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# SENSORLESS PASSIVITY BASED CONTROL OF A DC MOTOR VIA SOLAR POWERED SEPIC CONVERTER

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***ABSTRACT-- In last couple of decades, the control of motors has increased drastically. With this increase, current control techniques are developed. In sensor-less passivity control of a DC Motor the term passivity means the property of stability in an input and output. To maintain the stability at the input side the solar pv panel is connected with MPPT which extract maximum and stable voltage. For output we simultaneously regulate, both, the output voltage of the SEPIC-converter to a value larger than the solar panel output voltage, and the speed of motor, in any of the turning senses, so that it tracks a pre-specified constant reference. For a sensor less current control of a PMDC motor, its small-signal model that contains a number of parasitic parameters the observed current may diverge due to the parasitic resistors and the forward conduction voltage of the diode. Moreover, the divergence of the observed current will cause steady state errors in the output voltage a self-correction differential current observer (SDCO) is proposed to eliminate this steady-state error and gain high transient response speed. By carrying out a series of MATLAB simulation verifications, further investigation proves that the proposed algorithm has good robustness. Finally, the effectiveness of the proposed algorithm is verified by experimental results.***

***KEYWORDS: Sensor less, SEPIC converter, Differential current observer, Self-correction ,Solar panel , PMDC motor, PCC***

## I **INTRODUCTION**

In recent years, digital control for a permanent magnet dc motor has become one of the research hot topics. Compared with the voltage control mode, the current control mode has higher response speed and larger loop gain bandwidth. However, in current control mode, when the pulse width modulation (PWM) duty ratio is higher than 50%, a slope compensation circuit becomes necessary to maintain system stability. Due to its high robustness and high response speed, predictive current control (PCC) has been brought into sepic converter current control loop design and has been widely investigated. In PCC mode, the inductor current of the next switching cycle should be predicted, and the duty ratio for the next switching cycle can be calculated according to the reference current and predicted current.

In this application, the power converters transfer the Solar panel power to the load represented by a DC motor. As an advanced current control strategy, the predictive current control (PCC) has the characteristics of high robustness and high response speed. It can be combined with the current observer to realize sensor less PCC (SPCC). Both the PCC and current observer technologies have been widely investigated. For the PCC, an algorithm was investigated to eliminate the inductor current disturbance in one switching cycle in peak, average, and valley current control modes. However, in order to maintain the current control loop stability, the specific combination of current control mode with pulse width modulation (PWM) modulation scheme should be obeyed, and it restrains the flexibility of system design.

The DC Motor/SEPIC converter combination powered via a solar panel has been used for the speed sensor less control. Following the design of these models, speed sensors less controllers were designed. Switched implementations of average dynamic output feedback control laws; by means of a PWM-modulator, are widely known in classic communications and analog signal encoding literature; for novel applications see. While, the SEPIC converter topology has been widely used in control methods for tracking maximum power point in photovoltaic power systems. Here we develop a solar panel fed drive for DC motor speed regulation. The power converters (SEPIC) are used as an interface. The controller drives the combined system to a constant set-point allowing the output voltage of the SEPIC converter feed the load, a DC motor. The regulation is carried under a certain maximum power condition on the solar radiation hitting the solar panel.

## II **PROPOSED SYSTEM FOR PASSIVITY CONTROL OF PMDC MOTOR**

### *A.SOLAR MPPT TECHNOLOGY*

A set of solar photo voltaic (PV) modules electrically connected and mounted on a supporting structure. To generate and supply electricity in commercial and residential applications. A photovoltaic system typically includes a panel or an array of solar modules. Single Solar Cell produces 0.5 Volts Connected 42 Cells Series and 2 cells Parallel. DC output power ranges from 100 to 320 watts. Solar energy is free. Solar energy does not cause pollution. Low power consuming devices can be powered by solar energy effectively. Solar energy is infinite (forever).Solar power provides energy reliability.

 

In order to continuously harvest maximum power from the solar panels, they have to operate at their MPP despite the inevitable changes in the environment. This is why the controllers of all solar power electronic converters employ some method for maximum power point tracking (MPPT). The three algorithms that where found most suitable for large and medium size photovoltaic (PV) applications are perturb and observe (P&O), incremental conductance (ICT) and constant voltage/current method.

