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Kalman Filter Based Controller Design of SEPIC Converter for Power Factor Correction

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ABSTRACT

DC-DC Converter plays an important role in the design of the power supply. In this work the Kalman filter-based controller is designed for SEPIC (Single-Ended Primary-Inductance Converter). This method uses the regional spatial analysis of the SEPIC converter. The SEPIC converter is designed by calculating the activity cycle, the values of two inductors and two capacitors from the specification of the transformer taken from this function. AC supply is provided to the SEPIC converter via DBR (Diode Bridge Rectifier). To control the SEPIC converter, a Kalman file-based PI controller is used. The first step involves a predictor-corrector algorithm that incorporates both the latest world estimates and the error rate covariance ahead of time to calculate the predicted number of regions for the current period. The second step involves adjusting the predictive value calculated in the first step by combining the most recent process rate to produce a revised state estimate. This leads to a reduction in harmonics and noise in voltage. In addition, it is used in MATLAB / Simulink to ensure the performance of the proposed project and to demonstrate the effectiveness of the project.

Keywords: SEPIC (Single-Ended Primary-Inductance Converter), Kalman filer, PI controller and DBR (Diode Bridge Rectifier).

I. INTRODUCTION

Converted dc-dc converters to electric power systems that convert one level of electricity to another level of power with the help of switching action. These are widely used in portable electric batteries and systems due to their high efficiency, small size and light weight [1]. The SEPIC converter is a type of dc-dc converter and is capable of providing a constant output voltage that can be greater than, less than or equal to the input voltage and widely used in battery operated machines. The output of the SEPIC converter is controlled by the activity cycle of the control transistor. The SEPIC converter has two modes, one Continuous Conduction Mode (CCM) and the other Discontinuous Conduction Mode (DCM) and is a four-dimensional system. Here SEPIC is used in CCM [2]. The SEPIC converter has excellent features such as power grip transmission, full transformer utilization, excellent short-term operation and optimal power efficiency such as wide conversion rate, continuous input continuity and capacitor voltage [3].

The SEPIC converter is made up of two capacitors, two inductors, a power switch and a diode and is therefore a fourth non-linear system and in this paper parallel series resistance (ESR) for inductors and capacitors is considered. For a feedback control design a line model is required [4]. The converter line model is available with switch and diode converter with a limited signal switching module. SEPIC can be modelled in such a way that not only inductor currents and voltages in all capacitors are specified as circuits. In harmonic-based modelling techniques the most advanced, taking into account the frequency change, harmonics current signals and voltage are considered as systemic conditions as well, leading to models in which current ripples and voltage are measured accurately and complex behaviour programs are being investigated [5].

One of the most widely used Kalman (KF) filtering tools that has found applications in industrial electronics due to its efficiency, easy editing, and fast real-time performance. Many industrial problems were solved using KF. However, the correct KF is not robust and tends to produce large errors and the model does not match the process exactly or has some unexpected temporary changes. Such conditions are natural to real-world activities, so many efforts have been made over the decades to improve KF performance [6]. KF is employed in 1) sensory control, diagnostic, and error-tolerant control of ac drive; 2) distributed production and storage systems; 3) robots, vision, and sensory integration techniques; 4) applications for signal processing and instrument processing and 5) real-time implementation of KF for industrial control systems. The Kalman filter is like a real-time viewer. The plant model is made up of one or more variables and an outgoing equation. The scale uses the same plant model to produce moderate variability. The original KF was also extended over a period of stochastic process. In this framework, the correct KF generally cannot be calculated, and measurements similar to the known extended KF should be used [7 - 11].

II. MODELLING OF THE PROPOSED WORK

The goal of the converter is to achieve high efficiency and high profitability with fast response to service delivery. DC-DC Converter plays an important role in the design of the power supply. In this work the Kalman filter based controller is designed for the SEPIC converter. The SEPIC converter is designed by calculating the activity cycle, the values of two inductors and two capacitors from the specification of the transformer taken from this function. The Kalman filter is used as a real-time measurement of the direct transfer function of the SEPIC converter. Figure 2.1 shows a block diagram of the proposed activity.

