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Automatic Positioned Controller Parabolic solar Dish Prototype

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Abstract:

This paper discusses the development of dual axis parabolic dish tracker application for automatized position power system. This prototype tackles solar light in solar sterling design system or concentrated photovoltaic design by implementation of digitalize control circuit to enhance Concentrating solar power and Concentrating photovoltaic applications. A normally 121.92cm dish is designed with H-bridge controller technique & Slew drive actuator mode to capture solar irradiances. The surface of dish is polished with 12 aluminum bars to concentrate the solar irradiance in one reflective axis. Economic justification for Pakistan's industries would be possible if these automated based renewable prototypes are promoted in market in compare of single PV panel. This prototype controls the all weather conditions, utilizing real time flexible timing control strategy and photoelectric tracking scheme to provide cost effective product for industrial power generation applications. This locally adaptive material based prototype encouraged the result about 33% efficient with compared to photovoltaic panel.

Keywords: *Pakistan Energy future; Solar concentrator; Thermal energy utilization.*

1. Introduction

The world-wide rate of countries are utilizing decentralized power system to maintain the energy demand with small power energy system. These mini energy systems can be fabricated with renewable sources such as solar cooker, solar geyser, solar hydrogen productive devices and parabolic solar dish collectors [1, 2]. Utilization of parabolic reflector is proven to be effective through observation of different researchers that worked on heat collector by designing parabolic solar dish [3, 4]. The solar heat collectors are more reliable in operation when the suitable tracking scheme is installed with it. The different heat collectors are used from ancient times in bucolic sites as in 212 BC, Archimedes used sun light to burn roman fleet and in 10th century Ibn Sahl worked on parabolic mirror. The same trend is followed by new researchers on parabolic solar dish to capture heat and dispatch an economical and optimized prototype in market with different applications [5, 6, 7]. In proposed prototype the solar dish is fabricated with aluminum glass that is integrated with controller scheme of tracking with concerned measurement of Azimuth angle to gain efficient sun-light. As by researcher there are different scenarios of designing this prototype on small level application to commercial based with alteration of its tracking control techniques such as PLC, SCADA & Microcontroller to

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make parabolic heat collector efficient [8, 9, 10].The integrated technology of this proposed system that is comprised of Arduino based dual axis tracker, 12v operating power window motors and sensor fault control strategy to maintain elevation and tilt angles smoothly enhance the future work of power industries.

2. Proposed Dish Prototype

For Pakistan, in rural or desert areas where sunlight appears invariably under seasonal mode, the desired system is proposed to capture the solar irradiance in regular and seasonal mode. With high reflective glass material the heat collection is merged under a single focal point of parabolic dish [11, 12]. The maintenance of solar dish elevation angle and tilt angle is done through LDR actuators and power window motors. The whole tracking of proposed parabolic solar dish is based on Arduino based chip board that regulate the whole system in optimal and efficient mode. The power running actuators get their startup power service from an external battery to improve the remedies of sensor mechanism. The designed automated dual axis tracking prototype is capable to attained high temperature applications like as hot water & steam generation. As in previous research of dual axis the system rotates with their both operative modes which make the tracker slower in perception of heat measurement and sensor functioning so, to improve this state of sensor the optional mode is included in designed parabolic dish prototype that is tested at Indus University Karachi with Latitude 23.9207°N and Longitude 67.0882°E which gives you option to run your dish on single axis or both axis as suitable with your application area.

Fig. 1. Designed Prototype.

3. Hardware Development

The system is integrated with different parts to achieve the efficient output that is also calculated with some algorithms. The adoptive algorithm are included as parabola calculator2.0 for designing parameters of solar dish, solar angle meter for angle calculation of X-axis & Y-axis geometry, Arduino assembly for programming of controller chip, generalized equation are adopted with used of solar geometry tools that are as sun calculator & sun Earth tool for solar positioning and shadow effect rate.The arrangement of these integrated tools are shown in figure 3.

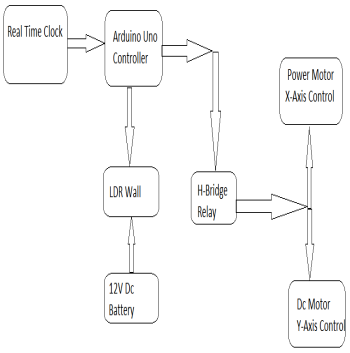

Fig. 2. Block Diagram.

3.1. Parabolic solar Dish design

TABLE I. Detailed sheet of dish.

Sr: No.	Parameters	Values	Units
1	Linear Diam.	14	Ft
2	Diameter	13.12	Ft
3	Depth	2.24	Ft
4	Focal Length	4.724	Ft
5	Volume	4.28	cubic ft
6	F Length/Diam	0.36	N/A
7	Area	134.43	ft^2

TABLE II. Automatic Tracking parameters.

Tracking Control	
Tracking	Dual axis Azimuth and elevation algorithm
Tracking Accuracy	$0.06^0 \cong 1mrad$
Control Scheme	*Arduino Uno based microcontroller*
Control apparatus	
X-axis control Motor with Pin #	180^0 limiting switch # 4
Y-axis control Motor with Pin #	55^0 limiting switch # 5
H-bridge	Relay Based Module
Motor Logical direction Controller	L298 module

3.2. Sensor Configuration

There are a lot of sensors used to run the trackers with opto-electronics technology. Here in this designed prototype we have installed LDR wall that will function with 12v output power. The designed wall is configured with H-Bridge drive module and power motor rotation. As by research mostly implemented motor are servo motor and DC gear motors, but due to misalignment and speed management challenges this prototype is designed with 12v DC gear with slew controller technique and 12v wiper motor. Slew controller technique is installed to tilt the dish with optimum speed rate according with input rated pulse of PWM generator. Each motor gets its input from H-Bridge dual axis module which had internal 5v AVR and 2 Pulse generators.