The incremental conductance method is used as an MPPT method. The advantage of using this method to track MPP is that it is more efficient than the P&O method in a way that it is able to correctly locate the operating point of the PV array. There is a tradeoff between the power efficiency and reliability of tracking MPP. Mathematics of the Incremental Conductance method is discussed below. The output power from the source can be expressed as

$$P=V*I \quad (1)$$

The fact that P=V*I and the chain rule for the derivative of product yields

$$dP/dV = d(VI)/dV$$
$$=I+ V\, dI/dV \quad (2)$$

Let us define the source conductance G as

$$G=I/V \quad (3)$$

And source incremental conductance as

$$G=dI/dV \quad (4)$$

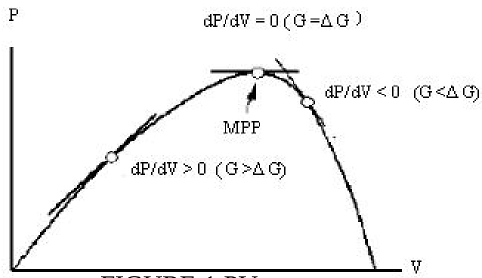

FIGURE 1 PV curve

The job of this method is therefore to search the voltage operating point at which the conductance is equal to the incremental conductance. Figure 1 shows the operating points of the incremental conductance method.

*B. SDCO*

1. S*ELF CORRECTION MODULE*

For the basic current observer, an integral self-correction module can be added to the system for voltage loop steady-state error elimination. As shown in Figure 2, in the integral self-correction module, $I_L{}'$ multiplies K/s, and the result is subtracted by $I_L$; the relationship between $I_L{}'$ and $I_L$ is

$$I_L{}'=I_L(S/S+K)$$

In the following, the open-loop transfer function with the self correction module is derived. First, the equation of the basic current observer without self-correction can be described as

$$I_L(k+1) = I_L(k) + \frac{T}{L}\{V_{IN}(k) - V_o(k)[1-D(k)]\} \quad (5)$$

Transferring the above equation to continuous domain, then

$$I_L = \frac{1}{S_L}[V_{IN} - V_0(1-D)] \quad (6)$$

Impose small-signal disturbances ˆ*I*REF, ˆ*D* and ˆ *VO* onto *I*REF, *D* and *VO*, respectively, and then substitute them into. After eliminating dc elements and higher order infinitesimals, the following can be obtained:

$$\frac{\hat{I_L}}{\hat{D}} = \frac{1}{S_L}[V_O - \frac{\hat{V_O}}{\hat{D}}(1-D) \quad (7)$$

$G_{ID}(S)$is the transfer function from *D* to *IL*. Combining the self-correction module with the current observer, $G_{ID}(S)$is

$$G_{ID}(S) = \frac{\widehat{I_L{}'}}{\hat{D}} = \frac{1}{(s+K)L}[V_O - \frac{\hat{V_O}}{\hat{D}}(1-D) \quad (8)$$

 

With regulating rule of PCC the $G_{PCC}$ is derived. $G_{PCC}(s)$, i.e., the transfer function from $\Delta I$ to $D$, can be obtained by the same method, i.e.,

$$G_{PCC}(s) = \frac{L}{2T}\frac{1}{V_O - \frac{\hat{V}_O}{\hat{D}}(1-D)} \quad (9)$$

