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ARTICLE

Water Manipulation through Curvature Energy on Humidity Microparticles

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ABSTRACT

The electric field created in a curvature energy sensor on air microparticles is used to obtain a temperature-humidity map $\mathsf{G}: M \to SO(2) \cup F$, by stereo-radially of the sensor design to detect and measure the temperature and humidity of certain local region of the environment space. Likewise, considering the curvature energy as the deviation of any field interaction, even the obstruction to its proper flow, is designed and created a humidity-resistor sensor to the control and optimization of humidity in a space with different gradients of humidity, pressure and temperature in a radial detection and measuring. Then the sensing problem is a problem of free boundary conditions where is satisfied an energy functional of norm $\|\xi\|_2$, to curvature functions κ, that satisfy in the temperature and humidity function ξ, the change limit condition $\xi|_{\partial\Omega} \leq 2\pi\xi(r)$. This carries to that the temperature-humidity sensor must be designed on a length gauge to measure the changes of humidity and temperature in the space.

1. Introduction

Let $M \subset \mathbb{R}^3$, a space where we want to detect and measure the humidity and temperature considering the humidity micro-particles in the air of an environment bounded to the boundary conditions of an electromagnetic field of managing and geometrical design of the proper sensor to optimizing and measuring of sensed with several research and application goals:

i) Measurement and detection in a region, at least of certain kilometers of radius, of the humidity and temperature to realize a distribution map of these characteristics. This will come considering the humidity micro-particles in the air of the environment, directly.

ii) The managing of water microparticles to their storage and use.

iii) The obtaining of energy through curvature energy to diverse uses and applications. For example, to energy transducer through humidity microparticles.

The goal iii) will be realized in the second part of this

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research although will be given the bases to its development.

Likewise, is necessary consider the general thermic-pressure-humidity process described under the framework of differential equations [1]:

$$\frac{d\boldsymbol{\upsilon}}{dt} = -\alpha\nabla P - \nabla\varphi + \boldsymbol{F} - 2\boldsymbol{\Omega}\times\boldsymbol{\upsilon}, \tag{1}$$

$$\frac{\partial\rho}{\partial t} = -\nabla\bullet(\rho\boldsymbol{\upsilon}), \tag{2}$$

$$P\alpha = RT, \tag{3}$$

$$Q = C_P\frac{dT}{dt} - \alpha\frac{dP}{dt}, \tag{4}$$

$$\frac{\partial pq}{\partial t} = -\nabla\bullet(\rho\upsilon q) + \rho(E - C), \tag{5}$$

where the humidity phenomena depends on the temperature and pressure of the system of interest.

Likewise from (1)-(5), $\boldsymbol{\upsilon} = (\upsilon_x, \upsilon_y, \upsilon_z)$, is the velocity field of the gas, $q = T(t)$, and $p = P(t)$, is the temperature and pressure functions depending of time, $\rho = \frac{1}{\alpha}$, (with $\alpha = \mathrm{V}/nR$)① is the gas density, Q, is a heat.

In this case, the gas will be the air.

We consider a mass constant of sensing, thus from (2) we have

$$\frac{\partial\rho}{\partial t} = 0, \qquad \rho\nabla\boldsymbol{\upsilon} = 0, \tag{6}$$

and the general law gas is reduced to the law $P/T = cte$, where volume of the air sensor sample is constant [2].

The humidity is a function of two gas state variables, the temperature and pressure, which are time functions. Likewise, the humidity is the 2-dimensional surface:

$$\xi = \xi(T(t), P(t)), \tag{7}$$

The function (7) will be used in the spectral study of the humidity through humidity sensor outputs whose frequency variation will be useful to conform a stereo radial mapping of the environment to a scale factor captured through humidity, temperature and pressure signals, which combining will obtain a energy spectra of humidity.

Under certain constant volume of air with high content of water steam,② we have the following criteria to behavior of the function ξ,

i) If $T\to\infty$, then $P\to 0$, and the humidity $\xi\to\infty$, thus the clime is humid.

ii) If $T\to 0$, then $P\to\infty$, and the humidity $\xi\to 0$, thus the clime is dry.

Likewise, we consider the sensor chip to obtain directly pressure and temperature through humidity gradient with:

$$X_\xi = -\mathrm{grad}\,\xi(T, P), \tag{8}$$

We obtain inside an isochoric semi-spherical region that:

$$\mathrm{div}\nabla\xi = \nabla^2\xi = 2\pi\rho = cte, \tag{9}$$

with the corresponding spherical coordinates system, because has been chosen a semi-sphere as region where will be located the humidity sensor in its center (see the Figure 1). Here must be satisfied the Poisson equation to constant distribution of air. Then the sensing will be using the curvature energy, and the radial detection of the airflow to measure their humidity and temperature. This optimizes the sensoring and detection of humidity and temperature.

Figure 1. Flow conservation-detection region.

