Harmonics Reduction in One Phase Inverters Using Bipolar SPWM and LCL Passive Filters

Warky Temorubun, Ponco Siwindarto, Bambang Siswojo

Abstract— **one important element in the process of electrical energy conversion is an inverter, which functions to convert voltage and direct current (DC) to alternating current and voltage (AC). One type of inverter is full bridge, this type of inverter is able to convert direct current into alternating current one phase. The use of a single phase inverter is widely used in household appliances. One problem that often arises in the conversion process is total harmonic distortion (THD). Where harmonics are a sinusoidal signal formation whose value is a multiple of the basic frequency. bipolar SPWM functions as an IGBT (insulated gate bipolar transistor) switch controller in regulating the outgoing voltage on the inverter. While the LCL passive filter used is a combination with 2 components of inductors (L) and capacitors (C) arranged in parallel to the load in order to reduce the harmonic wave from the box wave to sinusoidal. While the LCL passive filter used is a combination with 2 components of inductors (L) and capacitors (C) arranged in parallel to the load in order to reduce the harmonic wave from the box wave to sinusoidal. The addition of the LCL passive filter in the inverter circuit can reduce current harmonics from 8% to 1.02%.**

Index Terms— **Full Bridge Inverters, LCL Passive Filters, Bipolar SPWM, THD**

I. INTRODUCTION

Electrical energy is an energy that is very necessary in modern life today. Solar energy is an energy that can be converted into electrical energy to meet the needs of human life. In the solar cell system there are elements that have different functions. These elements are the maximum power point tracker (MPPT), buck-boost converter, and inverter.

The inverter itself functions to convert DC (direct current) voltage from solar cell to AC (alternating current) voltage. Inverters are not only used in PLTS but are also widely used to convert DC electricity from other sources such as generators, batteries or from AC sources which experience two times the conversion of energy. The inverter is no longer difficult to obtain.

However, these inverters still lack both the price and the output power and quality of the inverter's power. From these problems it is necessary to make a device in this case an inverter that is able to reduce the effect of harmonic distortion significantly so that the effects of distortion that causes interference with the power system can also be reduced. Harmonics are sinusoidal current and voltage waves whose frequencies are multiples of integers of fundamental frequencies [1].

There are several previous studies that have discussed harmonics on inverters. Reduction of harmonics on a single bridge type full bridge inverter, by adding a rectifier circuit and LC filter which serves to reduce harmonics by using RLE loads. In this way, the voltage loss can be reduced by 7.96% [2].

research on reducing harmonics in a full bridge one phase inverter by using the confined band variable pulse pulse width modulation (CB-VSF PWM) method by comparing two sinusoidal and triangular signals in the process of switching and adding a LCL filter circuit to reduce current harmonics arising on the inverter. In this way, it can reduce the total harmonic distortion current (THDi) by 3% [3].

in his research, then the comparison of SPWM and Unipolar SPWM bipolar, and the addition of passive LC filter circuits in reducing harmonics arising in the H-bridge type single phase inverter. Where the SPWM bipolar results are more efficient in reducing harmonics compared to the SPWM unipolar method. The THD value (total harmonic distribution) obtained is 2.3% [4]. The design of a bipolar SPWM inverter and LCL passive filter aims to reduce current harmonic waves, so that the inverter output approaches sinusoidal waves.

II. HARMONICS REDUCTION IN FULL BRIDGE INVERTER

2.1 Full Bridge Inverter

The full bridge converter is a circuit used to convert DC voltage to AC. The full bridge configuration consists of 2 pairs of switches namely (S1, S2) and S3, S4 which works alternately. DC voltage is changed to AC by opening a switch that is determined sequentially so that the polarity reverses the load quickly.

2.2 Bipolar SPWM

The main function of Bipolar SPWM is to set the IGBT switch (insulated gate bipolar Tarnsistor) in converting outgoing voltage to the inverter. In the switching switching technique, the Bipolar SPWM signal is generated by comparing the reference signal (Vref) with a triangle carrier wave (Vcr) [6].

