Photovoltaic charger system for mobile devices using quick charge 3.0 technology.

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***Abstract*– The systems to charge batteries of mobile devices are evolving, nevertheless in off-grid photovoltaic systems the traditional battery charging system is still being used, which presents drawbacks regarding the time it takes for them to complete their charge.**

The present work implemented a fast charging system using quick charge 3.0 technology to achieve faster and more efficient loading of mobile devices. For this, we experimented with a mobile device charging it with a photovoltaic solar system with quick charge 3.0 technology and a photovoltaic solar system with a conventional charging method of 5V to 2A. The results showed differences of up to 100 minutes in the loading time between one and another technology. Concluding that photovoltaic systems with quick charge 3.0 technology are faster when loading mobile devices.

***Keywords*—Photovoltaic charger, quick charge, mobile device, solar charger.**

I. INTRODUCTION

Since the popularization of the so-called smartphones in the presentation of the iPhone; Consumers have been increasing their demand for the autonomy of these devices [26]; either by optimizing consumption or improving technology, it has been a common practice for manufacturers to increase the capacity of the batteries from the 1400mAh [10] [14] [16] of the original iPhone to existing dozens of devices over 5000mAh [2] and close of the ten that exceed the capacity of 6000mAh [3].

This increase in battery capacity leads to the need to improve recharging methods, since the total charge times of the lithium battery increase proportionally to its capacity, in such a way that different manufacturers look for ways to accelerate the charging of batteries in order to satisfy this demand of its customers. The manufacturer Qualcomm [4] has a patented charging technology in its third iteration with gradual voltage decrease, in steps of 200mV from 20V to 3.6V in a maximum power of 18W, through the negotiation with the device that is charged [5].

There are currently deployments of mobile device's chargers taking advantage of photovoltaic energy, academic as commercial, using voltage regulators [6] and in the best cases dc-dc converters [7] resulting in inefficient load times and increasing the dissatisfaction of the end users of these chargers.

The present investigation implements a photovoltaic system for charging mobile devices using the quick charge 3.0 technology at the National University of Juliaca, studying its benefits with respect to previous implementations [26] [6].

II. METHODOLOGY

The present work was developed following the following parameters

A. Structure of a photovoltaic energy system

The structure of the photovoltaic system see figure 1 shows a 50W photovoltaic panel connected to a PWM charge controller that manages the energy received from the panel and is responsible for charging the battery or consuming the battery according to the energy need; this energy is delivered to the quick charge 3.0 circuit that is responsible for charging mobile devices taking into account the intelligent negotiation for optimal voltage, the fast charging systems use the 4 connectors of the USB port to perform the charging, before starting the charger communicates with the processor of the mobile device asks about the battery charge level and after knowing the level of charge sends the energy according to the information obtained, this communication is made through the 2 data connectors that have the USB ports and the charge is made through the 2 remaining connectors.

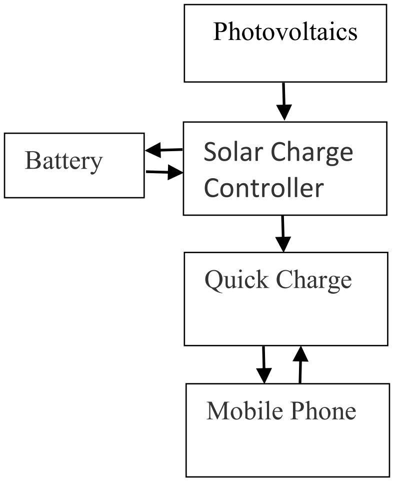

Fig. 1 The structure of the photovoltaic.

