Available online www.jsaer.com

***Journal of Scientific and Engineering Research*, 2016, 3(4):279-284**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Design of a Signal Stabilizer against Weather Fluctuations in Regard Air Temperature, Air Pressure and Relative Humidity Using a Variable-Transmitter and a Micro-Controller

Joseph Amajama

Electronics and Computer Technology Unit, Physics Department, University of Calabar – Nigeria

Abstract The dynamics of air parameters: temperature, pressure and relative humidity on radio signal strength have been studied in the tropical city of Calabar – Nigeria. Mathematical models relating atmospheric radio wave refractivity with the weather parameters: air temperature, air pressure and relative humidity and atmospheric radio wave refractivity with signal strength have found application in the design of a signal stabilizer across an atmospheric channel, against weather fluctuations in regard air temperature, air pressure and relative humidity using a variable transmitter and a micro-controller. The controller functions to raise the output of a transmitter to counterbalance any loss in signal strength with fluctuations in weather and reduce output during favourable fluctuations to minimize amount of signal released into the atmosphere. If implemented, this may reduce health concerns (even though not truly established), radio wave interference (collision) due to excessive emission of signals to attain high power density as a result atmospheric impedance without quantifying the impedance and wastage of useful energy to transmit at high power density when unnecessary during favourable weather conditions. This design may not really answer quizzes on rain and wind. However, in regard to wind, since the transmission under study is omni-directional like most others in the broadcast universe, it is unwise to incorporate the idea of wind effect on radio wave propagation. None the less, it will be useful for uni-directional transmission, since the speed of the wind aids signal travel to some little extent if it is coursing parallel to the signal, but becomes detrimental when tangential or anti-parallel.

Keywords Design, Signal, Stabilizer, Weather, Fluctuations, Variable-transmitter, Micro-controller, Air temperature, Air pressure and Relative humidity.

Introduction

Weather is defined by meteorologist as the state of the atmosphere at a place and time as regards temperature, wind, humidity, pressure etc [1]. Several science literatures have proven beyond contestation that weather affects signals that are transmitted through the atmosphere [2-4]. Generally, the atmosphere is a communication channel which impedes signals. The magnitude of the impedance depends upon its condition at a particular time and it is characteristic of a particular weather and climate [5-13].

Meteorologically, four major atmospheric components control our weather [14]. They are: atmospheric temperature, pressure, humidity and wind [14]. These constituents of weather individually have a negative impact on signals that propagate through the atmosphere. A rise in any one of the above quarter with the other triplet observed constant: results in the decay of signal [9-11, 13].

Collectively, the above-listed atmospheric components: temperature, pressure, humidity and wind are functions of the atmospheric radio wave refractivity [15-17]. The aforementioned components have a direct force on atmospheric radio wave refractivity. A rise in any of the atmospheric components with the others observed constant results in a rise in the atmospheric radio wave refractivity [15-17].

Researchers have shown that there is a relationship between radio signals strength and atmospheric radio wave refractivity [15, 17]. Atmospheric radio wave refractivity is inversely proportional to radio signal strength. Mathematically, $S_1 N_1^2 = S_2 N_2^2$: where S is signal strength and N is the atmospheric radio wave refractivity

[15]. Since the atmospheric components fluctuate with time and simultaneously the atmospheric radio wave refractivity: hence $S_1 N_1^2$ is the initial state condition and $S_2 N_2^2$ is the final state condition.
The essence of this work is to design a system that will transmit a stable radio signal Across an atmospheric channel in a residential area, from the transmitter of a radio station to 2 Km away, however the fluctuations of the weather parameters: air temperature, air pressure and relative humidity. A micro-controller is incorporated in a transmitter. The controller functions to raise the output of a transmitter to counterbalance any loss in signal strength with fluctuations in weather and reduce output during favourable fluctuations to minimize amount of signal released into the atmosphere. Also, this research aims as realizing a method where by the volume of radio signal released into the atmosphere is regulated to reduce health concerns (even though not truly established), radio wave interference (collision) due to excessive emission of signals to attain high power density as a result atmospheric impedance without quantifying the impedance and wastage of useful energy.

