A Combined Technique For Elimination Of Islanding Phenomenon

تكنيك مركب لحذف ظاهرة الأنعزال

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ملخص البحث

نتيجة للزيادة المطردة في ربط نظم الطاقة الشمسية بشبكات القوى ذات الجهد المتوسط و شبكات التوزيع فأنه عند حدوث اعطال و فصل هذه الشبكات جزئيا عن الشبكه الرئيسية مع استمرار توليد الطاقة الشمسية فأنه ينشأ ما يعرف بظاهرة الانعزال .

توجد اساليب فعالة للحد من هذه الظاهرة باستخدام ملفات أو مكثفات مما ينتج عنه تغير ملحوظ في الجهد المغذى للأحمال من حيث السعة و التردد.

هذا البحث يقدم طريقة مركبة للحد من ظاهرة الأنعزال مع الأحتفاظ بقيم الجهد حول القيم القياسية.

ABSTRACT

As a growing tendency substantial number of PV-systems are interconnected to the utility on medium and distribution levels. Due to disconnection of some faulty sections , a number of PV's could be cut off from the grid but continue to operate . this generates what is called the islanding phenomenon . Active techniques to suppress this phenomenon utilizing a reactor or a capacitor show a considerable change of voltage and frequency from nominal values . This paper introduces a novel combined technique to eliminate the islanding phenomenon with maintained power quality operation of the isolated sections .

INTRODUCTION

The residential utility - interactive photovoltaic power system show promise of widespread application as an alternative energy source . In this concept the PV-systems operate with the inverters in parallel with the utility feeder and use the utility as an infinite energy source to supply energy when needed and to accept any surplus PV generated energy . It is clear that these PV systems could not only conserve significant amount of non- reversible fuels, but also have significant social and environmental impacts .

From an electric utility's viewpoint, distributed PV demand-side generation systems can be economically evaluated by considering the energy benefit, capacity benefit and dollar per watt

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calculations . The evaluation could use hourly utility cost and performance data as a function of the utility's load duration curve. Weighted average capital cost of 8.78 % together with a social discount rate of 3% allow that the energy and capacity benefit values calculated equate to an allowable installed PV system cost of $ 4.72/w . The higher the allowable installed cost, the easier it will be for the PV-industry to enter the utility market [1] .

However, if the economical aspects of PV-systems show promising future, still some operational problems to be addressed and resolved . One of these problems is the 'islanding' or isolated operation of PV-dispersed[2]units, which usually refers to the continued generation from grid-connected PV-systems following the interruption of utility power .

Such islanding or run-on conditions may pose a safety hazard to utility personnel or endanger the integrity of protective and other utility equipments. Line crew personnel, working to repair a fault occurring on the grid, may mistakenly consider the load side of the line to be inactive; in fact islanded PV sources may be feeding power back to the utility grid through power conditioning units. These units are normally designed to shut down when such events occur. Also, depending upon the duration of an islanding condition, automatic reconnection of the PV system may present severe resynchronization problems with consequent detrimental effect upon the integrity of the utility equipment [2]

Main measures of islanding phenomenon are classified into two categories; the first one includes passive measures such as abnormal voltage and frequency , phase monitoring, harmonic monitoring and frequency change rate monitoring. The second category includes the active measures such as frequency bias and output power variation measures. The optimum method has cleared that the abnormal voltage and frequency detection are the most reliable measures to identify this phenomenon[3].

One active technique to suppress this phenomenon is to introduce a reactor which results of increasing the voltage and decreasing the frequency. Another technique implementing the insertion of a capacitor shows the contra trend; the voltage drops while the frequency rises. It is clear that in both techniques, a considerable variation from the nominal values takes place which affects the power quality[4].

Now the question to be answered is ; if a combined technique implementing reactor and capacitor, to achieve suppressing of the islanding phenomenon and maintaining the voltage and frequency close to their nominal values, could be realized? The proposed technique is a trial to investigate this possibility .