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PV Panels

Solar cells absorb sunlight and convert it to DC electricity. in this system calculates the annual energy output of the solar PV (SPV) array by using the following formula [1]

$$E_{SPV} = \lambda_{SPV} \times PSH \times \eta_{SPV} \,. \tag{1}$$

where λ_{SPV} is the rated capacity of the SPV array (kW), PSH is the peak solar hour which is equivalent average daily solar radiation and η_{SPV} is the efficiency of the SPV is used to account the effects of dust, wire losses, temperature, and other factors that can affect output energy of the solar array

Battery Model

A battery bank is used as a backup system and store excess electricity for future consumption by the Quick Charge during night, load shedding, or if solar energy is failed to feed the Quick Charge demand completely. The battery is modeled based on the state of charge (SOC) condition. The minimum SOC of the battery $B_{SOC_{\min}}$ is the lower limit that does not discharge below the minimum state of charge. The depth of discharge (B_{DOD}) indicates how deeply the battery is discharged and can be expressed as [1].

$$B_{DOD} = 1 - \frac{B_{SOC_{\min}}}{100} \,. \tag{2}$$

However, battery bank autonomy (B_{aut}) is an important parameter implies the potential number of days that the battery bank can provide the necessary energy load if the PV array malfunctions.

$$B_{aut} = \frac{N_{batt} \times V_{nom} \times Q_{nom} \times B_{DOD} \times (24\frac{h}{day})}{L_{BS}} \tag{3}$$

where N_{batt} is the number of batteries in the battery bank, V_{nom} is the nominal voltage of a single battery (V), Q_{nom} is the nominal capacity of a single battery (Ah) and L_{BS} is the average daily of system load in kWh.

On the other hand, battery lifetime is another crucial factor that has a direct impact on replacement costs throughout the project duration. is calculated the battery bank life (L_{batt}) using the following equation [1]

$$L_{batt} = \min(\frac{N_{batt} \times T_{batt}}{T_a}, R_{batt,f}) \tag{4}$$

where T_{batt} is the lifetime throughput of a single battery (kWh), T_a is the annual battery throughput (kWh/year) and $R_{batt,f}$ is the battery float life (year) without losing the Generality.

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B. *Device under test*

The device that was used for this work is one that complies with the technical specifications to load with quick charge 3.0 with a Li-Po battery 4000mAh a Qualcomm SDM636 Snapdragon 636 chipset.

C. *Condition*

Two tests were performed on the same equipment, one with the Quick Charge 3.0 and the other with a 5 Volt, 2 Amp charger; both tests were performed with the cell phone turned off and completely discharged.

D. *Energy Generation and consumption*

The charging system has a 50watt photovoltaic panel, the module is installed in the city of Juliaca at 3800 meters above sea level in Perú with an abundant solar resource, as can be seen in the following figure the solar panel manages to generate up to 300W of power per day and the energy consumption of the fast charging system does not exceed 180W per day, allowing you to save energy in the battery for the night or days where there is no abundant solar resource. the data obtained were throughout the month of October.

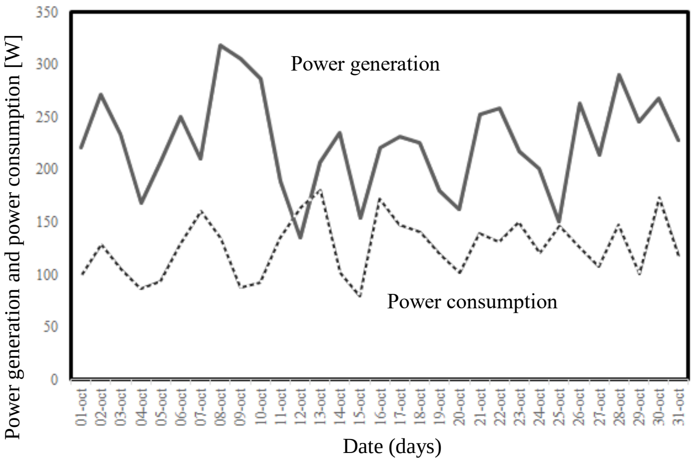

Fig. 2 Solar energy harvest VS Energy consumption of system.

III. RESULTS

The results obtained are shown in the following tables.

