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Measurement Experiment of LTE Terminal Transmit Power for Interference Estimation in Satellite/Terrestrial Integrated Mobile Communications System

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***Abstract* - Satellite/Terrestrial Integrated mobile Communications System (STICS) employs the frequency sharing between the satellite and terrestrial components for efficient spectrum utilization. It is required to estimate the interference level between the satellite and terrestrial link to realize the frequency sharing because co-channel interference occurs between the satellite and terrestrial link outside the satellite beam. Measurement campaign of the cellular phone transmit power in 3G network operated in Japan has been carried out to obtain the reference data of estimating the interference level. On the other hand, recently, Long Term Evolution (LTE) is rapidly penetrated into terrestrial mobile network in Japan. Therefore, in future application of LTE to terrestrial component in STICS, we have conducted the measurement experiment of transmit power for LTE terminal to estimate the interference level in STICS satellite receiver. Measurement setup to measure LTE signal is studied and a real-time spectrum analyzer is applied to measure the time-and-frequency-based LTE signal. Measurement has been carried out at six to eight measurement sites per mobile communication carrier with population density of from 60 to 27,000 /km^2 in Kansai district in Japan for the operational band of 1920 – 1980 MHz. The initial analysis of the measured data indicates that the correlation between transmit power and population density is not observed in LTE signal. This trend is different from the fact that the correlation between the measured EIRP of 3G voice transmission in LTE terminal and the population density is observed. From these observations we confirmed the trend of LTE terminal transmit power.**

***Index Terms* — Satellite communications, STICS, interference, LTE, transmit power**

I. INTRODUCTION

National Institute of Information and Communications Technology (NICT) has conducted the research and development on Satellite/Terrestrial Integrated mobile Communications System (STICS) [1]. In STICS, a mobile handheld terminal can be connected to either terrestrial or satellite link. STICS employs the frequency sharing between the satellite and terrestrial components for efficient spectrum utilization. It is realized by dividing a frequency band into several sub-bands to be allocated to satellite multi-beams, and using different sub-band frequency between satellite and terrestrial link in a particular satellite beam. However, co-channel interference occurs between the satellite and terrestrial link outside the satellite beam. Therefore, it is required to estimate the interference level between satellite and terrestrial link to realize the frequency sharing of the system. Especially, it is important to estimate the transmit power of the mobile terminal because huge number of mobile terminals using the terrestrial link would interfere the satellite receiver. To obtain the reference data of estimating the interference level from terrestrial uplink to satellite in STICS, we have conducted the measurement campaign on the cellular phone transmit power in 3G network operated in Japan [2]. The measurement result indicated that the transmit power have correlation with population density, which means that the transmit power tends to be lower in the higher population area. On the other hand, recently, Long Term Evolution (LTE) is rapidly penetrated into terrestrial mobile network in Japan. However, trend of the transmit power of LTE terminal in actual operation is not found in the literature as well as the measurement methodology of the LTE signal. Therefore, in future application of LTE to terrestrial component in STICS, we studied the measurement methodology of LTE signal and have conducted the measurement experiment of transmit power for LTE terminal to estimate the interference level in STICS satellite receiver. Section II describes the measurement methodology. Measurement experiment is described in section III with initial analysis of the data. Section IV concludes this work.

II. TRANSMIT POWER MEASUREMENT METHODOLOGY

Figure 1 illustrates the block diagram of the measurement system for LTE terminal transmit power. Transmit power (Equivalent Isotropically Radiated Power; EIRP) is calculated based on the received signal power of the antenna for the measurement (dipole antenna) located near the LTE terminal under test (distance=10 cm).

LTE signal transmission is scheduled with resource block as basic data transmission unit (frequency unit=180 kHz and temporal unit=1ms). It means that the time and frequency measurement is required. Therefore a real-time spectrum analyzer with FFT function is applied for the LTE signal measurement. The real-time spectrum analyzer samples the LTE signal (bandwidth=10 MHz) with sampling speed of 12.5 Msps. FFT with 1024 points is employed for the sampled data. After the process, resolution of the data sampling (frequency unit=12.5 kHz, temporal unit=178 μ sec with measurement period of 13 seconds) is obtained. Since LTE signal is burst signal, none-transmission period of the measured data is removed to calculate the rms value of the EIRP.

