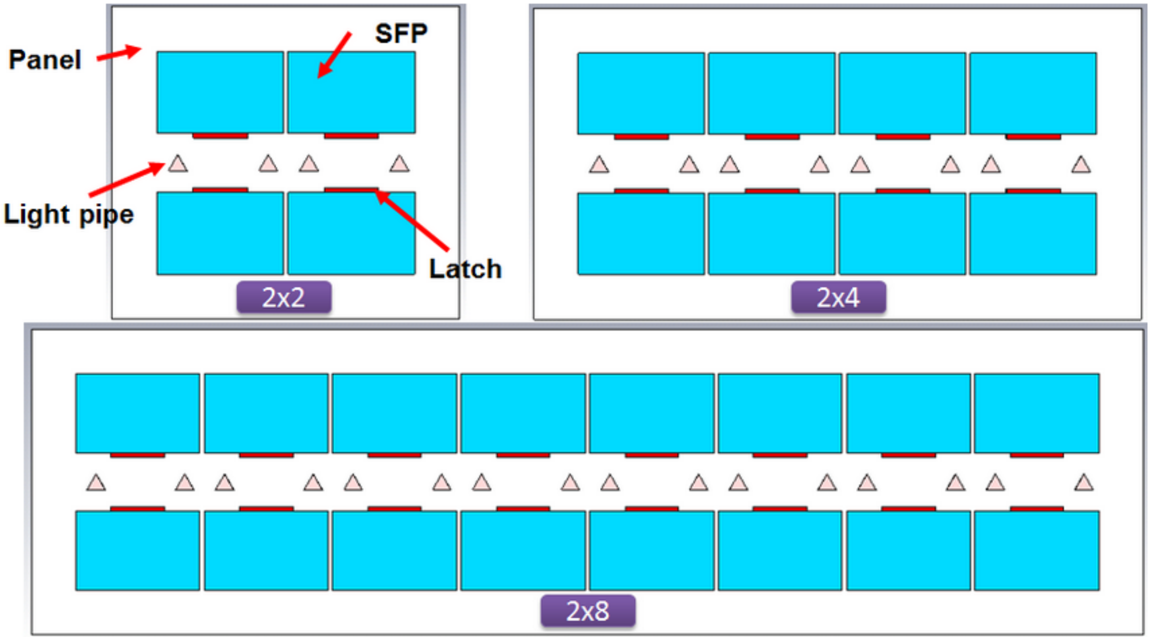


*Figure 3*

Figure 4 below illustrates simulation results. The gain over frequency and radiation pattern shows that the maximum radiation of 2x2, 2x4, and 2x8 cages increased by 3dB.

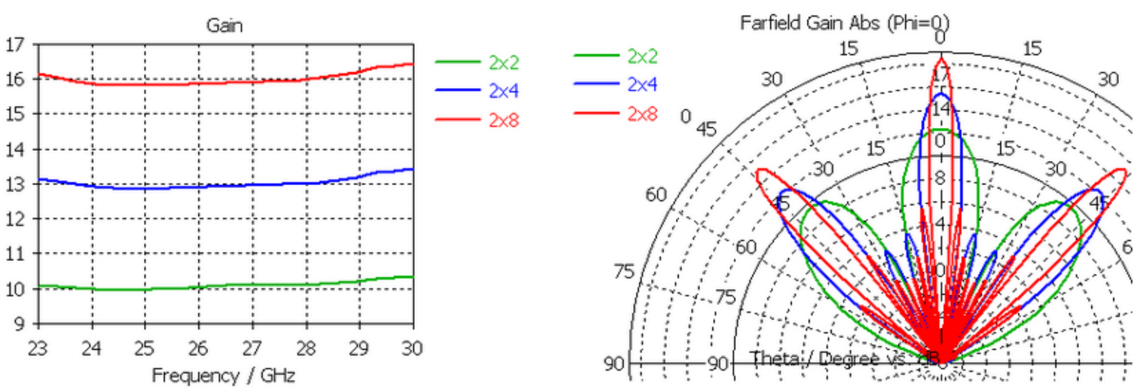


*Figure 4*

Accordingly, as illustrated in Figure 5 below, implementations are provided herein to change the port profile to different shapes. This causes the radiation to rotate to different directions. Thus, the radiation maximum values do not superpose to bigger level. In other words, the radiation of the multi-port machine decreases by about 3dB or more.


*Figure 5*

Figure 6 below illustrates a C-type example. As shown, two L slots are added for each SFP pair to create a C-type slot. The “C” of the two sides produce a rotational symmetry.

