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Evaluation of the Efficiency and Control of a 250 W Solar Micro Inverter Connected to the Electrical Distribution Network Operating Above 3800 masl.

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***Abstract*—Micro inverters, with a distributed orientation and unlike a conventional inverter that had a centralized installation approach, are installed behind each solar panel and convert direct current electricity to alternating current, just below the panel. All micro inverters can be connected directly to the home network, independently of the other micro inverters in the system. When a panel is shaded, for example, it will in no way affect the performance of the other panels. The main objective of this work is to evaluate the efficiency and regulation of the 250W grid connection micro inverter operating in the geographical and climatic conditions of 3800 meters above sea level, to improve the operation of these systems in the area. from Puno. If the evaluation and regulation of the micro inverter will be carried out, we will have better efficiency in the work of this team, which is the micro inverter. The methodology will go with the correct voltage found through a technique called Maximum Power Point Tracking or MPPT. When the maximum power point is applied at the panel level rather than a system as a whole. Performance will increase dramatically, bringing a better solution to the customer. Finally, a measurement system was used that helped us to collect data. As a result, the efficiency of our micro inverter is greater than 90 percent, at the same time it works with power factors very close to unity, if the equipment works at a capacity greater than 20%, on the date of analysis the maximum efficiency was 93.215%. One of the conclusions in this case, as the power of the micro inverter is greater than that of the photovoltaic generator, does not have limitations or what guarantees that it operates in optimal conditions.**

Keywords—Connected to the Electrical Distribution, Micro Inverter, Irradiation, PPT, Network Operating.

I. INTRODUCTION

In the present research work an analysis of control and regularization will be given of a 250 W micro inverter connected to the grid, which in this case will be on grid, by theory We take into account that said equipment transforms this power from direct current to alternating current, also determine the performance that this device exhibits under operating conditions at a high area at sea level that would be at 3800 meters above sea level [1]. The work will be structured in several chapters, In the second chapter materials and methods, The motivations, objectives as well as the proposed hypotheses will be discussed and bibliographic review of the various precursors of this work, as well as a theoretical framework. Then the third chapter will present the methodology of the investigation, in this case the documentation used that will serve later in the Data collection will be manipulated and analyzed in the work [2]. In the fourth chapter, we will explain the results and discuss accordingly. In the fifth chapter you will see the conclusion of this study, at the end of the sixth chapter the recommendations will be seen.

II. MATERIALS AND METHODS

What will be shown in this chapter will be what type of investigation is the present work, in turn raised the design of the methodology [3].

Applied research can be described as thesearch for the multiplication of intellect with direct application to the possible circumstances in our society or as it can also be the productive sector. It is basically governed by technological meetings of basic research, attending to the course together with the theory in turn with the product. It is itself primarilya method of joining theories with their products in which in the basic technologies gains in research, as well asprojected in the present work research where we apply theoretical ideas where they will help us to the installation of on grid systems with micro inverters. As it is also seen that it is a preliminary investigation type, It is worth mentioning that there are few similar investigations that were treated in geographical climatological situations such as in the region of Puno. The preliminary investigation is where unknown or little investigated issues arehandled, in the end the results will be useful to a close perception of the object.In other words, a study of apparent or trivial level [4].

This research work is of a pre- experimental nature, since it has a smallrange of observation in the variables denoting character design pre- experimental lies in using a single pre-

test to any set, later an incentive is givento use then finally a post test is carried out, which is decide whether or not a change occurred. [5].

a. Population

Theoretically, population is described as the group of elements or individuals that are It points to a universal character in itself together similar to the group of observation elements. Not However, forthe project that is investigated in the following we see that, in the population described through the investigation obtained by means of the micro inverter,by the peculiarities in where they have been appreciated in the tesis [7].

b. Sample

This describes the sample as a small partof a population, mixed by the mostcharacteristic, where they apply various instruments or equipment for the collection of data, it manages to finditself mixed by people, elements, objectsthat must group the essentialparticularities in order to reach our objectives raised. In such a way that the sample in this research work was the Information collected during the periodfrom September 1 to 31, 2022 [8].

c. *Place of study*

The exact place where the study wascarried out was on the school premises. Electrical mechanical engineering professional in the city of puno in the oldpavilion above the automationlaboratory specifically on the roof of it. [9].

d. Materials

The materials used were photovoltaic panel, solar microinverter, ac electric meter, dc electric meter, together with RS485 communication and mudbusprotocol.

e. *Information processing*

Duly ready for analysis with the data willbe carried out to produce various reportsof the electrical criteria measured in alternating current, this development is executed using Jupyter Notebook, also the This panda library will help us to usedata and to finish with the Matplotlip thatin this case will help to obtain good quality graphics, the two libraries already mentioned are the Python programming language.

