

JOURNAL

**INFORMATICS TELECOMMUNICATION ELECTRONICS
(INFOTEL)**

ISSN : 2085 – 3688; e-ISSN : 2460 - 0997

JUDUL

**Doppler Shift Effect at The Communication Systems with 10 GHz around
Building**

(INFOTEL, Vol.12, No.4)

Terakreditasi Peringkat S2

Keputusan Menteri Riset dan Teknologi / Kepala Badan Riset dan Inovasi Nasional

Nomor : 200/M/KTP/2020

Oleh,

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**FAKULTAS TEKNIK
UNIVERSITAS JEMBER
2021**

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Kementerian Riset dan Teknologi/
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Petikan dari Keputusan Menteri Riset dan Teknologi/
Kepala Badan Riset dan Inovasi Nasional
Nomor 200/M/KPT/2020
Peringkat Akreditasi Jurnal Ilmiah Periode III Tahun 2020
Nama Jurnal Ilmiah
JURNAL INFOTEL

E-ISSN: 24600997

Penerbit: LPPM Institut Teknologi Telkom Purwokerto

Ditetapkan sebagai Jurnal Ilmiah

TERAKREDITASI PERINGKAT 2

Akreditasi Berlaku selama 5 (lima) Tahun, yaitu
Volume 12 Nomor 2 Tahun 2020 sampai Volume 17 Nomor 1 Tahun 2025

Jakarta, 23 Desember 2020

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INFORMATIC, TELECOMMUNICATION, and ELECTRONICS (INFOTEL)

ISSN : 2085 – 3688; e-ISSN : 2460 – 0997

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Doppler Shift Effect at The Communication Systems with 10 GHz around Building

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Received 18 May 2020, Revised 23 June 2020, Accepted 25 October 2020

Abstract — This research described the Doppler shift effect for the communication systems. The mobile station moves with various velocities around the building's environment. Doppler's shift influences the communication systems. The frequency communication was used 10 GHz and its influenced by atmospheric attenuation. This research consisted of propagation with LOS and NLOS conditions, mobile station velocity variation, height buildings variation, and transmitter power variation. This research described frequency maximum at Doppler shift, coherence time, and signal to noise ratio. More increase Doppler shift of coherence time caused signal noise ratio to decrease.

Keywords – Doppler shift, building, atmospheric, velocity

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I. INTRODUCTION

The communication systems with millimeter-wave still developed. The research related to millimeter wave, such as vehicle positioning, used 5G millimeter-wave [1]. Millimeter-wave communication for 5G [2]. Determination of mobile station location around building at 47 GHz [3]. The radio base station's communication with femtocell was influenced by code rate at road pole lamp, that communication was used 47 GHz [4] and multipath effect around building using 47 GHz [5]. The other research related to another frequency, such as the communication systems of RBS femtocell using 10 GHz at streetlamp pole [6]. The communication systems through trees at 2.3 GHz [7]. Propagation of mobile communication with tree obstacles using OFDM-QAM at 10 GHz [8]. Median 60 GHz is wideband for indoor radio channel measurement [9]. An indoor office was used wideband millimeter-wave for propagation measurements and channel model at 28 GHz and 73 GHz for ultra-dense of 5G wireless network [10]. Small scale, local area, and transitional millimeter-wave propagation used 5G communications [11]. An area segmentation strategy for adaptive transmission to achieve near-uniform high-quality coverage was 30 GHz fixed wireless cellular systems in tropical regions [12]. Self-

backhauling at the resource in 5G network [13]. Self-backhauling relay nodes and centralized transmission coordination at millimeter-wave [14].

The research related to the Doppler effect, such as analysis characteristic of Delay Doppler at indoor environment [15] and research about fading multipath channel for Doppler shift and Doppler spread average [16]. Buildings, trees, and other massive objects caused obstacles to communication propagation. The high of buildings affect Signal to Noise Ratio (SNR) value. Some research related to the building found that the building's existence influenced diffraction at a communication system that used millimeter waves [17]. Research for cellular communication propagation that used 38 GHz and 60 GHz frequency around building environment [18], ACM around building environment for mobile station communication at the train [19], and the communication system of building from outdoor to indoor with AMC at 10 GHz [20].

