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안테나 일체형 소출력 무선기기의 3차원 측정 시스템 개발

Development of 3-Dimensional Measuring System for the Antenna Mounted Small Radio Equipments

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요 약 최근에 개발되는 대부분의 800MHz 이상 소출력 무선기기는 회로 본체에 안테나를 별도로 돌출 분리시키지 않고 일체형으로 설계하고 있다. 이와 같은 일체형 무선기기의 성능평가는 고전적 개념의 송신기 출력, 안테나 성능을 분리하여 측정하던 방식의 변화를 요구하고 있어, 본 연구는 이와 같은 시대적 환경에 적합한 새로운 측정방식을 제안하고 관련 기기를 개발하였다. 즉, 소형 무선기기를 원점으로 360도 전방향으로 전계를 측정하여 TRP를 측정하고, 반대로 수신레벨 역시 360도 전방향에서 측정하여 TIS를 측정하여 무선기기의 정량적 평가를 할 수 있도록하였다. 뿐만 아니라 송신기의 급전점 전력을 측정할 수 있는 경우 PCB상에 부착된 안테나의 이득, 회로 주변 유전재료, 도전재료가 방사 또는 수신레벨에 미치는 영향을 정량적으로 측정할 수 있도록 하여 효과적인 주파수 관리에 기여하고 일체형 무선기기의 최적설계와 성능관리에 효율성을 제고시킬 수 있었다.

Abstract The brand-new small output radio equipment which is over than 800MHz has an all-in-one interior antenna. We suggested new measuring method and developed related equipment because all-in-one radio equipment's performance evaluation requests old way, which is measuring transmitter output and antenna capacity separately, to be changed. That is, origin of small radio equipments with the 360 degree field measured by measuring the TRP, and also 360 degree opposite reception level measured at the radio equipment by measuring the TIS to make a quantitative evaluation was to be. Furthermore, we made managing frequencies, all-in-one radio equipment's best design and capacity management efficiently by measuring the gain of an antenna mounted on a PCB, the circuit around the genetic material, conductive material on the effects of radiation or the reception level.

Key Words : TRP(Total Radiated Power), TIS(Total Isotropic Sensitivity), EIRP(Effective Isotropicadiated Power)

Ⅰ. Introduction

The brand-new small output radio equipment which is over than 800MHz has an interior antenna. We required new way of measurement to evaluate all-in-one antenna small output radio equipment.

All-in-one antenna radio equipment makes completely different radiative patterns by dielectric substances, which are around antennas, an electric conductor, surrounding components. In addition, it has a limit to estimate the electric power of radiation because radio equipment output- output of impedance among antennas- impedance among wattmeter. In other words, we cannot keep estimating all-in-one

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antenna radio equipment with the old ways.

The world trend is to make all-in-one antenna radio equipment to be able to estimate TRP, TIS and EIRP. We developed the product which can estimate BER and FER with any directions in a radio communication with a case of not the sound but the data transmission. The system formation is made with TIS, TRP, EIRP, loss of routes, 3-dimensional turn table development in base of gain of antenna and factors and the development of measuring S/W.

II. Related Research

1. Theory

가. Configuration of Measuring System

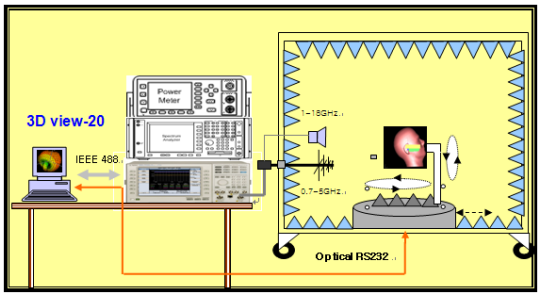

그림 1. 전체 측정 시스템
Fig. 1. Total Measuring System

The composition of the device is setting a 3-dimensional turn table in small MIN chamber[1]. Then, we control it with the optical fiber cable and we read each values of the measurement with the origin of radio equipment's feeding point or volume center.

나. TRP (Total Radiated Power)[2]-[4]

When we estimate by thinking it is a sphere (if we define Theta cuts as N and Phi cuts as M), TRP can be described as this expression (1).

$$TRP = \frac{\pi}{2NM}\sum_{i=1}^{N}\sum_{j=1}^{M} EiRP(\theta_i,\phi_j)\left|\sin(\theta_i)\right| \qquad (1)$$

In this expression, Θi is 360 degree (revolution direction), and Φj is 180 degree (perpendicular direction), so we estimate the sphere by dividing upside and downside.

The physical meaning of expression (1) is we find TRP by adding values of EIRP by every angles.

다. TIS(Total Isotropic Sensitivity)

TIS, which is inducted to estimate receiving reception, is expressed by expression (2).

$$TIS = \frac{2NM}{\pi\sum_{i=1}^{N}\sum_{j=1}^{M}\left[\frac{1}{EIS_{\theta}(\theta,\phi)}+\frac{1}{EIS_{\phi}(\theta,\phi)}\right]\left|\sin(\theta_i)\right|} \qquad (2)$$

TIS and TRP are reciprocal.

라. EIRP(Effective Isotropic Radiated Power)[5]-[7]

It is impossible to estimate all-in-one antenna radio equipment's practical radiative electric power directly. Accordingly, we use the substitution method to estimate the practical radiative electric power. Practical radiative electric power is calculated by multiplying antenna's feeding point electric power and antenna's gain (adding if we use Log), however for all-in-one antennas, it is hard to calculate so that is why we use the substitution method to estimate it. To estimate EIRP with the substitution method, the most important thing is making sure to have a very accurate loss between transmitting antenna and receiving antenna.