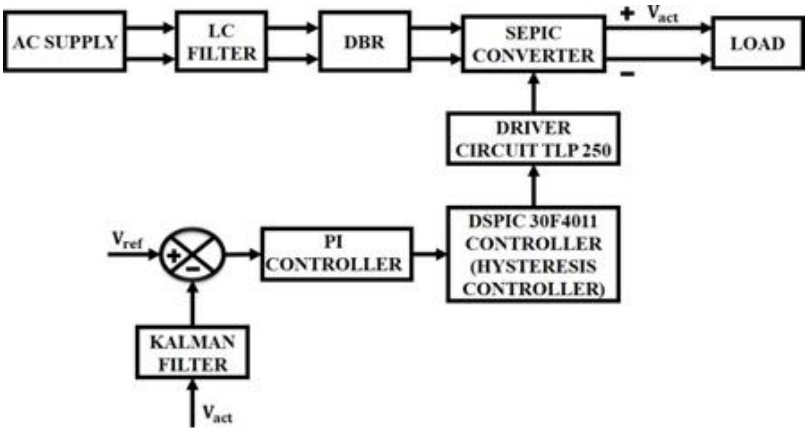

Figure 2.1 Block diagram of the proposed activity

Initially, the AC supply is supplied to the SEPIC converter via the LC filter and the Diode bridge converter (DBR), which converts the AC supply to a DC supply. Then, the SEPIC converter increases the incoming DC voltage and is charged. To control the SEPIC converter, a Kalman-based PI filter is used. Then with the DSPIC 30F4011 control the pulses are transferred to the SEPIC converter switch.

2.1. Modelling of SEPIC Converter

In the first phase, the AC filter is applied using an LC filter and supplied by DBR which converts the incoming signal into DC. In addition, it is provided with a SEPIC converter, which amplifies low DC into high DC. The SEPIC converter is a standard DC-DC converter, which has an output voltage with the same polarity of the input voltage. The output voltage generated is greater than, less than or equal to the input voltage. It includes an active power switch (IGBT), diode D, two LA and LB inductors and two capacitors CC and $C0$ as shown in Figure 2.2.

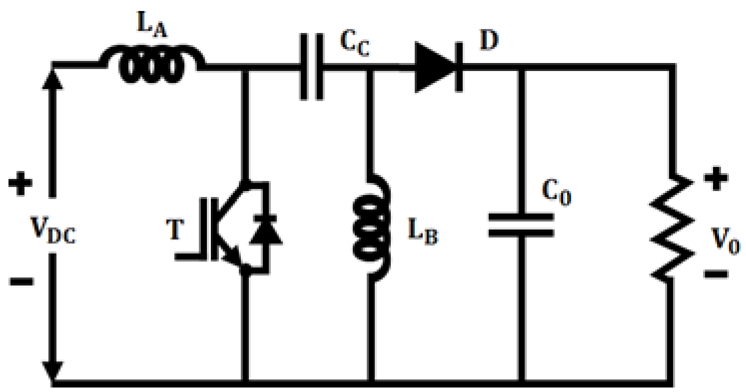

Figure 2.2 Modelling of SEPIC converter

T

T_{ON} condition: When switch T is ON, $LA$and LB are charged by Vi and Vc . Coupling capacitor CC has a negative polarity and so diode D operates in a reverse biased position. When the coupling capacitor comes out, both LA and LB are charged. When the coupling capacitor comes out, both LA and LB are charged. A circuit diagram of the TON status is shown in Figure 2.3.

