MEASUREMENT OF 775 MHz, 1.5 GHz AND 2.3 GHz BAND MULTIPATH DELAY SPREAD IN URBAN AREA

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1. Abstract

Measurements of delay profile characteristics in 775 MHz, 1.5 GHz and 2.3 GHz bands are carried out within a 2 X 1.5 km area in the Tokyo metropolitan area. Delay profile is measured and recorded on analog MT at 51 millisecond intervals while a measurement vehicle runs along a test route. In the experimental results, the influence of obstacles on the average excess delay is almost the same in the three frequency bands. For the 1.5 GHz band delay spread, the maximum value observed is 4.6 microseconds, ten percent of the area exceeds 3.3 microseconds. For correlation bandwidth at 0.9 correlation the average is 21 kHz, the maximum value is 156 kHz, the minimum value is 7.7 kHz and 10 percent of the area is less than 9.7 kHz.

2. Measuring equipment

The transmitted wide-band sounding signal used is a 775 MHz, 1.480 GHz and 2.380 GHz carrier modulated by a 5-Mbps M-sequence code signal. Rubidium atomic clocks with frequency stability of less than 2×10^{-11} a day are used as the master-oscillators of measuring equipment in each of the two stations. That makes for long time clock synchronized measurement.

The received signal is sliding correlated with replicas of transmitted code signals in two quadrature correlators. Although, the two correlator output signals represent in-phase and quadrature-phase components of delay profiles, the data analysis in the paper treats only the envelopes of delay profiles. System parameters of the measuring equipment are shown in TABLE I [1][2].

3. Measurement procedures

The instantaneous delay profile extracted from analog MT shows 1.28 meter intervals along the test route. To conveniently evaluate a delay profile, an average value of 16 points for the delay profile along the test route is obtained by processing the data. (accordingly, the average value is obtained every 20 meters) A map of the experimental area in Tokyo is shown in Fig. 1. The bold line shows the test route. Terrain is almost flat except for an area 0.2 km distant from the transmitting station. There are a few high-rise buildings taller than the transmitting antenna within the propagation distance of 0 to 0.6 km. Mean building height along the test route is about 10-stories within the propagation distance of 0.6 to 4 km. The transmitting station is in the four-story Azabu Post Office building, and the transmitting antenna mast is set up on the roof of the building.

The transmitting station antenna mast reaches approximately 26.4 meters above ground level and 53.4 meters above sea level. Each transmitting antenna except the 775 MHz antenna is a vertically polarized half-wave sleeve type having a gain of about 2 dBi relative to an isotropic antenna, and the radiation pattern is horizontally omni-directional. The receiving antenna used is the same type as the transmitting antenna. The 775 MHz transmitting antenna as well as the 775 MHz receiving antenna are quarter-wave Brown types. These receiving antennas are positioned 3.0 meters above the ground. The measurement vehicle travels over about 3 km per frequency while data is being recorded on the analog MT.

4. Experimental results

Excess delays calculated in this paper are not first moments of the delay profiles with respect to the measured first arrival delay [3][4][5], but a first moment of the delay profile with respect to the theoretically assumed first arrival delay. Fig. 2 shows the average excess delay of the three frequency bands for measuring the route from A intersection to E intersection. According to figures, these average excess delays become slightly increases as propagation distance increases. The influence of obstacles on the average excess delay is almost the same in the three frequency bands. Fig. 3 shows average excess delay versus propagation distance in the 1.5 GHz band for measuring the route from A intersection to C intersection. Fig. 4, Fig. 5, and Fig. 6 are of D intersection to F intersection, F intersection to G intersection, and G intersection to I intersection. The average excess delay shown in Fig. 3 is somewhat larger than those of other figures. The average delay profile in front of A intersection (at a propagation distance of 2.3 km) is shown in Fig. 7. In this case, high buildings off the measuring route toward the transmitting station are obstacles in the shortest path from the transmitting station. Furthermore, reflected paths with long delays are not blocked by buildings (no high buildings) along the measuring route. Therefore, a large excess delay can be detected in A intersection.

On the other hand, relatively small excess delays can be seen in some other cases. The average delay profile for F intersection (at a propagation distance of 2 km) is shown in Fig. 8. In this case, as there are no high buildings (only up to 15-stories), the shortest path from the transmitting station (strongest path) is reached with little obstruction. Long delay paths strength drawn in Fig. 8 is not so weak compared with long delay path drawn in Fig. 7. However, long delay paths drawn in Fig. 7 have relatively large obstruction when compared with the shortest path. Therefore the influence of the long delay paths on average excess delay is small. Generally speaking, when the shortest path is blocked by obstacles, and obstruction around the mobile station is small, average excess delay increases.

Cumulative distribution in the 1.5 GHz band for average excess delay is shown in Fig. 9, and for delay spread in Fig .10. According to reference 6 and Fig. 10, when raised cosine pulse-shaped BPSK modulation with DPSK detection is assumed, maximum usable bit rates for an error rate of 10^{-4} is 7.4 kbps, 10^{-3} is 22 kbps over 95 percent of test area.

