Electromagnetic Field Immunity Test System applying Array Antenna Technology

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***Abstract*— We examine about the electromagnetic field immunity test system applying array antenna technology. This system is able to get an electric field uniformity and high power electric field near the antenna, in a wideband, by beam forming. In this paper, we calculated a uniformity of Electromagnetic field immunity test system applying 64(8x8) elements plane array antenna using wide band antenna. We constructed an electromagnetic field immunity test system applying 64 elements array antennas as prototype, measured an electric distribution and compare calculated value and measured value.**
Key words: Immunity, array antenna, uniformity, wideband

I. INTRODUCTION

The electromagnetic field immunity test system which exposes an electromagnetic field of 100V/m or more (such as MIL-STD [1], SAE J1113-21 [2]) needs a high-powered amplifier of the kilo-Watt-class. The initial cost getting high-powered amplifier is very expensive. Meanwhile, a uniformity of the electric field distribution is defined by regulation (e.g. IEC 61000-4-3 [3]) or the industry association standard (e.g. [2]).

Therefore, it is anticipated for the electric field test system that can expose a high electric field on a low cost and get electric field uniformity, in wideband, near the test system. We propose a new electric field test system applying the array antenna technology using a low price and low power amplifier as shown in Figure 1. An output of signal generator (SG) divides and input to each amplifier which is connect to element antenna. By using electromagnetic field radiated from each element antenna, this system forms a uniform electromagnetic field which is defined by regulation or the industry association standard in front of equipment under test (EUT). This system uses it in the anechoic chamber and measures a wide bandwidth in which it is decided to EMC standard and a technological standard.

In this paper, we show an examination to realize this system. First, we show a wide-band antenna using this system and measured radiation pattern. Second, we show calculation results to realize this electromagnetic field immunity test system. Finally, we design a prototype of this system, measure an electromagnetic filed distribution and compare calculation results with measurement results.

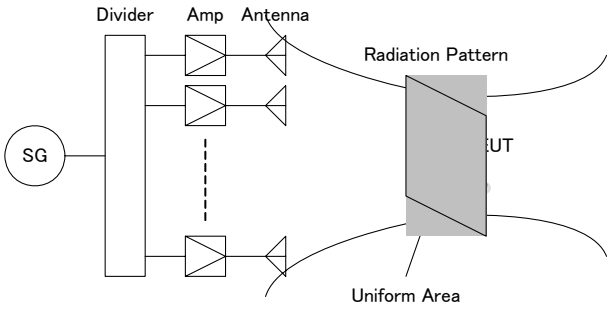

Fig. 1 System configuration.

II. ELEMENT ANTENNA

The element antenna in this system needs characteristic of wide bandwidth and sharp directivity. In this paper, we examined frequency range between 1.0 GHz to 3.2GHz. As an antenna that covers this bandwidth, we choose a tapered slot antenna (TSA) [4] with shielded guide and designed by theoretical calculation using the finite-difference time-domain (FDTD) and finite element method (FEM). Figure 2 shows a designed TSA using in this paper. A tapered conductor consists on PTFE-PCB (εr=2.1). To reduce a coupling between antenna and ambient environment, we added a shielded guide around TSA.

A measured radiation pattern at 1GHz is shown in Figure 3 and a radiation pattern at 3.2GHz is shown in Figure 4.

Fig. 2 Tapered slot antenna (TSA) covered by shielded guide.

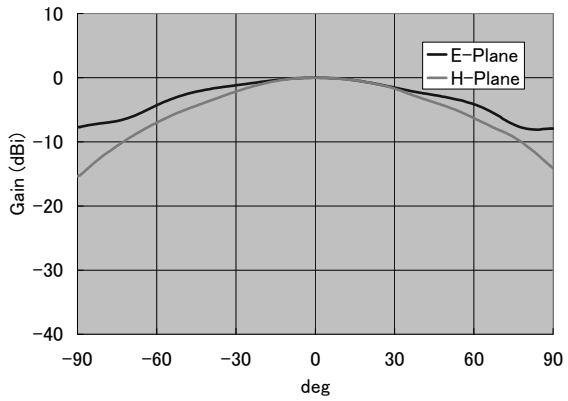

Fig. 3 Measured radiation pattern at 1GHz.