Methodology

Radio signal strength from a residence in Calabar – Nigeria ($4^0$57'31.7"N, $8^0$20'49.7"E) was measured half hourly for a length of about two days, in addition, the atmospheric temperature, pressure and humidity at every instance of signal measurement with wind speed and direction was recorded. This is to study the dynamics of the weather in relation to radio signal through a sphere of reference of about 2 Km in the residential area, from the Cross River State Broadcasting Cooperation Television transmitter (CRBC-TV) ($4^0$57'54.7"N, $8^0$19'43.7"E), radiating signal at 519.25 MHz and 35mdB.
The output of the transmitter will be determined by the response of the micro-controller. The micro-controller will have three interfaces that input the atmospheric temperature, pressure and humidity. The effect of wind and rain was outside the horizon of this work, since their mathematical impacts at the moment has not been ascertained. Also, for an omni-directional transmission like this, it is within the bounds of impossibility to bring to bear the impact of the wind. However, for a uni-directional transmission, it is achievable to some considerable extent. In the latter situation, the wind speed and direction is taken into account on how it affects the signal as it travels through the atmosphere to a particular station of interest. None the less, most signal broadcasts, most especially, commercial ones are omni-directional.
Meteorologically, the atmospheric condition that amounts to a clear sky through the course of this investigation (the wet) in Calabar, where the research was conducted: has an air temperature of (77 °F), air pressure of 29.91 inHg and relative humidity of 82%. It is assumed that under this condition of a clear sky, as the signal propagates through the atmospheric or air channel, the best quality of signal will be registered with the lowest air radio characteristic impedance. The refractivity under this condition is the reference refractivity, N_r (362.908994). The signal strength transmitted minus the signal strength received at this condition is referred to the free space path loss, L_{fs} and it was 25 mdB for a distance of about 2 Km away on this day in the wet.
The transmitted signal strength from the station is 35 mdB and it is the reference signal strength transmitted, S_r. From the experiment carried out, the best strength of signal received in the residence under the clear sky condition above was 10 mdB at about 2 Km away. In other word as earlier stated, for the most favourable conditions of the sky (or weather) in the course of the experiment, 25 mdB was lost.
The signal stabilizer is a MISO (Multiple Inputs and Single Output). It will employ four interfaces, of which, three will be connected to the thermometer, barometer and hygrometer to input signals to the controller that is: the air temperature, air pressure and humidity respectively. The last interface will give outputs to the variable transmitter depending upon the inputs or conditions at the gate of the controller. As the triplet simultaneously arrive the controller, the refractivity of the sky is computed with the formula below in Eqn. 1 [16].

$$N = K \times P^2 \times \sqrt{T} \times \sqrt[3]{H} \quad (1)$$

Where K = Constant = 0.01064097915
P = Atmospheric pressure in inHg
T = Atmospheric temperature in ^{0}F
H = Relative humidity in %
N = Radio refractivity $[(\text{inHg})^2\ {}^0F^{1/2}\ \%^{1/3}]$
The output S_o of the transmitter is determined by the mathematical relationship from Eqn. 2 programmed in the controller thus:

$$S = N_r^2 \times S_r / N^2 \quad (2)$$

N is the computed air wave refractivity by the controller as a result of a new state of atmospheric condition (air temperature, air pressure and relative humidity) – a consequence of weather fluctuations. Hence:
If $S \geq S_r$
Compute $S - S_r = S_d$: Release $S_r - S_d$ as output
That is $S_o = S_r - S_d$, if $S \geq S_r$, but

