Proceeding of the 14th International Conference on QIR (Quality in Research)
Lombok, Indonesia, 10-13 August 2015
ISSN1411-1284

Factual Electromagnetic Field Exposure under 150 kV Power Transmission Line, Nusra II, Lombok

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Keywords: Electromagnetic field; 150 kV; SUTT/HVAC; Lombok; Transmission

Abstract. As population and tourism in Lombok grew rapidly, PT. PLN (Persero) have constructed 150 kV high voltage alternating current (HVAC) power transmission lines including Nusra II working area. These lines can induce electromagnetic field to the surrounding environment. Most research in electromagnetic induced by power line took measurements when the power line system energized. Whereas in this condition, measured values may not exclusively related to the fields generated by power lines. Activities of surrounding resident could be additional source of fields, which will interfere electromagnetic measurements results. This research analyze electromagnetic field measurements under two conditions, i.e. pre-energize and energized systems, to determine factual values of electromagnetic field exposures. Measurements are done on three specific characteristics environments (rice fields, residential, and garden) at three different times (morning, midday, and night). Results show that measured fields are not zero in pre-energized conditions; however they will be higher in energized conditions. Measurements in the morning resulted in higher values rather than in the midday, except for the residential environments. Magnetic fields measured in garden are higher than in rice fields. All factual values are still far from (much lower than) the exposure limits based on SNI 04-6950-2003.

Introduction

Tourism and population in Lombok, West Nusa Tenggara, grew rapidly caused power electricity sales of PT. PLN (the national power company in Indonesia) increased in the last five years by about 11% per year and electrification ratio increased by 57.5% [1]. PT. PLN have done some constructions for the generators and 150 kV power transmission line in Lombok, called as Saluran Udara Tegangan Tinggi (High Voltage Alternating Current, SUTT/HVAC) 150 kV.

SUTT/HVAC 150 kV as power transmiter can be a source of electromagnetic field exposure for the surrounding environments. Most of the electromagnetic field exposure researches focused on 500 kV HVAC system [2]. They mainly also took measurements for the energized system only, wereas in these conditions, the measured values may not necessarily be sourced by electromagnetic field exposure of SUTT/HVAC only. Sources of electromagnetic fields could be derived from some interference caused by other systems, such as surrounding resident activities and power distribution system. Other researchers have analyzed electromagnetic exposure of 150 kV HVAC, however only included mathematical models using software [3].

This research aimed to do real measurements under HVAC/SUTT 150 kV on pre-energize as well as energized conditions, to get factual intensity values by diminishing the measured values on pre-energize conditions from values of energized one. Measurements have been conducted in three different locations, which are rice fields, residential, and garden. On each location, measurements were done at three different times (morning, midday, and night). The factual values will be examined based on the exposure limits of SNI 04-6950-2003 [4].

Methodology

Measurements are done on three different locations:

1. Rice Fields: This location is located in lines Sengkol- Paokmotong, Sengkol village, Pujut District, Central Lombok. Geographical location is at 08°48,846'S, 116°17,557'E.
2. Residential: This location is located in lines Sengkol- Paokmotong, Sukaraja village, Jerowaru District, East Lombok. Geographical location is at 08° 46, 604'S, 116° 26,759'E.
3. Garden: This location is located in lines Sengkol- Kuta, Kuta village, Pujut District, Central Lombok. Geographical location is at 08° 52, 489'S, 116° 16,726'E.

Spectran NF 5035 ®, a handheld spectrum analyzer equipment, were used to measure the field intensity in 3D [5]. The resolutions are 0.1 V/m for electric fields and 0.1 nT for magnetic fields, with accuracy of 3 %. The equipment can measure electromagnetic fields in the frequency range of 1 Hz–30 MHz, and they were set to the main power frequency of 50–60 Hz. Measurements in one location have been done at 5 (five) positions, and for every positions at least 30 values were recorded using data logger. Complete measurements sessions are depicted as the flowchart in Fig. 1.

