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Developing Block Chain Technology on ABCN Network Controller for Fly Back Converter fed PV Grid in Modern Power Systems using IOT

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ABSTRACT

In recent years, smart grid power transmission and distribution have created a lossless transmission of supply sources. This has the problem of a centralized source of distribution which identifies poor voltage regulation and a hidden source of power supply to each distribution station and feeder. The proposed model introduces a decentralized distribution system leveraging blockchain technology, which addresses issues such as poor voltage regulation in centralized models. The integration of the Adjustable Backstepping Chebyshev Neural (ABCN) network controller and blockchain enhances voltage regulation by ensuring secure, immutable, and real-time monitoring of energy transactions at both the transmission and consumer ends. The power distributed in the network will be monitored and controlled using block chain technology. These audit the energy source and regulate the voltage variation both at the transmission side and at the receiving side and the data is stored in IOT. Simulation results indicate that the proposed model maintains a stable output voltage of 30V with a duty cycle of 33% (0.33) even under varying load conditions. Compared to conventional controllers, it achieves faster settling time and minimal peak overshoot, as stored and validated through IoT-integrated blockchain web interfaces.

1. INTRODUCTION

The smart grid in the power system represents a transformation toward decentralized and intelligent energy distribution. Traditional centralized distribution systems are limited by inefficiencies, poor fault isolation, and lack of transparency. To address these, this work employs blockchain for its decentralized, secure, and tamper-proof characteristics, integrated with ABCN control to enhance voltage regulation and data integrity. The smart grid enhances not only the power quality but also its work is to be a Decentralized one to convey its energy transactions all over the system components. Each component data is to be stored and given to block chain which generates the desired output voltage. The sliding mode controller improves the system voltage with its efficiency, but the reliability of the output will be lagged in the system [1-3]. The fuzzy logic controller along with the boost converter in the transmission system provides good output voltage but it could not meet the basic requirements at the sending end side[4-6]. The model predictive controller has the good voltage regulation with the boost converter, but the reference voltage applied will be changed without the knowledge of that block. The monitoring of the whole system is lagging [7-10]. The nonlinear Decentralized controller in the power system makes smooth regulation in voltage but the grid connected PV system is not regulated to get the desired output [11-13]. The block chain technology for Smart Grid (SG) makes it more efficient in energy trading and reduces the cost of tariff at consumer side [14-15]. The multi input DC-DC converter is modeled for renewable energy systems which show poor power under different load variations [16-20]. The neuro fuzzy technique is used to provide good voltage regulation in power electronic converter but the uncertainty parameters should be considered for harmonic distortion [21-25]. The parameter uncertainty is considering which regulates both the output voltage and harmonics in system but the periodic updating of data cannot be provided [26-28]. So, the proposed block chain technology based CNNC not only emphasis the energy trading at consumer side but also decentralize all the blocks of power system over a single controlled centre of block chain. The IoT modules, communicating via MQTT protocol with TLS encryption, continuously send real-time data to the blockchain, where it is hashed and validated to prevent tampering, ensuring a trustworthy decentralized monitoring environment. This makes the system more efficient in power quality improvement. The voltage, current and power values of the proposed controller is stored in block chain. So, there could not be any possibility of fault occurrence and mismatch between the load sides as well as in the PV grid system.

Section II illustrates the problem statement of the existing controller for the power converter. Section III depicts the modeling of the proposed controller for the power converter. Section IV illustrates the results and discussion with a comparison of the existing controller to the proposed one using Simulink. The proposed model is concluded in Section V.

2. Problem Statement of Conventional Model

The conventional method of voltage regulation has only the centralized control of the power converter in Figure 1. The boost converter is used in the transmission line of the DC link which enhances only the reference voltage from the controller and gives it to the converter of the DC transmission system. This improves the voltage supplied from the PV grid to get desired output voltage. But it is centralized even if the controller circuit fails and a mismatch occurs in the system. Thus, all the components utilized in the power system must be centralized to enhance the voltage regulation without any error or mismatch between the load side as well at the sending end. The drawbacks are analyzed and determined as (i) This type of conventional method gives a mismatch of load between the consumer side and PV grid. (ii) The centralized system is formed resulting in switching errors all through the system. (iii) The individual parameters of the system should not be modified. (iv) System becomes more complex to identify the fault occurring. (v) It holds control only in a controller used in the system. (vi) With the help of the controller the error that occurs in the grid and in the transmission line converter could be varied.