If $S < S_r$

Compute $S_r - S = S_d$: Release $S_r + S_d$ as output

That is $S_o = S + S_d$

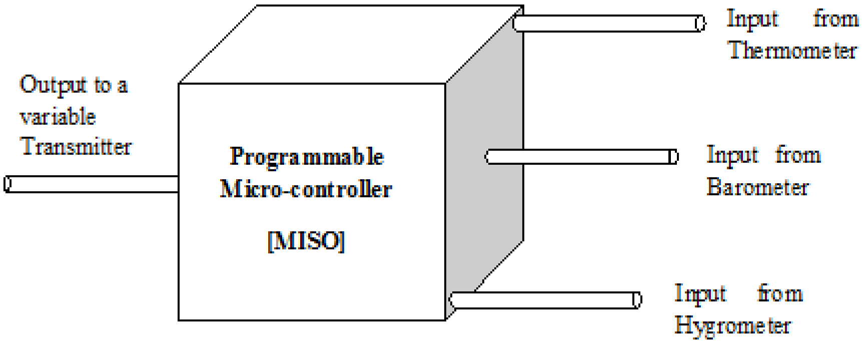

Figure 1: Input, 1 Output interface Micro-controller [MISO] system

Results and Analysis

The following is the result obtained as shown in Table 1.

Table 1: Computed parameters from air temperature, air pressure and relative humidity for an omni-directional radio signal transmission

Air Temp. (^{0}F)	Air Pres. (inHg)	Relative Humidity (%)	Air Radio wave Refractivity ($inHg^{20}F^{1/2}\%^{1/3}$): N	Computed signal strength (mdB): $S = N_r^2 \times S_r / N^2$	Signal Loss (mdB): through a combination of the weather parameters (without wind/Rain) $S_d = S - S_r$	Output from transmitter (mdB): $S_o = S_r + S_d$	Anticipated signal to be received at a distance 2 Km away (mdB): $S_{ar} = S_o - L_{fs} - S_d$	Measured Signal received without micro-controlled stabilizer 2 Km away SE of the transmitter	Wind speed and direction (Mph) N ↑
77.0	29.91	94	379.8123	31.95401	3.0459893	38.04599	10	9.5	0NA
77.0	29.91	94	379.8123	31.95401	3.0459893	38.04599	10	8.5	7 WSW
77.0	29.91	94	379.8123	31.95401	3.0459893	38.04599	10	8.5	7 WSW
77.0	29.91	94	379.8123	31.95401	3.0459893	38.04599	10	8.6	5 WSW
77.0	29.91	94	379.8123	31.95401	3.0459893	38.04599	10	8.7	5 WSW
78.5	29.94	94	384.2636	31.21799	3.7820117	38.78201	10	9.0	0NA
78.5	29.94	94	384.2636	31.21799	3.7820117	38.78201	10	9.0	0NA
78.0	29.94	94	383.0379	31.4181	3.5818964	38.5819	10	9.3	0NA
78.0	29.94	94	383.0379	31.4181	3.5818964	38.5819	10	8.4	2 W
78.0	29.94	94	383.0379	31.4181	3.5818964	38.5819	10	8.1	2 W
78.0	29.94	94	383.0379	31.4181	3.5818964	38.5819	10	8.3	0NA
78.0	29.94	94	383.0379	31.4181	3.5818964	38.5819	10	8.3	0NA
79.5	29.94	94	386.7034	30.82531	4.1746908	39.17469	10	7.8	0NA
79.5	29.94	94	386.7034	30.82531	4.1746908	39.17469	10	7.8	0NA
79.0	29.94	94	385.4855	31.02041	3.9795939	38.97959	10	8.0	0NA
77.0	29.94	94	380.5746	31.02041	3.1738691	38.17387	10	9.3	0 NA
77.0	29.91	100	380.5746	30.66272	4.3372846	39.33728	10	8.5	0 NA
77.0	29.91	100	380.5746	30.66272	4.3372846	39.33728	10	8.5	0 NA
77.0	29.91	100	380.5746	30.66272	4.3372846	39.33728	10	8.6	2 W
77.0	29.91	100	380.5746	30.66272	4.3372846	39.33728	10	8.6	2 W
78.0	29.91	88	373.9578	32.96236	2.0376409	37.03764	10	9.1	5 WSW
78.0	29.91	88	373.9578	32.96236	2.0376409	37.03764	10	9.1	5 WSW
77.0	29.85	85	365.8097	34.44712	0.5528757	35.55288	10	9.1	6 SSW