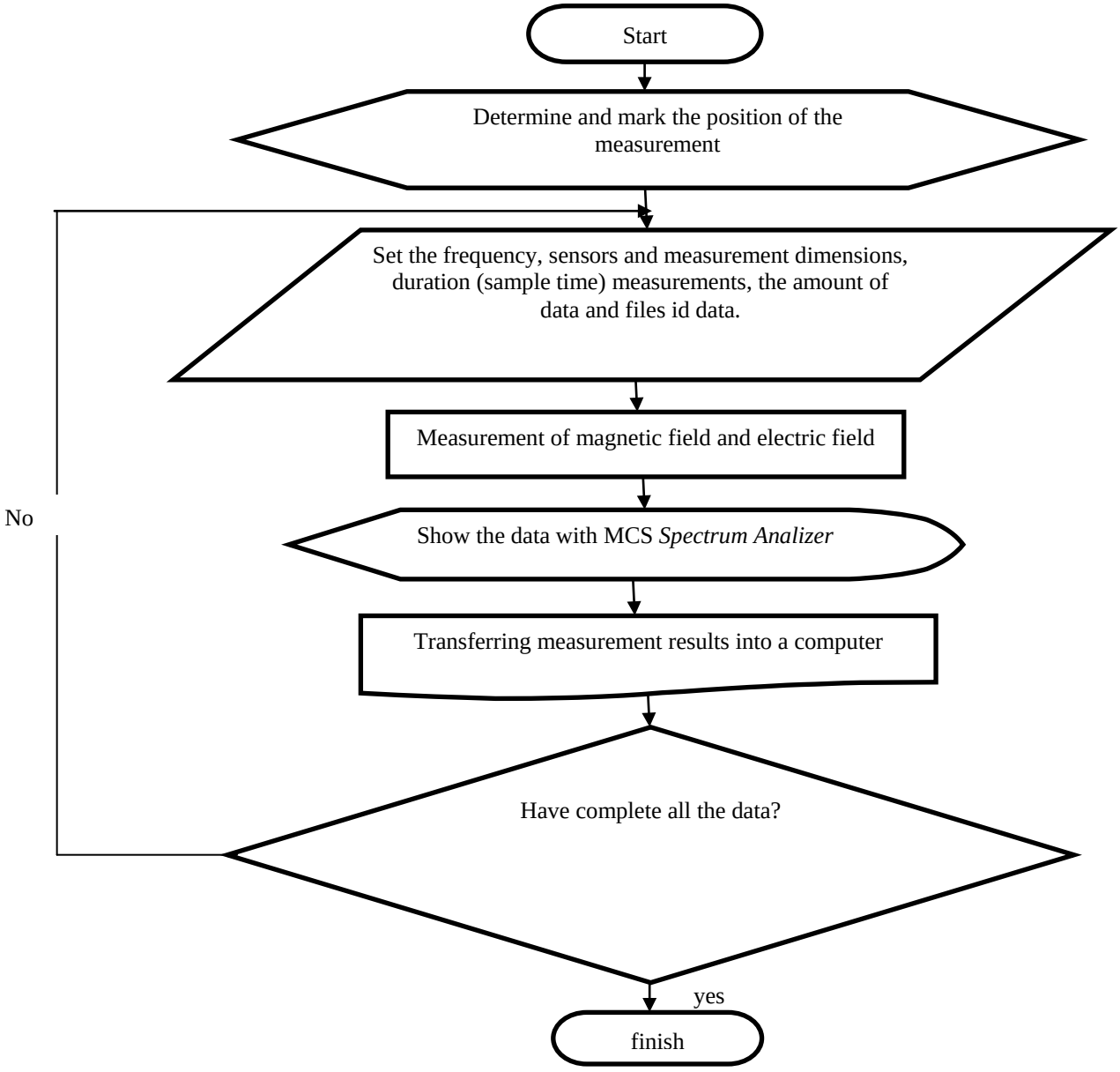


Fig. 1. Flow chart of complete measurements sessions

Results and Analysis

Measurements results on three locations in two conditions (pre-energize and energize) as well as the calculated factual values are depicted in Tables 1 to 4 and Figs. 2 to 5. Complete results of the measurements can be found in Ref. [6].

Table 1. Measurements and factual values of Electric Field on Rice Fields

Position of Sensor		-20		-10		0		+10		+20	
		Electric Field (V/m)									
Line System Condition →		P	E	P	E	P	E	P	E	P	E
Morning	Measurement Value	0.32	73.44	0.31	68.58	0.35	69.14	0.31	75.30	0.31	21.46
	Factual Value	73.13		68.27		68.79		74.99		21.15	
Midday	Measurement Value	3.03	53.12	1.25	67.93	0.64	68.35	0.94	70.63	2.10	14.62
	Factual Value	50.09		66.68		67.71		69.69		12.52	

P : *Pre-energize;* E : *Energized*

Table 2. Measurements and factual values of Electric Field on Residentials

Position of Sensor		-20		-10		0		+10		+20	
		Electric Field (V/m)									
Line system Condition →		P	E	P	E	P	E	P	E	P	E
Morning	Measurement Value	0.11	0.40	0.11	0.43	0.11	0.77	0.12	2.43	0.39	4.62
	Factual Value	0.29		0.32		0.66		2.31		4.24	
Midday	Measurement Value	0.28	0.26	0.28	0.24	0.51	0.54	0.31	5.12	0.29	0.76
	Factual Value	-0.02		-0.04		0.02		4.81		0.46	
Night	Measurement Value	0.31	0.32	0.31	0.29	0.10	0.40	0.31	2.15	0.39	1.61
	Factual Value	0.01		-0.02		0.30		1.84		1.22	