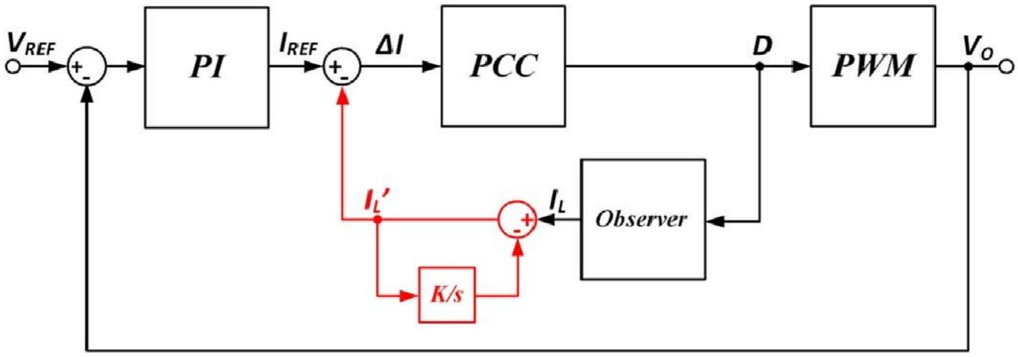


FIGURE 2 Block diagram of the current controller with self-correction

*2. Differential Current Observer*

After involving the self-correction module into the current observer, the output voltage steady-state error can be eliminated, and *IL* tends to be constant. However, the problem still exists in two respects. First, the predicted current *IL* is still increasing, eventually leading to the calculation result overflowing. More importantly, the influences on the parasitic parameters, e.g., device aging, will diverge $I'_L$ from the actual inductor current. As shown in Fig.2, in order to deduce $D(k+1)$, it I only necessary to calculate $\Delta I$ rather than *IL*. After extracting common factor $1/sT$ , $\Delta I$ becomes

$$\Delta I = I_{REF} - I_L = \frac{1}{sT}(\Delta I_{REF} - \Delta I_L) = \frac{1}{sT}\Delta I' \quad (10)$$

In , $\Delta I$REF and $\Delta IL$ are the differential values of $I_{REF}$ and *IL*, respectively. When the system reaches its steady state, both of them converge to zero, and the calculation overflow can be effectively avoided. The current observer equation in the continuous domain can be converted , i.e.,

$$I_L = \frac{1}{sT}\frac{T}{L}[V_{IN} - V_O(1-D)] \quad (11)$$

Then the differential current observer is

$$\Delta I_L = \frac{T}{L}[V_{IN} - V_O(1\text{-D})] \quad (12)$$

Whereas $\Delta I$REF can be calculated by

$$\Delta I_{REF} = K_P(1 + 1/sT1)sT \quad (13)$$

The block diagram of the current controller with differential observer is shown in Fig. 2. Compared with Fig. 3, additional modules are added, as marked in red.

When the common factor $1/sT$ is extracted from the PI controller, the PI controller becomes a proportional–derivative controller. The model with differential observer is shown in Fig.4. The computational complexity of the algorithm does not increase with the modification of the control structure.

