Comparison test the difference between rectangular patch antenna and conical antenna for harvesting energy inside the pipeline

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Abstract: The purpose of this paper is to develop and check the difference between the rectangular patch antenna and the conical horn antenna for fastening the maximum of energy propagation inside- thought-the pipeline for charging the battery of robot Crawler [1]. This paper presents the idea to use the pipeline as a circular waveguide to minimize the attenuation of energy as well as to maximize the power recovered to the level of antenna. Receiving and converting microwave energy into Directly Current (DC) that is a receiving antenna covers a large area, allows having relatively high effective radiated power and acceptable gain. This research document suggests a novel methodology using a novice technique to transfer energy using the oil and gas pipeline as a circular waveguide. We search each antenna can use for harvesting the maximum of energy inside the truck line.

Key words: Conical horn antennas, rectangular patch antenna, circular waveguides, pipeline, pipe inspection robotic crawler, harvesting circuit.

1. Introduction

The advantage of guided wave wireless energy transmission is that highly efficient method of transferring energy from one are to other with a low price. The efficiency it is more important parameter in wireless power charging design system for that we proposed and we studied two topologies of receiver antenna in the harvesting stage circuit. We checked with really simulation and testing the better design antenna can give us the maximum of energy with high level of efficiency. We will study and build a circuit to control the power output and reduce the radiation ranges power [2]. The objective of this electronic system is to reduce the power drawn magnetron from 800w to 4w to test the radio frequency rectifier in a short pipe in the laboratory.
The maximum microwave radiation from the magnetron source inside the pipeline is between 4w to 27w. The utility is to charging battery of robot during the time of pipeline inspection.

2. Microwave power transmission

The microwave source (Magnetron) is constituted of a microwave oven magnetron with electronics to control the output power. When the positions are (P1, P2, P3, P4, P5) this means that the positions of the electronic control of the output power range are no more 800w but rather 4w as used in the following course of our work research [3]. Microwaves from all the cavities are summed up in a channel at the end of the tube. Hence, in this way the microwaves are collected from the one end of the magnetron.
The electrical diagram in figure 1 represents the principle of microwave emitter.

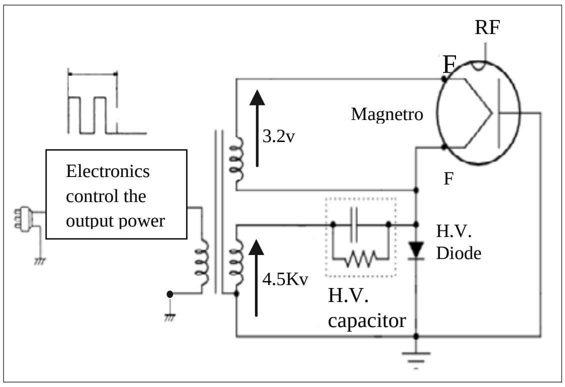

Fig.1. Electronics control circuit of the magnetron emitter

3. Electronics variable power control

The coil of power relay B is energized intermittently by the digital programmer circuit, when the magnetron is set at any power selection except for high power position. The digital programmer circuit controls the ON-OFF time of power relay (B) contacts in I order to vary the output of the magnetron from "Low" to "High" power. One complete ON and OFF cycle of power relay B is 34 second.
The ON/OFF time ratio does not correspond with the percentage of microwave power, since approximately 3 second are required for heating of magnetron filament.

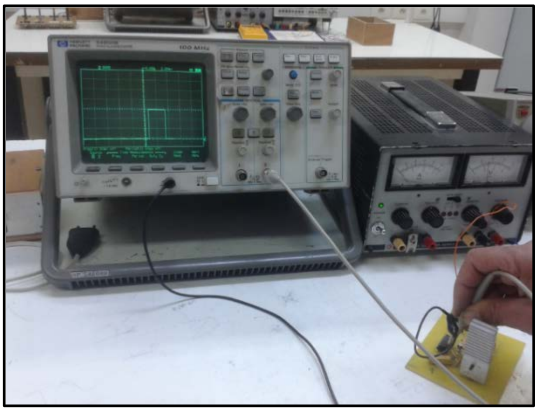

Fig.2. Electrical variable power control of the magnetron

The relation between indication on the control panel and the output of the microwave source is as shown in table below.