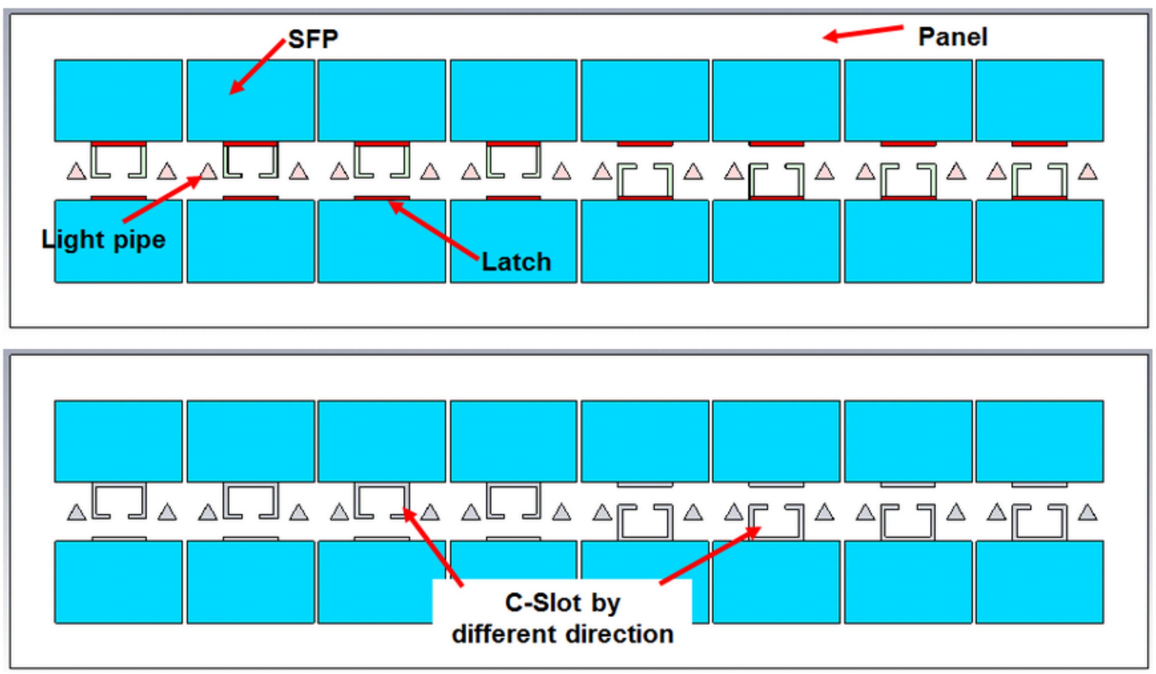


*Figure 6*

As illustrated in Figure 7 below, C-type decreases the radiation by about 3dB at approximately 28GHz compared with the original design.

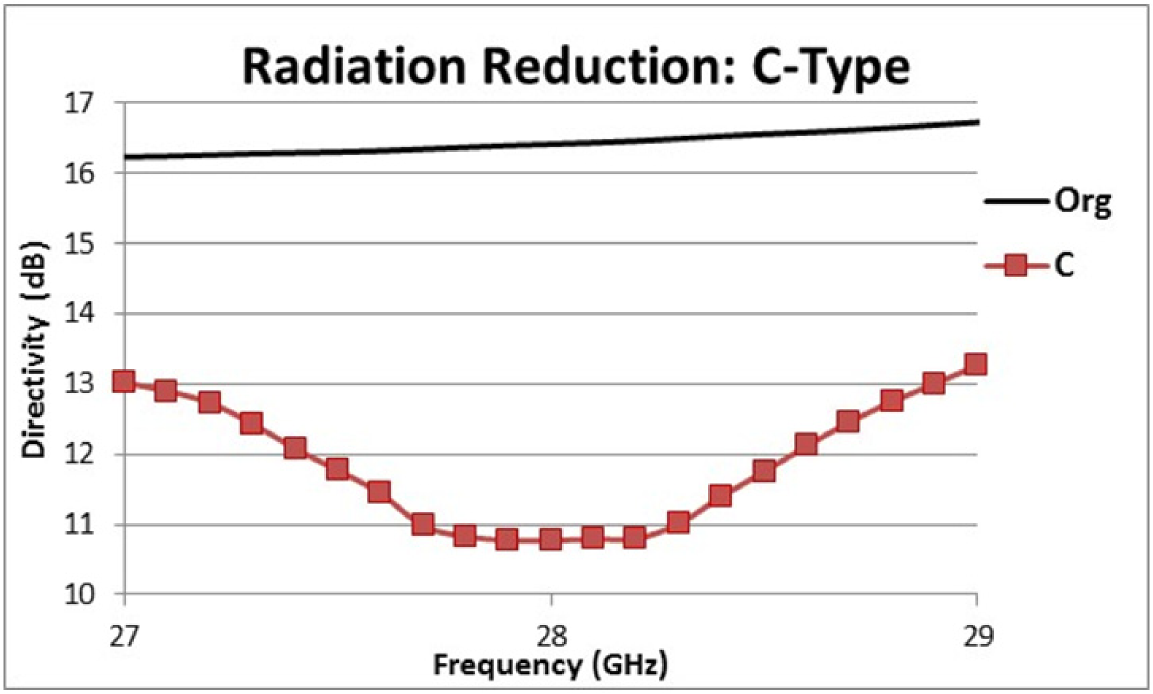


*Figure 7*

Figure 8 below illustrates a U-type example. As shown, two vertical slots for each SFP pair create a U-type slot. The "U" of the two sides produce a rotational symmetry.