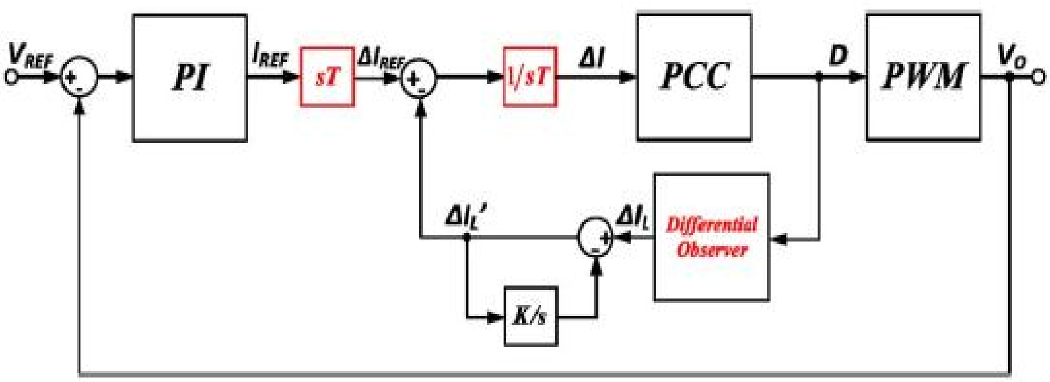


FIGURE 3 Block diagram of the current controller with differential observer

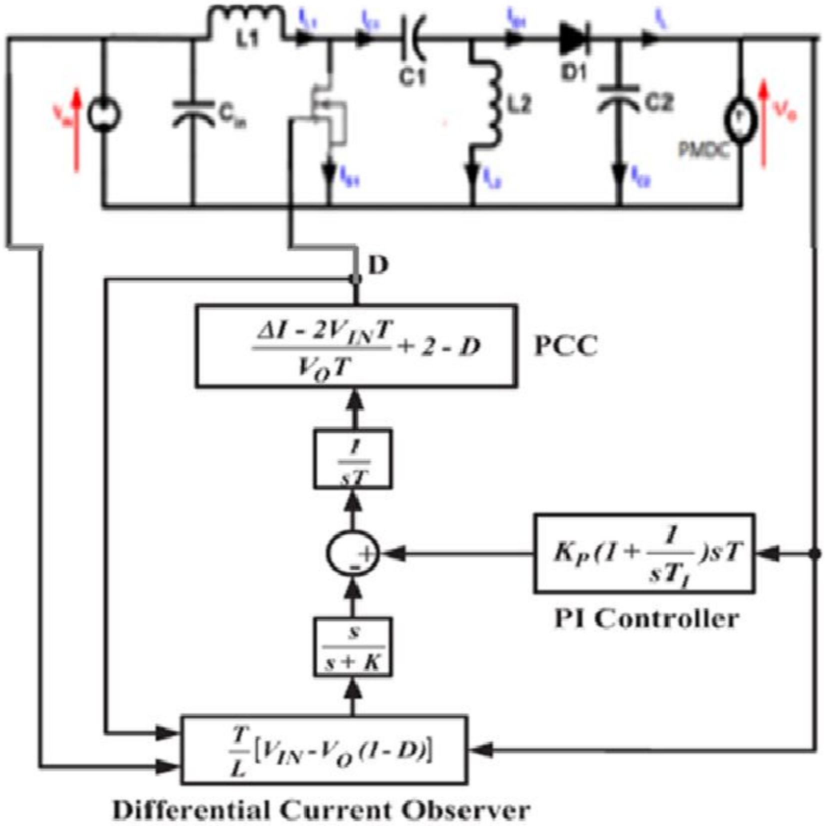


FIGURE 4 Block diagram of SPCC with differential current observer.

*C.PERMENANT MAGNET DC MOTOR*

In PMDC motor, a fixed magnetic field generated by the permanent magnets interacts with the perpendicular field induced by the currents in the rotor windings, thus creating a mechanical torque. As the rotor turns in response to this torque, the angle between the stator and rotor fields is reduced, so that the torque would be nullified within a rotation of 90 electrical degrees. To sustain the torque acting on the rotor, permanent-magnet DC motors incorporate a commutator, fixed to the rotor shaft. The commutator switches the supply current to the stator so as to maintain a constant angle = 90, between two fields. Because the current is continually switched between windings as the rotor turns, the current in each stator winding is actually alternating, at a frequency proportional to the number of motor magnetic poles and the speed.

Since the starting current and torque of the motor is high we have to minimise them. Current and torque has similar characteristics. By SDCO method we control the current of the motor.. When they getting reduced the speed of the motor is increased .Figure 5 shows the torque speed charecteristics of PMDC motor.

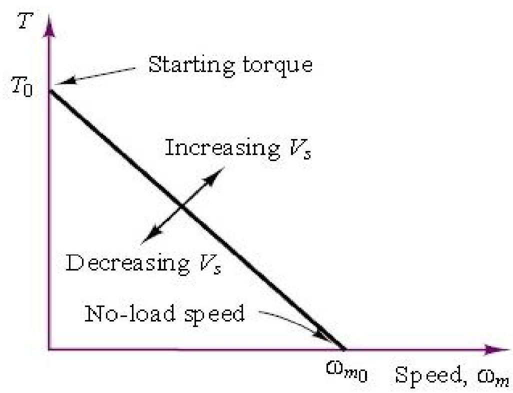


FIGURE 5 Torque speed characteristic of PMDC motor

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## III. EXPERIMENTAL RESULTS

The following model has been created using SIMULINK Fig.4 shows MATLAB model PMDC motor/SEPIC converter combination powered via a solar panel. This model contains renewable solar energy source, permanent magnet DC motor, and predictive current controller, control circuit which has PI controller, PWM, zero comparator, and sepic converter interface.

