ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 10, October 2015

Solar Panel Maximum Power Transfer Increases from 63.6% to 90% by using two Sinewave Inverters with 90^{o} phase shift

Soundra Pandian G, PhD

Professor, Dept. of Electrical Engineering, Shiv Nadar University, India

ABSTRACT: This letter shows that the theoretical efficiency at which the solar panel operates at the Maximum Power Transfer Point is only 63.6% with a single pure sine wave inverter (PWM based) and the efficiency can be increased to 90% by using two sine wave inverters with 90 degree phase shift. A 3 phase inverter can further increase the efficiency to 95.54%.

I. INTRODUCTION

With the advent of PWM MOSFET inverters, it is possible to generate a pure sine wave voltage output, when connected to the solar panel. We know well the need for maximum power transfer from a Solar panel. A large number of publications are available relating to Maximum Power Point Tracking (MPPT) [1-6]. But all these MPPT techniques assume a constant dc load current to the solar panel. A dc-dc converter is often used to control the MPPT point. But very few articles are there to study the issue with single phase ac load. One good paper [7] mentions that for single phase ac load "the power injected into the grid follows a sinusoidal wave, raised to the second power, $\sin^2 wt$, for which reason the inverter must contain a power decoupling device". Another article [8] published in 2013 states, "In single-phase inverters, the instantaneous demanded power consists of a dc value and a twice line-frequency oscillation. As the generated power in the PV module is pure dc, an internal storage device, usually a capacitor is used in order to maintain the power balance. The value of this decoupling capacitor is determined by the amount of energy to be stored in it." Both the papers were considering the Grid-connected cases. In this paper we try to analyse what happens to the theoretical efficiency of the solar panel when we use for off-grid applications without using any power decoupling device.

II. THEORETICAL ANALYSIS

We try to adjust the operating voltage and current of the solar panel depending up on the light input received so that the maximum power transfer is done. Assume a constant light input and the operating voltage controlled at a level say Vdc, for maximum power transfer. Instead of a constant dc resistance load to this solar panel, if we used a single phase sine wave PWM inverter with an AC load, the DC current from the panel will not be constant but will be varying matching the sine wave voltage (at twice the frequency) as shown in Figure 1. The sinusoidal solar panel load current will defeat the maximum power transfer concept in the real sense. The average dc current that we draw is $2\ I_m/\pi$ where I_m is the peak current. We would have got more power out of the solar panel if the load current was equal to I_m at all times.

The average DC panel current

$$= \frac{1}{\pi/2}\int_0^{\pi} I_m \sin\omega t\, d(\omega t) = 2\,I_m/\pi$$

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 10, October 2015

That means the theoretical efficiency of the solar system for maximum power transfer with one sine wave inverter is $2/\pi$ that is 63.6% only.

III. EFFICIENCY CAN BE INCREASED TO 90%

In case the solar panel is giving ac power to houses, we can improve the efficiency if we have one more inverter connected in parallel and the sine wave voltage of the second inverter is made 90 degree phase shifted.

The average DC panel current with two inverters

$$= \frac{1}{\pi/2} \int_0^{\frac{\pi}{2}} I_m [\sin \omega t + \sin(\omega t + \pi/2)] d(\omega t) = 4 I_m / \pi$$

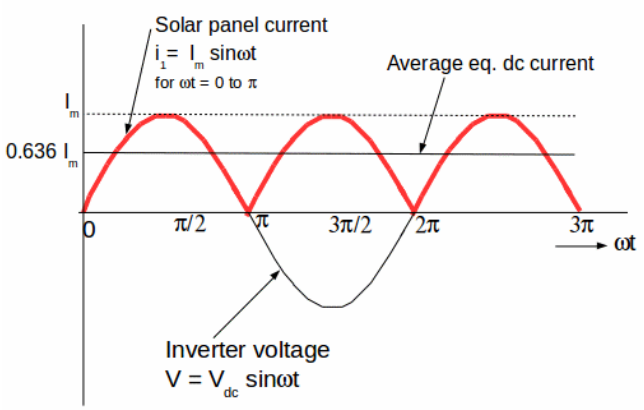

Figure 1: A pure sine wave inverter is not ideal for maximum power transfer from the solar panel and the efficiency is only 63.6%