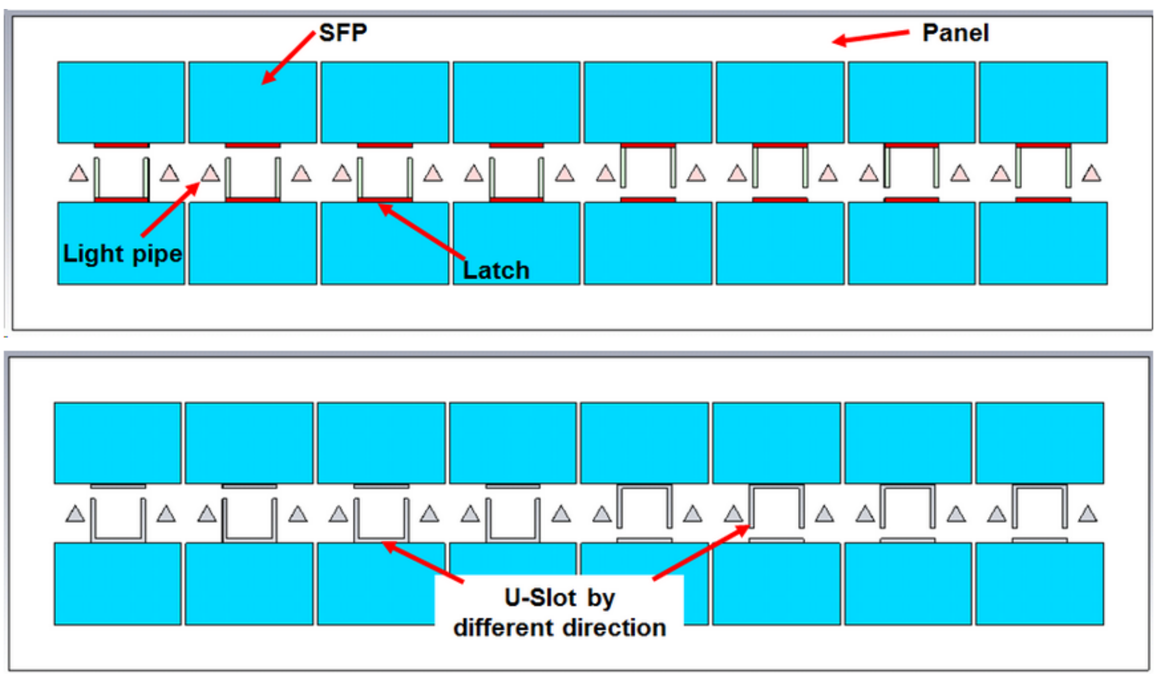


*Figure 8*

As illustrated in Figure 9 below, U-type decreases the radiation by about 3dB at approximately 28GHz compared to the original design.

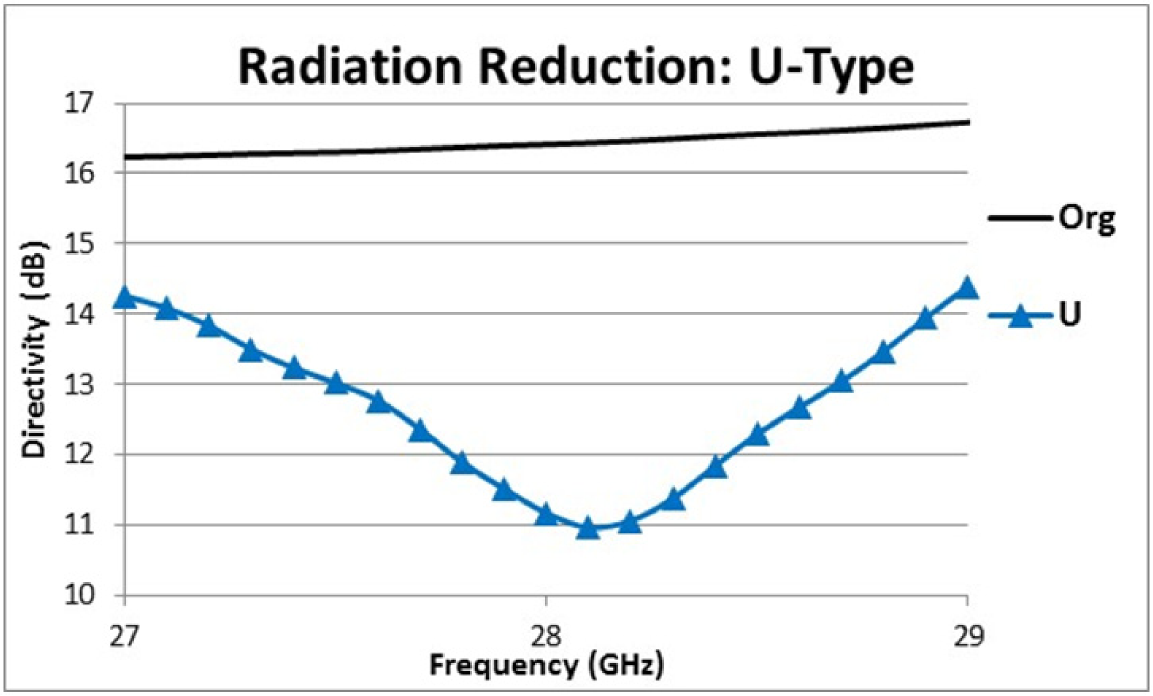


*Figure 9*

Broadband performance for random phases is now discussed. As illustrated in Figures 10 and 11 below, ten sets of random phases (range = 0 - 360) were applied to the original, U-, and C-types.