Likewise, from the energy equation (5) we have in energy-interchange due mass that :

$$E = C, \tag{10}$$

Then the energy flow satisfies that:

$$\frac{\partial pq}{\partial t} = -\rho\nabla(\tilde{\boldsymbol{\upsilon}}q), \tag{11}$$

which para a local coordinates system, (11) can be re-write as:

$$\begin{aligned}&\left[\frac{\partial P}{\partial x}\frac{dx}{dt} + \frac{\partial P}{\partial y}\frac{dy}{dt} + \frac{\partial P}{\partial z}\frac{dz}{dt}\right]\\ &\quad + \left[\frac{\partial q}{\partial x}\frac{dx}{dt} + \frac{\partial q}{\partial y}\frac{dy}{dt} + \frac{\partial q}{\partial z}\frac{dz}{dt}\right] =\\ &\quad -\rho\left(\frac{\partial\upsilon_x}{\partial x}q + \frac{\partial\upsilon_y}{\partial y}q + \frac{\partial\upsilon_z}{\partial z}q\right),\end{aligned} \tag{12}$$

which establish the energy interchange of the flow conservation-detection region of the sensor in the 3-dimensional space.

Likewise, we consider (7) and we take an isochoric process with constant pressure given by the atmospheric (barometric) pressure of the place. Then (7) takes the form:

$$\xi = P\xi(T(t), 1) = P\xi(T(t)), \tag{13}$$

Likewise its variation respect to time will be:

① Likewise, the general gas law is $PV = nRT$. If $\rho = cte$, then we have the classical general gas law form: $\frac{P\mathrm{V}}{T} = cte$. Here R, is the Boltzmann constant (1.381×10−23 J·K^{-1}), n, is the number of gas molecules.

② The volumen of humidity

$$P\frac{d\xi(T(t))}{dt}=P\frac{d\xi(T(t))}{dT}\frac{dT}{dt}, \tag{14}$$

However, we are interested in the humidity as state function, thus we consider the variation of humidity respect to temperature and pressure (but pressure is constant), proportional to it-self humidity with respect to pressure and volume constants:

$$P\frac{d\xi(T)}{dT}=k\xi(T), \tag{15}$$

with initial condition $\xi_{ext}(T_0)=\xi_{\text{int}}(T_0)$, where $T_0 \pm \Lambda$, depending of the increasing or decreasing of temperature and measure scale.

Likewise the general law that will govern the physical process of humidity is:

$$\xi(T)=\xi(T_0)e^{k(T-T_0)}, \tag{16}$$

Here the constant $\xi(T_0)$ ③ involves the barometric pressure, the volume of the scale region, the rate of relative humidity diffusion and other constants relative to the relative humidity④.

We want to detect the functions $\xi(T)$, as energy signals to the sensoring process, inside a region where is satisfied the Poisson equation (9) to air density or distribution ρ.

Due to the electronic component of our humidity sensor only can be installed with its receptor in one direction, we need consider a surface Σ, whose speed of direction change can be taken in the inner and consigned by electronic signals of energy accord to its geometrical invariant [3]. Then we require curvature energy [4-6].

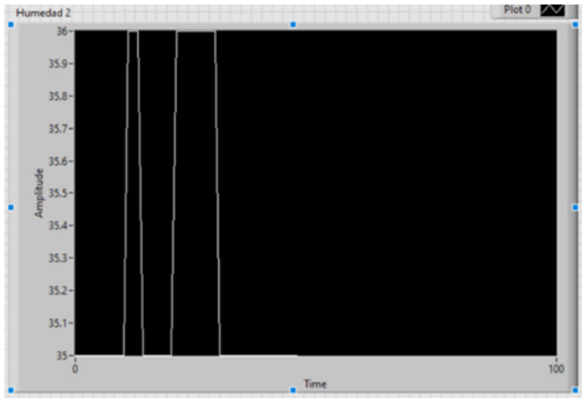
However, what curvature energy? This will be from a normal curvature obtained. Why?

The flow conditions and behavior of the air without enclosure Σ, no reflects an ordered behavior of the air then cannot be sensed and detected by humidity sensor (see the Figure 2A), even in disclosure conditions the airflow cannot be bounded for electronics parameters range. Then we need an enclosure given by Σ (see the Figure 2B).

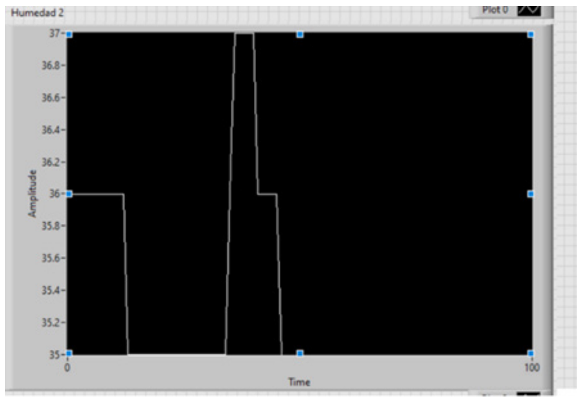
The perfect enclosure Σ, will be the geometrical enclosure, which can establish permanent conditions of the humidity field as has been established in (8) and whose boundary conditions no vary and have not different direction in inputs inside the enclosure (Figure 2B).

③ $\xi(T_0)=\frac{V\phi}{nRT}K$, where K, is the characteristic function defined to the enclosure or sensing region which is a semi-sphere.