Table 1. The control panel and the output of the microwave source

Power	Output power (w)	ON-OFF time circuit	
		ON (s)	OFF(s)
P1	4	0,1	29.9
P2	7	0,2	29.8
P3	14	0,4	29.6
P4	20	0,6	29.4
P5	27	0,8	29.2

4. Harvesting electronic circuit

The purpose of the RF-DC converter is to take the incoming microwave signal from the antenna and rectify it into a DC voltage that could be used to power the circuit [4] [5].
This is rectifier topology circuit is used for the two types of received antenna (rectangular patch antenna and conical horn antenna).

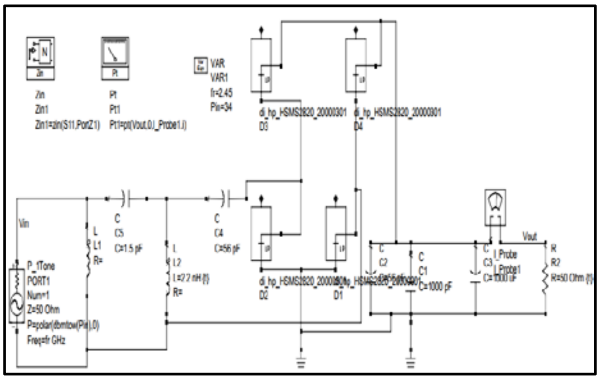

Fig.3. Schematic diagram of microwave harvesting circuit of full wave bridge rectifier

5. Conical Antenna receiver

The waveguide (or metal funnel cone) guides the microwaves in a linear direction, and allows them to be focused in a specific direction. Once directed, the microwaves can generate electrical current in any conductive metal they encounter [6]. How much electricity they generate is determined by the distance from the magnetron and the power of the output. The picture below shows the impedance adaptation between the conical horn antenna and the feed-pin source.

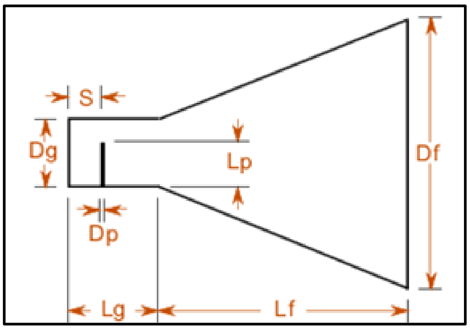

Fig.4. View of the conical horn antenna in Antenna Magus

The table 2 represent all dimension and size of the receiver conical horn antenna.

Table 2. Dimension of conical horn Antenna

Abbre viation	**Signification**	**Values (mm)**
Dg	Diameter of the waveguide	82.05
Lg	Length of the waveguide	182.1
Df	Diameter of the flare	239.3
Lf	Length of the flare	80.65
Lp	Length of the feed-pin	27.31
S	Feed-pin inset	43.09
Dp	Diameter of the feed-pin	15.05

After the step of construction the horn antenna and the PCB rectifier circuit, we will tested this receiver system. The figure below present the wirelessly power transfer system from the emitter to receiver thought the oil pipeline using conical horn antenna 2.45 GHz.

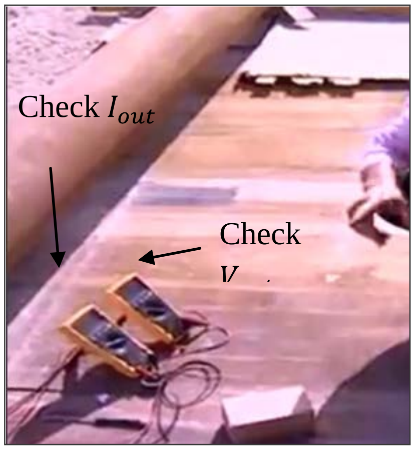

Fig.5. Scheme of wirelessly charging device with conical antenna

We testing the voltage and the current of the harvesting system and we get the results on the table below:

Table 3. Measurement result by using horn antenna

Power-Position	Output power (w)	V_{out} (v)	I_{out} (A)	load Resistance	Efficiency
P1	4	9.12	0.10		30%
P2	7	9.78	0.14		20.55%
P3	14	13.71	0.24	50	24.68%
P4	20	15.74	0.28		22.03%
P5	27	17.67	0.30		19.88%

It can be observed that the quantity of energy rectified form the harvesting system it is more important and we can use for charging battery of robot. In the next steps we tested along with bulb light (12w and 5w). A receiving antenna captures a portion of this power determined by it's effective capture Area (A). The received e power available at the antenna terminals is the power density times the effective capture area (A) of the receiving antenna [7].