77.0	29.85	85	365.8097	34.44712	0.5528757	35.55288	10	9.4	6 SSW
77.0	29.85	94	365.8097	32.2117	2.788297	37.7883	10	9.1	3 S
77.0	29.85	94	365.8097	32.2117	2.788297	37.7883	10	9.2	3 S
79.5	29.85	89	377.4422	32.35657	2.6434272	37.64343	10	9.1	3 SW
79.0	29.85	89	376.2534	32.56136	2.4386388	37.43864	10	8.7	3 SW
79.5	29.85	89	377.4422	32.35657	2.6434272	37.64343	10	8.6	2 NA
79.0	29.85	89	376.2534	32.56136	2.4386388	37.43864	10	8.6	2 NA
79.5	29.85	80	364.2648	34.73995	0.2600496	35.26005	10	9.4	0 NA
79.0	29.85	80	363.1175	34.95982	0.0401765	35.04018	10	9.2	0 NA
77.0	29.84	100	385.9146	30.95145	4.0485507	39.04855	10	9.3	0 NA
77.0	29.84	100	385.9146	30.95145	4.0485507	39.04855	10	9.4	0 NA
77.0	29.91	94	379.8123	31.95401	3.0459893	38.04599	10	9.5	0 NA
77.0	29.91	94	379.8123	31.95401	3.0459893	38.04599	10	9.4	0 NA
77.0	29.91	94	379.8123	31.95401	3.0459893	38.04599	10	9.4	0NA
77.0	29.91	94	379.8123	31.95401	3.0459893	38.04599	10	9.4	0NA
77.0	29.88	94	379.8123	32.08253	2.9174665	37.91747	10	9.7	0NA
77.0	29.91	90	374.3466	32.89392	2.106082	37.10608	10	9.6	0NA
77.0	29.85	94	378.29	32.2117	2.788297	37.7883	10	9.8	0NA
77.0	29.85	94	378.29	32.2117	2.788297	37.7883	10	9.8	0NA
77.0	29.88	89	372.2072	33.27315	1.7268523	36.72685	10	9.7	0NA
77.0	29.91	89	372.955	33.13986	1.8601447	36.86014	10	9.7	0NA
79.0	29.81	89	375.2457	32.73648	2.2635193	37.26352	10	9.4	0NA
79.0	29.81	89	375.2457	32.73648	2.2635193	37.26352	10	9.4	0NA
79.0	29.94	84	371.3002	33.43591	1.5640867	36.56409	10	8.5	0NA
81.0	29.94	84	375.9708	32.61034	2.3896648	37.38966	10	8.5	0NA
81.0	29.81	94	386.9522	30.78569	4.2143143	39.21431	10	10.0	0NA
77.0	29.85	74	349.2954	37.78138	-2.7813764	32.21862	10	9.5	12 SW
86.0	29.85	74	369.1448	33.82751	1.1724885	36.17249	10	9.5	12 SW
86.0	29.85	74	369.1448	33.82751	1.1724885	36.17249	10	9.4	12 SW
84.0	29.85	74	364.8271	34.63293	0.3670716	35.36707	10	9.4	12 SW
82.0	29.85	79	368.3999	33.96444	1.0355645	36.03556	10	8.7	9 SW
82.0	29.85	79	368.3999	33.96444	1.0355645	36.03556	10	8.7	9 SW
81.0	29.85	89	380.9864	31.75738	3.242623	38.24262	10	8.8	9 SSW
81.0	29.85	89	380.9864	31.75738	3.242623	38.24262	10	8.8	9 SSW
79.0	29.85	89	376.2534	32.56136	2.4386388	37.43864	10	8.8	7 SW
79.0	29.85	89	376.2534	32.56136	2.4386388	37.43864	10	8.8	7 SW
79.0	29.88	94	383.942	31.27032	3.7296826	38.72968	10	8.8	9 W
79.0	29.88	94	383.942	31.27032	3.7296826	38.72968	10	8.8	9 W
79.0	29.91	94	384.7133	31.14505	3.8549516	38.85495	10	8.8	5 WSW
79.0	29.91	94	384.7133	31.14505	3.8549516	38.85495	10	8.8	5 WSW
77.0	29.91	100	387.7274	30.66272	4.3372846	39.33728	10	8.8	0NA
77.0	29.91	100	387.7274	30.66272	4.3372846	39.33728	10	8.8	0NA
79.0	29.44	94	372.7177	33.18207	1.8179327	36.81793	10	9.0	2 E
79.0	29.44	94	372.7177	33.18207	1.8179327	36.81793	10	9.0	2 E
77	29.91	82	362.909	35	0	35	10	10.0	0NA