This research describes communication propagation where the mobile station moved around the building environment. The frequency for communication was used 10 GHz. That frequency was an effort for frequency spectrum slot of operating band [21]. The utilization of that frequency was influenced by atmospheric attenuation. The mobile station moved

at the track with random velocity. The location communication took place around the building environment. That communication was caused by building existence. This research analyzed some variations such as LOS and NLOS, velocity variation of the mobile station, and power transmitter variation. Power transmitter variation consists of 20 dBm, 25 dBm, and 30 dBm, transmitting the characteristic at a maximum output power of the base station [22]. The building influenced NLOS condition. That building was modeled with different high. As a result, shows frequency value from the Doppler shift effect toward the mobile station was random velocity, coherence time from Doppler shift for communication when LOS and NLOS condition, and signal to noise ratio value.

II. RESEARCH METHOD

A. Environment Model

The frequency communication used 10 GHz. That frequency was influenced by atmospheric attenuation, such as oxygen and water vapor. Atmospheric attenuation parameter of A was s was showed at equation (1). As shows in γ parameter gaseous attenuation, and r_o was path length (km) [23].

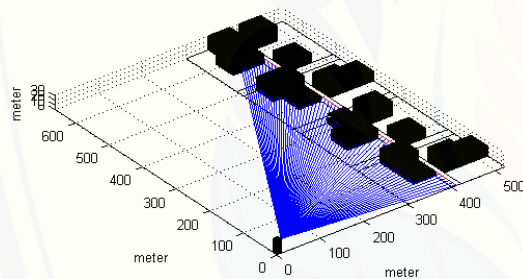


Fig. 1. Buildings obstacle of LOS propagation

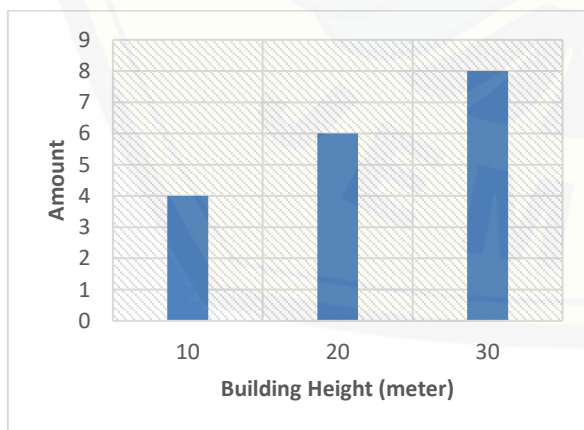


Fig. 2. Amount of building height

$$A = \gamma r_o \text{ dB} \tag{1}$$

The movement of the mobile station at the track showed in Fig. 1. Fig.1 also shown mobile stations around the building environment. The obstacle at

communication was caused by high building. The building height model was used around 10 meters until 20 meters, shown in Fig. 2. The road is modeled with a comprehensive road of 8 meters that consisting of sidewalk space and a long track for the mobile station of 600 meters.

The mobile station moved through 600 meters long track with various velocities. The velocity was used around 20 km/hour until 90 km/hour. This communication propagation was observed Doppler shift influence. The mobile station's movement was related to Doppler shift, that signal spectrum entirely would movement to frequency. The Doppler shift was affected by mobile communication system performance. The movement of the mobile station caused the Doppler effect of shift frequency. Angle-of-Arrival (AoA) was the definition of AoA direction obtained from mobile station movement direction toward base transceiver station. The equation for Doppler frequency or Doppler shift was shown in equation (2). f_n parameter was the frequency maximum of Doppler shift at the n th path, based α_n THE angle from the mobile station [24].

$$f_n = f_m \cos \alpha_n \tag{2}$$

The decision of maximum frequency at the Doppler effect is shown in equation (3) [21]. As shown in the f_m parameter, it was the maximum frequency of Doppler shift (Hz), $\Delta V_{relatif}$ was velocity (m/s), and λ was wavelength (m).

$$f_m = \frac{\Delta V_{relatif}}{\lambda} \tag{3}$$

The coherence time was time duration over the channel impulse response. The coherence time parameter of T_c (s) was shown in equation (4) [25].

$$T_c \equiv \frac{1}{f_n} \tag{4}$$

The noise equation parameter of N was shown in equation (5). That equation existed some parameter was consisting of Boltzmann constant value (K), bandwidth parameter (B), signal to noise ratio (SNR), T_o was standard noise temperature (290°K), and F parameter was noise figure [24]. As shown in F, the value used 7 dB, and bandwidth used 5 MHz.

$$N = k T_o B F \tag{5}$$

The effect of building environment used single knife-edge method. Representation of Fresnel Kirchhoff was showed in equation (6). Parameter v , λ , h , d_1 , and d_2 were represented Fresnel Kirchhoff, wavelength (m), diffraction height (m), transmitter distance toward diffraction node, and receiver distance toward diffraction node (m).