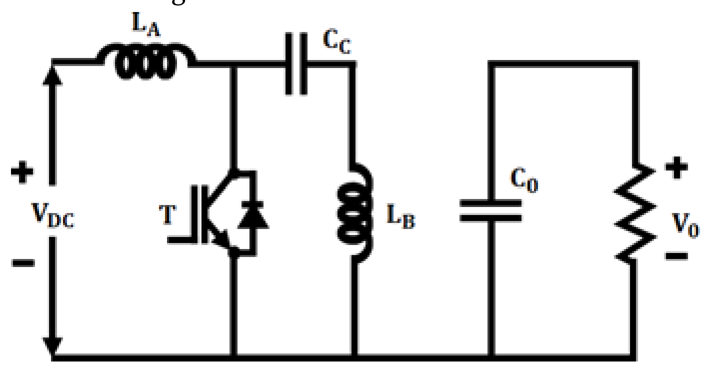

Figure 2.3 TON condition of SEPIC converter

T_{OFF} condition: In this mode, diode D operates in a forward biased position. The inductor LA charges the coupling capacitor CC and the inductor LB transfers its power to the output. In this mode, diode D operates in a state of precipitation. The diagram of the TOFF circuit is shown in the Figure 2.4.

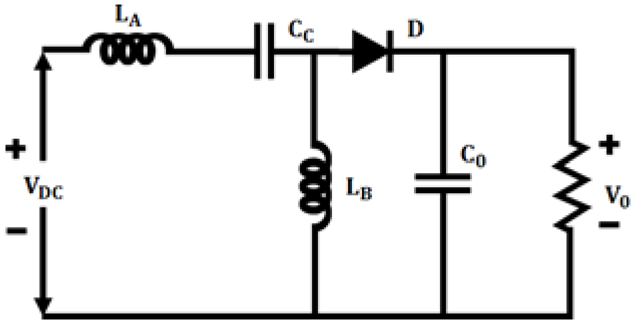

Figure 2.4 TOFF condition of SEPIC converter

The SEPIC conversion cycle is provided by,

$$D = \frac{V_o+V_D}{V_i+V_o+V_D} \quad (1)$$

Where V_i= input voltage

V_o= output voltage

V_D= diode voltage

The inductance values are given by,

$$L_A = L_B = \frac{V_{i(min)}}{\Delta I_L * f_{SW}} \quad (2)$$

Where $V_{i(min)}$= minimum input voltage

ΔI_L = ripple current of inductors = $I_o * \frac{V_0}{V_{i(min)}} * 40\%$

f_{SW} = switching frequency

The peak voltage of the MOSFET is given by, $V_P = V_i + V_o$ (3)

The peak current of the MOSFET is given by, $I_P = I_{LAP} + I_{LBP}$ (4)

Where I_{LAP} = peak current across L_A

I_{LBP} = peak current across L_B

The minimum peak reverse voltage of the diode is given by,

$$V_{PRD} = V_{i(max)} + V_{o(max)} \quad (5)$$

The rms current across the coupling capacitor is given by,

$$I_{Cc}(rms) = I_o * \sqrt{\frac{V_o+V_D}{V_{i(min)}}} \quad (6)$$

The rms current across the output capacitor is given by,

$$I_{o(rms)} = I_o * \sqrt{\frac{V_o+V_D}{V_{i(min)}}} \quad (7)$$

And the output capacitor $C_o \geq \frac{I_o * D}{V_{rip} * 0.5 * f_{SW}}$ (8)

The proposed SEPIC converter gets improved power gain and output power compared to other conventional converters. As the workload increases, the voltage gain also increases. Due to the presence of a single machine, the circuit remains flexible with reduced switching. The proposed SEPIC converter receives improved voltage gain and output power compared to other conventional converters. As the workload increases, the voltage gain also increases. Due to the presence of a single switch, the circuit remains vulnerable to reduced switching losses.

2.2. Modelling of closed loop PI controller

The closed loop PI controller determines the error signal by detecting the difference between the output and the default point of the system. The controller calculates the error number for different output acceptable for preferred reference inputs. The error is also minimized by adding or removing dynamic input and zoom to the default location. A block diagram of the PI controller is shown in Figure 2.5.