P : *Pre-energize;* E : *Energized*

Tabel 3. Measurement and factual value of Electric Field on Gardens

Position of Sensor		-20		-10		0		+10		+20	
		Electric Field (V/m)									
Line System Condition →		P	E	P	E	P	E	P	E	P	E
Morning	Measurement Value	0.11	0.19	0.10	3.04	0.11	17,94	0,10	8,64	0,32	0,51
	Factual Value	0.08		2.93		17.83		8.54		0.19	
Midday	Measurement Value	0.32	3.23	0.31	15.56	0.28	23.71	0.33	1.58	0.35	1.61
	Factual Value	2.91		15.25		23.43		1.25		1.26	

P : *Pre-energize;* E : *Energized*

Table 4. Measurements and factual values of Magnetic Field on Rice Fields and Gardens

Location	Position of Sensor	-20		-10		0		+10		+20	
		Magnetic Field (nT)									
	Line System Condition →	P	E	P	E	P	E	P	E	P	E
Rice field	Measurement Value	5.27	143.91	2.57	178.50	1.64	215.70	3.49	209.79	1.82	198.53
	Factual Value	138.64		175.93		214.06		206.30		196.71	
Garden	Measurement Value	0.00	164.19	0.00	211.42	0.00	254.36	0.00	254.47	0.00	238.73
	Factual Value	164.19		211.42		254.36		254.47		238.73	

P : *Pre-energize;* E : *Energized*

ISSN 1411-1284

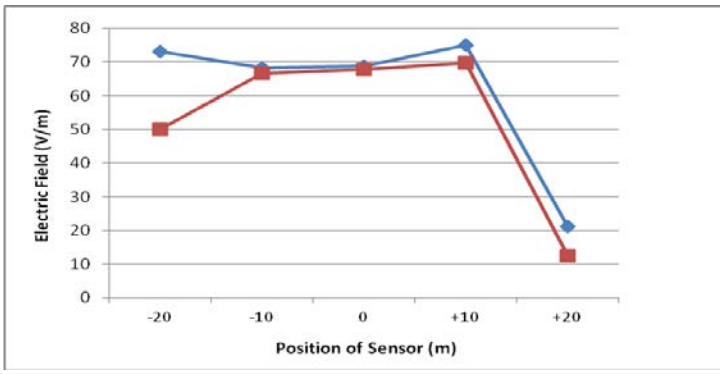


Fig. 2. Electric field measurements results on Rice Fields (blue= morning and red=midday)

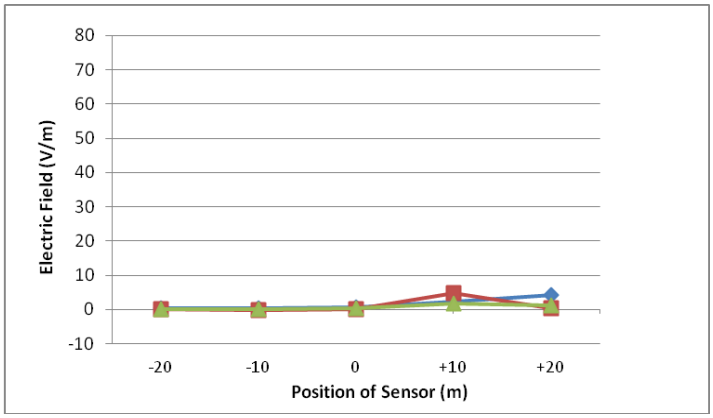


Fig. 3. Electric field measurements results on Residentials (blue= morning, red=midday, and green=night)

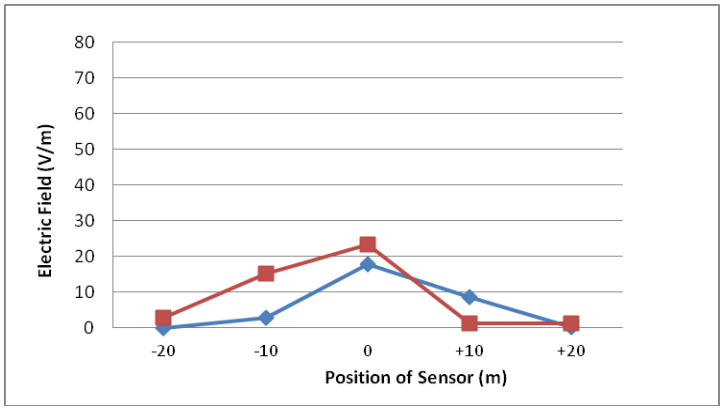


Fig. 4. Electric field measurements results on Gardens (blue= morning, red=midday)