$$v = h \sqrt{\frac{d(d_1 + d_2)}{\lambda d_1 d_2}} \tag{6}$$

The transmitter power variation consists of 20 dBm, 25 dBm, and 30 dBm. SNR value is shown in equation

(7). The SNR, S, and N parameter was represented by signal to noise ratio (dB), signal, and noise power.

$$SNR = \frac{S}{N} \quad (7)$$

III. RESULT

This section described the result of this research. The communication system of mobile station movement is modeled with the Doppler Shift effect. The building environment caused the obstacle in communication. The building's environment is modeled with high variation. The analysis used LOS and NLOS communication, velocity variation of the mobile station, high building variation, and transmitter power variation. The mobile station moved at the track around the building. That communication propagation was influenced by Doppler shift maximum frequency and coherence time Doppler shift.

Figure 3 shown the communication propagation at LOS and NLOS conditions. The equation used for that result-based diffraction for LOS and NLOS as in (6). LOS condition modeled without building obstacle. NLOS condition modeled with building single obstacle. Some data was obtained from that communication, such as MS at 51 meters obtained LOS distance 414 meters and NLOS distance 416.8 meters. MS at 300 meters obtained LOS distance 508.8 meters and NLOS distance 521 meters. Furthermore, MS at 450 meters obtained LOS distance 609.4 meters and NLOS distance 632.9 meters.

Figure 4 shown the Doppler shift of MS. The mobile station was moved at the track around the building's environment. The equation used for that result is based on diffraction for LOS and NLOS as in (6) and the maximum Doppler shift frequency (3). Some data was obtained, such as MS at 51 meters with a velocity of 46 km/hour, obtained f_m Doppler shift for LOS condition 27.4 Hz and NLOS condition 35.07 Hz. MS at 300 meters with velocity 41 km/hour obtained f_m Doppler shift for LOS condition 224.8 Hz and NLOS condition 234.3 Hz. And MS movements at 450 meters with a velocity of 39 km/hour obtained f_m Doppler shift for LOS condition 267.2 Hz and NLOS condition 274.9 Hz.

