A NEW GENERATION METHOD OF ROTATING-EM FIELD FOR RF RADIATED IMMUNITY/SUSCEPTIBILITY TEST

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1. Introduction

Several kinds of RF (radio frequency) radiated immunity/susceptibility test methods have been proposed, and put to practical use. The test methods using transverse-electromagnetic (TEM) devices such as TEM cell and GTEM cell have already been standardized. By using these methods, the immunity/susceptibility characteristics to the electromagnetic (EM) field in a fixed direction or of a constant polarization can be obtained. On the other hand, an immunity/susceptibility test method using EM field with slowly rotating polarization (rotating-EM field) has been proposed in reference [1]. The rotating-EM field differs from the circular-polarization field, that is, the polarization plane of the field rotates in a much lower frequency than the carrier frequency. By using the rotating-EM field in the immunity/susceptibility measurement, the radiated immunity/susceptibility characteristics of equipment under test (EUT) for various polarizations can be obtained easily in a short time. Moreover, by using a turntable together, the immunity/susceptibility characteristics for incident angles of the EM field can be automatically measured at the same time. However, there are a few weak points in the system in [1]; some synchronous signal generators (SGs) is necessary to generate the rotating-EM field accurately and the generating system is complicated. Therefore, the immunity/susceptibility measurements to various frequencies in a wide band are difficult in the method.

In this study, a new system for generating the rotating-EM field is proposed. The new generating system is composed of a microprocessor, some voltage-variable attenuators (VVAs), and some bi-phase switches, and only one SG is necessary for the system to generate the rotating-EM field. By using this system, it is expected that the rotating-EM field of an arbitrary polarization in a wide-frequency band can be generated more easily. The principle of the proposing system is clarified. Moreover, the rotating-EM field is generated in an anechoic chamber and then the basic characteristics of the resultant field are examined. In addition, the

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susceptibility of an EUT is measured by using the new generating system, and the effectiveness of our proposed system is verified.

2. Principle of new generating system

The rotating-EM field can be generated by using two different double-side-band suppressed-carrier (DSB-SC) signals given by

$$E_x = \sin\omega t \cos\Omega t \tag{1}$$

$$E_y = \sin\omega t \sin\Omega t \tag{2}$$

where ω and Ω are angular frequencies of the carrier and field-rotating rate, respectively. The DSB-SC signals are usually generated using a mixer in the telecommunications equipment. However, these DSB-SC signals for generating the rotating-EM field used in the proposed immunity/susceptibility test method cannot be generated by using the mixer because the rotating rate of the field is less than 1 Hz, so that the unwanted components included in the DSB-SC signal generated using the mixer cannot be suppressed. These DSB-SC signals can be rewritten in an expansion form

$$E_x = \frac{1}{2}\{\sin(\omega+\Omega)t + \sin(\omega-\Omega)t\} \tag{3}$$

$$E_y = \frac{1}{2}\left[\sin\left\{(\omega+\Omega)t - \frac{\pi}{2}\right\} + \sin\left\{(\omega-\Omega)t + \frac{\pi}{2}\right\}\right] \tag{4}$$

These equations show that the DSB-SC signals are composed of four-signal components with different frequencies and phases. Based on this idea, two DSB-SC signals have been generated by combining four signals generated using four SGs corresponding to the above four components. In this method, unwanted-frequency components are not theoretically generated because nonlinear elements are not used. Therefore, the DSB-SC signals not including any spurious components can be generated. However, four SGs are needed in this method, and it is difficult to generate the DSB-SC signal of an arbitrary frequency in a wide-frequency band easily. A new generation method of DSB-SC signals proposed here is composed by a microprocessor, some attenuators, and bi-phase switches as shown in Fig. 1. The envelopes of the DSB-SC signals expressed by Eqs. (1) and (2) are $|\cos\Omega t|$ and $|\sin\Omega t|$, respectively. And the phases of these DSB-SC signals are reversed periodically. Such time variances in these amplitudes and phases are adjusted with some VVAs and bi-phase switches, which work under the control through a direct-digital synthesizer by a microprocessor. Figure 2 shows an example of measured waveforms of the output signals generated by the new DSB-SC signal generator. These waveforms show the envelopes of two