ELIMINATION TECHNIQUES

In this section the three techniques; reactor insertion, capacitor insertion and the combined technique are introduced .The first two techniques are briefly referred. It is assumed that the data of load profile of the country-wide distribution lines follows the standard pattern in the residential area, as well as that the PV-systems has no storage battery.

Reactor Technique

Figure (1) represents the modeled dispersed PV-system connected to the load through inverter, step-up transformer and medium T.L. which are represented with equivalent reactance L1. The reactor L is to be connected across the load during islanding. For the heaviest loading conditions, figure (2) shows the mathematical simulation of the load voltage with a clear declination from nominal voltage . The load nominal voltage is that value at zero time, which is taken as reference value (100 %) .

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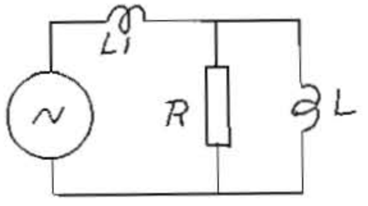


Fig(1): Equivalent circuit for reactor technique

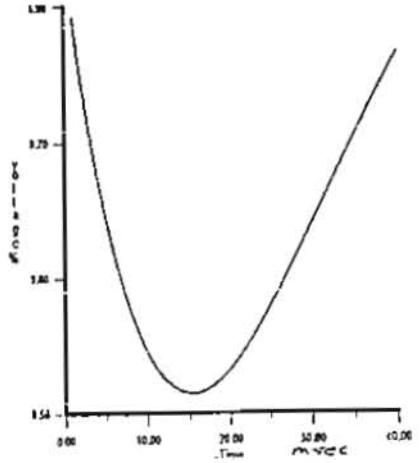
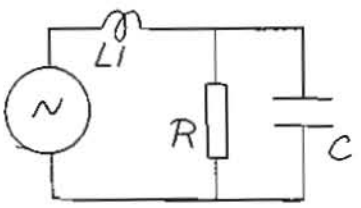


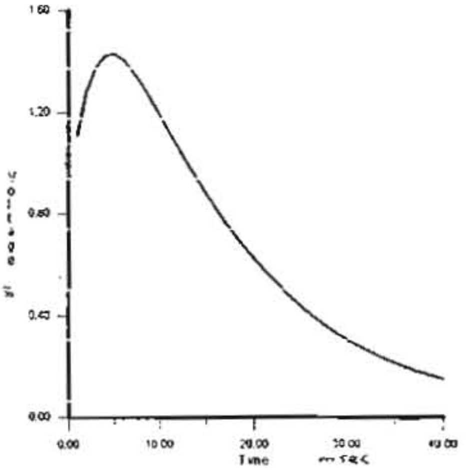
Fig.(2): Load voltage for reactor technique

Capacitor Technique

The equivalent circuit and load voltage characteristics after insertion of a capacitor bank are shown in figure (3) and figure (4), respectively. The mathematical simulation assures a sharp rise followed by slower declination in load voltage due to capacitor connection



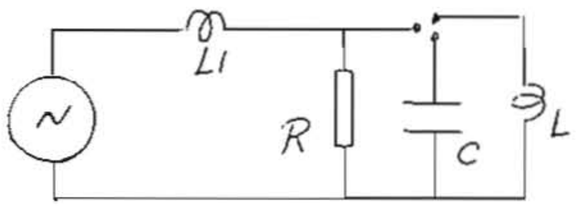
Fig(3): Equivalent circuit for capcitor technique



Fig(4): Load voltage for capacitor technique

Combined Technique

In this technique two variants are considered ; a reactor bank is to be connected followed by the connection of a capacitor bank which will be refered to as reactor / capacitor variant the second variant studies the connection of a capacitor bank followed by a reactor bank , which will be refered to as capacitor / reactor variant . The equivalent circuit is give in figure (5)



Fig(5):Equivalent circuit for combined technique

DISCUSSION OF RESULTS

For the reactor/capacitor technique ,figure (6) shows a drop in load voltage of 39.3 % the initial value followed by slower recovery and a second drop .