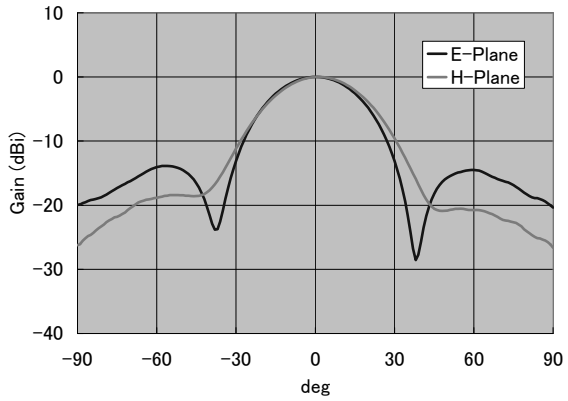

Fig. 4 Measured radiation pattern at 3.2GHz.

III. System configuration and calculation results

We focused attention on the beam forming in the short range. A number of element antennas of this electromagnetic field immunity test system are 64(8x8) because it is easy to construct by using 4-dividers. We apply radiation patterns shown Figure 3 and Figure 4 to each element for calculating a radiation pattern from array antenna. All element antenna drives by the same amplitude and equal phase.

Under such condition, we calculated electric field distribution at every 200MHz between 1GHz and 3.2GHz. We examined a 64(=8x8) elements electromagnetic field immunity test system for calculating as shown in Figure 5. The electric field strength of each calculating points are sum of radiation pattern of all element antenna.

Figure 6 illustrates 2dB interval contour map of an electric field distribution of X-Z plane at 1GHz. Figure 7 illustrates 2dB interval contour map of an electric field distribution of X-Z plane at 3.2GHz. The area where the uniformity is within +3/-6dB (see [2]), not only 1GHz bat also 3.2GHz, is approximately 6m away from antenna.

Figure 8 illustrates an electric field distribution at 1GHz which is 6m away from system. Figure 9 illustrates an electric field strength distribution at 3.2GHz which is 6m away from system. The uniform area which is within +3 / -6dB (see [2]) is about 0.5m x 0.5m, not only 1GHz bat also 3.2GHz.

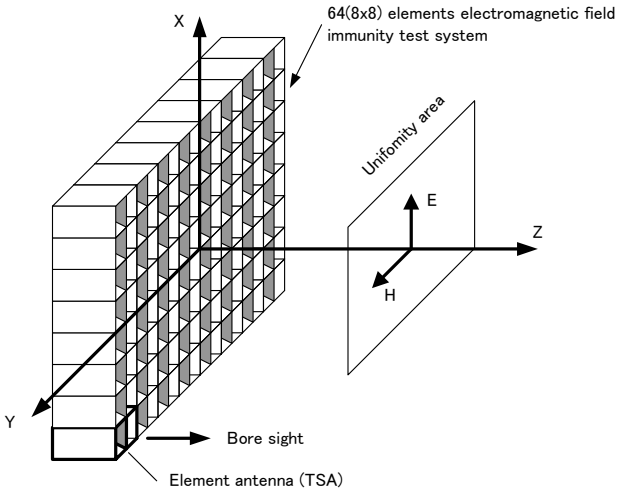

Fig. 5 Coordinate system of 64 (8x8) elements electromagnetic field immunity system for calculation.

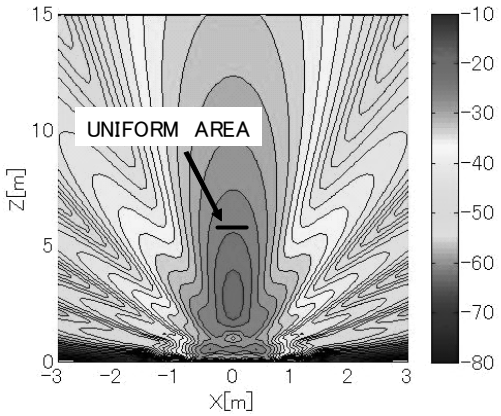

Fig. 6 Calculation result of electric field distribution at 1GHz (X-Z plane).