Fig. 2 shows the variance of the three weather parameters: air temperature, air pressure and relative humidity with the received signal strength, 2 Km away, south east (SE) of the transmitter without the micro-controlled transmitter stabilizer and the anticipated received signal strength, 2 Km away, south east (SE) of the transmitter with the micro-controlled transmitter stabilizer. As the weather fluctuates, the power of the signal transmitted is regulated to neutralize the degrading effect on the signal, since the weather components: air temperature, air pressure and relative humidity have a negative effect on signal transmissions. None the less, in the event of a favourable weather, depending on the value of the computed refractivity by the micro-controller, the power of transmitted signal is reduced to regulate the amount of signal radiated, but maintain a stable signal through the area of the atmospheric channel in operation.

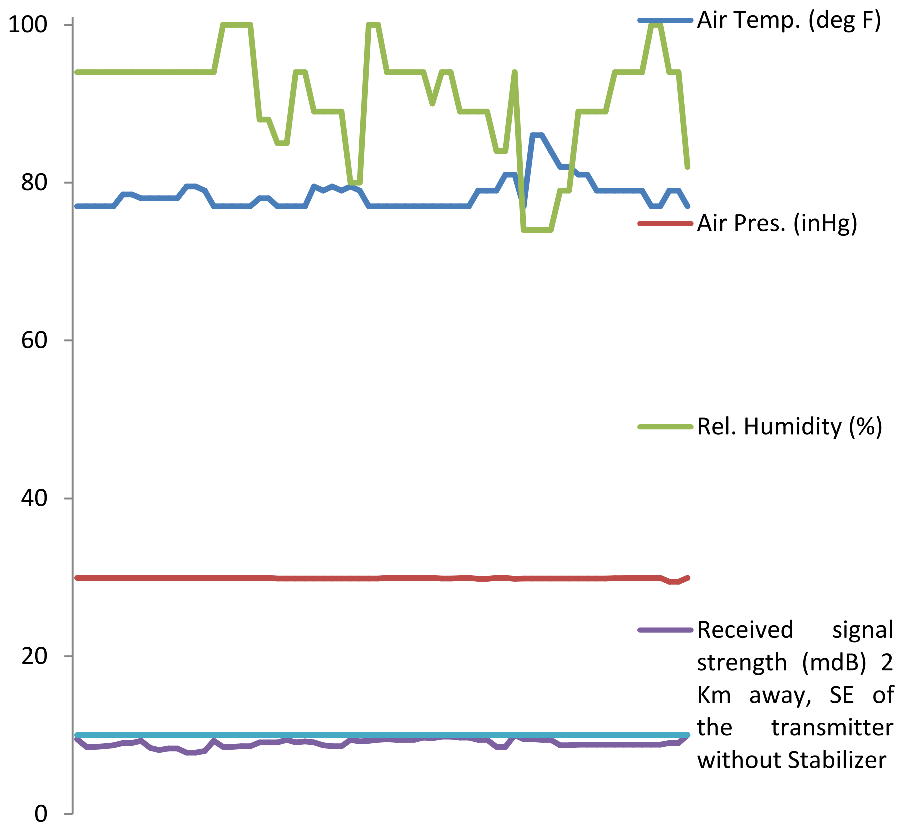

Figure 2: Weather parameters' variance and transmitter output with and without stabilizer

Conclusion

Weather poses a serious challenge to communications' scientists. Studies have shown that weather is not a friend of radio wave propagation. There is quest by various scientists in the sphere of communication to proffer a solution to this problem. The content of this paper provide knowledge to stabilize signal across a sphere of the atmospheric channel if properly digested. This will find application in the tropics were the research has been conducted.

The variation of refractivity, which is a function of the air temperature, air pressure and relative humidity, has a heavy impact on radio signal propagation [16]. Refractivity has a negative relationship with the signal across an atmospheric channel, also as the air temperature, air pressure and relative humidity [15, 17]. The aforementioned knowledge was applied in the design to counter weather challenges of signal transmission induced by air temperature, air pressure and relative humidity.