2.3 LCL Passive Filter

The filter circuit serves to eliminate harmonics that are still carried by alternating voltage results of the close mode open the static switch generated from the controller circuit settings. The most common harmonic filter is a passive filter that presents a very low impedance at the tuning frequency. Passive Fiter as a harmonic filter functions to reduce the amplitude of one or more specific frequencies of a voltage or current. At fundamental frequencies, filters can compensate

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for reactive power and improve system power factor. From Figure 3 it appears that an LCL filter consists of L1 mounted on the side of the inverter, L2 is installed on the network side, Cf is a capacitor with a series resistor Rf, R1 and R2 are resistors and Vi and Vg are input and output voltages. With the installation of C, high frequency currents will flow through the capacitor because the capacitor has a low impedance at high frequency. In order for harmonic free load voltage, filter C is installed which is parallel to the load. By using filters all high frequency current ripples will flow through the capacitor, not to the load [7].

III. Design Filter Passive LCL and Bipolar SPWM

LCL passive filter design in this study, which is used in the form of combinations with 2 components inductor (L) and capacitors (C) which are arranged in parallel to the load in order to reduce harmonic waves. SPWM is used to control IGBT switches in regulating the voltage conversion process from DC to AC. The SPWM bipolar signal is generated by comparing the reference signal (Vref) with a triangle carrier signal (Vcr). The input variables used are DC voltage, switching frequency, modulation index and load output power. While the output variable is the THD value of current below 5% (see Fig. 1).

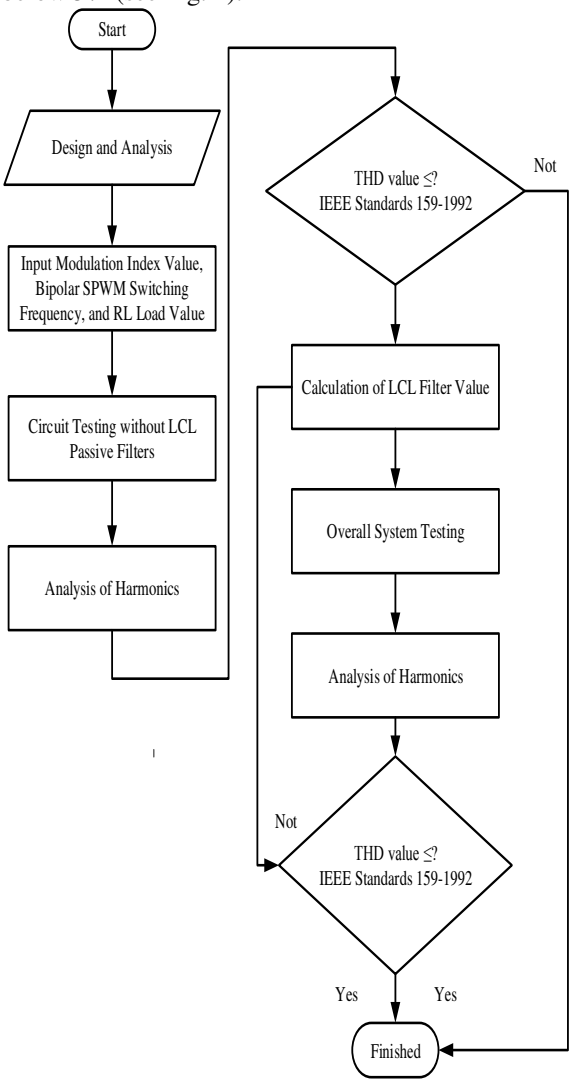

Figure 1

Before designing a full bridge inverter circuit, first determine the value of each component to be used see table 1

Table 1 Parameters of Full Bridge Inverters

Number	Parameter	Value
1	Voltage (V_{DC})	200 Volt
2	Output Power (P_{out})	1000 Watt
3	Fundamental Frequency	50 Hz
4	Modulation Index (m)	0.8
5	Switching frequency	2500 Hz
6	RL load	40 Ω & 0.031 H
7	LCL passive filter	0.0318 H, 0,1272 H & 0,188 µF

IV. SIMULATION

Simulation is operated using software and analysis using FFT. The first test inverter circuit without using the LCL passive filter and the second test using the LCL passive filter. The first test result (see picture 1) and the second test result (see figure 2).