| Port | Org | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 140 | 134 | 291 | 269 | 150 | 226 | 74 | 249 | 326 | 167 |
| 3 | 0 | 130 | 346 | 73 | 32 | 26 | 154 | 311 | 40 | 94 | 127 |
| 4 | 0 | 235 | 204 | 344 | 228 | 162 | 35 | 212 | 66 | 283 | 146 |
| 5 | 0 | 307 | 20 | 24 | 257 | 252 | 202 | 272 | 105 | 136 | 97 |
| 6 | 0 | 349 | 342 | 22 | 6 | 180 | 250 | 334 | 144 | 104 | 20 |
| 7 | 0 | 234 | 131 | 286 | 155 | 146 | 329 | 119 | 201 | 331 | 88 |
| 8 | 0 | 341 | 189 | 137 | 145 | 340 | 301 | 195 | 112 | 227 | 352 |

*Figure 10*

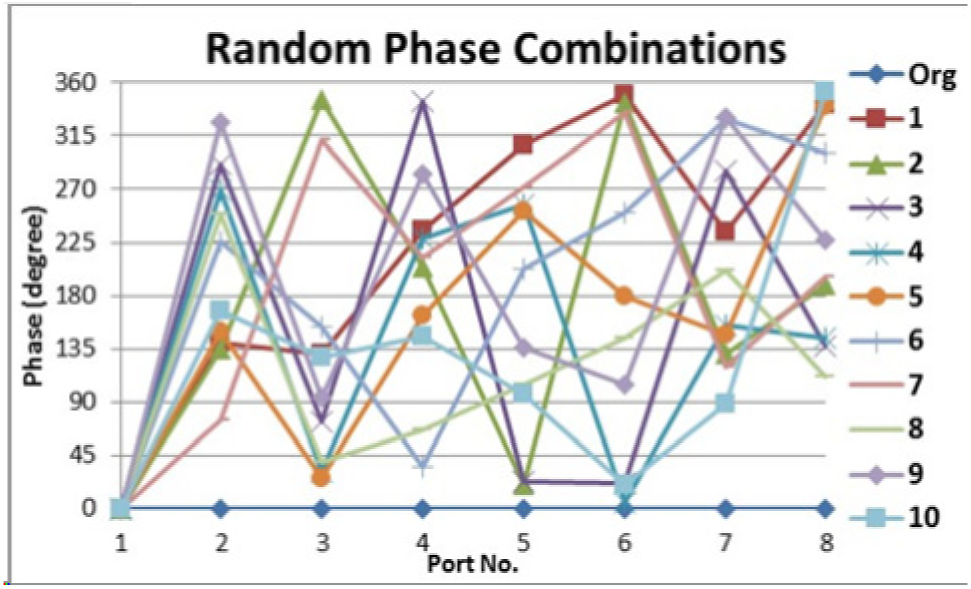


*Figure 11*

Figures 12-22 below illustrate performance results. As shown, C/U-types are better than the original design by about 3dB or more at approximately 28GHz in all random phase combinations, but about 1-3dB worse than the original design at approximately 10-16GHz in some phase combinations.