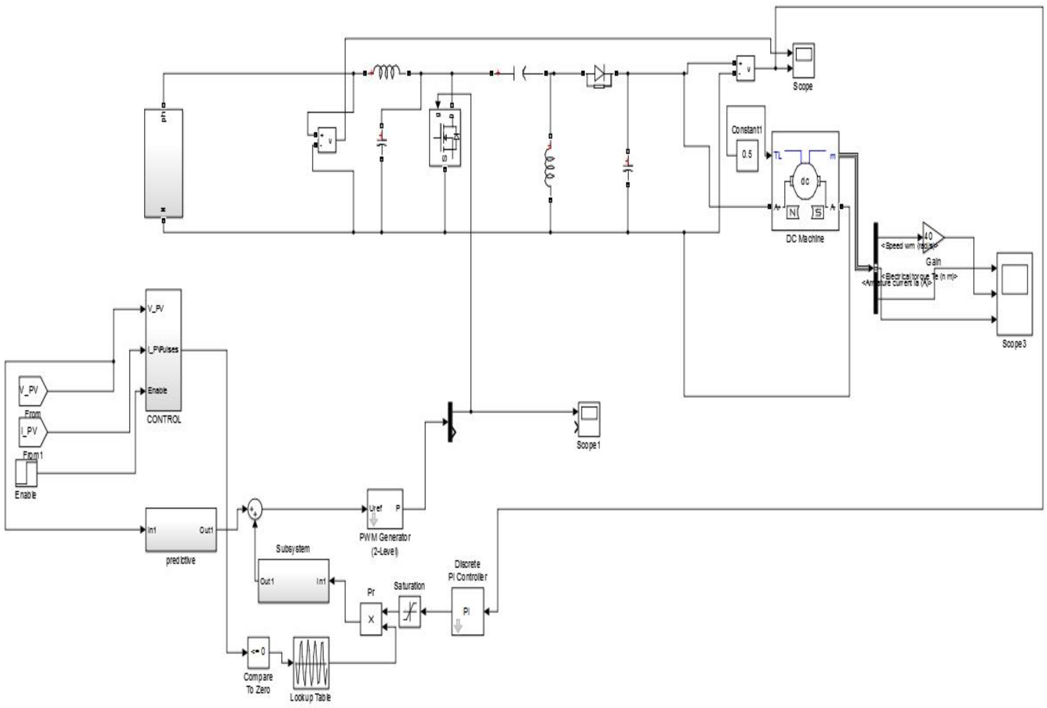


FIGURE 6 Simulink model of sensor less control of PMDC motor

An experimental prototype can be developed to verify this theoretical value based on the design specified earlier. The waveforms based on these calculations are shown as follows

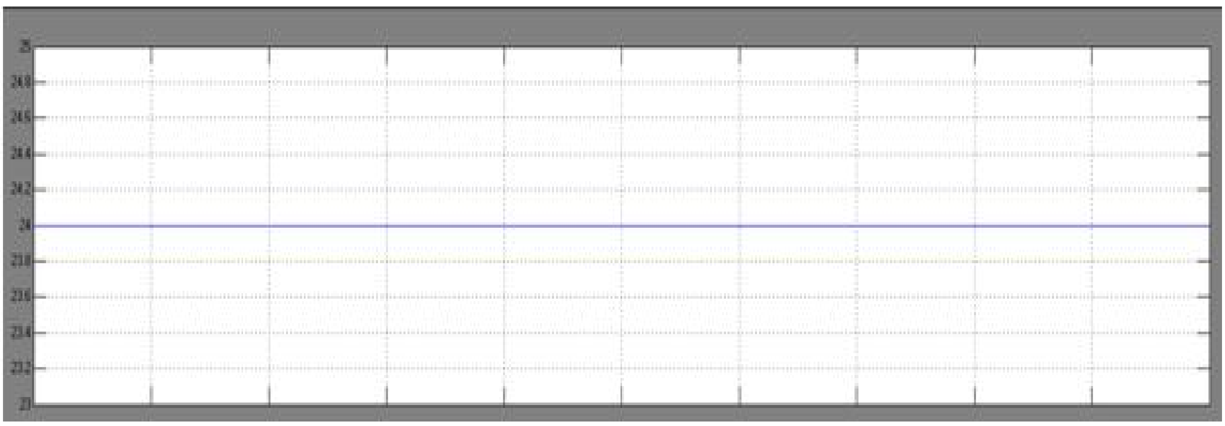

FIG 7 Input voltage

Fig 7 shows the input voltage of 24V, which is obtained from solar mppt. As was previously explained, MPPT algorithms are necessary in PV applications because the MPP of a solar panel varies with the irradiation and temperature, so the use of MPPT algorithms is required in order to obtain the maximum power from a solar array.