5. Conclusions

The average excess delay is not as varied as frequency increases. The average excess delay is slightly increases as propagation distance increases.

6. Acknowledgment

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References

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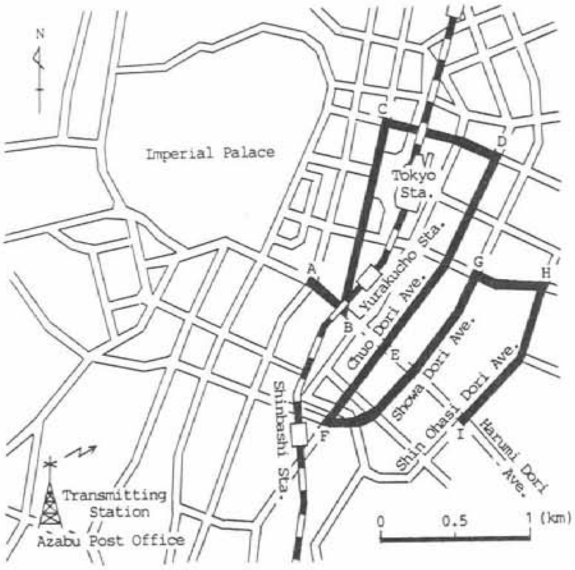

Fig. 1. Map of experimental area in Tokyo

TABLE I System parameters of measuring equipment.

Frequency	775 MHz	1.48 GHz	2.335 GHz
Transmitting power (Nominal value)	5 Watts	20 Watts	20 Watts
Resolution time	0.2 microseconds		

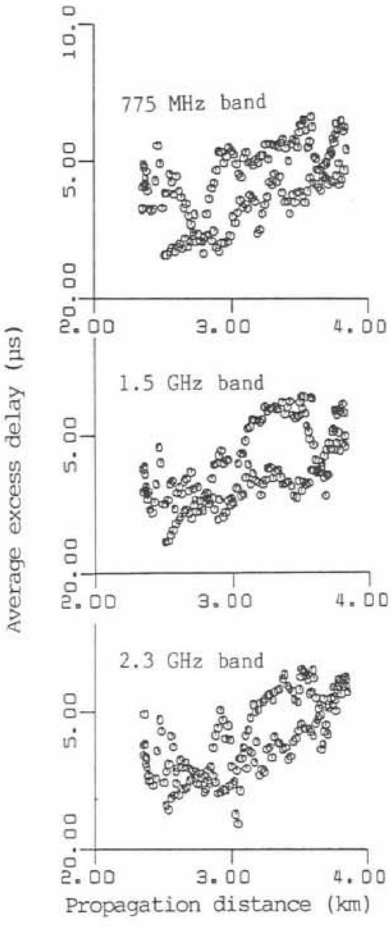

Fig. 2. Average excess delay for measuring route from A intersection to E intersection (775 MHz, 1.5 GHz and 2.3 GHz bands).

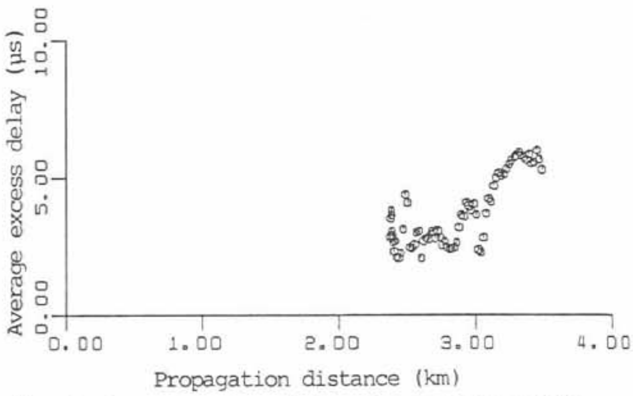

Fig. 3. Average excess delay for measuring route from A intersection to C intersection (1.5 GHz band).

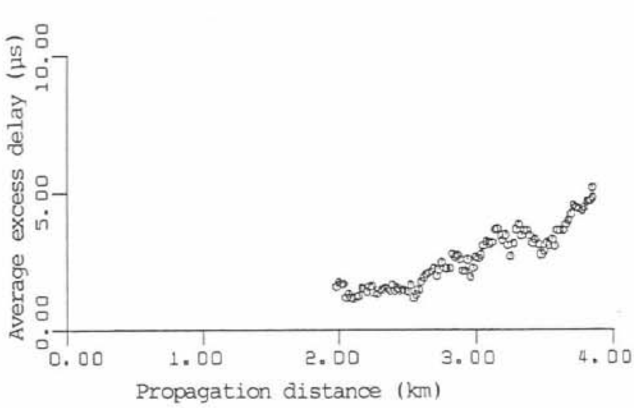

Fig. 4. Average excess delay for measuring route from D intersection to F intersection (1.5 GHz band).