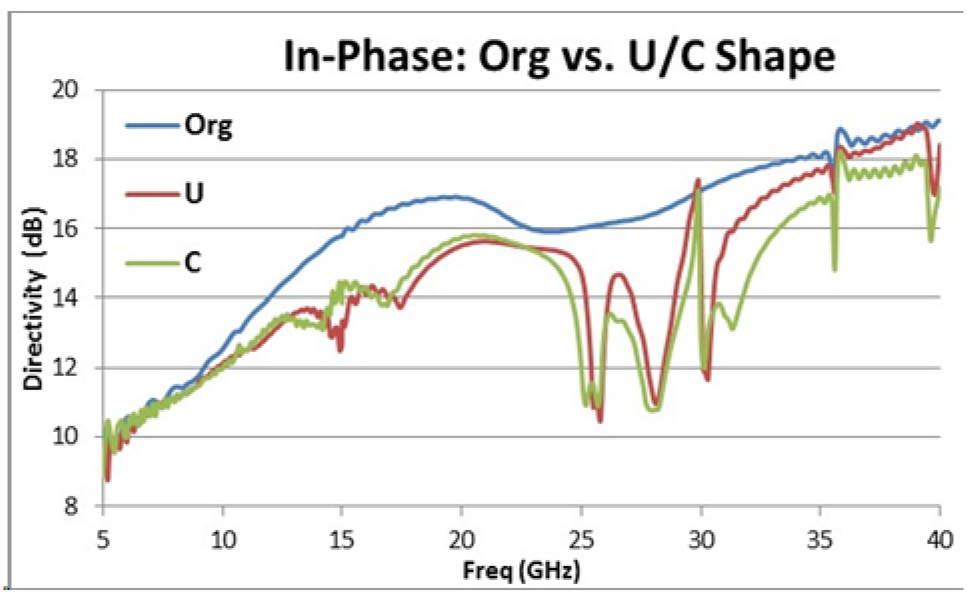


*Figure 12*

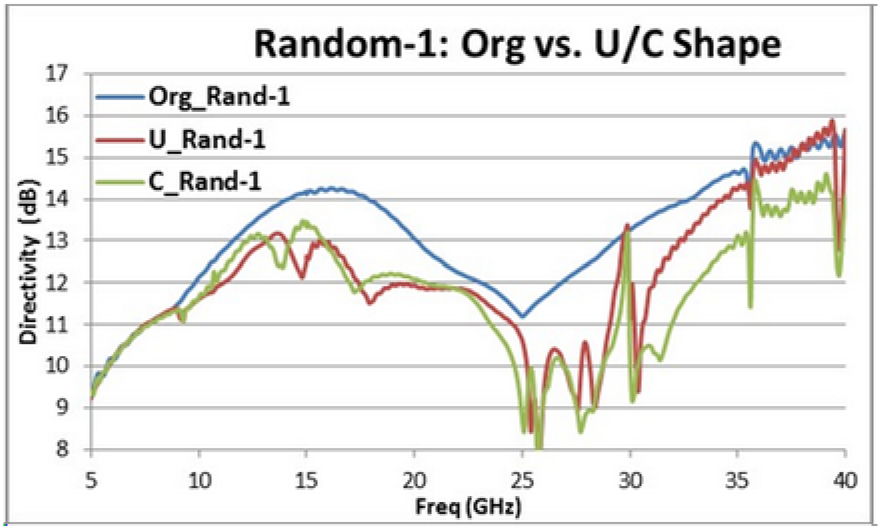


*Figure 13*

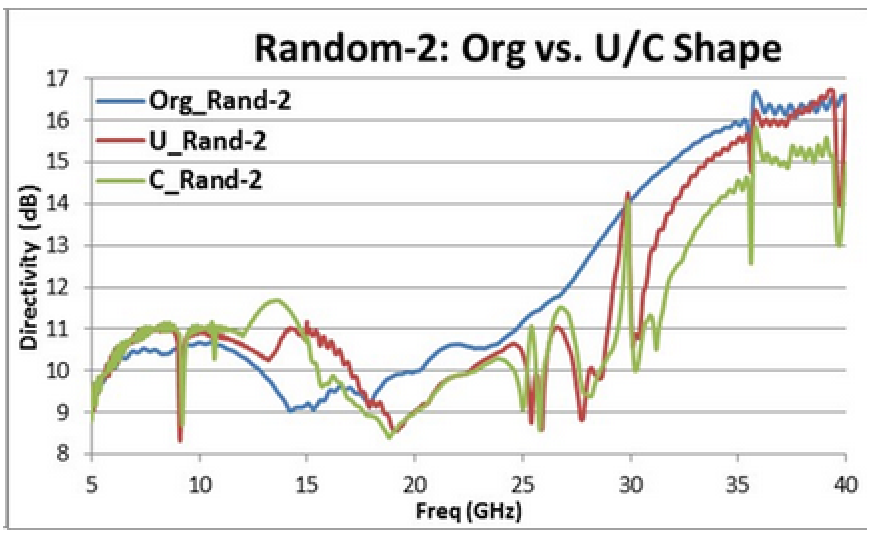


*Figure 14*

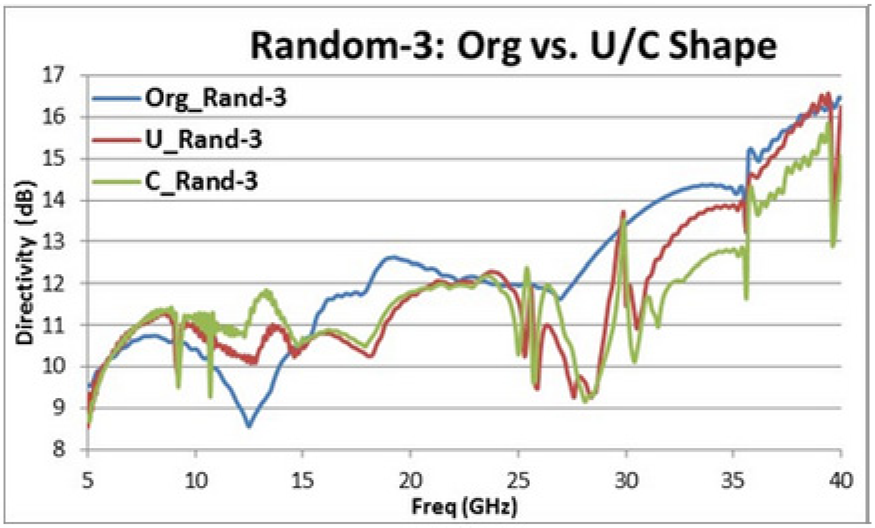


*Figure 15*

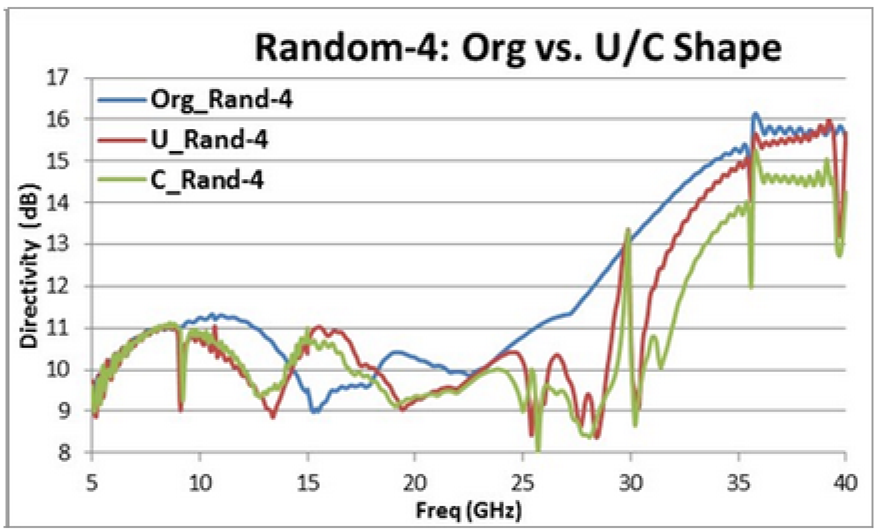


*Figure 16*

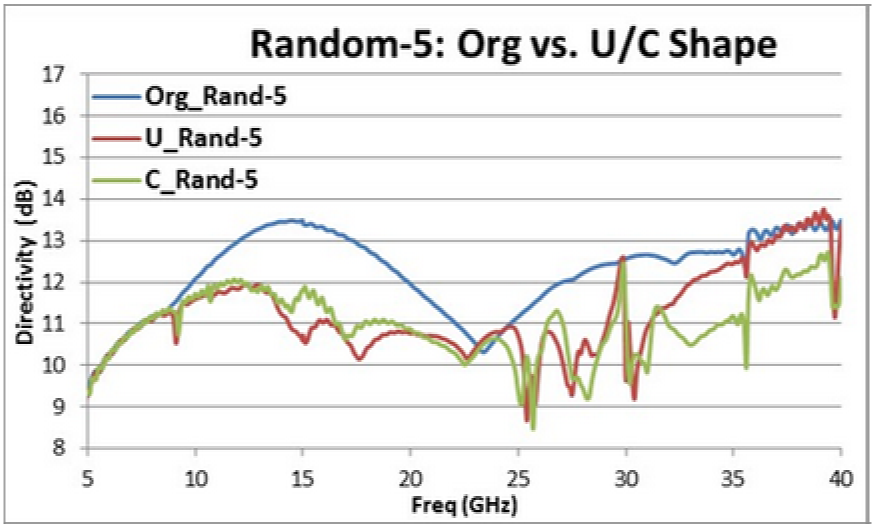


*Figure 17*

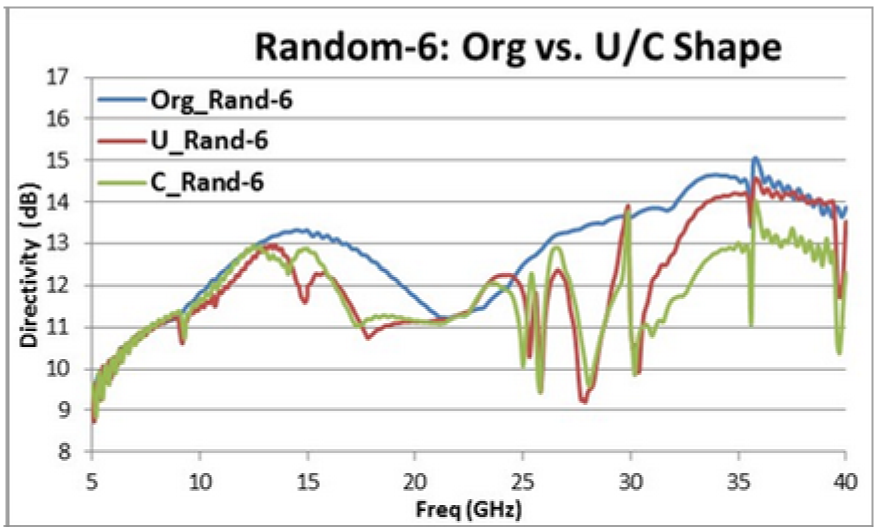


*Figure 18*

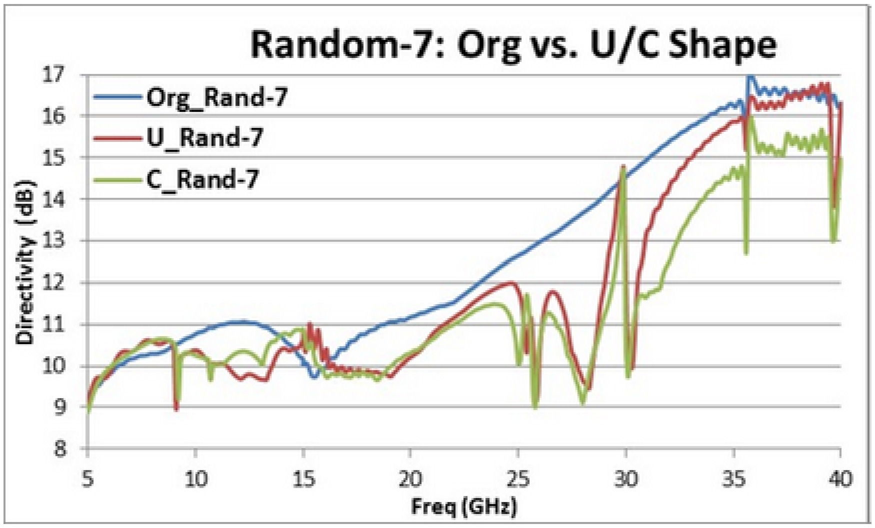


*Figure 19*

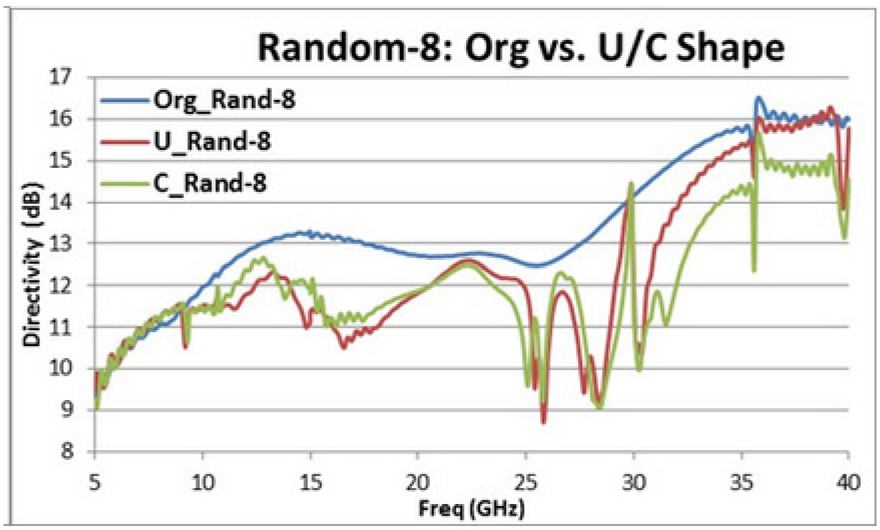


*Figure 20*

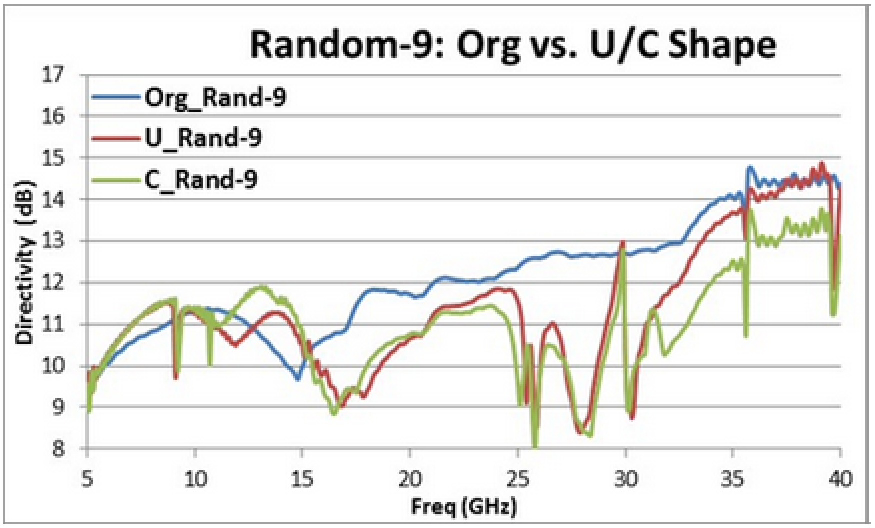