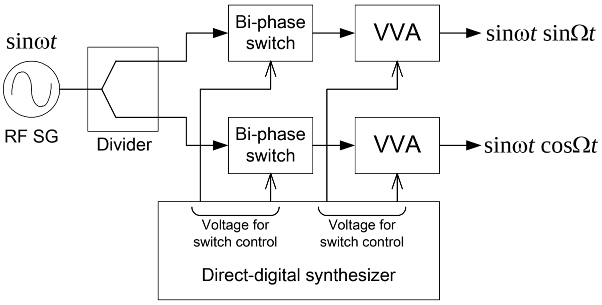

Fig. 1. Block diagram of new DSB-SC signal generator

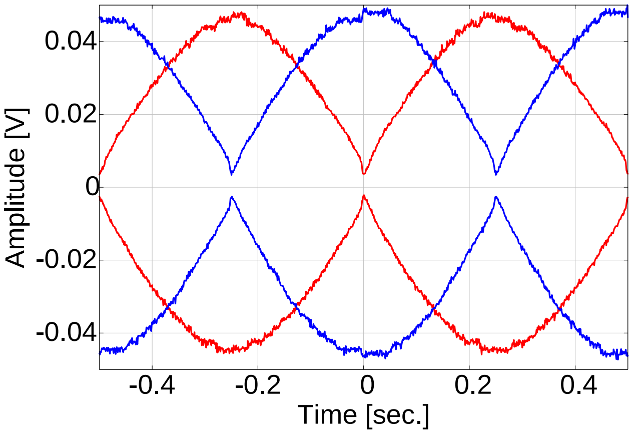

Fig. 2. Envelopes of output signals of DSB-SC signal generator

DSB-SC signals for generating the 1-GHz EM field rotating at a frequency of 1 Hz.

3. Basic characteristics of rotating-EM field

Estimation of the basic characteristics of the rotating-EM field generated by the new DSB-SC signal generator has been conducted in an anechoic chamber. The rotating-EM field generated by a dual-polarized horn antenna as a transmitting antenna is observed at a position 4 m away from the transmitting antenna (See Fig. 3). The output signals of an orthogonally arranged dipole antenna as a receiving antenna were connected to a digitizing oscilloscope through a pre amplifier, and observed by the oscilloscope with envelope mode. Figure 4 shows a measured waveform of the 1-GHz-EM field rotating at a frequency of 1 Hz. From the observation result, it can be confirmed that the peak of the envelope of each output signal appears alternately at every 250 milliseconds. The results provide evidence that the EM field rotates two dimensionally in a vertical plane including two elements of the orthogonal-dipole antenna. The EM-filed uniformity in a vertical plane near the observation point was also measured according to the standard specified by International Electrotechnical Commission (IEC). From the results, we confirmed that the EM field was satisfied with the standard of IEC enough.

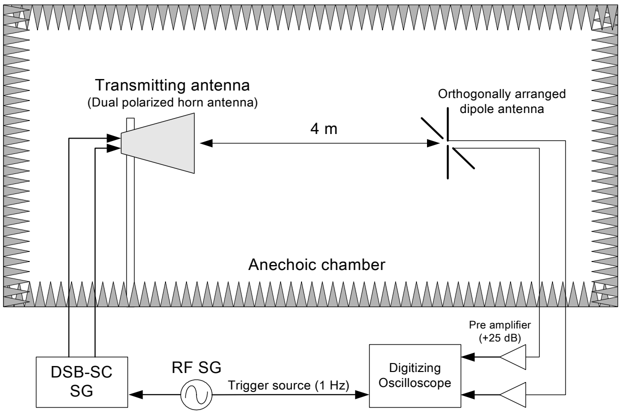

Fig. 3. Observing system of rotating-EM field in anechoic chamber.

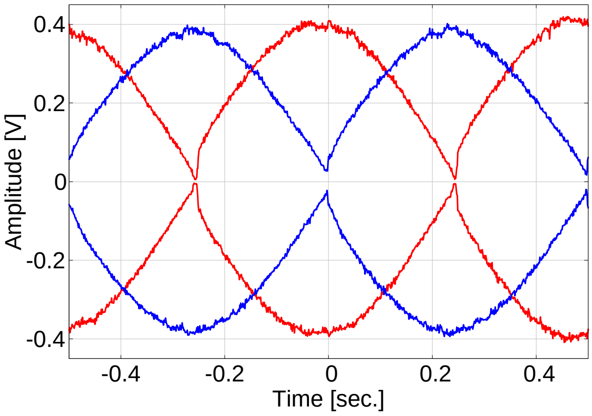

Fig. 4. Envelopes of output signals of orthogonally-arranged dipole antenna.

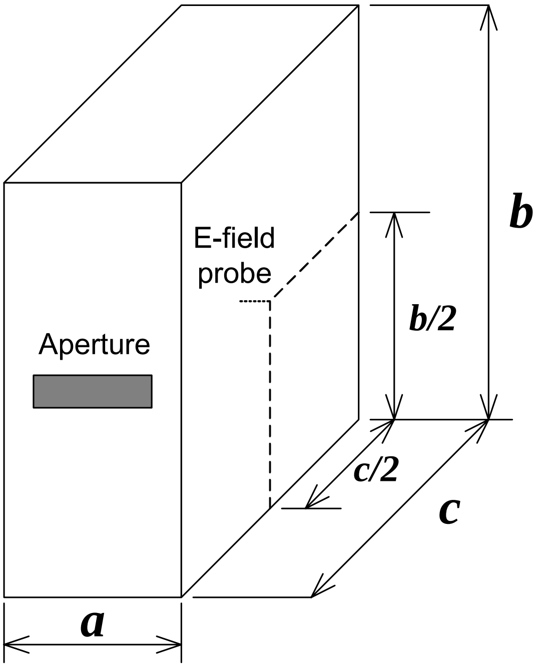

Fig. 5. Structure of cavity with an aperture.