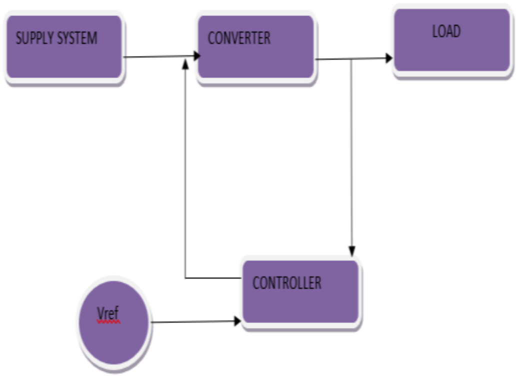


Figure 1: Block diagram of Conventional model

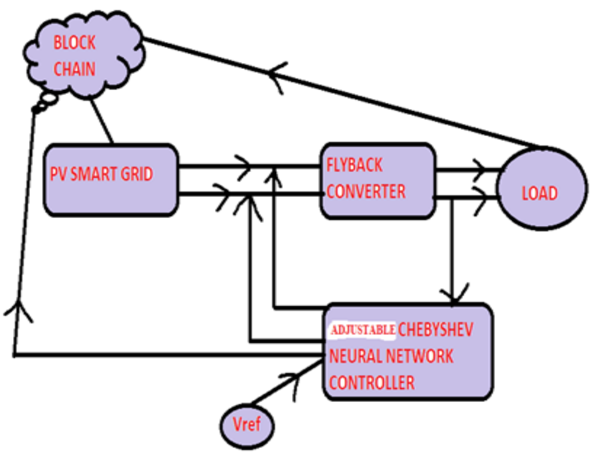


Figure 2: Block diagram of the proposed ABCN

3. Modeling of Block chain to the ABCN Controller

The adjustable back-stepping Neural Network-based Chebyshev Controller plays a vital role in the voltage regulation of the power system at the consumer side. The DC transmission system which is effective now-a-days tends to control the supply voltage from the grid. Then it makes use of it for transmission system. The proposed model defines the block chain technology for ABCN in the power grid to improve the voltage regulation as well as make the system to be decentralized. The block diagram of the proposed controller is shown in Figure 2.

The controller ABNC used in the system improves the output voltage to the load side by having the desired reference voltage. It also controls the voltage supplied from the PV grid. Here the fly back converter topology is used which uses for small power applications. The ABCN is installed here to improve the output voltage from the grid to the load side. The blockchain framework, implemented using Ethereum and employing Proof of Authority (PoA) consensus, securely controls the PV grid, flyback converter, transmission line, and ABCN. All control data (voltage, current) are hashed and stored as immutable blocks, ensuring cybersecurity and traceability. The variation from all the components is sent as blocks to the system. The system will capture and correct the error and sent it to the transactions.

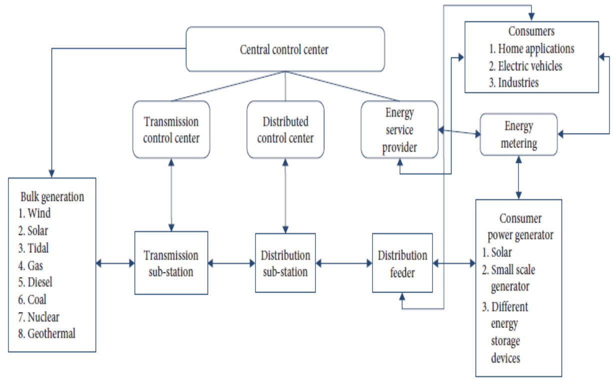
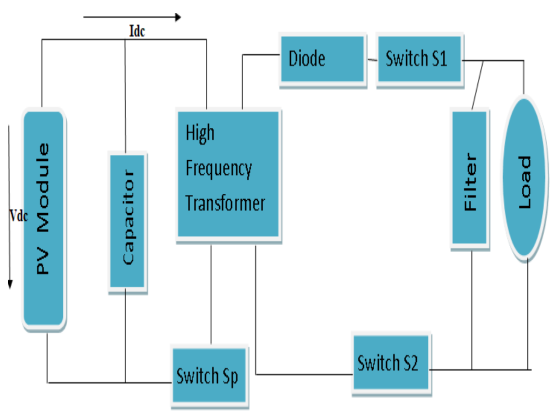


Figure 3:Circuit diagram of one model PV and flyback converter

Figure 4: Block Chain technology-based security model for Smart grid

3.1 Overview of Blockchain:

The BC is a pc network primarily based totally archives (massive information machines),in which hackers can get entry to any area worldwide. This is a completely



obvious machine, in which if provisioned for public BC, all carrier vendors and purchasers can see the alternate made and transactions. For this, BC targeted on responsiveness in lots of industries. This is substantially carried out within the electricity industry, communication, information exchanges, e-treading, and authorization and authentication tamper-evidence mechanisms. In the factor of electricity trading, the BC era adopted the grid electricity. The block transaction of BC is carried out with the aid of using stable and incorporated consensus algorithms. In 2008, the primary cryptocurrency, Bitcoin, changed into delivered within the marketplace and that is the peer-to-peer digital forex switch process. In this transaction process, without authorization from one birthday celebration to some other birthday celebration, forex. changed into securely completed online transactions with the aid of using a relied on 0.33 birthday celebration and changed into the first carried out in the era. This BC era is substantially and effectively carried out within the monetary industry, SG, electric-powered automobile(EV) machines, healthcare, IoT, delivery chain, etc.