III. RESULTS

DC current, result análisis. All DC current data that is collected in the monitoring methods they have to be crafted. The following processing is displayed in the table below where it appears on September 20 of this year, intotal there are 781 records achieved witha space of 1 minute.

TABLE 1. RESULTS OF THE MEASURED PARAMETERS IN DC.

	Date	Hour	Voltage DC	Current DC	Active Power	Import active energy	Export active energy	System power demand	Maximun system Power demand
0	20/09/2022	05:30:00	8.41963	0	0	73.615	0	0	229.60001
1	20/09/2022	05:31:00	10.70332	0	0	73.615	0	0	229.60001
2	20/09/2022	05:32:00	14.25322	0	0	73.615	0	0	229.60001
3	20/09/2022	05:33:00	19.96828	0	0	73.615	0	0	229.60001
4	20/09/2022	05:34:00	18.02884	0	0	73.615	0	0	229.60001
...	...	...	...	...	...	...	...	...	...
776	20/09/2022	18:26:00	0	0	0	74.461	0	0.01667	229.60001
777	20/09/2022	18:27:00	0	0	0	74.461	0	0.01667	229.60001
778	20/09/2022	18:28:00	0	0	0	74.461	0	0	229.60001
779	20/09/2022	18:29:00	0	0	0	74.461	0	0	229.60001
780	20/09/2022	18:30:00	0	0	0	74.461	0	0	229.60001

a. *The tension generated*

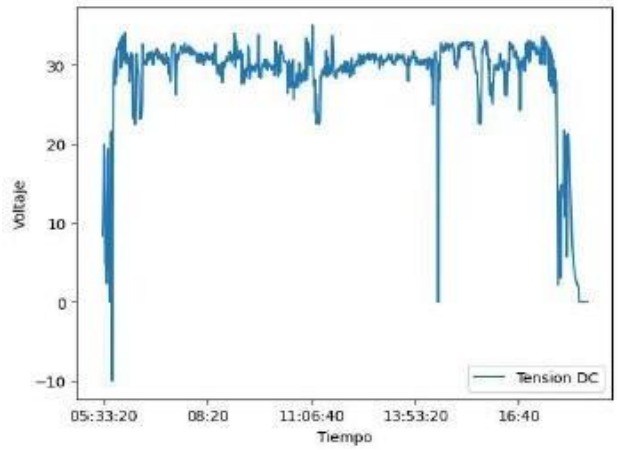


Fig. 1. At the input of the measured micro inverter, there is the voltage in DC current

b. *The generated current*

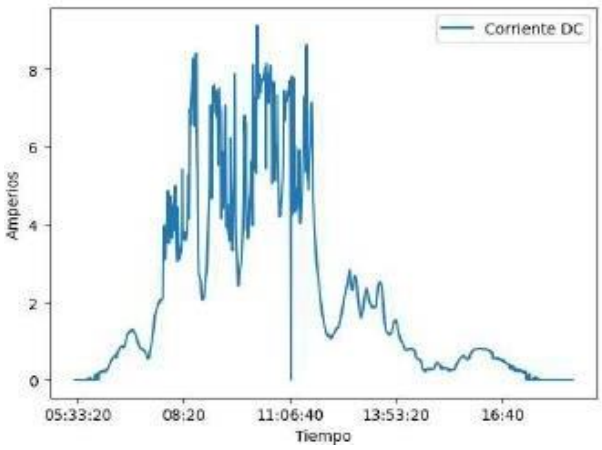


Fig. 2. At the input of the measured micro inverter, we have the DC current.

c. *The power generated*

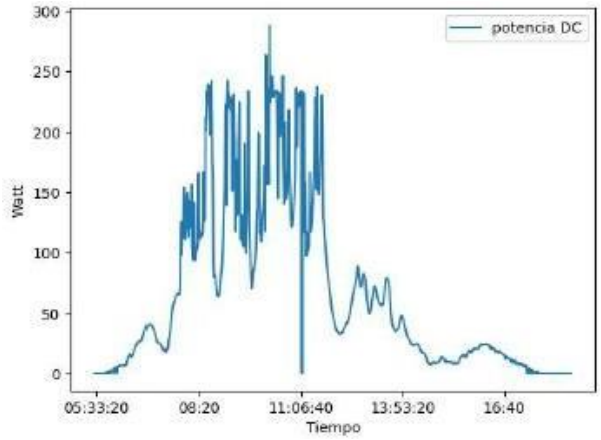


Fig. 3. Photovoltaic panel and its generated power.