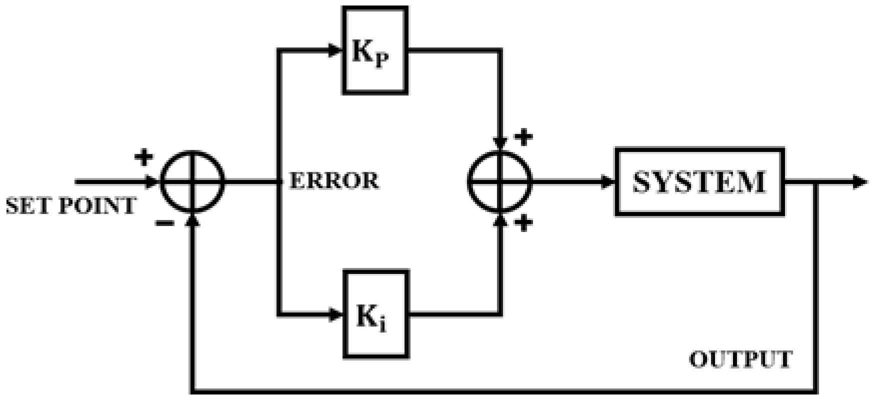

Figure 2.5 Block diagram of PI controller

The feedback error is used to measure the output of a PI controller in the time domain, which is given as,

$u(t) = Kpe(t) + Ki \int e(t)dt$ (9)

The tracking error denoted by the variable e is the difference between the expected and actual performance. Applying Laplace transform on both sides of equation (12),

$$U(S) = (K_p + \frac{K_i}{S}) E(S)$$

$$\frac{U(S)}{E(S)} = K_p + \frac{K_i}{S} \quad (10)$$

Hence the transfer function of the proportional controller is given as Kp

$+ Ki$.

S

The PI controller is connected to the SEPIC converter, which minimizes the status quo error and stabilizes the system by removing variables. These controls provide the best short-term response to improved profits and category genes. However, for better control of the SEPIC converter, the Kalman filter by PI Control is connected to the SEPIC converter, which minimizes the default status and stabilizes the system by removing the variables. These controls provide the best short-term response to improved profits and category genes. However, in order to obtain better control of the SEPIC converter, a Kalman filter is used to direct real DC power.

2.3. Kalman filter

The Kalman filter is a very rare algorithm, as it is one of the few that works best. It is used in various fields such as aeronautics, signal processing, and futures trading. At its core, it spreads the phenomenon characterized by the Gaussian distribution through efficient line conversion activities. As it stands, it has remained unchanged since its first launch, but has received many extensions for use in addition to specific Gaussian systems. The Kalman filter is a recurring method of calculating a set of different calculations and measures the state of the process which minimizes the minimal error of the square. The advantages of the Kalman filter are that it can predict system conditions (both past, present and future), and provides an accurate measurement of an unknown system. Considering the various time management processes, represented by a set of different statistical measurements of status 'x' are listed as given below.

$xk = Axk-1 + \mathrm{B}uk-1 + wk-1$ (11)

Where, A and B are n x n matrices,

xk is estimate at the current time step k,

$xk-1$ is the previous estimate at time k-1,

$uk-1$ is control input,

$wk-1$ represents the process noise. The measurement equation is given by,

Where, zk represents the scale,

$zk = Hxk + vk$ (12)

H shows the changing m x n matrix in each step,

vk means the measuring sound.

The Kalman filter uses a predictor-corrector algorithm, which uses a specific response control. Filter statistics are divided into two categories such as time update and update rating statistics. The time update is also called forecasting statistics and the measurement update is also called adjustment statistics. In addition, the reduced volume of the actual signal is compared to the reference signal and is provided by the PI control. Then the output signal of the PI controller is supplied with the DSPIC 30F4011 controller, which produces the required pulses and is given the SEPIC converter switch, thus keeping the voltage of the DC connector constant, which is also loaded. The Kalman filter that assisted SEPIC produces reduced noise, better DC-link power retention and reduced switching loss.