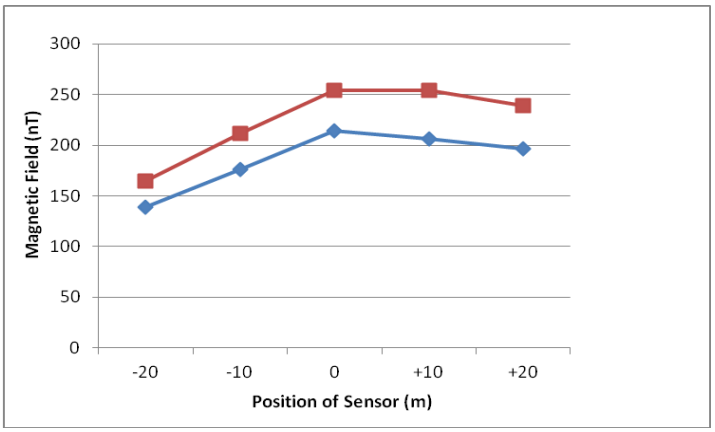
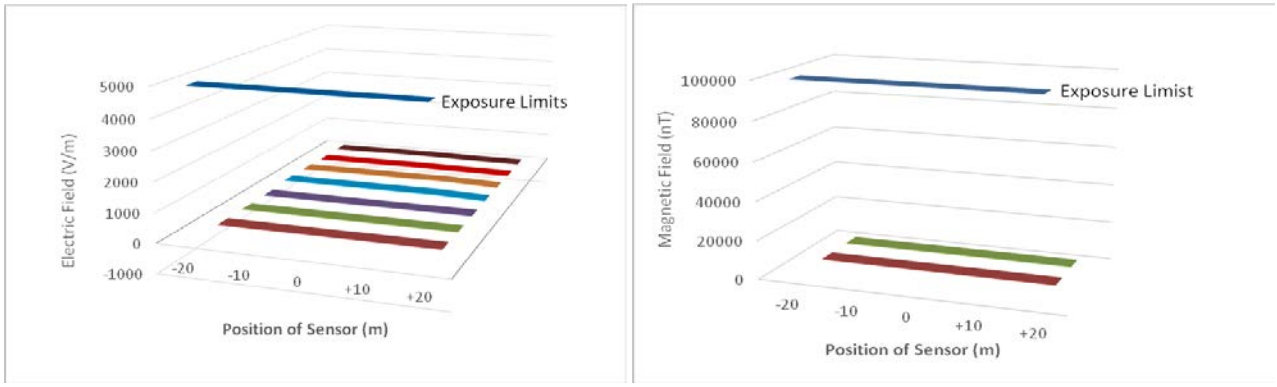


Fig. 5. Graph of magnetic field measurements results on Gardens (red) and Rice Fields (blue)

The results show that measured fields are not zero in pre-energized conditions, which may due to ambient/initial electromagnetic conditions of these environments, which may contents some electromagnetic inducing sources. However the values will be higher in energized conditions, therefore we can get the factual values by diminishing the initial values from measurements results of energized conditions. Measurements in the morning resulted in higher values rather than in the midday, except for the residential environments which may switch on much electrical utilities in the morning then switch them off in the midday. Magnetic fields measured in gardens are higher than in rice fields. Comparing the results with the limits of exposure as stated in the SNI 04-6950-2003, we found that all factual values are still far from (much lower than) the exposure limits (Table 5).

Table 5. Exposure limits of Electric and Magnetic Fields of 50-60 Hz in SNI 04-6950-2003 [4]

Classifications	Electric Fileds	Magnetic Fields
	(kV/m)	(nT)
Work Environment:		
- Throughout of workday	10	500,000
- Short time	30 (to 2 hours/day)	5,0 (to 2 hours/day)
- Limb	-	25,000,000
Public Environment:		
- 24 hours/day	5	100,000 (open area)
- a few hours/day	10	1,000,000



(a) (b)

Fig. 6. Comparison between factual values and electromagnetic limits of exposure:
(a) Electric fields; and (b) magnetic fields

Summary

Measured fields are not zero in pre-energized conditions, however they will be higher in energized conditions, therefore we can get the factual values by diminishing the initial values from measurements results of energized conditions. Measurements in the morning resulted in higher values rather than in the midday, except for the residential environments. Magnetic fields measured in gardens are higher than in rice fields. All factual values are still far from (much lower than) the exposure limits based on SNI 04-6950-2003 [4].

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