We removed the load resistance 50Ω and we put the light bulb 12w. This light active is on regulate the power emitter at 13.33 w (position P3).

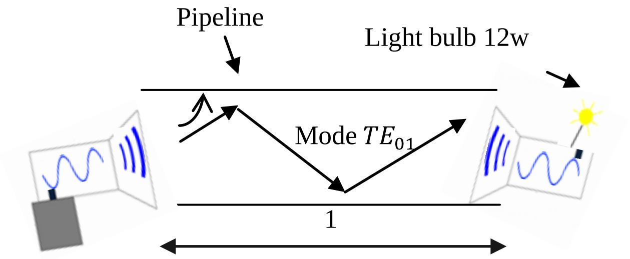

Fig.6. Scheme of wirelessly charging device with conical antenna

This light active is on regulate the power emitter at 6.66w (position P2)

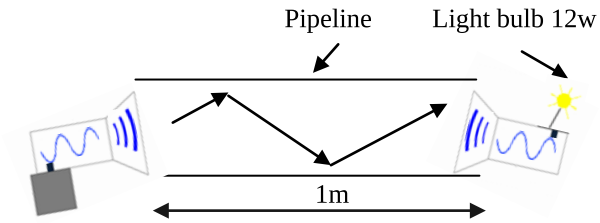

Fig.7. Scheme of wirelessly charging device with conical antenna

The following sections describe the design process, beginning with the conception and testing of the voltage rectifying circuit. Figure below is a photograph of the test circuit built on the breadboard.

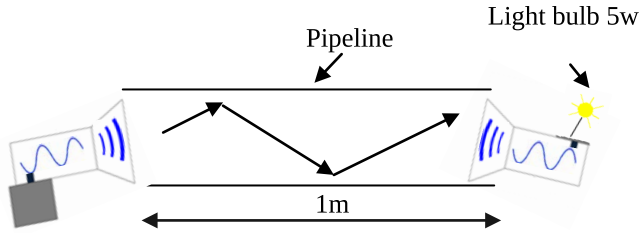

Fig.8. Photo of the rectifier circuit testing inside pipeline with light bulb 12W

6. Patch Antenna receiver

After studied the harvesting system with the conical horn antenna, we studied in the present phase the rectifier circuit with rectangular patch antenna. We check the performance in voltage and current and we calculate the efficiency of the topology circuit.

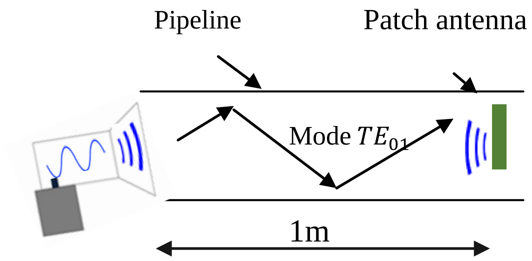

Fig.9. Scheme of wirelessly charging device with patch antenna

Here the resonant frequency is 2.450 GHz. The dimensions taken to design above the rectangular patch antenna are [8].

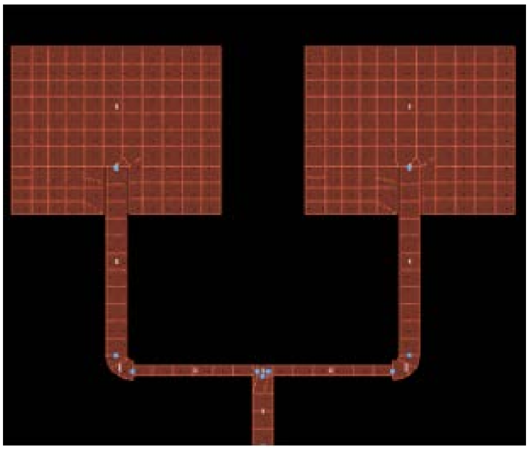

Fig.10. Sketch of the rectangular array patch antenna

After prepare the PCB antenna with rectifier circuit, we testing the voltage and the current of the harvesting system and we get the results on the table below:

Table 4. Measurement result by using patch antenna

Power-Position	Output power (w)	V_{out} (v)	I_{out} (A)	Efficiency
P1	3.33	9.75	0.15	43.91%
P2	6.66	10.32	0.163	25.25%
P3	13.33	12.41	0.221	20.48%
P4	20	14.04	0.238	16.14%
P5	26.66	16.87	0.31	19.61%

The following sections describe the design process, beginning with the conception and testing of the voltage rectifying circuit. Figure below is a photograph of the PCB circuit.