III. RESULTS AND DISCUSSION

This paper examines experimental design experiments based on the Kalman graphics SEPIC converter and closed loop PI controller. The Kalman filter is simulated using a predictor-corrector algorithm. The test system contains a SEPIC converter output that feeds the Kalman filter and the error is calculated. The difference between the estimated value and the reference is considered an error in this Simulink. Every model is modeled using MATLAB / SIMULINK. Table 3.1 lists the converter parameters and specifications.

Table 3.1 Parameter SEPIC Converter its specifications

Bridgeless Landsman converter	
Parameters	**Values**
Input AC supply range (V_{AC})	180 – 270 V
Input power rating	1 kW
Output DC voltage range (V_{DC})	270 – 330 V
L_{I1}, L_{I2}	1 mH
L_{01}, L_{O2}	3.7 mH
C_1, C_2	47 μF
C_O	570 μF

The software results found in the MATLAB / Simulink converter are provided below. The current waveform and voltage waveform of the AC source are shown in Figure 3.1(a) and (b). The current AC input has a range from + 2.5A to -2.5A at the beginning and gradually decreases to a stable value of + 2A to 2A. The voltage waveform of the AC source does not change without variable. Software results obtained from the MATLAB / Simulink converter are provided below. The current waveform and voltage waveform of the AC source are shown in Figure 3.1. The current AC input has a range from + 2.5A to -2.5A at the beginning and gradually decreases to a stable value of + 2A to 2A. The voltage waveform of the AC source does not change without fluctuations around 70V. approximately 70V value.

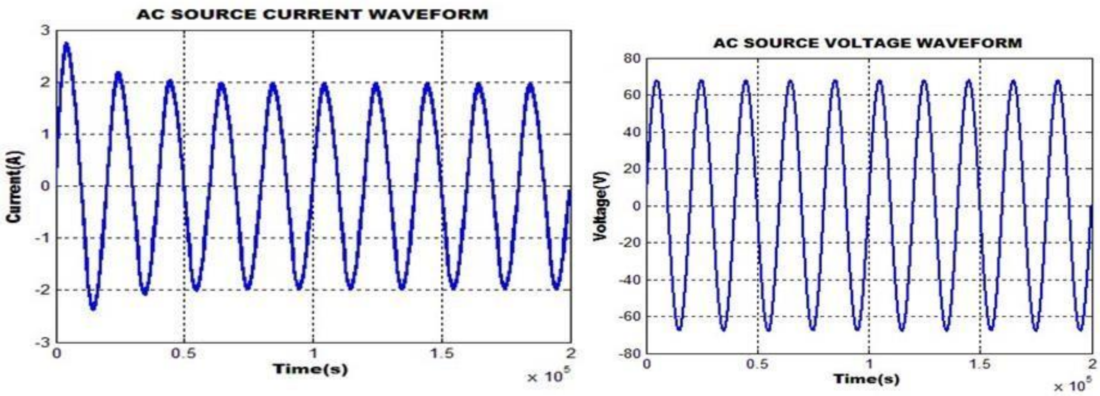

Figure 3.1 Input AC source (a) Current waveform and (b) Voltage waveform

The power waveform of the AC input supply is given in Figure 3.2. Input power of between 50W to 70W is provided by a bridge-free Landsman converter from 0.6s. The voltage at capacitors C_1 and C_2 is given in Figure 3.3. The waveform of the current load is given in Figure 3.4 and the waveform of the load voltage is given in Figure 3.4.