TABLE I

DATA OF QUICK CHARGE 3.0

Time Minutes	Voltage	Amperage	Load %
0	7.35	1.84	0
4	6.95	1.75	5
9	6.95	1.75	10
14	6.94	1.78	15
19	6.95	1.78	20
24	6.94	1.78	25
29	6.94	1.78	31
33	6.94	1.81	35
38	6.94	1.81	41
42	6.94	1.81	45
47	7.14	1.75	51
51	7.11	1.78	55
56	7.11	1.81	60
61	7.11	1.81	65
66	7.33	1.75	70
71	7.33	1.81	75
76	7.3	1.81	80
82	6.13	1.64	85
89	5.38	1.31	90
101	5.05	0.73	95
120	5.11	0.26	100

TABLE II

DATA OF 5V AND 2A

Time Minutes	Voltage	Amperage	Load %
0	5	1.49	0
7	4.97	1.52	5
15	4.91	1.46	10
25	4.98	1.37	15
34	4.97	1.37	20
42	5.03	1.31	25
52	5.02	1.31	31
58	5.02	1.31	35
67	4.97	1.23	41
74	4.93	1.17	45
84	4.94	1.17	51
92	4.93	1.17	55
102	4.95	1.08	60
112	4.96	0.99	65
124	4.97	0.99	70
135	4.97	0.96	75
150	5.07	0.73	80
166	5.11	0.67	85
183	5.09	0.67	90
202	5.12	0.58	95
221	5.19	0.32	100

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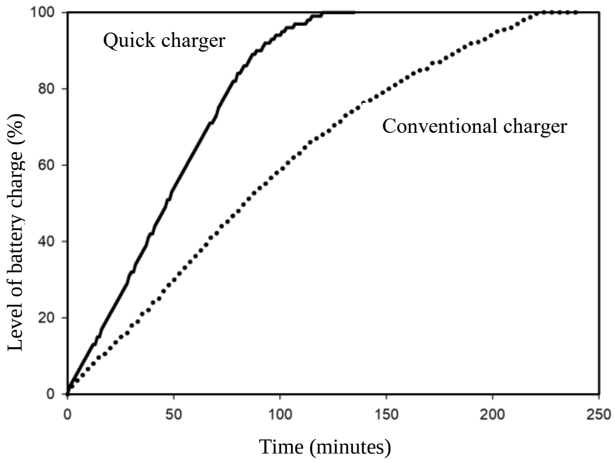

Fig. 3 Battery charging time, quick charge vs. conventional charging

As you can see in the Fig. 3 with the quick charge 3.0 it is possible to fully charge the device in 120 minutes however with the conventional system of 5 volts and 2 amps it is possible to charge in 221 minutes

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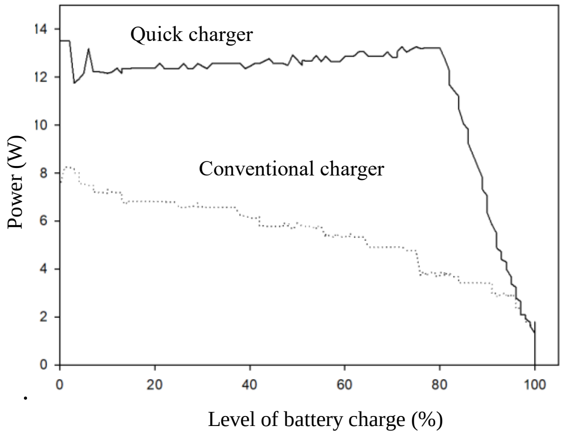

Fig. 4 Energy delivered to the mobile device vs the load percentage

In this fig. 4 we can see that the power delivered by the quick charge 3.0 starts at 13.5w having its break point when the battery reaches 80% load suddenly falling power to reach 1.32 w however in the conventional system the power starts at 7.45w decreasing gradually until 0.32w when the full load is achieved.

IV. CONCLUSIONS

The photovoltaic solar system, use fast load technology is more efficient than a conventional charging system, achieving a time saving of up to 100 minutes because the fast charging system takes advantage of the information it provides regarding the level of load that the battery at all times allowing the circuit to adjust the optimal voltage and this achieve a power of 13.5 watts when the battery is without charge.

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