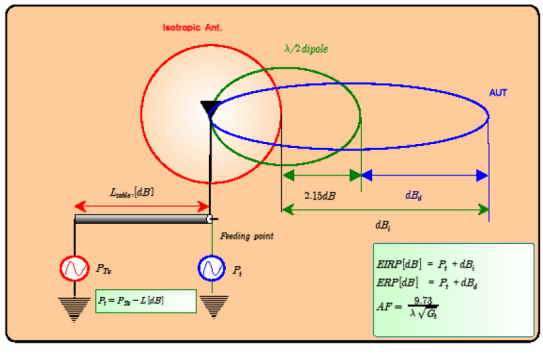

그림 2. dBi의 정의
Fig. 2. Definition of dBi

We use RF rotator not to twist the coaxial cable. However, it makes a big problem for practical measurement. Since a rotator's loss value is totally changed by rotating the same axle coupler, it changes the value of measurement. In the part of this research, we improved this problem.

The way and steps of measurement of practical radiative electric power are explained in reference[5].

Isotropic antenna actually does not exist in Fig. 2, so we use the standard antennas or dipole antennas to measure the gain. In case of the dipole antennas, we add 2.14dB to dBd to get dBi.

2. Development of 3-Dimensional Turn table

We developed the product as Fig. 3 to get 3-dimensional data in the receiving point by rotating two axes. For elements, we used Teflon which has the smallest permittivity. Additionally, driving motor was controlled by a PLC, and we used step motor.

We made geared belt for upside drive, optical fiber cable to control, and special filter for power part.

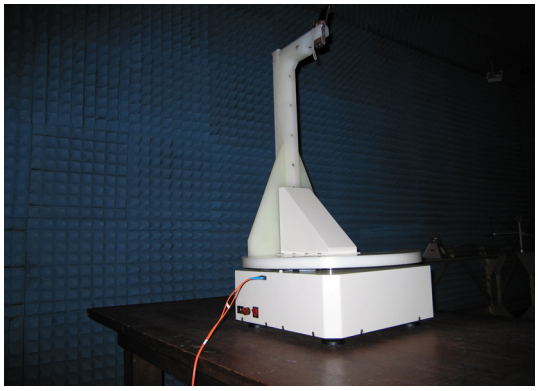

그림 3. 3차원 턴테이블
Fig. 3 3-D Turn Table

3. The Rest of Measuring Environment

Reception antenna is made with Quad-shaped which can estimate both horizontally and perpendicularly at the same time. Furthermore, a chamber is made with the developed MIN chamber which is in reference[1].

Ⅲ. Performance of Developed System[8]

1. Performance Demand

Software is developed to have these measuring capacities for demanders' various requests.

- Small antenna's 3-dimensional radiative pattern
- Measuring radiative pattern's maximum, minimum, average gains, and radiation efficiency
- Function of change from 3-dimensional pattern to 2-dimensional, 2.5-dimensional, and cylindrical coordinates
- Measuring function of H plane
- Measuring function of E1
- Measuring function of E2 pattern
- Measuring function of maximum and minimum dBi by every angles
- Sector-shaping function by measured values of every angles
- Function of Self-calibration
- Function of expressing maximum radiative direction
- Color expression by the amount of radiation of every angles
- Standard user's set-up function for maximum and minimum best expression
- Measuring function with any directions
- 3-dimensional cut view function at maximum
- H,V individual and compounding measuring function
- Tx/V-Rx/H, Tx/H-Rx/V measuring function
- Measuring function of 200 frequencies at the same time
- Set-up function of frequency optionally
- Self-measuring sample antenna special evaluation by using folding sides
- Manual measurement of user's angles and frequencies
- Monitoring function of measuring sample during measurement
- Measuring sample expressed function at 3-dimensional view

- Highest reliability and lowest uncertainty
- Frequency : 100MHz-40GHz

2. Results

This developed product's capacity has set a really wonderful value than foreign products.

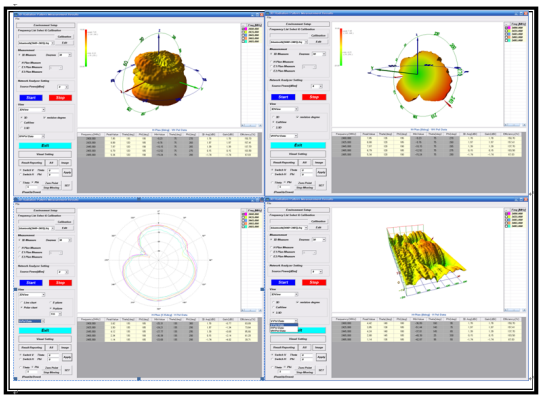

그림 4. 개발/측정결과의 예
Fig. 4. Development/Examples of measuring results

If we compare these to existing foreign products, these are better because of inserting a sample form to 3-dimensional section, decreasing uncertain measurement, section expressing of maximum radiation point and easily and automatically summating the results of measurements. The example of the result of measurement is showed on Fig. 4.

IV. Conclusion

This research was developed to have a better capacity than demander's request and its evaluation was really good by a demander and it even could measure every items that CTIA requests. Especially, it could decrease the Rotator's uncertainty by the growth of loss of value by the change of an elapse of a year, which was the existing foreign products' big problem and it inserts a shape of a sample on a 3-dimensional graph so that we can see when that sample reacts to the greatest radiation. This research's result will be able to manage frequency resources through antenna mounted every radio equipment's best design and control exported good's capacity efficiently.

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