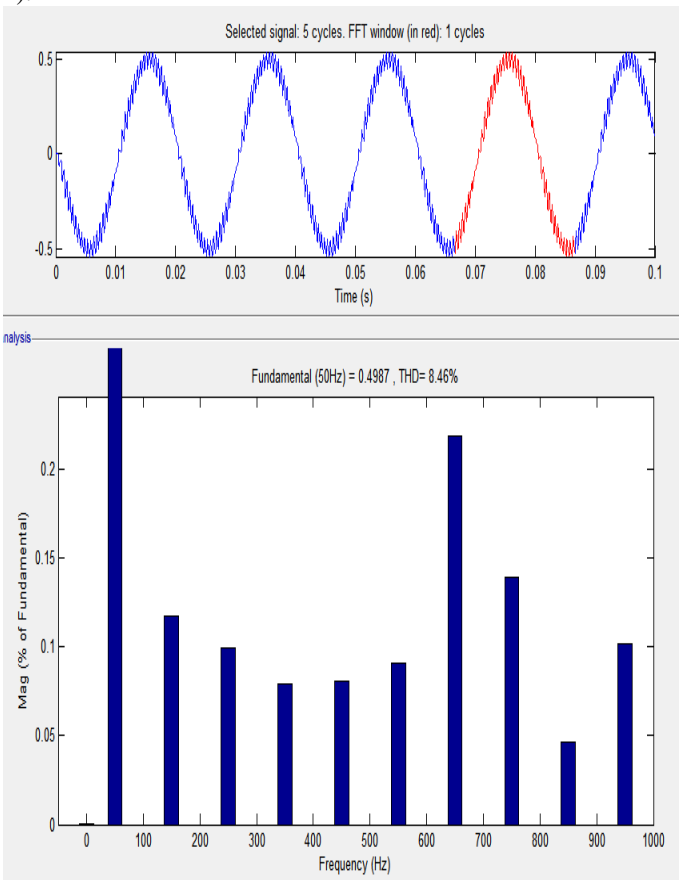

Figure 2 simulation results of inverter circuits without using Filters

Figure 2 is the simulation result of an inverter circuit without using the LCL passive filter. Where current waves are still mixed with harmonic waves, so that the current wave is not close to the sinusoidal wave.

To reduce harmonic current, the passive LCL filter circuit is added (inductor, capacitor, inductor). LCL filters can educate current harmonics because harmonic currents will flow at lower reactance. With the installation of C, high frequency currents will flow through the capacitor because the capacitor has a low impedance at high frequency.

The second image is a simulation of an inverter circuit with a LCL passive filter where the harmonic current THD value can be reduced from 8.46% to 1.02%.

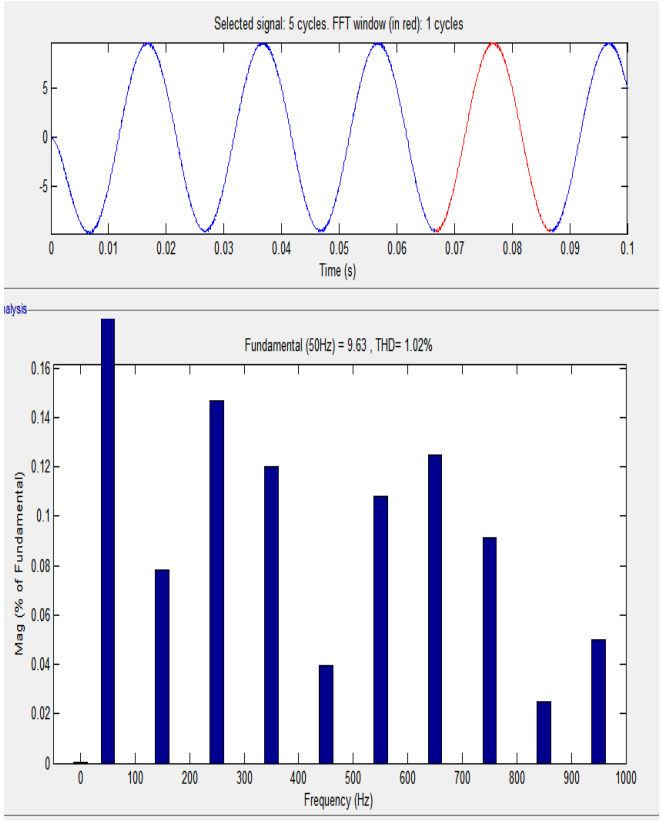

Figure 3 simulation results of inverter circuits using filters

CONCLUSION

This study discusses the reduction of harmonic currents in a full bridge one phase inverter by using a LCL passive filter. With IEEE 519-1992 harmonic standards below 5%. LCL passive filter can reduce current harmonics from 8.46% to 1.02% and approach the sinusoidal current wave.

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