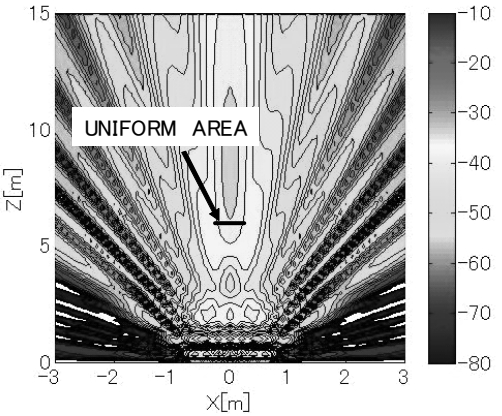

Fig. 7 Calculation result of electric field distribution at 3.2GHz (X-Z plane).

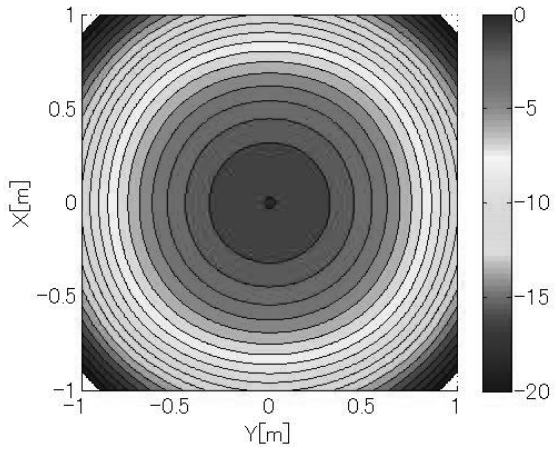

Fig. 8 Calculation result of electric field distribution at 1GHz (1dB interval).

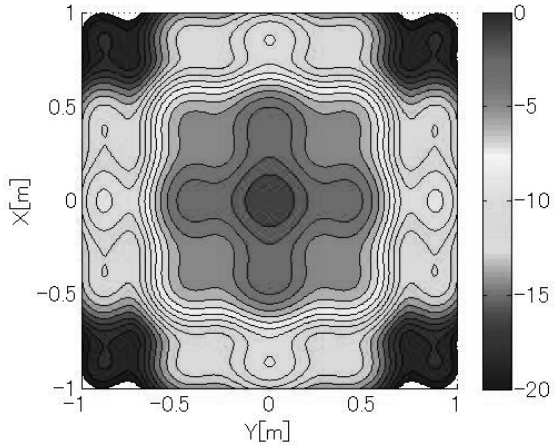

Fig. 9 Calculation result of electric field distribution at 3.2GHz (1dB interval).

IV. MEASUREMENT RESULTS

Figure 10 shows 64 (8x8) elements prototype model of electromagnetic field immunity test system using TSAs (see Figure 2) for measuring electric field distribution. We focused attention on the beam forming and uniformity for comparing calculation results and measurement results in this measurement. Therefore, the prototype model is a simple array antenna which constructed from antennas and dividers.

Figure 11 shows a measurement system of electric field distribution. We measured the electric distribution of 2m x 2m area, every 0.1m intervals, 6m away from system in anechoic chamber with absorber on a floor. The measurement system consists of a vector network analyzer HP 8753D and near field measurement system. The receiving antenna is a log-periodic antenna (LPD-118A).

Figure 12 shows 1dB interval contour map of a measured field distribution at 1.0GHz. The measurement result are similar calculate result except that contour map is slightly compress in vertical direction. It could be due to reflection from floor.

Figure 13 shows 1dB interval contour map of a measured field distribution at 3.2GHz.The contour map is not symmetrically. It could be due to multipath reflection of ambient environment.

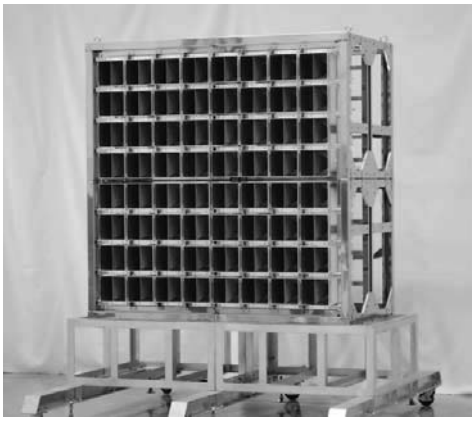

Fig. 10 64 (8x8) elements prototype model of electromagnetic field immunity test system using TSA.