*Figure 21*

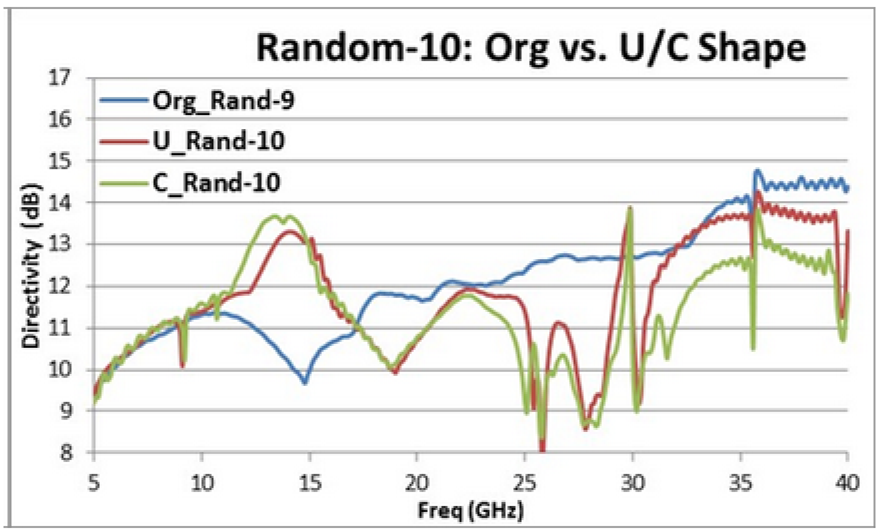


*Figure 22*

Figure 23 below illustrates an average of eleven sets of phase combinations (in-phase plus ten random). U/C-types are not worse than the original design in the full band. Thus, U/C-types are statistically improved over the original design.

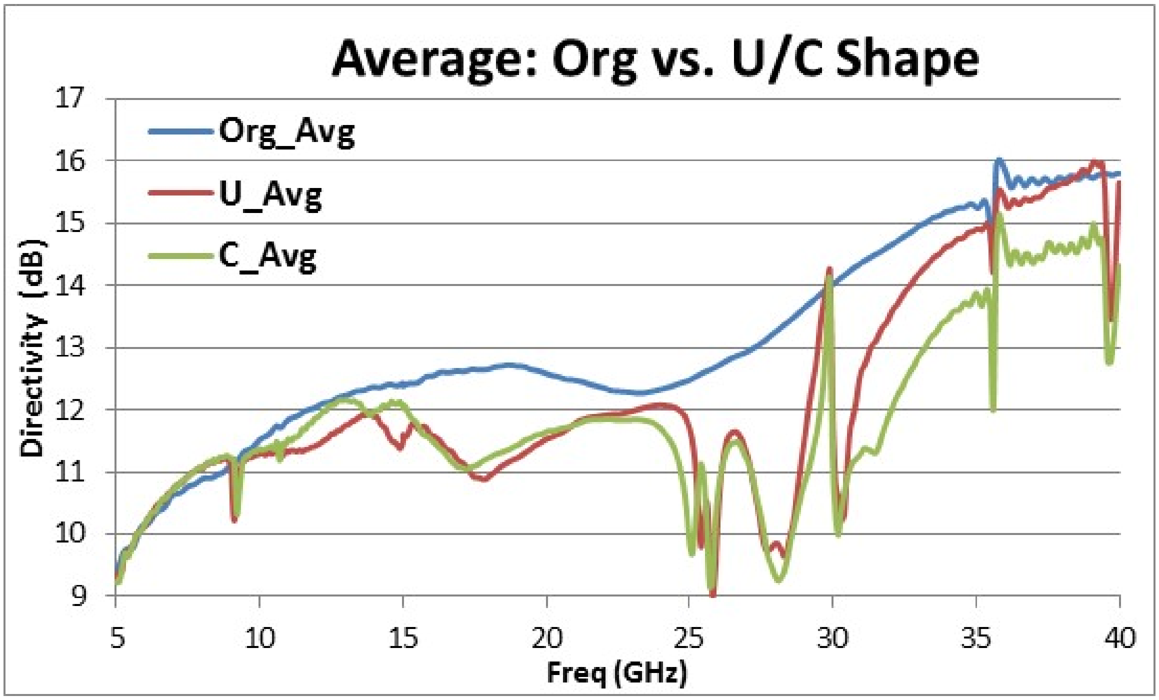


*Figure 23*

The techniques described herein may improve EMC radiation performance by about 3dB, and save debugging time and cost. Moreover, they may be used without an extra cost increase over existing solutions. This method is not limited to implementation in the front of an SPF cage. Any solution (e.g., adding a stub) may reduce the maximum radiation if it changes the port radiation pattern heterogeneously.

Techniques described herein may not cover the full band in all random phase combinations (5-40GHz). However, high frequency (e.g., 28GHz) is difficult to achieve in current EMC designs, as more and more failures have occurred. There are no cheap and effective methods to resolve this currently. For low frequency (e.g., 10GHz), there are many well-known and cheap solutions. The radiation margin at 10GHz is sufficient to bear the potential degrade of about 1-3dB. Therefore, these techniques could be useful for EMC designs to increase the EMC performance of certain products.

In summary, techniques are provided herein for using different profiles on different ports for different radiation directions in multi-port projects. Because the superposition effect is weakened, the maximum radiation of a project is about 3dB smaller than those with uniform ports.