Two port model with an innovative parameter for evaluation of domestic inverter systems

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Abstract

In Asian continent particularly in India, domestic electrical power is drastically in scarcity and deficit. This leads to a significant use of alternate power resources like inverters. Even extensive and non-planned use of inverters can lead to the most undesirable scenario of heavy depletion of battery resource. This can further result into "DC load shading" a case similar to "AC Load shading" dominant in India. Thus, with the motive of using domestic inverters optimally and thereby studying and analyzing the behaviours of various rated inverters right from smallest rating like 15 VA to highest rated like 1400 VA were rigorously tested on similar load and battery side conditions. A new innovative two port dynamic trans-resistance model for performance evaluation is proposed. The results revealed same facts which the earlier proposed time ratio model depicted. What implies in nut-shell is smaller the rating of inverter smaller is the value of trans-resistance and larger is the back-up time performance of an inverter used in domestic conditions.

1. Introduction

All With fast changing pace of life and overall industrial growth the world is going towards new trends and technologies, causing natural rise in the use of electrical energy. Electrical power is basic building block for Industrial, commercial as well as domestic purpose. There are many sources for generation of electrical power. Power electronics, semiconducting devices play an important role in power conversion.

When one looks at energy resource problems, there is no doubt that they reduce to problems of technology and engineering to be developed on the basis of chemistry and physics. Any technology relevant to transportation, storage and transformation of energy can be placed in the category of energy conversion. This is very fertile ground in which chemists, physicists and biologists can contribute greatly to present-day concern about energy resources.

Issues like transportation, storage and transformation of energy forms the most integral part of energy related research area rather one can say they are the main research area to be taken up for working. Idea for choosing this problem definition for research work gets connected here aptly and in context. Let us first consider and treat what are operational issues? The obvious answer was carrying out functional performance analysis of different rated domestic inverter systems on specific routine and uniform conditions. Gathering and observing the test results gave absolutely different dimension to treat data generated and those finally became research contributions.

In nut-shell, various rated domestically used inverter systems with uniformly based specific battery and load conditions were tested rigorously with observations of performance parameters like charging/discharging times and behaviour. Specifically, behaviour was noticed by back-up time periods which consequently gave a different and miraculous basis of treating the functional performance aspects of inverters. Additionally, it paved way for some other interesting experimentation like distributed use of inverters.

2. Objective

There are different inverters of variable VA ratings available in market. Some inverters are used for domestic purpose and some are for specific applications such as industrial. It is difficult to select an appropriate VA inverter for domestic/household purpose. There should be proper selection criteria according to load requirement, and it should be reliable for domestic purpose. There is an apparent need of true justification of currently used capacities of domestic inverters in

view of their VA ratings and battery AH ratings. No standard system of accrediting the performance of domestic inverter systems exists as on date. Knowledge is all available with the so called experienced shop-keeper or vendors and reaches innocent consumers who mostly believe majority opinions, may they be incorrect, unjustifiable and uneconomic. Vendors naturally go by their own business interests and voluminous turn-over aiming to sell extravagant AH capacity of the batteries making two way loss. The first loss occurs to innocent consumer society and other to the world of DC resources due to their illogical uncontrolled depletions.

Following were the facts noticed during the course of entire experimentation.

1. None the standard performance analysis method exists for domestic inverter systems

2. Claims projected by vendors about back-up performance of the inverter systems on the data sheet or product brochure were at all not meeting and found to be highly deviating from the specifications

3. Counter sale of the inverter systems is not even in the basic interest of consumer but also not caring the for crucial energy domain

4. This problem definition forms a potent area of research on cross functional areas like Electronics, Electrical Engineering, Chemical Engineering and Bio-technology

3. Experimentation Methodology

1. Domestic inverter systems of ratings (15VA, 30VA, 40VA, 110VA, 250VA, 600VA and 1400VA) were tested along with fully charged batteries on uniform resistive load of 60% of inverter ratings (Lamp load)

2. Charging/Discharging cycles of batteries were observed meticulously and recorded on regular time basis

3. A single 250 VA inverter (Centralized) system was tested on resistive load of 55% of inverter ratings

4. A 250 VA decentralized version of above system was tested by means of Four inverters on the same load

5. Overall approximately 310 man-hours were purely involved in carrying out 35 charging/discharging tests on all inverters specified above.

6. Tabulation of all observations was done with parameters like Battery side parameters VL(dc), IL(dc), P(dc), and load side parameters like VL(ac), IL(ac), PL(ac) and times recorded for starting and stopping events

7. Plots between VL(dc) and IL(dc), VL(ac) and IL(ac), and the most important pertaining to proposed model the plots between VL(ac) and I(dc) for all inverters were developed, studied and analyzed.

8. A new performance parameter ratio PBT/TBT, proposed in the first stage of research and has been already published is now accompanied by second proposed innovative Two-port Network model approach. Model particularly deals with a proposed performance parameter viz. dynamic trans-resistance Rd, (i.e. VL(ac) / Idc) Relevant findings were plotted to arrive at significant interpretations.

4. Observations

With parameters trans-resistance Rd, (i.e. VL(ac) / Idc) as projected in the table proposed for performance analysis of inverter systems, the proposed two port network for performance evaluation follows as below:

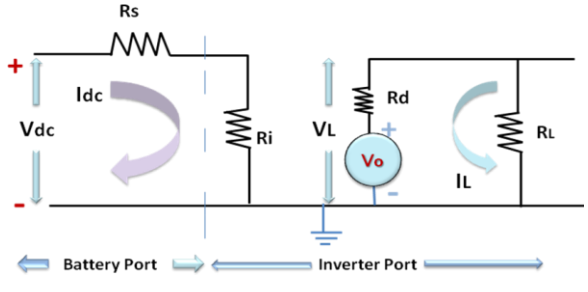


Fig.1: Proposed two port network model for performance evaluation depicting parameter Rd

As seen from the above proposed model,

$$VL = Vo - IL.Rd$$

Hence, smaller the value of Rd, Better the value of VL

i.e. As parameter Rd decreases the output voltage "VL" increases thereby increasing the sustained value of VL and so the back-up performance enhances. Let us revisit the table once again.