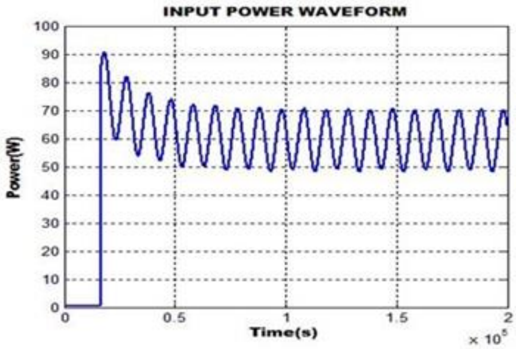

Figure 3.2 Input power waveform

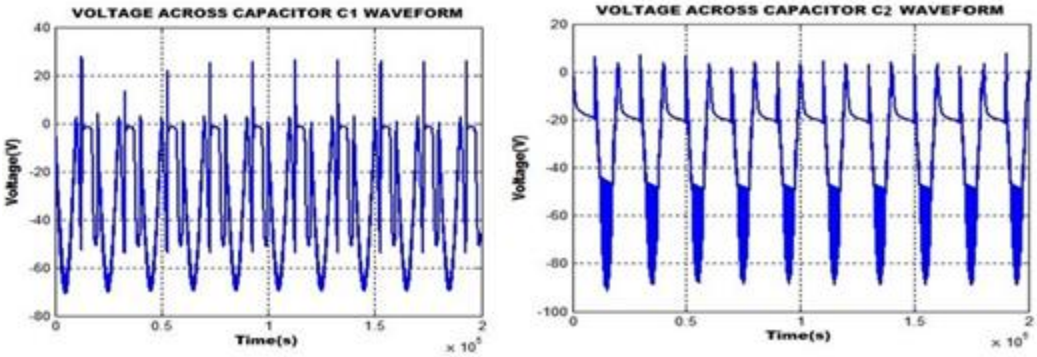

Figure 3.3 voltage across capacitor C1 and C2

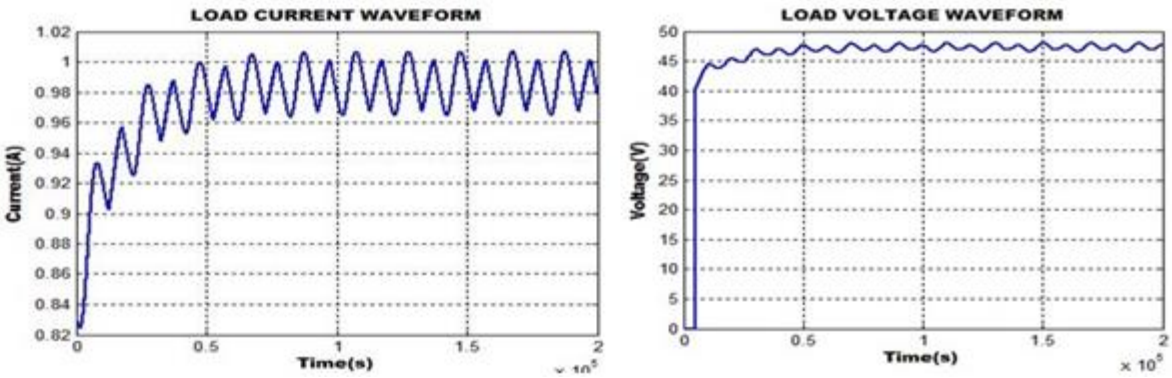

Figure 3.4 Load current waveform and Load voltage waveform

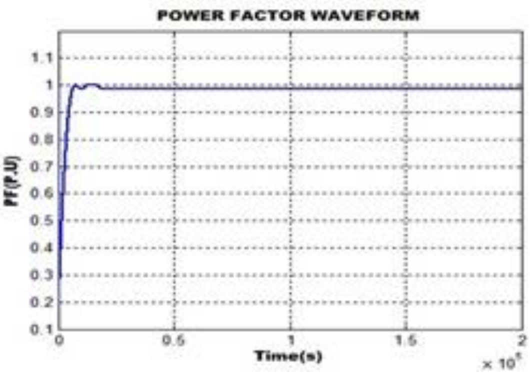

Figure 3.5 Power factor waveform

The waveform of the power factor is shown in Figure 3.5. From this figure it is noted that the proposed SEPIC Landsman converter is able to detect the nearest power factor. Hardware settings and the results obtained. The hardware configuration and results obtained are shown from Figure 3.6 to Figure 3.10.