3.3. Arduino Controller

Arduino is an open source digital it that assemble the software and hardware designed projects with less complexity. The Omega controller Arduino is computationally installed with this prototype which is easy to program with in running project as compared of other technologies. As this prototype needs simple management to provide an optimum output result so the easy configurable controller is used to track and run the parabolic solar tracker.

3.4. Equations

a) ***Hour angle***

$$H.A = \frac{no.of\ minutes\ past\ midnight}{\frac{4^\circ}{min}}$$

b) ***change in hour angle:***$=\frac{sin\infty - sin\delta.sin\emptyset}{cos\delta.cos\emptyset}$

c) ***Declination angle***

$$D.A = sin^{-1} * [sin(Earth\ Tilt\ angle) * sin(earth\ eliptical\ position)]$$

d) $Altitude\ Angle = sin \propto = sin\delta * sin\emptyset + cos\delta * cosw * cos\emptyset$

e)

$$Azimuth\ angle. \quad = \frac{sin\alpha}{sinw.cos\delta} = \frac{}{cos\alpha}$$

f) ***Shadow Length*** $= |OP| = h/tan\alpha$

4. Parabolic Dish Working

As concerned with dual axis solar heat collector from previous research work, different challenges were occur that are in sense of Cosine effect, Dish alignment, sensor actuation and MPPT technique(choice of controller). So, an automatic motorized control prototype is presented with 121.92cm diameter dish to enhance the solar irradiance application. The working is performed at Karachi, Sindh Pakistan with coordinate location of Latitude 23.9207°N and Longitude 67.0882°E .The whole implementation of solar designed dish with its all configured

controller is accomplished on 4*4ft rectangular frame. The system perform its working when it get the input pulse from preset topology of controller to derive the motor in suitable direction either to tilt the dish or curve the dish with the help of DC-gear and power wiper motors. The output is performed with placement of 20w Solar panel on parabolic dish.

TABLE III. Result Analysis.

Change in hour angle	Angles measured		Time hour	Static solar PV			Prototype Result			Shadow length(ft)
	Altitude	Azimuth		Voc	Isc	power	Voc	Isc	power	
12.49^0	23.55^0	130.19^0	9am	19.7	0.15	2.95	20.3	0.29	5.88	7.51
25.09^0	32.9^0	141.91^0	10am	20.5	0.36	7.63	20.3	0.33	5.69	5.05
34.29^0	39.8^0	157.02^0	11am	20.1	0.16	3.22	19.2	0.36	6.91	3.93
38.67^0	43.15^0	175.18^0	12pm	20.1	0.34	8.33	19	0.69	13.11	3.51
37.15^0	42.04^0	194.12^0	1pm	20.4	0.42	8.57	19	0.94	17.86	3.64
30.19^0	36.80^0	210.9^0	2pm	20.2	0.43	8.68	20	0.67	13.4	4.39
19.1^0	28.5^0	224.2^0	3pm	20	0.36	7.2	20.5	0.51	10.45	6.03

Date	Time	Hour angle	Change in H.A	Yearly average Solar irradiance rate	Angles		Shadow length(ft)	Prototype LDR output volts			
					Altitude angle	Azimuth angle		y-axis		x-axis	
								LDR 1	LDR 2	LDR 3	LDR 4
28.jan	Sunrise	0.46^0		1941							
	9.am	-45^0	12.49^0		23.73^0	130.10^0	7.51	0.723	0.567	3.631	3.783
	10am	-30^0	25.09^0		33.15^0	141.80^0	5.05	0.733	0.816	3.9	3.78
	11am	-15^0	34.29^0		40.07^0	157.02^0	3.93	3.211	2.297	3.910	3.696
	12pm	0^0	38.67^0		43.34^0	175.27^0	3.51	4.888	4.941	4.95	4.99
	1pm	15^0	37.15^0		42.19^0	194.28^0	3.64	3.830	3.910	4.985	4.990
	2pm	30^0	30.19^0		36.92^0	211.11^0	4.39	3.45	4.05	4.976	4.985
	3pm	45^0	19.1^0		28.58^0	224.4^0	6.03	3.93	3.846	4.941	4.892

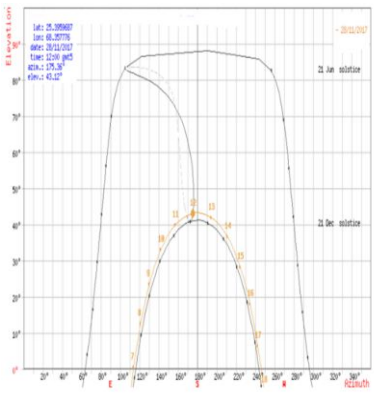

Fig. 3. Sun Position Graph.

Fig. 4. Prototype Parts.

5. Conclusion

The tariff of electric price is become inverse proportion to oil and fossil fuel tariff that creates that hazard effect of load shading. So to provide a sustainable tool with development of power optimized techniques, we have to promote renewable energy applications with help of technical expertise. In this research an innovative low cost parabolic dish is analyzed optically to compensate the MPPT tracking issues. The thermally analyzed result is obtained with hour angle formulae tools and flux meter that is about $210 w/m^2$ on parabolic dish at $21.8℃$ temperature. This research concluded that the design and function of the prototype is proven to be efficient. Parabolic dish with single axis sun tracking mechanism upturns the magnitude of current, voltage and power of mounted solar panel is about 23.6% in compare of the static solar penal and Parabolic dish with dual axis sun tracking mechanism upturns the magnitude is about 33% in compare of the static solar penal.

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