d. *The energy injected into the network*

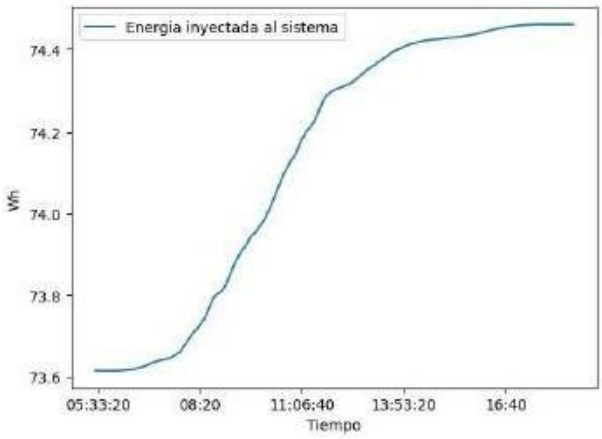


Fig. 4. Power supplied to the micro inverter on 09-20-2022.

AC current, result analysis. From the information obtained from the processing of the results by measuring the system, parameters produced by the micro inverter in the orientation of the AC current are Visualize in the following table, the data corresponding to September 20, 2022.

TABLE 2. RESULTS OF THE MEASURED PARAMETERS IN AC

	Date	Hour	Voltage	Current	Active power	Reactive power	Power factor	Frecuency	Export energy	Import energy
0	20/09/2022	05:30:00	216.2	0	0	0	1	59.99	413.07	0
1	20/09/2022	05:31:00	216.7	0	0	0	1	60.04	413.07	0
2	20/09/2022	05:32:00	217.2	0	0	0	1	60.01	413.07	0
3	20/09/2022	05:33:00	216.9	0	0	0	1	60.05	413.07	0
4	20/09/2022	05:34:00	216.8	0	0	0	1	59.99	413.07	0
...	...	...	...	...	...	...	...	...	...	...
776	20/09/2022	18:26:00	217.3	0.3	63	16	0.966	60	413.68	0
777	20/09/2022	18:27:00	217.6	0.28	60	15	0.963	60.02	413.68	0
778	20/09/2022	18:28:00	217.1	0.27	57	18	0.955	60.01	413.68	0
779	20/09/2022	18:29:00	217.7	0.27	56	18	0.954	60	413.69	0
780	20/09/2022	18:30:00	217.6	0.27	56	18	0.956	60.04	413.69	0

e. *The output voltage of the micro inverter*

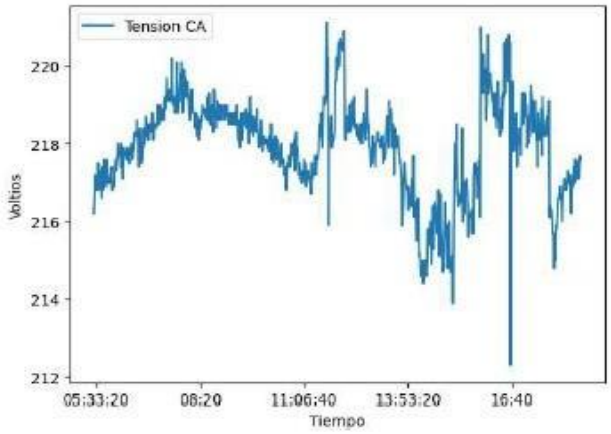


Fig. 5. The microinverter and its emitted voltage.

f. *The current produced by the microinverter*

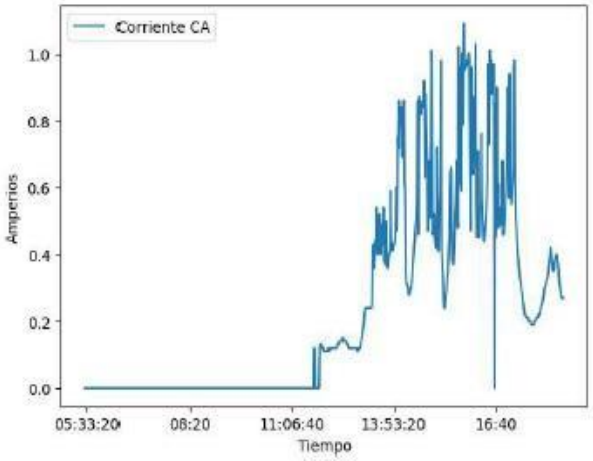


Fig. 6. Current injected into the grid.