④The relative humidity of an air-water mixture is defined as the ratio of the partial pressure of water vapor in the mixture to the equilibrium vapor pressure of water over a flat surface of pure water [7] at a given temperature.



A. without spherical dome or enclosure with air flow



B. with spherical dome or enclosure with air flow

Figure 2. Temperature and humidity.

Likewise, the air inputs-outputs through of enclosure must be radials and obey the following boundary conditions:

$$\xi\big|_{\Sigma}\leq 2\pi\xi(r), \tag{17}$$

which only has meaning in a spherical symmetry. Thus we choice a spherical dome where we consider the positive hemisphere (see the Figure 3).

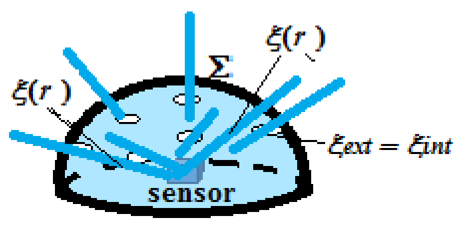


Figure 3. Air inputs-outputs through of enclosure must be radials.

Then an interesting conjecture derived directly of the chosen geometry to the sensor is:

Conjecture 1. 1. The radial humidity signal is 2π units its normal curvature.

2. Some Simple Experiments of Field of the Humidity Sensor with Geometrical References

Considering the mentioned in the section 1, we have the following lemma to analyze from a geometrical point of view, the reception of signals by sensor, and geometrical disposition of this.

Lemma 2. 1. The detection and measurement of humidity will be through the normal curvature of the surface Σ, which is its Radon transform [8].

Proof. We consider as characteristic function of curvature around the semi-sphere Σ, as the function:

$$K(x,y)=\begin{cases}\frac{1}{r^2}, +\sqrt{x^2+y^2+z^2}\leq r\\ 0, +\sqrt{x^2+y^2+z^2}>r\end{cases}, \quad (18)$$

Then the Radon transform on the polar disk is:

$$\hat{K}(r,\theta)=\int_{\sqrt{x^2+y^2+z^2}\leq r} K(x,y)ds=\frac{1}{r^2}\int_0^r ds=\frac{1}{r}, \quad (19)$$

For other side, the normal curvature of the semi-sphere Σ, comes given by (consider that in the semi-sphere its principal curvatures satisfy $k_1=k_2$), then

$$k(\boldsymbol{u})=k_1\cos^2\theta+k_2\sin^2\theta=\frac{1}{r}=\hat{K}(r,\theta),(20) \quad (20)$$

Furthermore, its normal curvature meets with its mean curvature

$$H=\frac{1}{2\pi}\int_0^{2\pi}k(\theta)d\theta=\left(\frac{k_1+k_2}{2}\right)=\left(\frac{\frac{1}{r}+\frac{1}{r}}{2}\right)=\frac{2}{2r}=\frac{1}{r}, \quad (21)$$

Joining (20) and (21) is proved the lemma.

Then in our real problem we consider the 2-dimensional problem. Then for a 2-dimensional surface in a 3-dimensional space, we have

$$\nabla^2\xi=2\pi\rho, \qquad \xi(x)=k(\boldsymbol{u}), \forall x\in\partial\Omega, \quad (22)$$

which will be the problem with boundary conditions depending of the geometrical enclosure of the sensor for sensing.

Likewise, finally our humidity function considering (9), (16), (17), the conjecture 1. 1, and the lemma 2. 1 will be:

$$\xi(T)=\frac{V\varphi\upsilon}{nRT}\frac{1}{r^2}\left\{\frac{6}{r^4}-\frac{4}{r^2}\right\}e^{k(T-T_0)}, \quad (23)$$

From a topological point of view, the humidity is the action of concentrate the water stem in the air.

We consider the following simple experiment that collect this concentration on a crystal plane (see Figure 4).

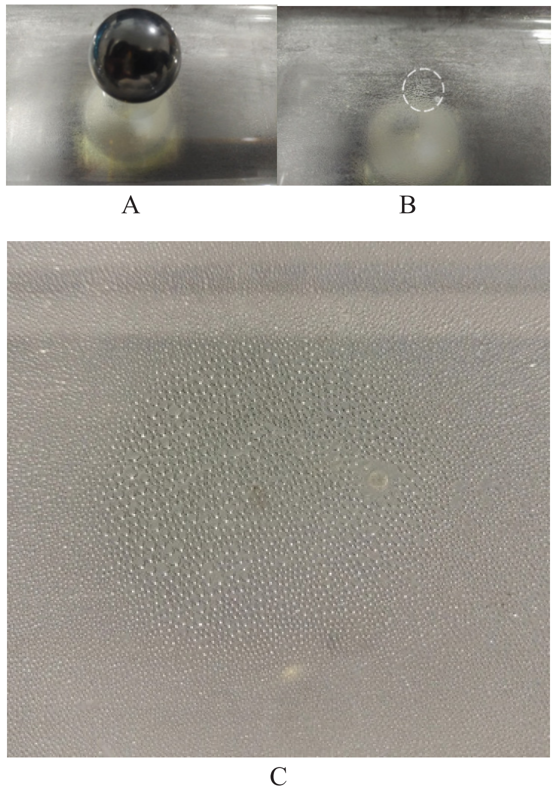


Figure 4. Experiment that evidences the concentration of water due humidity action.