 

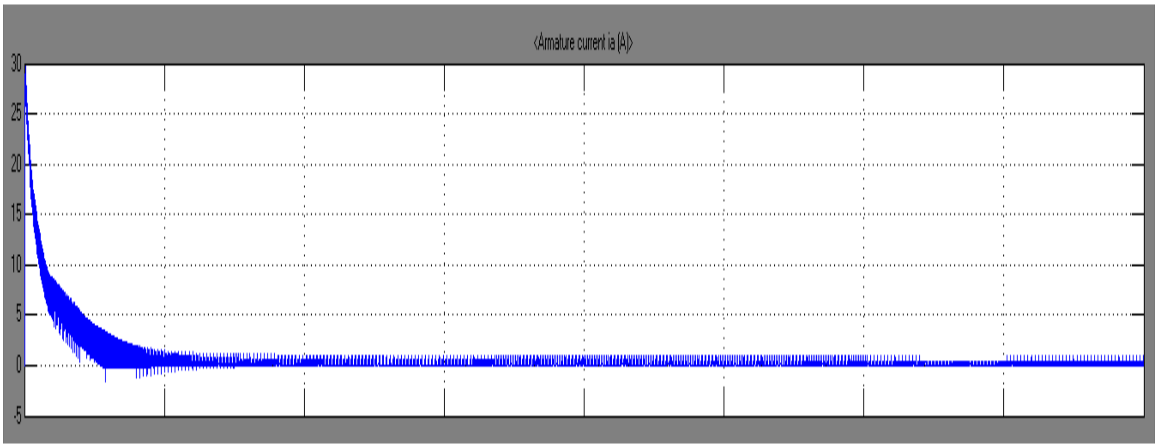


*FIGURE 8 Armature current of the PMDC motor*

Fig. 8 shows the output current obtained from simulation. On this basis, the system small-signal model, including the parasitic parameters, is constructed and analyzed. Then an SCDO is proposed. PMDC motor has high starting current and its getting reduced after the motor start to run at its desired speed.