g. The active power produced by the microinverter

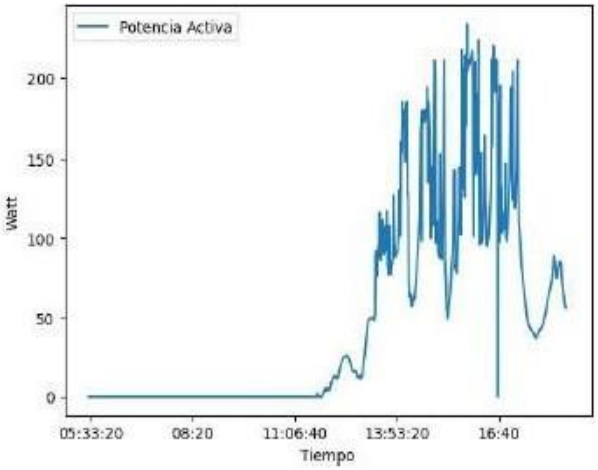
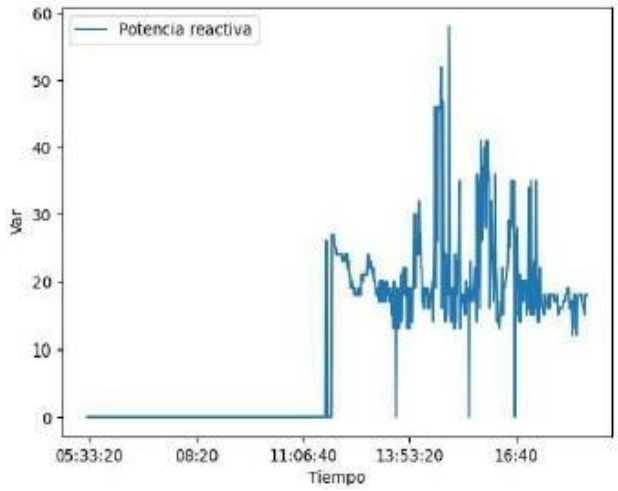


Fig. 7. Active power injected into the grid.

h. *Reactive power*

Fig. 8. Registered reactive power



i. Power factor

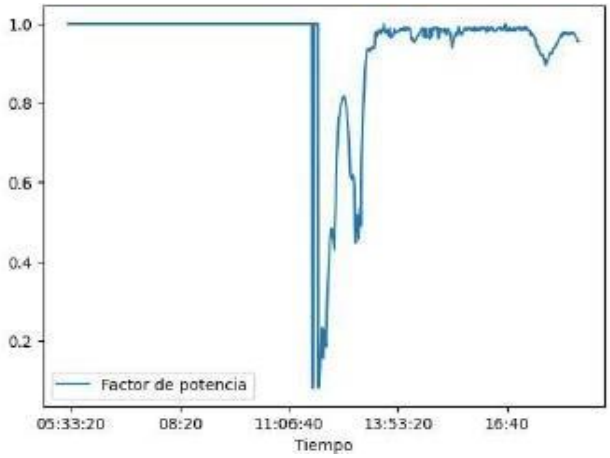


Fig. 9. Power factor and its variation

j. The frequency

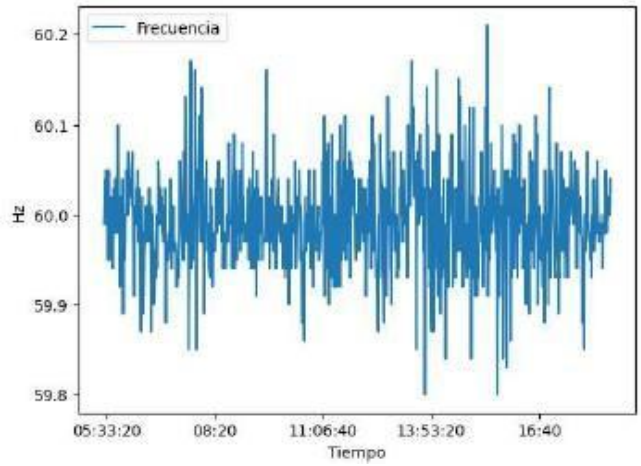


Fig. 10. Frequency measurement on 09/20/2022.