The average dc current drawn is $(4/\pi)\ I_m$ and the peak value of the panel current is 1.414 I_m. So the ratio of average dc panel current to peak current (1.414 I_m) becomes 0.9 or the equivalent efficiency works out to be 90%. This will help in providing a good "DC load" for the panel and the MPPT schemes used in the panel should perform well also. Of course in a practical system, we may need an additional power decoupling device like a capacitor for MPPT reasons, but the value of the capacitor need not be high.
Proceeding in the same way if we used a 3 phase inverter, the maximum power transfer efficiency of the solar panel can be shown as 95.54%.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 10, October 2015

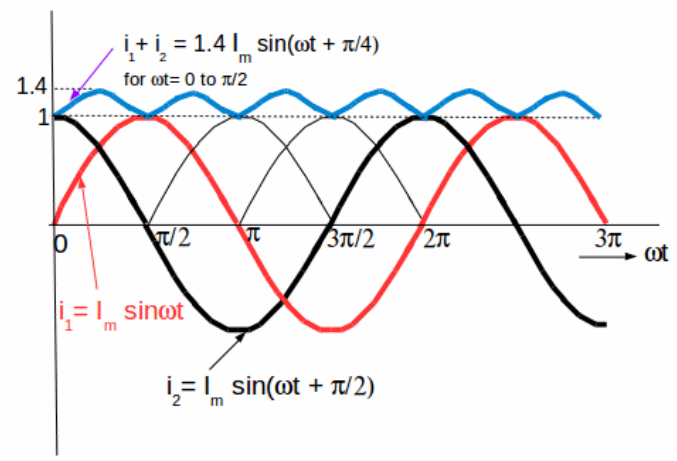

Figure 2: The load current of first sine inverter i_1 and that of inverter i_2. The magnitudes of two load currents are assumed to be equal. The total solar power of current is the sum of i_1 and i_2.

IV. CONCLUSION

We may conclude that when using the solar panel (off-grid) for houses, a two phase inverter may be selected to give a good efficiency of 90% instead of 63.6% possible with a single sine wave inverter. For house hold grid connected solar inverter feeding the grid, a three phase inverter can give higher theoretical efficiency of 95.54%. The 2 phase or 3 phase inverters will provide a better approximation of a "constant dc load" to the solar panel and will make the MPPT schemes to work well.

REFERENCES

1. Femia N, Petrone G, Spagnuolo G, Vitelli M, "Optimization of Perturb and Observe Maximum Power Point Tracking Method", IEEE Transactions on Power Electronics, 20: 16-19, Mar, 2004.
2. DeCesare G, Caputo D, Nascetti A, "Maximum power point tracker for portable photovoltaic systems with resistive-like load", Solar Energy, 80: 982-988, 2006.
3. Esram T, Chapman PL, "Comparison of photovoltaic array maximum power point tracking techniques", IEEE Transactions on Energy Conversion, 22: 439-449, 2007.
4. Esram T, Kimball JW, Krein PT, Chapman PL, Midya P, "Dynamic maximum power point tracking of photovoltaic arrays using ripple correlation control", IEEE Transactions on Power Electronics, 21: 1282-1291, 2006.
5. Femia N, Petrone G, Spagnuolo G, Vitelli M, "Optimization of Perturb and Observe Maximum Power Point Tracking Method", IEEE TRANSACTIONS ON POWER ELECTRONICS, 20: 963, July, 2005.
6. Jung DY, Ji YH, Park SH, Jung YC, Won CY, "Interleaved soft switching boost converter for photovoltaic power generation system", IEEE Transactions on Power Electronics, 26: 1137-1144, 2011.
7. Kjaer SB, John K, Pedersen, Blaabjerg F, "A Review of Single-Phase Grid-Connected Inverters for Photovoltaic Modules", IEEE Transactions on Industry Applications, 41: 1292-1305, SEPTEMBER/OCTOBER, 2005.
8. Meneses D, Blaabjerg F, Garcia O, Cobos JA, "Review and comparison of step-up transformer less topologies for photovoltaic AC-module application," IEEE Transactions on Power Electronics, 28: 2649–2663, 2013.