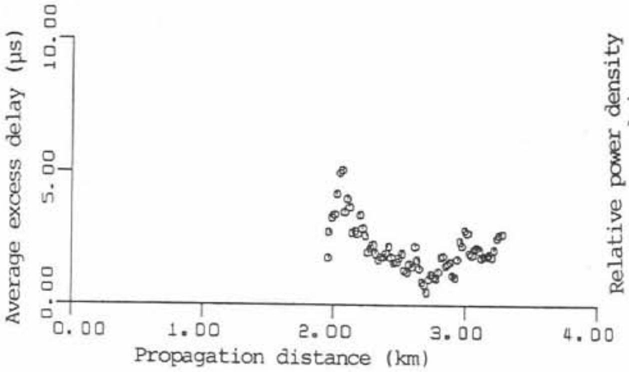

Fig. 5. Average excess delay for measuring route from F intersection to G intersection (1.5 GHz band).

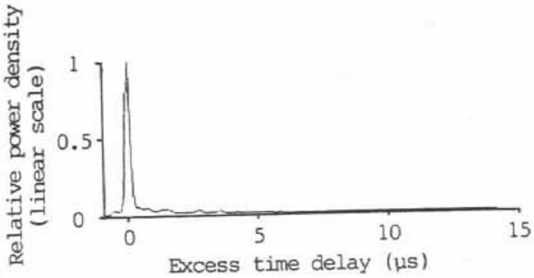

Fig. 8. Average delay profile for F intersection (1.5 GHz band)

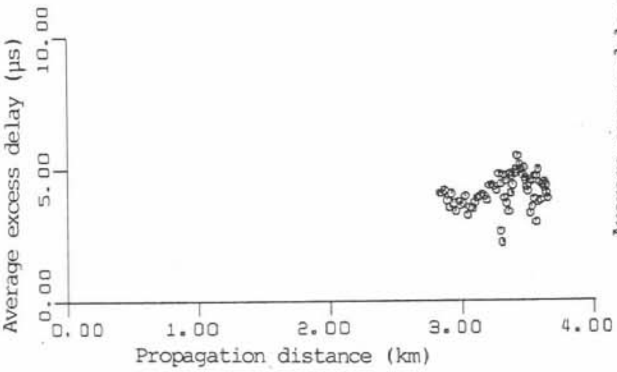

Fig. 6. Average excess delay for measuring route from G intersection to I intersection (1.5 GHz band).

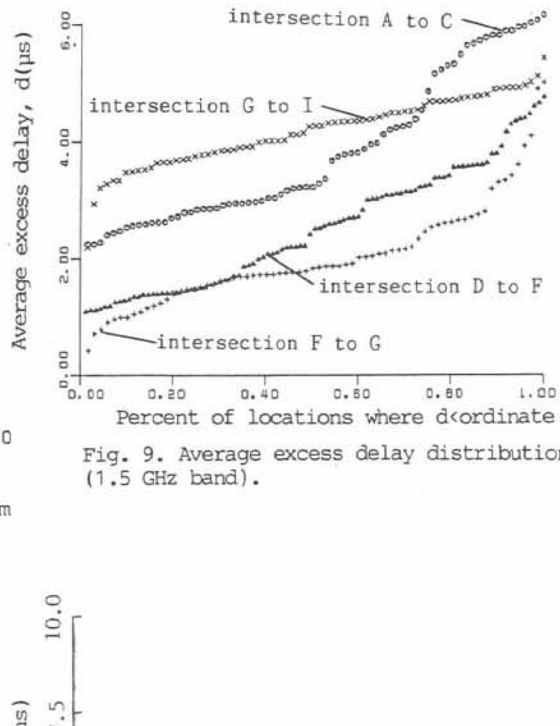

Fig. 9. Average excess delay distribution (1.5 GHz band).

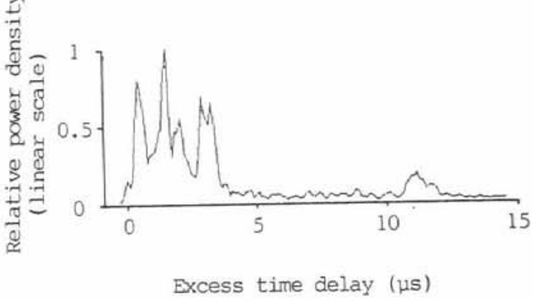

Fig. 7. Average delay profile for A intersection (1.5 GHz band)

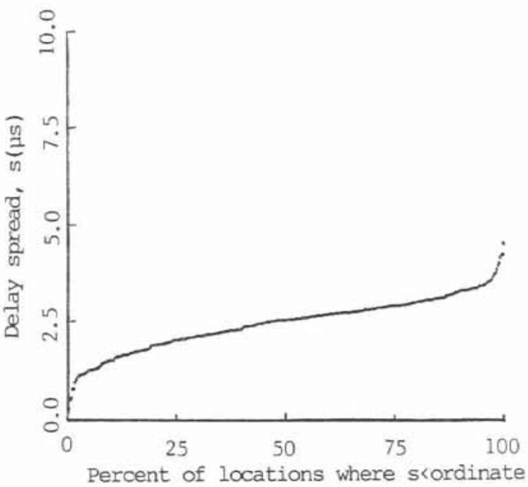

Fig. 10. Delay spread distribution (1.5 GHz band).