k. The energy injected into the network

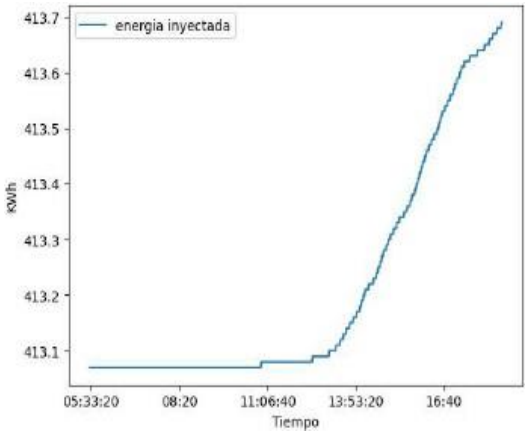


Fig. 11. Power injected into the grid

l. The energy imported into the grid

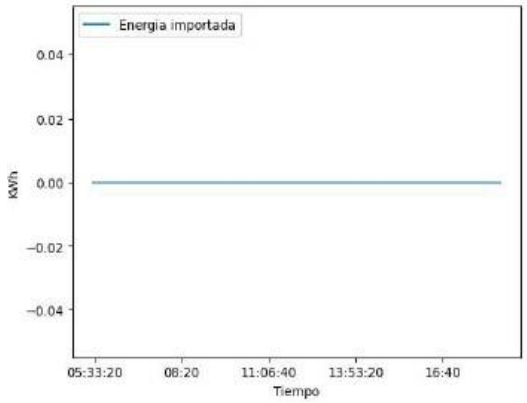


Fig. 12. Energy imported from the grid

m. Solar resource analysis

TABLE 3. DAILY HORIZONTAL IRRADIATION FOR THE DATE FROM 09/17/2022 TO 09/26/2022.

Day	Daily irradiation (kWh/m2)	Hps (h)
17/09/2022	6.72	6.72
18/09/2022	6.75	6.75
19/09/2022	7.01	7.01
20/09/2022	6.91	6.91
21/09/2022	3.33	3.33
22/09/2022	7.02	7.02
23/09/2022	6.51	6.51
24/09/2022	5.23	5.23
25/09/2022	7.34	7.34
26/09/2022	4.61	4.61

TABLE 4. COMPARISON OF THE ENERGY PRODUCED BY THE MICRO INVERTER THEORETICALLY AND THE ENERGY MEASURED BY THE MICRO INVERTIR.

Day	The theorical energy (kWh)	The measure energy (kWh)	The difference (kWh)
17/09/2022	1.4784	1.315	0.1634
18/09/2022	1.485	0.802	0.683
19/09/2022	1.5422	0.958	0.5842
20/09/2022	1.5202	0.801	0.7192
21/09/2022	0.7326	1.013	-0.2804
22/09/2022	1.5444	0.802	0.7424
23/09/2022	1.4322	0.958	0.4742
24/09/2022	1.1506	0.503	0.6476
25/09/2022	1.6148	1.431	0.1838
26/09/2022	1.0142	1.102	-0.0878

n. The comparison of the power in DC current and power in AC current in the micro inverter.

TABLE 5. MICRO INVERTER POWER CONSUMPTION

Day	The emergy DC (kWh)	The energy AC (kWh)	Consumption (kWh)	The percentage (%)
17/09/2022	1.431	1.315	0.116	6.64
18/09/2022	0.901	0.802	0.099	7.49
19/09/2022	1.05	0.958	0.092	7.47
20/09/2022	0.886	0.801	0.085	8.54
21/09/2022	1.103	1.013	0.09	7.14
22/09/2022	0.899	0.802	0.097	7.51
23/09/2022	1.031	0.958	0.073	8.08
24/09/2022	0.566	0.503	0.063	9.09
25/09/2022	1.544	1.431	0.113	6.66
26/09/2022	1.208	1.102	0.106	6.62