Studying the effect of changing the capacity of the reactor bank shows a slight variation , but maintaining the same trend , which is clearly given in figure (6) Figure (7) is the load voltage for different loading conditions The heaviest loading condition R1 shows a drop of 39.3 % of initial value , for R2 a drop of 32.5 % , which for R3 a drop of 23.4 % are recorded .

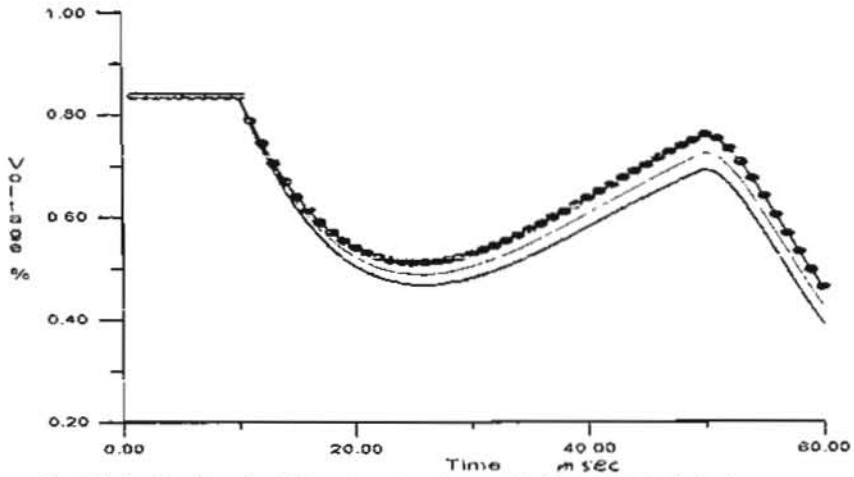


Fig. (6) : load voltage for different reactors in reactor / capacitor technique .
L , 2L , 3L

Considering the capacitor / reactor technique , Fig.(8) gives the general trend of load voltage variation with a quick rise followed by slower recovery trying to reach the initial value for different loading conditions . For R1 , the maximum is 1.79 times the initial value , 2.75 times for R2 and 6.3 times for R3 with a duration of about one cycle Changing the capacity of capacitor bank results in having higher peak values ; 4.29 times and 6.9 times the initial value as shown in figure (9)

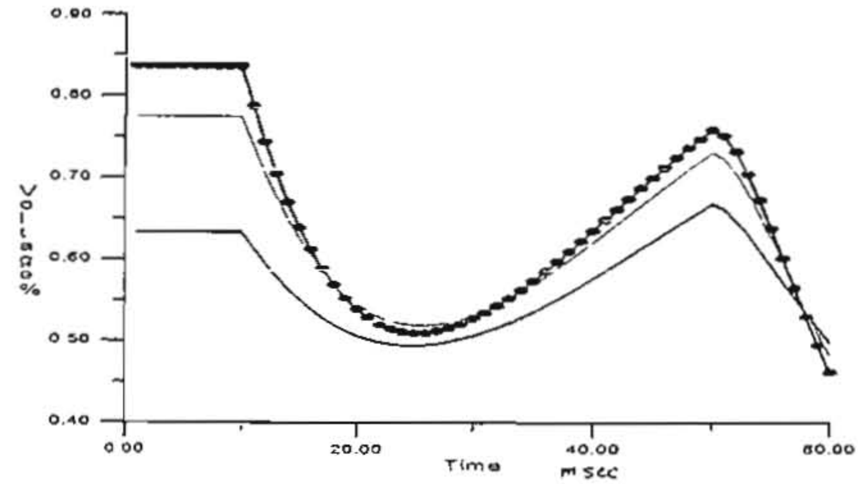


Fig.(7) : Load voltage for different loading conditions in reactor / capacitor technique R1> R2> R3