Then the maximum condensation of humidity will be in a geometrical enclosure region, which we can observe in the figure B, and C, generated by a magnetic sphere on the crystal plane. This proves that the region of sensing of maximum sensing will be in this condensation region. Therefore topologically this has an attribution given by the smooth embedding given for:

$$\sigma:\Sigma\rightarrow M^3, \quad (24)$$

where $\sigma(\Sigma)$, is the smooth submanifold embedded smoothly in the space with humidity (air with water).

Likewise, the sensing field whose humidification flow that impact in a surface determines a variation of electrical potential detected by the sensor resistance, which depends on temperature and pressure, this last considering constant (see Figure 5).

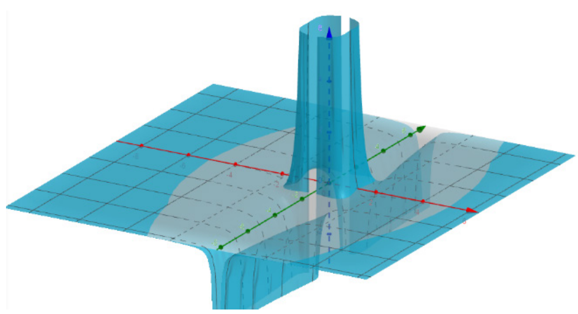


Figure 5. Humidity sensor radial function.

Geometrical enclosure of the sensor for sensing. This surface express the humidity model obtained to curvature energy sensor and proved by the experiment. The surface was done in 3D Geogebra program.

However, the boundary on the sensing region is given by $\xi|_{\partial\Omega} \leq 2\pi\xi(r)$, with $\xi_{ext} = \xi_{\text{int}}$. Their energy require a $L^2 -$ topology [1] defined by a norm or length $\|\xi\|_2$. This norm to measure flow energy will be used to design several sensors and their components to the sensing the humidity of a space and solve of wide form the humidity problem defined.

The radius when $r \to \infty$, then $\xi = 0$. This means that without the dome, the humidity is not sensed. Also, when $r \to 0$, then $\xi \to \infty$, (see the Figure 6). This means that the sensed is the proper resistive element, which senses all humidity element in the pole of the stereographic projection (see Figure 7).

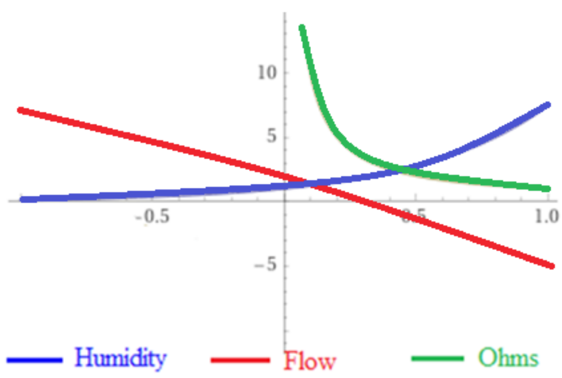


Figure 6. Humidity versus resistance of sensor.

Figure 7. Semi-spherical dome.

3. Minimal Turbulence and Flow Stability

We want to establish a 3-dimensional geometry that does possible the stability of the air dynamics in a determined volume.

The minimal turbulence and air flow stability permits have a volume of static air, optimal condition to measure average temperature and air relative humidity more precise and real (see the Figure 8A, and Figure 8B).

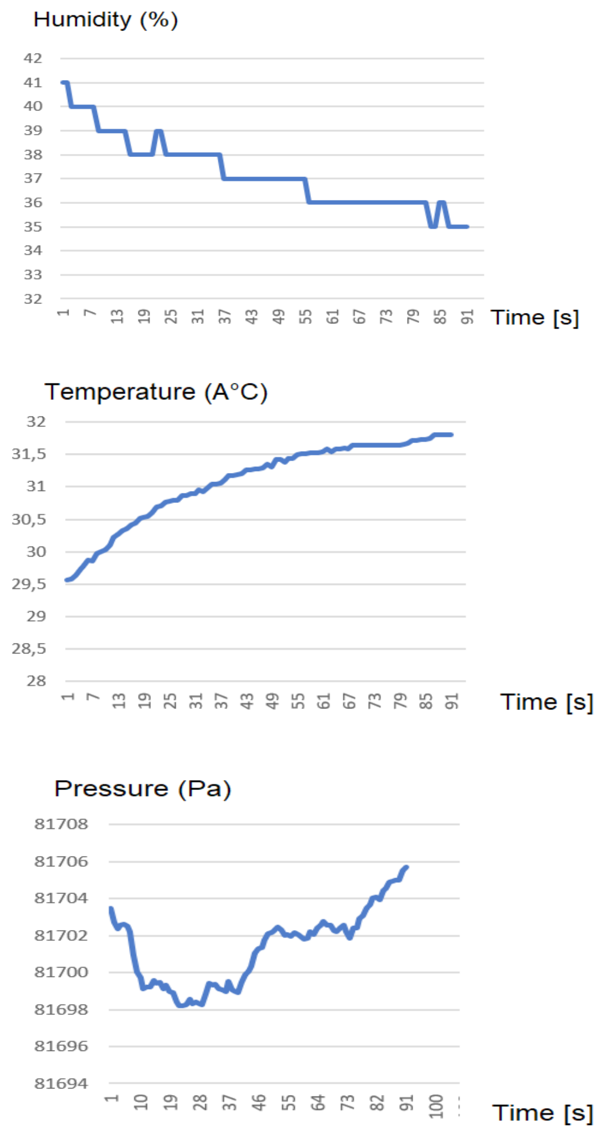
Likewise, and using the curvature energy concept explained in the before section 2, we consider the following design conditions of the sensor:

i) Spherical dome which satisfies all boundary conditions of sensing and permits associate a stereo-radial representation of the signals [9,10].

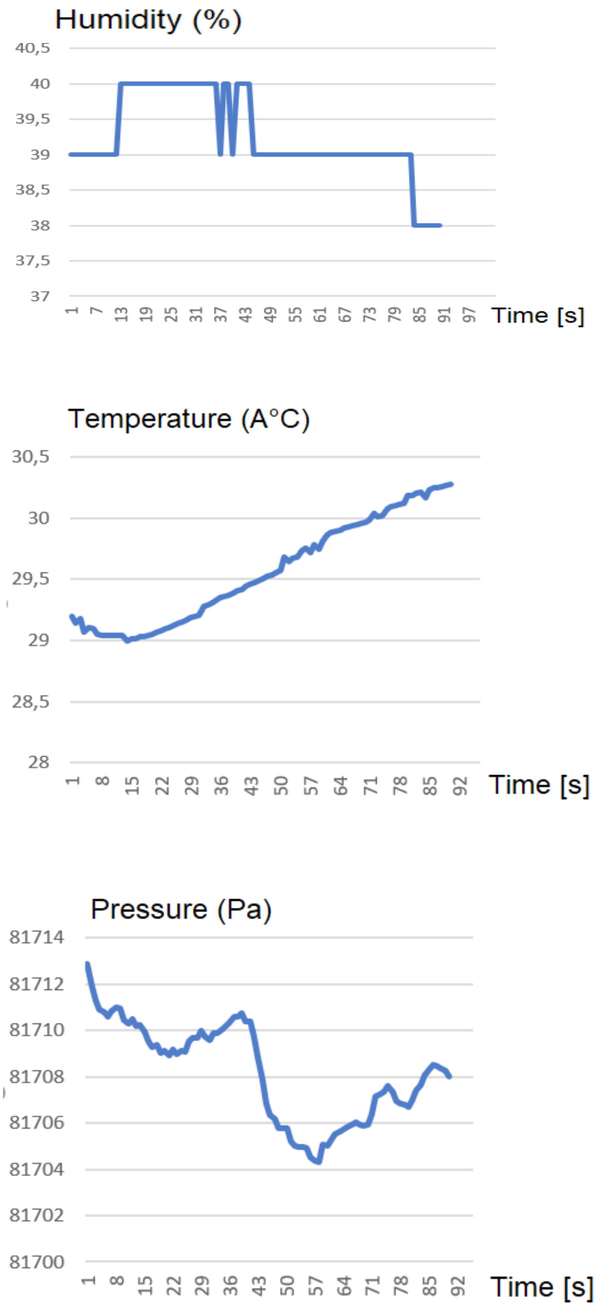
ii) A minimal hyperboloid permits a coupling of air in its inner cavity and the general medium (see the Figure 5 of humidity sensing surface).

iii) The geometrical element has a direct relation with the harmonicas with the sound phenomenology, criteria based on the musical instruments of air.

The experimental results on the optimality and stability of measurements realized with the sensor with semi-spherical dome are confirmed (see the following experimental sensing graphs (Figures 8A and Figures 8B)). We observe that the sensing with dome coincides or meets with the humidity sensing surface obtained in the Figure 5.



A. Without dome.



B. With dome.

Figure 8. Measurements realized with the sensor without/ with semi-spherical dome are confirmed.

4. Dynamical System Analysis of Sensor

The sensor device is a semiconductor device of solid state which consists of a resistive element whose interaction with water molecules in the air realizes electrons valence interchange that influence in the change of its electrical resistance (see Figure 9).

Likewise, the alteration of valence internal electrons of the proper semiconductor is realized when varies the temperature influencing in the electrical resistance.

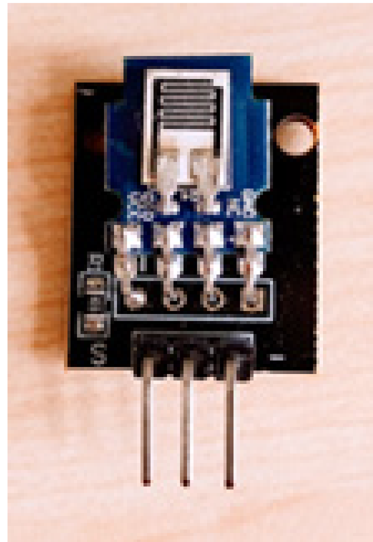
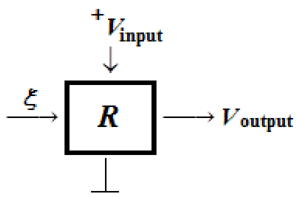


Figure 9. Sensor DTH11. Temperature and humidity sensor with a calibrated digital signal output.