Inverter ratings	dVL /dIdc trans-resistance, Rd
15 VA	0.10 Ω
30 VA	0.18 Ω
40 VA	0.53 Ω
110 VA	0.66 Ω
250 VA	0.77 Ω
600 VA	9.65 Ω
1400 VA	858 Ω

Table No. 1: VA rating Vs Trans-resistance

This practically signifies that as the value of Rd goes smaller value of VL improves i.e. functionally sustenance of VL goes better so the back-up time and performance improves. This recalls us that Rd implies dynamic change of VL and if it is smaller then VL is likely to maintain on its value.

Matrix equation for mathematical model

$$\begin{bmatrix} VL1 \\ VL2 \\ VL3 \\ VL4 \\ VL5 \\ VL6 \\ VL7 \end{bmatrix}_{7\times1} = \begin{bmatrix} 3E\text{-}05 & -0.001 & 0.039 & -0.358 & 0.666 & 51.67 \\ -7E\text{-}05 & 0.004 & 0.085 & 0.470 & 0.760 & 228.8 \\ 8E\text{-}05 & -0.004 & 0.094 & -1.015 & 2.499 & 193.0 \\ 3E\text{-}05 & 0.002 & 0.061 & 0.744 & 3.082 & 231.5 \\ 5E\text{-}07 & -7E\text{-}05 & 0.002 & 0.048 & 0.143 & 227.0 \\ -1E\text{-}06 & 0.00 & -0.012 & 0.395 & -6.094 & 260.7 \\ 0.000 & 0.009 & -0.307 & 4.261 & -24.07 & 249.8 \end{bmatrix}_{7\times6} \begin{bmatrix} Idc^5 \\ Idc^4 \\ Idc^3 \\ Idc^2 \\ Idc^1 \\ Idc^0 \end{bmatrix}_{6\times1}$$

5. Conclusions

A comparison of above trans-resistance based two-port model approach with the earlier proposed and published approach using ratio, PBT / TBT [1]

INVERTER RATINGS	Theoretical Back-up time (TBT)	Practical Back-up time (PBT)	% RATIO PBT / TBT Proposed
15 VA	4.5 Hrs	4.25 Hrs	94%
30 VA	5.4 Hrs	4.8 Hrs	89%
40 VA	3.5 Hrs	3.1 Hrs	88%
110 VA	8.18 Hrs	5.9 Hrs	73%
250 VA	7.04 Hrs	5.0 Hrs	71%
600 VA	5.45 Hrs	3.0 Hrs	55%
1400 VA	5.5 Hrs	2.57 Hrs	46%

Table No. 2: Ratio PBT/TBT Vs VA Ratings

It reveals that findings based on both the proposed parameters i.e. Trans-resistance Rd and ratio PBT/TBT go hand to hand for all the cases. The experimentation work is still going on in view of some other performance parameters and model that can work out to analyze the performance of domestic inverters and pave way for new standards. Relevant observation based on plot between VA ratings and parameter Rd of inverters is interesting from view point of typical inverter ratings worth to be used in domestic inverters. This plot is given below.

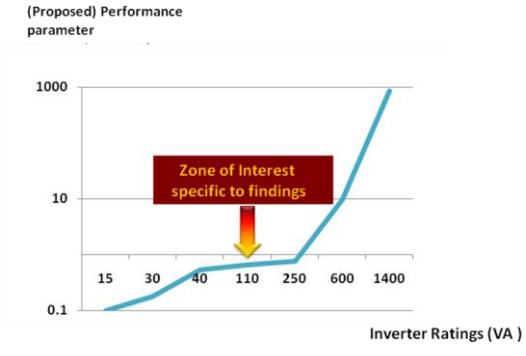
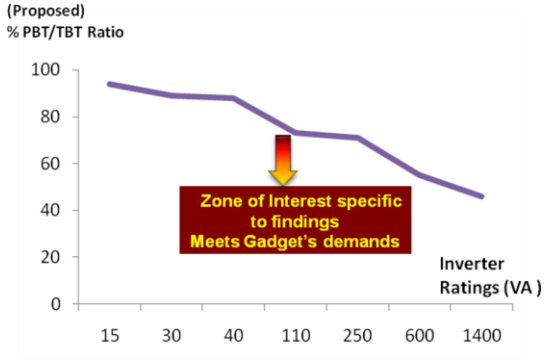


Fig No. 2: Trans-resistance Rd Vs VA ratings

It reveals that for ratings between 40 to 250 VA this resistance is fairly barely minimum $< 0.77\ \Omega$ and is almost constant. The same also gets confirmed from the plot of earlier proposed performance parameter i.e. ratio PBT/TBT. [1] This plot is given below for quick reference.



It finally can be concluded that experimentation proved that smaller the rating of domestic inverter, better the back-up performance as depicted by this new proposed performance parameter viz. Trans-resistance Rd. The same could also be established on the basis of earlier performance parameter ratio, PBT/TBT. It manifests from the observations that inverter ratings typically between the 40 VA to 250 VA enjoys optimum values of these parameters and this implies a more preferred used of such rated inverters in domestic scenario leading to otimum use of DC resources like batteries.

6. References

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