R1 ,------------ R2 , ———— R3

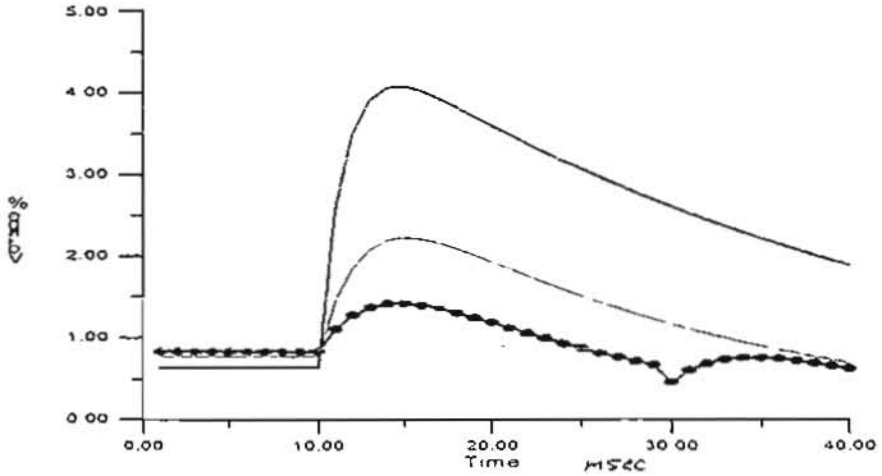


Fig.(8): Load voltage for different loading condition in capacitor / reactor technique,R1> R2 > R3

R1, ———— R2, ———— R3

The comparison of the two variants declared that the capacitor / reactor technique is to be implemented considering some design and operational constraints

To overcome the disadvantage of voltage peak value fault current limiter devices should be installed which will in return allow the decreasing of the rated installed circuit breakers and equipment current capacity

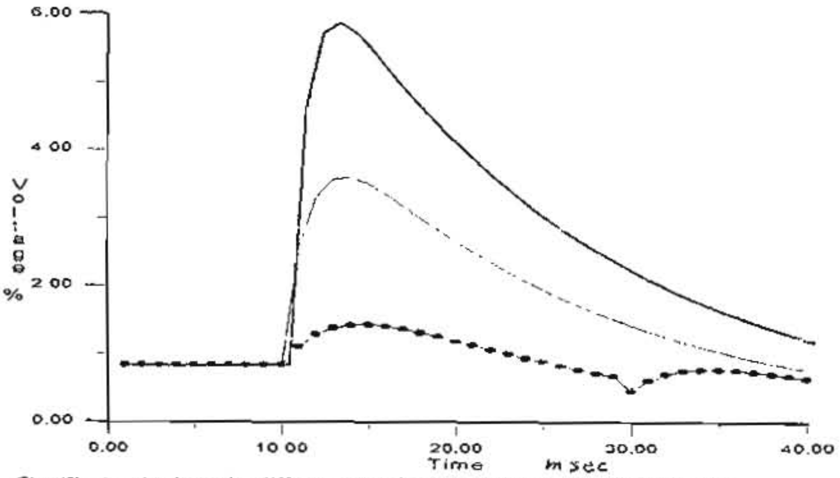


Fig. (9) : Load voltage for different capacitors incapacitor / reactor technique
—•—•— C , ———— C/2 , ———— C/3

CONCLUSION

As the results show , the combined technique could realize a conditional improved system performance after islanding. Since the analysis indicates that the degree of improvement depends upon two factors, namely the installed capacities of reactor bank and capacitor bank, as well as their connection timing . A pre-calculations of these values should be adequately done Concerning the installed capacities, the pre-calculations could be done as those of protection and load flow analysis, which are classified as off-line calculations. On the other hand, the determination of connection timing and different combinations of capacitor / reactor banks should be done on-line due to the intermittent nature of PV-systems and variable loading conditions This could be performed via an intelligent control system, fed constantly by the PV-system generation, load condition as well as grid-connection status. So in case of islanding, the intelligent control system could make the required decision ; when the capacitor and reactor banks are to be connected , satisfying given upper and lower voltage limits.

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