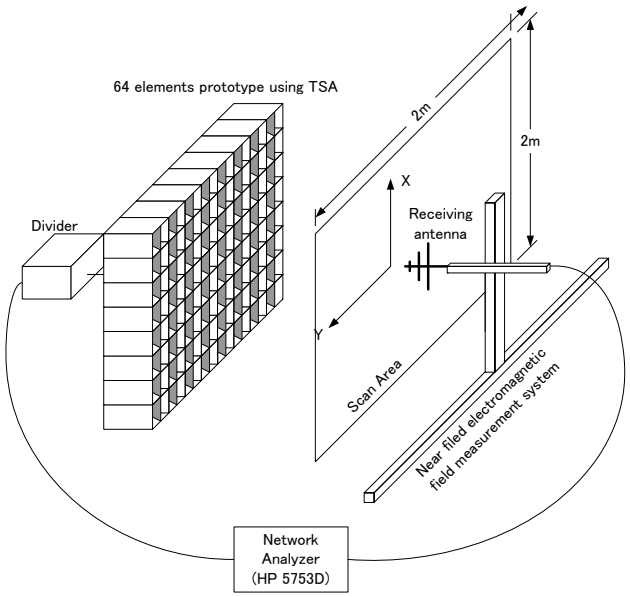

Fig. 11 a measurement system of electric field distribution.

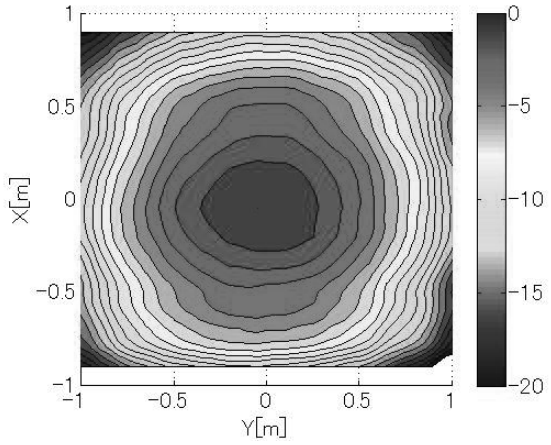

Fig.12 Measurement result of electric field distribution at 1.0 GHz.

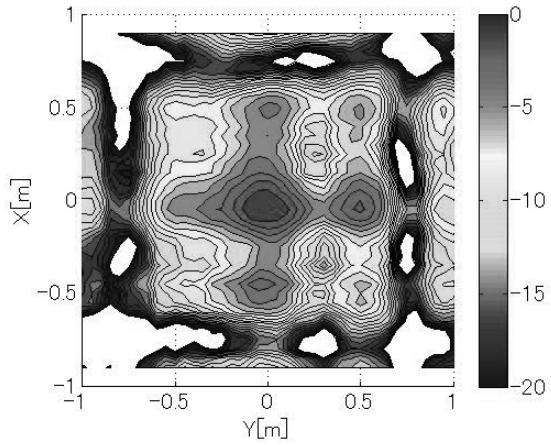

Fig.13 Measurement result of electric field distribution at 3.2 GHz.

V. Conclusion

We proposed a new electric field test system applying the array antenna technology using a low price and low power amplifier and show an examination to realize this system in this paper. This system gets a wideband uniformity of electromagnetic field form 1.0GHz to 3.2GHz. As an antenna that covers this bandwidth, we designed a tapered slot antenna with shield guide using FDTD and FEM. We measured a radiation pattern of this.

Using measured radiation pattern, we calculated electromagnetic distribution, from 1GHz to 3.2GHz, near the system which is constructed by 64(8x8) elements array antennas and shows a uniformity area. As a prototype model, we constructed an electromagnetic field immunity test system with 64(8x8) elements antenna and measured an electric field distribution of it.

We compared measurement results and calculation results, while there is an influence of multipath reflection of ambient environment, they are almost same.

As a result of this paper, we can get electromagnetic field of 100V/m or more, in 1.5m x 1.5m, when we use about 1000 elements electromagnetic field immunity test system with a lot of several watts amplifier.

References

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