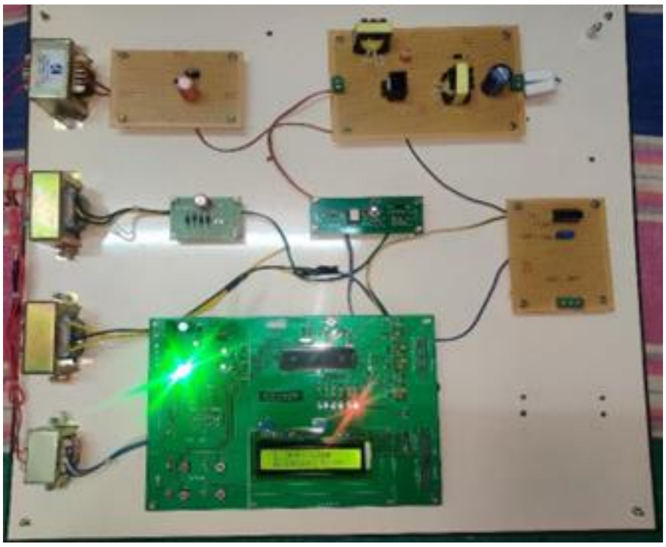

Figure 3.6 Hardware setup

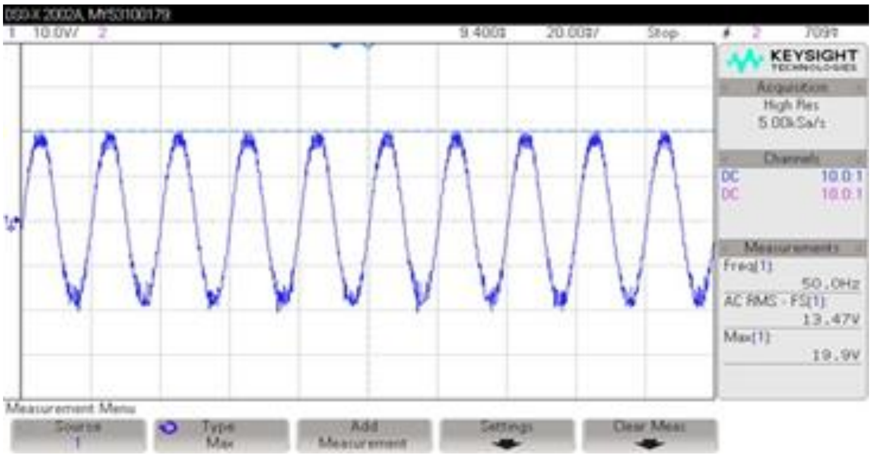

Figure 3.7 Input AC source voltage

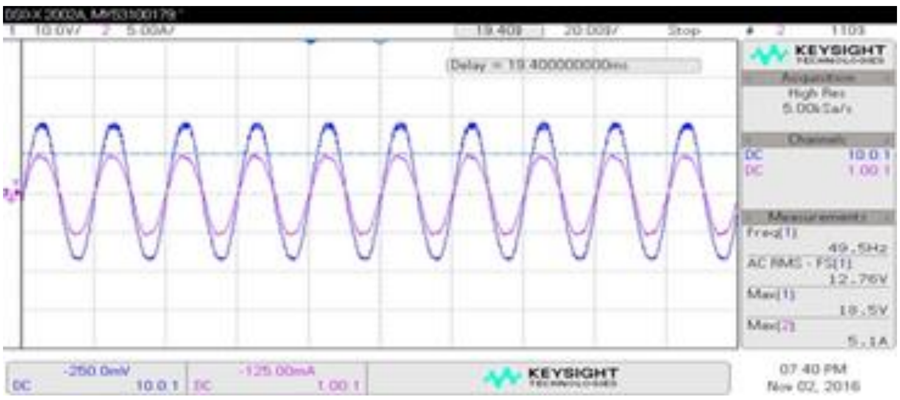

Figure 3.8 Input AC source voltage & current

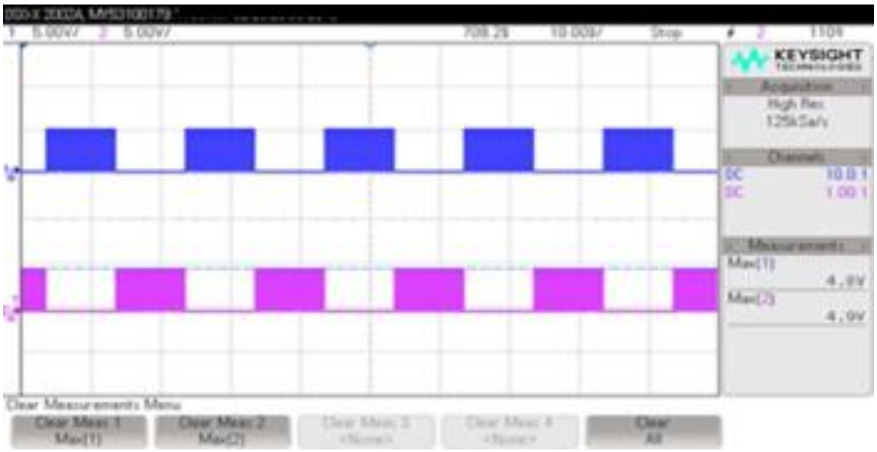
Figure 3.9 PWM pulse to the SEPIC converter

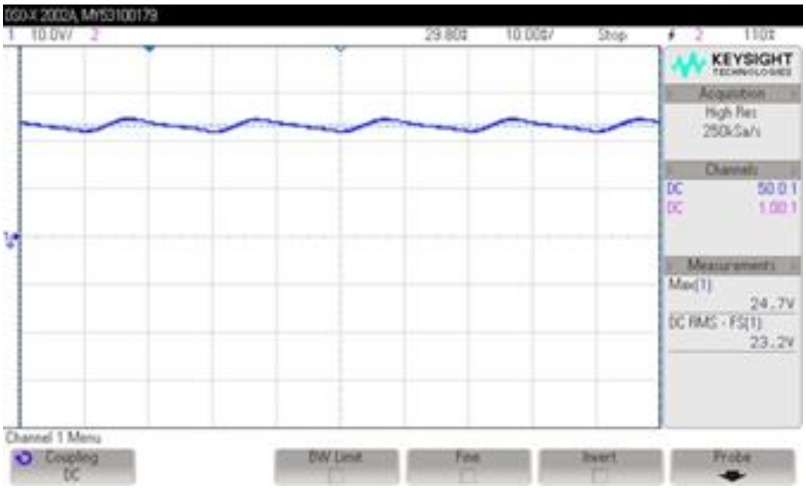
Figure 3.10 Output voltage of the SEPIC converter

By obtaining defined results, the proposed control module of the control system based on the Kalman SEPIC converter filter produces better SEPIC converter controls, reduced harmonics, improved DC-link power retention and reduced losses.

IV. CONCLUSION

This paper is about modeling the SEPIC Converter controller design using the Kalman filter. The role of the controller is important when used for a specific program. In this paper, the AC supply is inserted into the SEPIC converter via DBR. The converter control is then performed with the help of a Kalman filter based on a closed loop process. Then the outgoing controller of the SEPIC converter is loaded. Regional space analysis is used to create a SEPIC Converter model and the predictor corrector algorithm is used in the Kalman filter to design the entire control region. This design minimizes the distractions and harmonics produced in the converter and is quite satisfying.

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