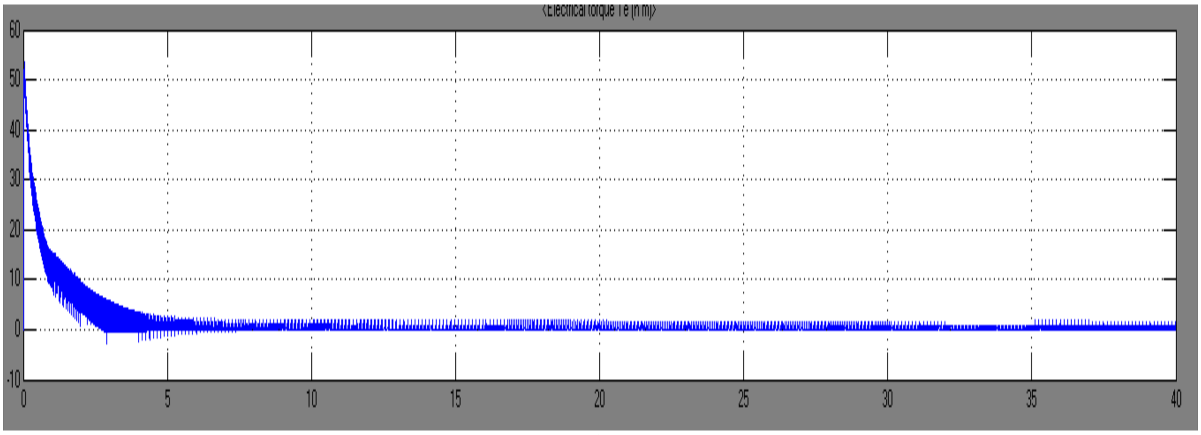

*FIGURE 9 Torque of the PMDC motor*

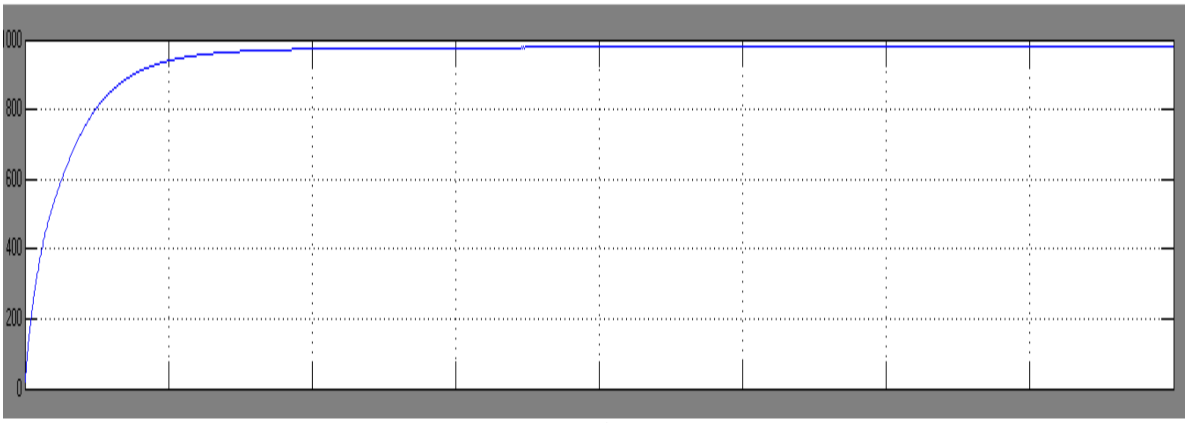

*FIGURE10 Speed of the PMDC motor*

Fig 10 shows the speed of the motor and Fig 9 shows the torque of the motor. The above figures are matched with the practical performance of the PMDC motor. When the speed increases the torque and the armature current decreases. Speed is inversely proportional to the torque. When torque increases speed will decrease and vice versa.

The basic cause of the output voltage steady-state error in a sensorless current-controlled boost converter has been proved through theoretical derivations. On this basis, the compensation strategy for output voltage sampling in both current loop and voltage loop has been proposed. In addition, the system modeling error caused by the parasitic parameters and nonlinear factors has been also compensated. The system ultimately achieves high-precision sensorless predictive peak current control without the voltage steady-state error with the comprehensive compensation strategy.

The specifications of the Sepic-converter/dc-motor system may be found in Table I

 

TABLE I -- SPECIFICATIONS OF THE SEPIC-CONVERTER/DC-MOTOR SYSTEM

| SYSTEM PARAMETERS | |
|---|---|
| DC MOTOR: | |
| Armature resistance | 0.6 ohm |
| Inductance | 0.012H |
| Torque constant | 1.8 Nm/A |
| Total inertia | 1 $Kgm^2$ |
| SEPIC : | |
| Power diode | D1 (BYV32) |
| Switching device MOSFET | (IRF640) |
| Commutation freq. | 45Khz |
| Solar panel | SX50U (Solarex) |
| DC Capacitor 1 | C1 = 22Mf |
| DC Capacitor 2 | $C_2$ = 470μF |
| Input Capacitor | Cin = 2μF |

This SEPIC converter could allow it to run on a large range of power with greater efficiency than simply reducing the voltage with a potentiometer to control the output. Most applications of the SEPIC converter control the voltage automatically. Usually it is best to use the SEPIC converter to hold a single output without the need for control when using a SEPIC as part of a large circuit.

According to the preceding experimental results, even when the system is subject to sudden load and line voltage disturbances, it is able to respond quickly and converge to a new steady state with no output voltage steady-state error. With the proposed algorithm, the system shows good robustness.

## III **CONCLUSION**

The basic cause of output voltage steady-state error in a sensor less current controlled PMDC motor powered via solar mppt with SEPIC converter interface has been established in theory. On this basis, the system small-signal model, including the parasitic parameters, is constructed and analyzed. Then an SCDO is proposed. I am using sensor less current control of PMDC motor. The current sensors have different advantages and drawbacks, and thus could meet different requirements. However, existing techniques might not suit applications which require isolation with minimal price, power loss and size. Therefore, a current observer (CO) turns out to be a suitable substitute for conventional current sensors in digitally controlled converters. The cost, size and power consumption can be reduced since it does not need any auxiliary hardware, even though the accuracy might be affected by the voltage ripple or the mismatches between the observer and the converter.

Simulation shows that the proposed algorithm is very robust. In addition, its computational complexity is low and easy to implement. With the proposed algorithm, the system ultimately achieves no voltage steady-state error with good transient performance despite parasitic parameters variation. Experimental results show that the control of permanent magnet DC motor is proposed in this paper is accurate and effective and has a good theoretical and practical application potential. The result of this property would be the increase of speed and efficiency. This system is suitable for industrial applications.

 

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