Then we have the scheme:



(25)

Then to the dynamics model of the sensor, we consider the fundamental equation:

$$V_s = 5Volts - \xi(T,P)R(t), \qquad (26) \qquad (26)$$

where R, is the resistance of the sensor. Likewise if we consider the potential difference constant then we can have the resistance versus humidity as the curve given by the hyperbole (Figure 10).

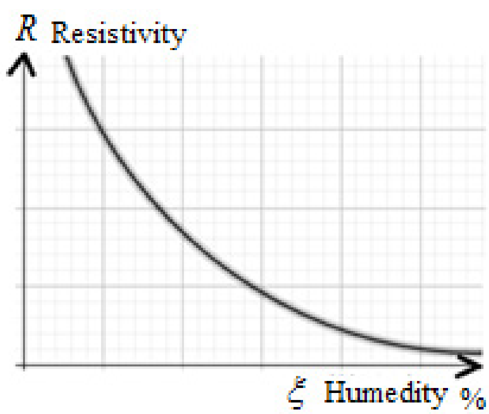


Figure 10. Behavior of the electrical resistance response of the sensor and the humidity variation in the environment.

The humidity signal is $\xi(t) = 60e^{-t/2} + 36$. This comes of the dynamics model of the sensor, and consider the fundamental equation to the model (26).

The resistive element R, is affected for the humidity $\xi(T,P)$, establishing an output voltage, whose difference with the initial voltage (feeding voltage) is directly proportional to the variation of the resistivity affected for the humidity.

The behavior of the electrical resistance response of the sensor and the humidity variation in the environment we can see it in the Figure 10.

The equation (26) implies that $\xi(T,P)$, has units of electric current or its inverse, the admittance. Likewise, there are no indications that there is a direct relationship between ampere [=A] and temperature units [=°C], pressure [=Pa] among others that can affect the phenomenon of humidity in the air.

A new experiment is carried out that consists of the producing an almost the humidity of 95%, a stability time at 95% to the point of going into decline for a time in order to obtain the humidity drop behavior curve and be able to characterize the response curve of the sensor by means of special functions.

Next, the curve that describes the response of humidity expressed in % in the air in a certain time (see Figure 11).

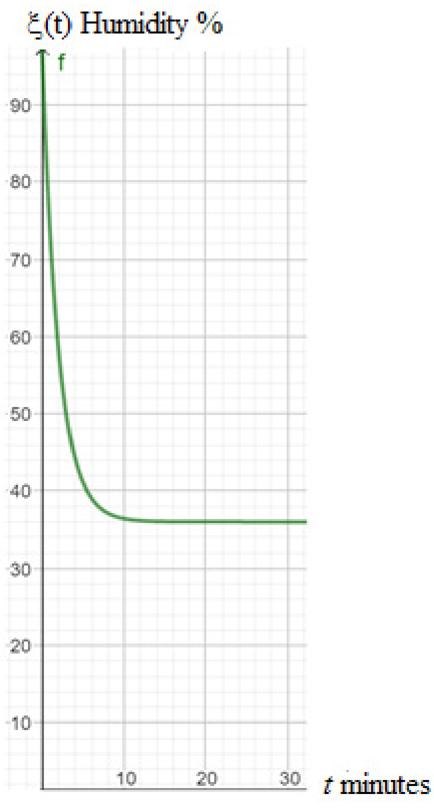


Figure 11. Characterized curve of 95% of humidity until 36% in 9 minutes.

We consider the value of resistance due the humidity as the function $R(\xi)$, where we will assume by separable variables that:

$$R(\xi) = \xi R, \qquad (27) \tag{27}$$

Then considering the variation with respect to the time, and considering the humidity as function of the pressure and temperature, the Equation (25) takes the form:

$$\xi \frac{dR}{dt} = -\frac{dV}{dt}, \tag{28}$$

which takes the form considering the Ohm law in the second member⑤:

$$\frac{dR}{dt} = -R\frac{V}{\xi L}, \tag{29}$$

whose general solution is the resistance function:

$$R(t) = \alpha e^{-(V/\xi L)t}, \tag{30}$$

which includes under measurement conditions the function obtained in laboratory given in the Figure 11. If we consider as initial condition $R(0) = 5volts$, then $\alpha = 5$, then we have the particular law for our sensor:

$$R(t) = 5e^{-(V/\xi L)t}, \tag{31}$$

Now we want to obtain all dynamical process including the functioning of the sensor in a time interval adding the initial condition and whose enveloping is the function $R(\xi)$, Then we consider the differential equation (29) with the initial condition $R(0) = 5$. Then to a time interval of sensor functioning we have the integral equation of Volterras's type:

$$R(t) = 5 - \frac{V}{L}\int_0^t R(\tau)\xi(x-\tau)d\tau, \tag{32}$$

where $\xi(t)$, acts as an admittance derived of the proper characteristic as humidity function interacting with the resistive elements justified by the Ohm law.

