Hierarchical Voltage Sensing to Perform Solar – Wind Renewable Energy Sources Complementary

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ABSTRACT – This study introduces the hierarchical voltage sensing-measurement using the voltage divider method to sense and measure the solar – wind energy sources regulated output voltage. To sense and measure the regulated output voltages, a simple voltage divider circuitry is designed and developed. Hence, this paper explains about the methodological design of hierarchical voltage sensing and voltage division method which performs the complementary between the solar-wind energy sources. The presented output in Figure 2 shows the voltage divider method has successfully validated the hierarchical voltage sensing-measurement for the hybrid solar – wind renewable energy sources.

1. INTRODUCTION

Due to the varying behaviour of renewable energy sources, especially solar photovoltaic (PV) and wind energy (WE), complementary based operation between these renewable energy sources are introduced. In [1, 2, 3] is explained the importance of having hybrid PV and WE for any kind of system application. In [4] modelling and simulation of integrating the variable speed control and maximum power point tracking to extract maximum power from both sources is explained. The variable speed control and maximum power point tracking is used as complementary profile to extract maximum power for optimum hybrid power system performances. In [5], fuzzy logic control technique is adopted to coordinate between PV and WS hybrid system as well as manage the energy flow from PV/WE to the battery/load. The proposed system has successfully performed the capability of feeding the energy to the battery/load during the energy unavailability period. In [6], reviews of developed control strategies using different techniques, methods and software is provided to understand the importance of implementing or integrating the complementary hybrid PV/WE power system. Hence, the brief review indicates the importance of implementing the complementary hybrid renewable energy sources as a power system.

Therefore, to perform complementary on hybrid PV and WE power system, proper complementary implementation technique is required. Thus, this paper introduces hierarchical voltage sensing – complementary solar – wind energy sources. This method senses and measures the regulated output voltages from the renewable energy sources and make the prioritization decision to perform the complementary on the hybrid PV and WE energy sources. Therefore, this research paper has been arranged as in the following.

2. METHODOLOGY

The hierarchical voltage sensing using the voltage divider method is presented in Figure 1.

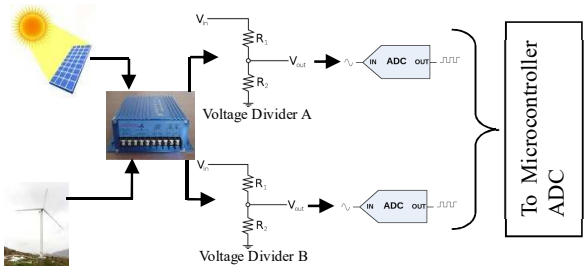

Figure 1 Solar – Wind hierarchical voltage sensing – voltage divider method

The solar - wind hierarchical voltage sensing using the voltage divider method is shown in Figure 1. The circuitry applies the voltage divider concept for hierarchical voltage sensing and measurement. Different value resistors are used to sense and measure the varying amount of regulated output voltages from solar – wind renewable energy sources. The varying amount of regulated output voltages from the solar – wind energy sources are converted into an equivalent voltage value for the analog to digital converter (ADC) at the microcontroller to perform the complementary objective between solar – wind renewable energy sources. Therefore, in the following the regulated output voltage from the renewable energy sources (V_{RES}) relationship with the input voltage at the microcontroller ADC (V_{ADC}) is discussed.

In this hierarchical voltage sensing and measurement – voltage divider method, it is assumed that the solar – wind renewable energy sources are producing 15 Volt of output voltage and it is known the ADC can

only receive maximum 5 Volt voltage. Hence, this specification is used to show the mathematical calculation and configuration for the complementary objective.

Where,

The microcontroller has 10 bit resolution of ADC, hence, $2^{10} = 1024 bits \left(0 - 1023\right)$,Equation (1) presents the voltage amount each bit can sense and measure at the microcontroller ADC.

$$1 \text{ bit} = \frac{15 Volt}{1024} \quad (1)$$

$$= 0.01367 Volt$$

$$V_2 = \frac{R_2}{R_1 + R_2} V_{PV/WE} \quad (2)$$

Lets $V_{PV/WE} = 15\ Volt$

$$V_{ADC} = 5 Volt$$

Let's assume, $R_2 = 3.6\,k\Omega$

$$5 Volt = \frac{3.6\,k\Omega}{R_1 + 3.6\,k\Omega} \times 15 Volt \quad (3)$$

$$5 Volt = \frac{50400}{R_1 + 3.6\,k\Omega}$$

$$R_1 + 3.6\,k\Omega = \frac{50400}{5 Volt}$$

$$R_1 = 10.08\,k\Omega - 3.6\,k\Omega$$

$$= 6.48\,k\Omega$$

$$= 6.2\,k\Omega + 270\,\Omega + 10\,\Omega$$

3. RESULTS AND DISCUSSION

The mathematical Equations (2) and (3) shows the different value of resistors used to sense and measure the varying amount of regulated output voltages from the renewable energy sources.

Referring to Figure 2, $V_{PV/WE}$ output a maximum of 15 Volt, the V_{ADC} port at the microcontroller sense and measure a maximum of 5 Volt. The relationship shown in Figure 2 is embedded into microcontroller and this allow the microcontroller to mathematically use Equations (2) and (3) to calculate and prioritize the complementary of solar - wind renewable energy sources.

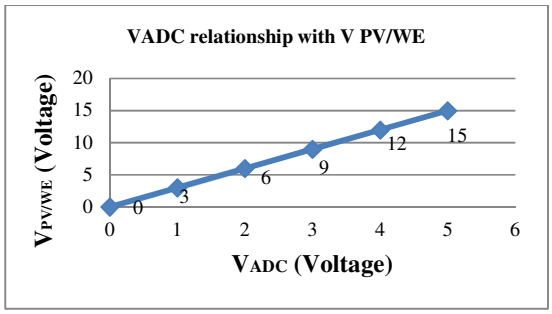

Figure 2 V_{ADC} proportion relationship with $V_{PV/WE}$

4. CONCLUSIONS

This research work proposes the hierarchical voltage sensing using voltage divider method for solar – wind renewable energy sources. The methodology adopted in Figure 1 validates the obtained results in Figure 2. The presented result in Figure 2 also verified the mathematical Equations (2) and (3) calculation in the microcontroller for hierarchical voltage sensing and measurement using the voltage divider method.

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