4. Susceptibility measurements using new system

The effectiveness of the proposing test system was confirmed by measuring the susceptibility of a cavity with an aperture as an EUT (See Fig. 5). The cavity is a housing model of a desktop personal computer, and the internal size is $a \times b \times c$ = 180 × 420 × 440 mm. The external fields couple to the internal-EM fields of the cavity through the aperture on the wall of the cavity. Because it is experimentally confirmed beforehand that the cavity resonates at a frequency of 490 MHz for the dominant TE_{011} mode, it can be expected that the cavity has high susceptibility for the frequency. The susceptibility of the cavity is evaluated by measuring the output power of the E-field monopole probe arranged inside the cavity. The cavity is set on the turntable arranged at a position 4 m away from the transmitting antenna as shown in Fig. 6. Figure 7 shows the susceptibility characteristics for the polarization angle θ and the incident angle ϕ of the EM field applied to the EUT. Here, the susceptibility is defined as an output power of the E-field monopole probe when the E-field of 1 V/m is applied to the EUT. Figure 8 shows a comparison of the measured results between using the new system and the conventional system in references [1] and [2] for $\theta = 90$ degree. From this result, because we find the good agreement between them, so that the validity of the test method using the new system can be confirmed.

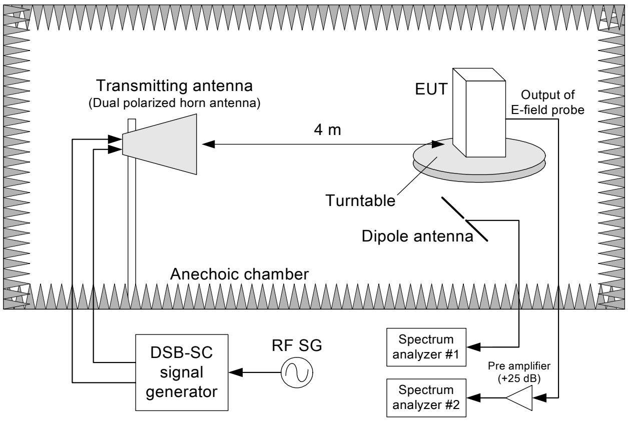

Fig. 6. Setup of susceptibility test.

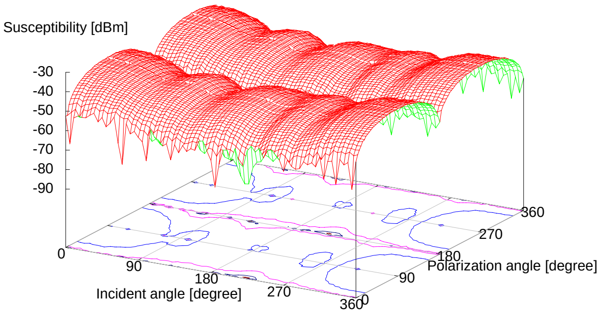

Fig. 7. 3D-susceptibility map of cavity with an aperture.

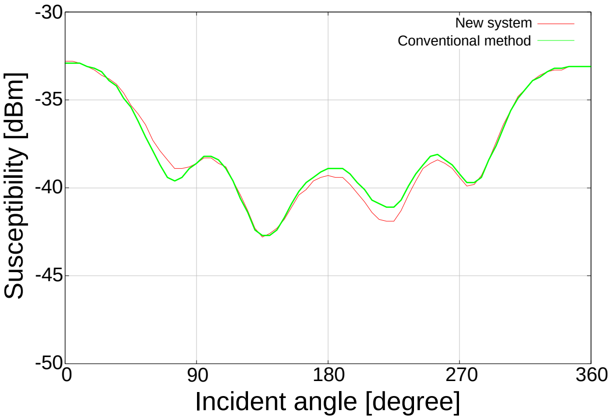

Fig. 8. Comparison between susceptibility measured using new and conventional system.

5. Conclusion

The principle of a new generation system of DSB-SC signal for generating the rotating-EM field has been shown, and the basic characteristics have been clarified. Moreover, the effectiveness of the radiated immunity/susceptibility test method using the newly constructed system has been experimently shown. Using the proposed system could generate the rotating-EM field modulated by various signals, such as analog or digital modulation signals. This shows that the immunity/susceptibility test corresponding to various actual electromagnetic conditions can be conducted by using the newly proposed system.

References

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