However, this research is within the compass of the afore-listed parameters. It may not really answer quizzes on rain and wind. In regard to wind, since most transmissions are omni-directional it is unwise to incorporate the idea of wind effect on radio wave propagation, but it will be useful for uni-directional transmission. Here, in the latter kind of transmission the length of atmospheric channel from the transmitter to the receiver is of utmost concern and the wind direction and speed is really significant. Results registered from a research have shown that at uniform atmospheric temperature, pressure and humidity, wind has a marked effect on radio signal [3] [13]. The signal transmits better if the wind propagates in a similar path as the signal, but worse in the contrary directions. That is, the speed of the wind aids signal travel to some little extent if it is coursing parallel to the signal, but becomes detrimental when tangential or anti-parallel [3].

References

[1]. Weather (2004). In Concise Oxford English Dictionary (11th ed.). Oxford: Oxford University Press.

[2]. Amajama, J., & Eshiet, M. (2016). Impact of Weather Components on (UHF) Radio Signal. *European Scientific Journal*, *12*(10).

[3]. Meng, Y. S., Lee, Y. H. & Ng, B. C. (2013). The effects of tropical weather on radio wave propagation over foliage channel. *IEEE transaction on vehicular technology*, 58(8), 4023 - 4030.

[4]. Weather versus propagation (2015), Introduction to wave propagation, Transmission lines, and Antrennas. Retrieved November 5, 2015 from www.tpub.com/neets/book10/40c.htm. Port Richey-Hwy: Integrated publishing inc.

[5]. Atmospheric attenuation due to humidity (2011). In Electromagnetic waves. Retrieved November 1, 2015, from cdn.intechopen.com/pdfs-wm/16080.pdf.

[6]. Jari, L. & Ismo, H. (2015). Effect of temperature and humidity on radio signal strength in outdoor wireless sensor. *Proceedings of the federated conference on computer science and information systems.* 5, 1247 – 1255.

[7]. American Friends of Tel Aviv University. (2013). Radio waves carry news of climate change: Surprising tool to measure our changing climate. *Science Daily*. Retrieved March 30, 2016 from www.sciencedaily.com/releases/2013/07/130730123421.htm.

[8]. Ian, P. (Ed.) (2015a). Radio signal path loss. Retrieved April 3, 2015, from www.radio-electronics.com.

[9]. Joseph, A. (2016). Force of Atmospheric Humidity on (UHF) Radio Signal. International *Journal of Scientific Research Engineering & Technology*, 5(2), 56-59.

[10]. Amajama, J (2016). Impact of Atmospheric Temperature on (UHF) Radio Signal. *International Journal of Engineering Research and General Science*, 4(2), 619-622.

[11]. Amajama, J (2016). Atmospheric Pressure Bearing on (UHF) Radio Signal. *International Journal of Scientific Engineering and Technology*, 5(3), 131-133.

[12]. Yeeken, O. O. & Michael, O. K. (2011). Signal strength dependence on atmospheri particulates. *International Journal of electronics and communication engineering*, 4(3), 283 – 286.

[13]. Joseph, A., & Oku, D. E. Wind versus UHF Radio signal. *International Journal of Science, Engineering and Technology Research*, 5(2), 583-855.

[14]. Weather parameters (2015). Retrieved November 10, 2015, from cees.tamiu.edu/cees/weather/parameters.html.

[15]. Amajama, J. (2015). Association between atmospheric radio wave refractivity and UHF radio signal strength. *American International Journal of Research in Formal, Applied & Natural Sciences,* 13(1), 61-65.

[16]. Amajama, J. (2015). Mathematical Relationships between Radio Refractivity and Its Meteorological Components with A New Linear Mathematical Equation to Determine Radio Refractivity. *International Journal of Innovative Science, Engineering & Technology*, *2*(12), 953-957.

[17]. Farmoriji, J. O. & Oyeleye, M. O. (2013). A test of the relationship between refractivity and radio signal propagation for particulates. *Research desk.* 2(4), 334-338.