Likewise realizing the transitory analysis of the system, we have using Laplace transform that:

$$\rho(p) = \frac{5L}{p} - \frac{V}{L}\left[\rho(p)\left\{\frac{60}{p+\frac{1}{2}} + \frac{36}{p}\right\}\right], \tag{33}$$

whose definition field is the space:

$$\mathsf{D}_{F(p)} = \{p \in \mathsf{C} \mid \operatorname{Re} p > 0, \operatorname{Re} p > -1/2\} \tag{34}$$

Then applying L^{-1}, to (33) we find that:

⑤Here has been considered an apparent inductor defined by the induction effects that could be established for the inner electrical circuit of the sensor [11,12].

$$R(t)=\frac{5L^2\delta(t)}{96V}-\frac{25e^{-\frac{3}{8}t}}{768V}, \tag{35}$$

which corresponds to the behavior hoped (see experimental graph Figure 12). Here we can consider the value $L=1$, since the inducing factor does not exist as such, however is considered due the effects that could be established for the inner electrical circuit of the sensor.

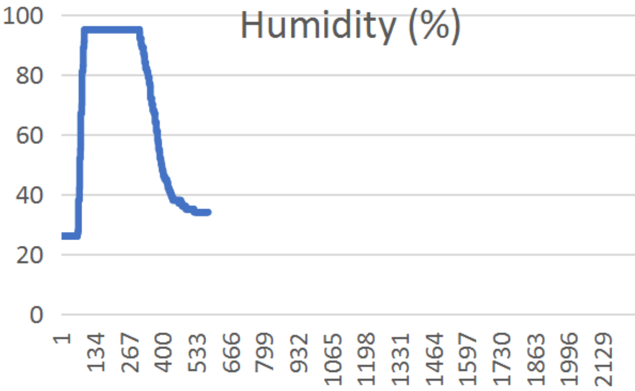


Figure 12. Total nebulizing of humidity with water steam produce the following straight lines and step function. After start decreasing of the humidity in percentage units.

The curvature energy is processed accord to the geometry of the sensor, and the outputs of resistance signals in the sensor involved this curvature energy as can be observed in the solution (35). This only happens in a bandwidth characterized by the average curvature energy

$$\left|\xi\right|_{2,\Omega\partial}\leq\kappa, \tag{36}$$

such and as is established by the Hilbert inequality of the theorem [20]. Then is translated to our spectral problem to [13]:

$$\kappa_2\geq H(\omega_1,\omega_2)\geq\kappa_1, \tag{37}$$

where ω_1, and ω_2, are the roots of the polynomial of the energy spectra of the corresponding Jacobi field. Likewise, the design of the sensor with the geometrical enclosure stays finally illustrated in the Figure 13.

The distribution of holes obeys the stereo-radial projection respect to the sensor, and stereographic projection respect any tangent plane $T\Sigma$, to the semi-spherical surface, which does uniform the inputs of air, because their direction is constant of all inputs. The 60 holes have dimensions barely of (0.001984 m) ≈ 2 mm of diameter, and the size of holes has been calibrated according to that no influence of the external turbulence.

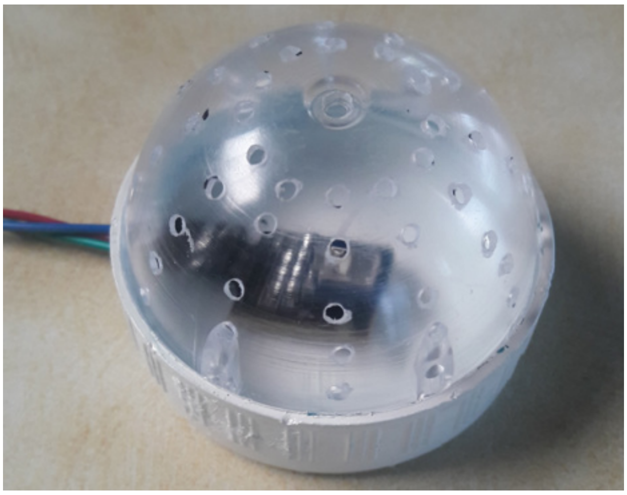


Figure 13. Curvature energy sensor device to humidity obtained.

5. Conclusions

Finally, we can to conclude that we have the possibility to use a conventional sensor to humidity with a special additional geometry to sense the humidity of a 3-dimensional region considering the average curvature energy that can to influence in the good signal reception and sensing process of the humidity under ambient conditions. For the geometrical design was necessary consider the searching of the stability of the air dynamics in a determined volume. The minimal turbulence and air flow stability permits have a volume of static air, optimal condition to measure average temperature and air relative humidity can be more precise and real. Further also, was necessary to consider their cycles in the space where happens this, re-interpreting these cycles from a topological point of view of the current air lines and their transformation in measurable signals as co-cycles where the value of certain integrals on said co-cycles result the sensing data (see the Table 1) useful in the detection and measurement of humidity. Sorting of these data will be obtained a humidity map in real time which can be useful in the study of water and humidity condition in a region of at most 1 kilometer. On the device surface must to exist the boundary condition, $\xi\big|_{\partial\Omega}\leq 2\pi\xi(r)$ to use the curvature energy due the dome geometry whose tangent space defined inside the device establish the addressing of humidity signals for be used in the sensing process. We have the incident humidity flow defined by the tangent space $T_q\Omega$, where in p, is located our resistive sensor.