TABLE 6. MICROINVERTER EFFICIENCY COLLATED DC AND AC POWER

Day	The emergy DC (kWh)	The energy AC (kWh)	The percentage (%)
17/09/2022	1.431	1.315	93.215
18/09/2022	0.901	0.802	91.984
19/09/2022	1.05	0.958	92.548
20/09/2022	0.886	0.801	90.654
21/09/2022	1.103	1.013	92.365
22/09/2022	0.899	0.802	91.152
23/09/2022	1.031	0.958	92.189
24/09/2022	0.566	0.503	90.254
25/09/2022	1.544	1.431	93.367
26/09/2022	1.208	1.102	91.741

a. *MPPT simulation in matlab of the behavior of our system*

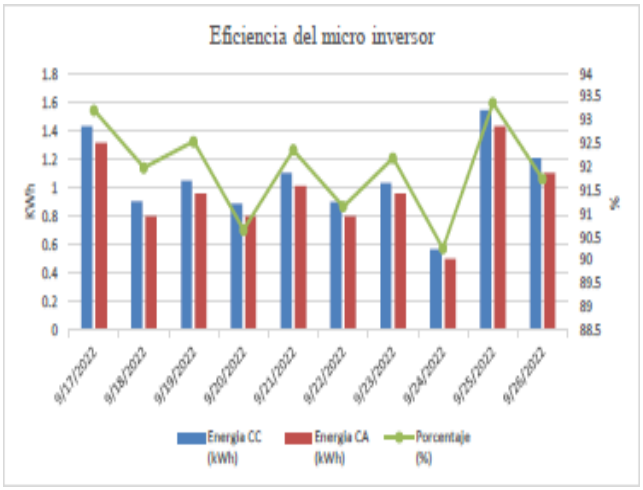


Fig.13. Microinverter efficiency for the dates, from September 17 to on the 26th of said month.

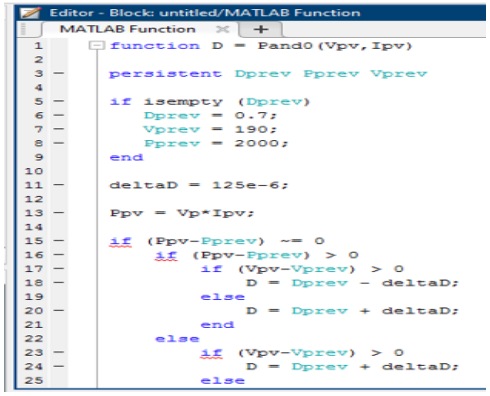


Fig. 14. Required algorithm

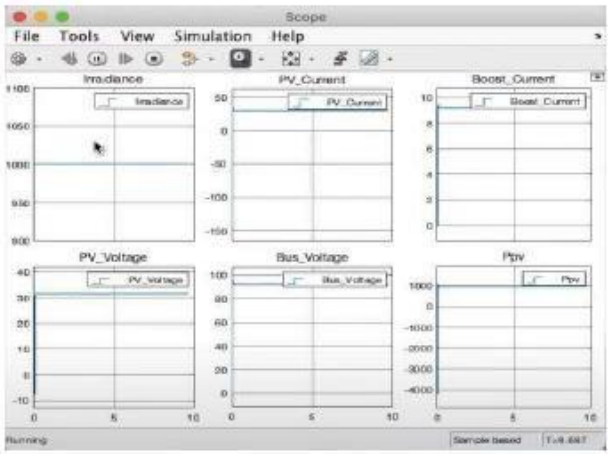


Fig. 15. system simulation

IV. CONCLUSION

In the Matlab simulation it was observed that the system does not present any type of anomalies according to the MPPT, but this type of simulation is not as effective, there are other types of more didactic software but they are difficult to access.
At the height of 3800 meters above sea level, the regulatory evaluation of our micro inverter supports the understanding

and improvement of the operation and selection of these systems in the Puno area.

For the stability of photovoltaic systems, it is necessary to make better use of the sun's energy. The use of grid-connected solar micro inverters authorizes its use in systems that receive power from AC current. In PV generation in the range of variables used, one of the most essential is irradiation, from which the energy generated by the micro inverter is determined.

In the technical quality standard, in the range of tolerable service margins are our different electrical parameters that were produced by the micro inverter

this from the measurements made. If PV generation systems tend to operate at maximum power, it is essential that the power of the micro inverter be at least equal to that of the photovoltaic generator. In this case, since the power of the micro inverter is greater than that of the photovoltaic generator, there are no limitations or what guarantees that it operates under optimal conditions.

Our micro inverter shows us efficiencies greater than 90% when it is operating at a capacity greater than 20%. Lower or lower efficiency occurs when the energy generated in direct current is low. Our micro inverter works with power factors close to unity when it operates at more than 50% of the capacity of the micro inverter, when it operates at 14% of nominal power the oriented power factor of 0.9 and for 25% of the capacity the power factor was around 0.95.

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