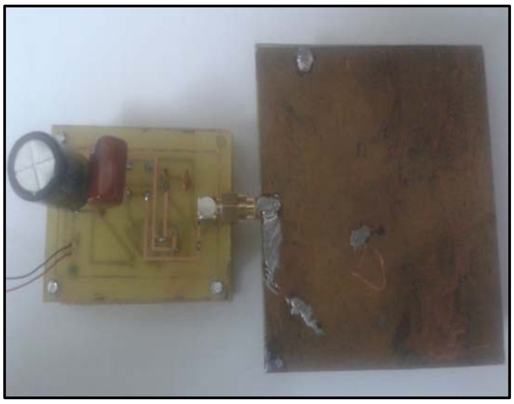

Fig.11. Photo of the PCB harvesting circuit

It can be experiential that the quantity of power rectified form the harvesting system it is extra significant and we can usage for charging battery of robot. In the next steps we tested along with bulb light (12w and 5w). We removed the load resistance 50Ω and we put the light bulb 12w. This light active is on regulate the power emitter at 6.66w (position P2)

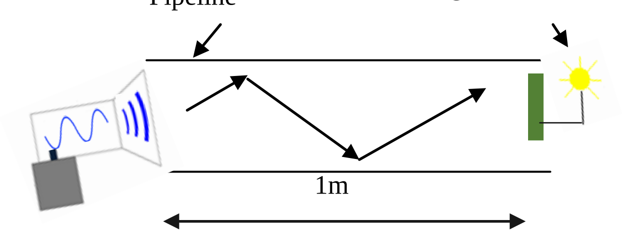

Fig.12. Scheme of wirelessly charging device with patch antenna

The time of we start up the microwave generator the light bulb active with distance is around 1m, as is shown in photograph number 13.

Fig.13. Photo of the rectifier circuit testing inside pipeline with light bulb 12W

7. Comparison the efficiency

After really test, it can be observed the patch antenna can used for low power transmitter inside pipeline because give us important efficiency. On the other side for high power level transmitter, we can use the conical horn antenna. Another most important parameter included in the text, this is effective capture (A) as is presented in table 5.

Table 5. Comparison the efficiency of receiver antenna

Power	Output power (w)	Patch antenna efficiency	Conical horn antenna efficiency
P1	3.33	43.91%	30%
P2	6.66	25.25%	20.55%
P3	13.33	20.48%	24.68%
P4	20.00	16.14%	22.03%
P5	26.66	19.61%	19.88%

8. The effective capture (A)

A receiving antenna captures a portion of this power determined by its effective capture Area (A). The received power available at the antenna terminals is the power density times the effective capture area (A) of the receiving antenna.

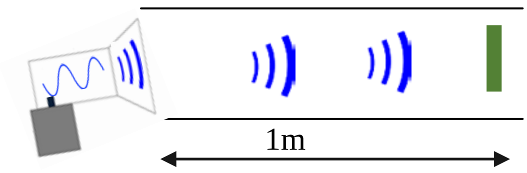

Fig.14. Receiving antenna captures

It can observed form the picture above the microwave energy go out the pipeline without captured by antenna because the effective capture area is same than the diameter of the circular wave-guide (oil pipeline).

9. Conclusion

This paper present the utility of receiving antenna for harvesting more energy in wireless power charging the battery of any robot Crawler. We proved the possibility of using the microwave of the microwave oven to transport energy from one side to the other inside the pipe. We will study and build a circuit to control the power output and reduce the radiation range of the output power. The objective of this system is to reduce the power drawn magnetron 800W to 4w minimum to test the radio frequency rectifier inside a short pipe in the laboratory.
We approved in the present paper that the wireless power transmission efficiency is more important with the horn antenna than rectangular patch antenna for high power. On the other side the rectangular patch antenna, give us more efficiency than conical horn antenna. We approved the effect of receiving area on the value of radio frequency energy to electricity conversion efficiencies.

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