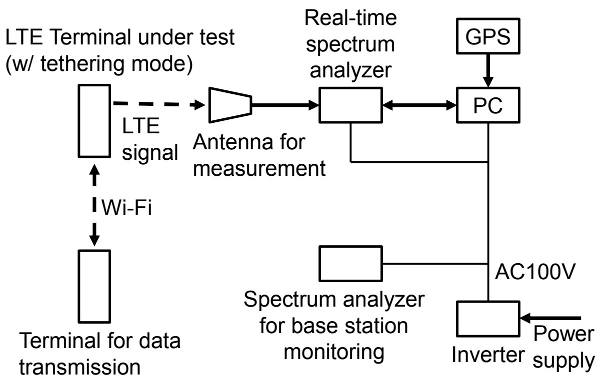

Fig. 1. Block diagram of the measurement system.

III. Transmit Power Measurement

Though 3G (CDMA) network is popular at the time of the measurement in [2], LTE smartphone is popular in the recent mobile network. Regarding the evaluation of the transmit power of the LTE terminal, it is valuable to compare the measured LTE data to the trend of transmit power of 3G terminal with respect to the population density measured in [2]. Therefore, measurement conditions similar to the conditions in [2] are employed such that the six to eight measurement sites per mobile communication carrier with population density of from 60 to 27,000 numbers/km^2 in Kansai district in Japan are selected, and that the operational band of 1920 – 1980 MHz is selected as the measurement frequency band. Population density values are quoted from data in the fiscal year 2010 written in the statistical handbook of Japan, Statistics Bureau, Ministry of Internal Affairs and Communications. iPhone5/5c terminals of three mobile communication carriers in Japan are applied in the measurement.

Figure 2 plots the relationship between the rms of the LTE transmit power (EIRP) and the population density. In the figure, two plots for particular population density and mobile communication carrier indicate the measured EIRPs in vertical and horizontal polarization at same measurement site. The measured result indicates that the correlation between transmit power and population density is not observed in the LTE terminals. This trend is different from the fact that the correlation between the measured EIRP of 3G voice transmission in LTE terminal and the population density is observed as shown in Fig. 3, which is also observed in [2].

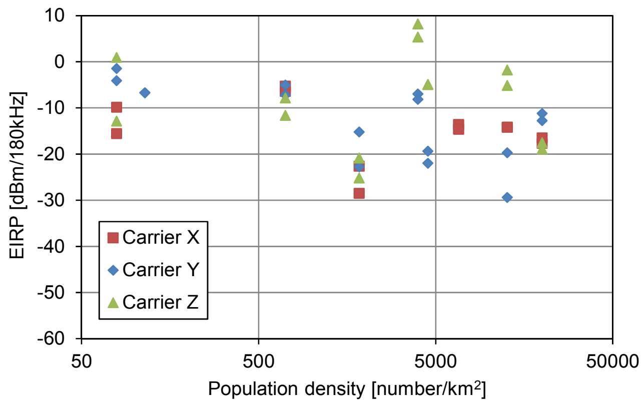

Fig. 2. Relationship between rms of EIRP of LTE and population density.

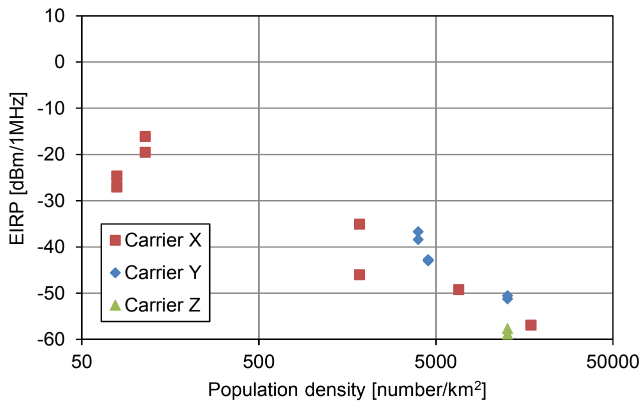

Fig. 3. Relationship between rms of EIRP of 3G voice transmission in LTE terminal and population density.

IV. Conclusion

In future application of LTE to terrestrial component in STICS, we studied the measurement methodology of LTE signal and have conducted the measurement experiment of transmit power for LTE terminal. By the initial analysis of the measured data we confirmed the trend of the transmit power of LTE terminal. Future work is to analyze measured data in detail to estimate the interference level in STICS satellite receiver.

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