Table 1. Obtained values during the sensor functioning in a short time interval described in the integral Equation (32) to the description of the dynamical analysis of the system

Time	Started Time(s)	Humidity (%)	Voltage (V)	Temperature(Â°C)	Pressure (Pa)	Altitude(m)
12:57:10	0.00	26	4.76	24.82	80324.17	1916.7
12:57:12	1.00	26	4.77	24.76	80323.6	1916.76
12:57:14	2.00	26	4.77	24.75	80323.21	1916.8
12:57:16	3.00	26	4.76	24.74	80322.5	1916.87
12:57:18	4.00	26	3.78	24.73	80321.8	1916.94
12:57:20	5.00	26	3.7	24.73	80321.43	1916.97
12:57:22	6.00	26	3.7	24.72	80321.4	1916.97
12:57:24	7.00	26	3.7	24.72	80321.36	1916.98
12:57:26	8.00	26	3.7	24.72	80321.03	1917.01
12:57:28	9.00	26	3.7	24.72	80321.17	1917
12:57:30	10.00	26	3.69	24.76	80321.49	1916.97
12:57:32	11.00	26	3.83	24.71	80320.82	1917.03
12:57:34	12.00	26	3.98	24.71	80319.66	1917.15
12:57:36	13.00	26	4.11	24.71	80319.83	1917.13
12:57:38	14.00	26	4.2	24.71	80319.65	1917.15
12:57:40	15.00	26	4.28	24.71	80319.33	1917.18
12:57:42	16.00	26	4.35	24.66	80319.47	1917.17
12:57:44	17.00	26	4.42	24.7	80320.1	1917.11
12:57:46	18.00	26	4.48	24.65	80319.28	1917.19
12:57:48	19.00	26	4.52	24.7	80319.75	1917.14
12:57:50	20.00	26	4.55	24.7	80320.57	1917.06
12:57:52	21.00	26	4.58	24.7	80321.06	1917.01
12:57:54	22.00	26	4.59	24.7	80321.36	1916.98
12:57:57	23.00	26	4.63	24.7	80322.02	1916.91
12:57:59	24.00	26	4.65	24.7	80321.84	1916.93
12:58:01	25.00	26	4.67	24.64	80321.99	1916.92
12:58:03	26.00	26	4.68	24.69	80321.99	1916.92
12:58:05	27.00	26	4.69	24.69	80321.83	1916.93
12:58:07	28.00	26	4.71	24.69	80321.48	1916.97

Conflict of Interest

There is no conflict of interest.

References

[1] Godunov, S.K., 1978. Equations of the Mathematical Physics. Mir Moscow.

[2] Perry, R.H., Green, D.W., 2018. Perry's Chemical Engineers' Handbook (9th Edition). McGraw-Hill, New York, USA, ISBN 0-07-049841-5.

[3] Kobayashi, S., Nomizu, K., 1969. Foundations of Differential Geometry. Interscince Publishers.

[4] Bulnes, F., Martínez, I., Mendoza, A., et al., 2012. Design and Development of an Electronic Sensor to Detect and Measure Curvature of Spaces Using Curvature Energy. Journal of Sensor Technology. 2, 116-126. DOI: http://dx.doi.org/10.4236/jst.2012.23017

[5] Bulnes, F., Martínez, I., Zamudio, O., et al., 2015. Electronic Sensor Prototype to Detect and Measure Curvature Through Their Curvature Energy. Science Journal of Circuits, Systems and Signal Processing. 4(5), 41-54. DOI: https://doi.org/10.11648/j.cssp.20150405.12

[6] Bulnes, F., Martínez, I., Zamudio, O., 2017. Fine Curvature Measurements through Curvature Energy and their Gauging and Sensoring in the Space. Book of Sensors and Applications in Measuring and Automation Control Systems (Advances in Sensors: Reviews, Vol 4, Chapter 20, (Ed.) Sergey Y. Yurish, IFSA Publishimg, Barcelona, Spain (2017).

[7] Wiederhold, P.R., 1997. Water Vapor Measurement, Methods and Instrumentation. Marcel Dekker, New York, NY ISBN 9780824793197.

[8] Bulnes, F., 2001. Radon Transform and Curvature of an Universe. UNAM Postgraduate Thesis.

[9] Wilczynski, E.J., 1904. Projective Differential Geometry of Curves and Ruled Surfaces. Leipzig B.G. Teubner.

[10] Kobayashi, W., Horst, S., 1983. Topics in Complex Differential Geometry Function Theory on Noncompact Kähler Manifolds. Birkhäuser Basel.

[11] Salam, M.A., Rahman, Q.M., 2018. Fundamentals of Electrical Circuit Analysis. Springer.

[12] Tietze, U., Schenk, C., Gamm, E., 2015. Electronics Circuits: Handbook for Design and Applications, Springer.

[13] Hsu, H.P., 1984. Applied Fourier Analysis. Books for Professionals Collection.