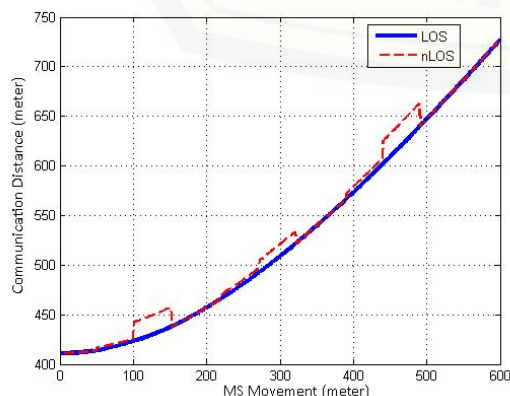


Fig. 3. LOS and NLOS communication

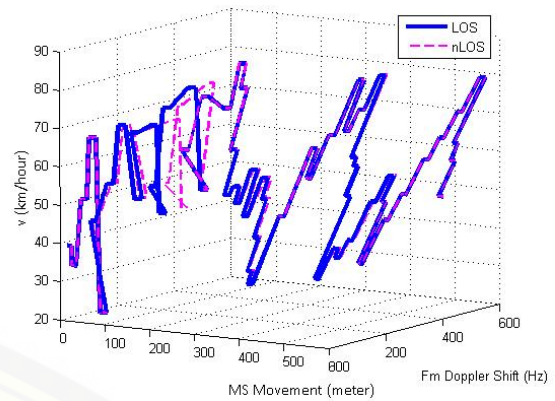


Fig. 4. The Maximum frequency of Doppler Shift at the mobile station

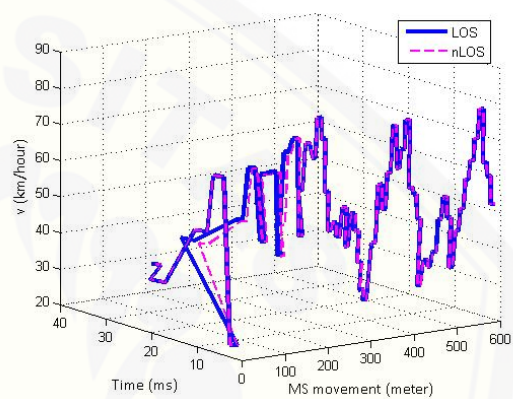


Fig. 5. The coherence time Doppler Shift from the mobile station

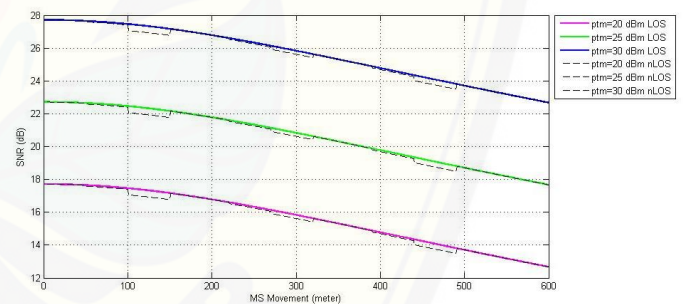


Fig. 6. SNR value for LOS and NLOS condition

Figure 5 shown the coherence time value of Doppler shift from the mobile station. Data resulted from communication propagation shows that MS at 51 meters with a velocity of 46 km/hour obtained coherence time for LOS condition 18.2 ms and NLOS condition 14.3 ms. MS at 300 meters with a velocity of 46 km/hour obtained coherence time for LOS condition 2.2 ms and NLOS conditions 2.1 ms. MS at 450 meters with velocity 39 km/hour obtained coherence time for LOS condition 1.9 ms and NLOS condition 1.8 ms. The velocity of the mobile station caused the effect of time duration for communication propagation. LOS and NLOS conditions were obtained a faster mobile station speed, so time duration to be more time.

Table 1. Some data communication propagation from Fig.6

Distance (Meters)	P_{tm} (dBm)	LOS (dB)	NLOS (dB)
51	20	17.64	17.58
51	25	22.64	22.58
51	30	27.64	27.58
300	20	15.83	15.62
300	25	20.83	20.62
300	30	25.83	25.62
450	20	14.23	13.91
450	25	19.23	18.91
450	30	24.23	23.91

Figure 6 shown the SNR value for LOS and NLOS conditions. Parameter of P_{tm} described transmitter power. The equation used for that result is based on the Signal to Noise Ratio (SNR) (7), diffraction for LOS and NLOS as in (6). Table 1 shown some data communication propagation from Fig.6. The transmitter power used consists of 20 dBm, 25 dBm, and 30 dBm. Some data from Table 1 obtained from communication propagation such as MS at 51 meters for P_{tm} 20 dBm with LOS condition obtained SNR 17.644 dB and for NLOS condition obtained SNR 17.58 dB. P_{tm} 25 dB with LOS condition obtained SNR 22.644 dB, and NLOS condition obtained SNR 22.58 dB, MS at 450 meters. P_{tm} 20 dBm with LOS condition obtained SNR 14.23 dB, and NLOS condition obtained SNR 13.91 dB. P_{tm} 25 dBm with LOS condition obtained SNR 19.23 dB, and NLOS condition obtained SNR 18.91 dB. P_{tm} 30 dB with LOS condition obtained SNR 24.23 dB, and NLOS condition obtained SNR 23.91 dB.

IV. DISCUSSION

This research focuses on the Doppler shift effect for communication around the building. Attenuation influenced communication propagation. The atmospheric attenuation consisted of oxygen and water vapor. Doppler shift and obstacles around the building caused a decrease in SNR. MS at 450 meters with P_{tm} 20 dBm was obtained SNR value such as LOS 14.23 dB and NLOS 13.91 dB. 450 meters MS with P_{tm} 30 dB was obtained SNR such as LOS 23.23 dB and NLOS 23.91 dB. Doppler shift depends on the reflection path. The increase of f_m value was obtained from the same location MS at conditions LOS and NLOS. Farther, the communication distance obtained an increase of f_m Doppler shift value. Some communication propagation MS at 450 meters obtained f_m Doppler shift for LOS 267.2 Hz. And NLOS 274.9 Hz. The coherence time at communication propagation was obtained NLOS more decrease than LOS. The increasing Doppler shift of coherence time caused the signal-noise ratio to be decreased.

The building environment is modeled with high building variation. The Doppler shift analysis was influenced by communication propagation such as the maximum frequency of Doppler shift, coherence time of Doppler shift, and signal to noise ratio. The communication distance at NLOS conditions farther than the LOS condition. Some communication propagation MS at 450 meters obtained distance LOS 609.4 meters and NLOS 632.9 meters. Some communication propagation for MS at 450 meters obtained coherence time for LOS 1.9 ms and NLOS 1.8 ms.

V. CONCLUSION

The SNR decrease is caused by atmospheric attenuation, distance communication, effect diffraction around the building, and velocity variation. MS's movement with an increase of velocity variation caused an increase of frequency influence by Doppler shift. More increase of MS velocity caused an increase of coherence time. More communication distance increases caused the decrease of coherence time. Further research development is needed such as SIMO, MISO, MIMO, etc.

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