3.2 Blockchain Mechanism for Smart Grid:

The integration of BC with the SG era is turning into state-of-the-art key answers for facilitating complete safety capability SG era. The middle associated interfaces, components, and programs of SG which are seriously safety structured are mentioned in reading the important thing RQs. The present centralized ledger machine can be transferred with the aid of using the BC era into an allotted ledger due to the general public key algorithm. It additionally has a stop-to-stop encryption era and, because of the distribution processing structure, ensures low costs. The concept of block chains is producing loads of studies and purposeful interest now. A BC is a cryptographic series of node blocks, in which the headers, corresponding transaction information, and auxiliary safety metadata are secured for every block. Intrinsically, the BC helps unfastened connectivity, incorruptibility, openness and stable storage, and switch of information. In recent years, numerous BC implementations have arisen past preliminary cryptocurrency programs, like Bit coins. Bitcoin`s BC system is a public information database that saves the records of Bitcoin fee transfers up to date regularly. To keep away from forgery, this ledger is created the usage of the cryptographic era.

3.3 Circuit Model of the Proposed Fly back converter with the PV module

The modeling of the Fly back converter is shown in Figure 3 with the PV module is explained by derivate below;

$$I_N = I_{ph} + I_d$$

Where, Iph = Photon Current, Id = Diode Current, Is = Saturation Current, Ipv = PV Current

The State space model of the flyback converter is;

$$\dot{x}_1 = I_{pv}/L - x_2/L \qquad (1)$$

$$\dot{x}_2 = -x_3(1-D)/nL + x_1 D/L \qquad (2)$$

$$\dot{x}_3 = x_2(1-D)/nC - x_3/RC \qquad (3)$$

Chebyshev Weight law for the system is described as;

$$z_1 = x_1 - V_{pvr} \qquad (4)$$

X1= PV voltage

Vpvr=reference voltage of PV

Differentiate equation (4)

$$\dot{z}_1 = \dot{x}_1 - \dot{V}_{pvr} \qquad (5)$$

Based on weight law

Ipv = w α

w-neural network weight

α - Chebyshev Polynomial

Equation (1) becomes;

$$\dot{x}_1 = w\alpha/L - x_2/L \qquad (6)$$

Now substitute equation (6) in (5)

$$\dot{z}_1 = w\alpha/L - x_2/L - \dot{V}_{pvr} \qquad (7)$$

Determining Lyapunov control function,

Let take 1st error variable,

$$\dot{z}_1 = -c_1 z_1$$

$$x_2 = x_2 d$$

C1-gain constant

Sub z1 and x2 in equation (7)

$$-c_1 z_1 = w\alpha - x_2 d/L - \dot{V}_{pvr}$$

$$x_{2d} = \hat{w}\alpha + Lc_1 z_1 - L\dot{V}_{pvr} \qquad (8)$$

Another error variable will be z2;

$$z_2 = x_2 - x_{2d} \qquad (9)$$

$$x_2 = z_2 + z_{2d} \qquad (10)$$

Substitute equation (10) in equation (7)

$$\dot{z}_1 = w^T \alpha/L - (z_2 + x_{2d})/L - \dot{V}_{pvr} \qquad (11)$$

Substitute x2d value in equation (11) therefore error variable z1 is;

$$\dot{z}_1 = w^T \alpha/L - \hat{w}^T/L - z_2/L - c_1 z_1 \qquad (12)$$

$\tilde{w}$ -is the expected weight value

$$\dot{z}_1 = \tilde{w}\alpha/L - c_1 z_1 - z_2/L \qquad (13)$$

Differentiate equation (8)

$$\dot{x}_{2d} = \dot{\hat{w}}^T \alpha + Lc_1 \dot{z}_1 - L\ddot{V}_{pvr}$$

Substitute z1 from equation (5)

$$\dot{x}_{2d} = \dot{\hat{w}}^T \alpha + Lc_1(\dot{x}_1 - \dot{V}_{pvr}) - L\ddot{V}_{pvr} \qquad (14)$$

Now substitute equation (6) in (14)

$$\dot{x}_{2d} = \dot{\hat{w}}^T \alpha + \dot{\hat{w}}^T \alpha c_1 - c_1 x_2 - Lc_1 \dot{V}_{pvr} - L\ddot{V}_{pvr} \qquad (15)$$

Then differentiate equation (9)

$$\dot{z}_2 = \dot{x}_2 - \dot{x}_{2d} \qquad (16)$$

Substitute equation (2) in (16)

$$\dot{z}_2 = -x_3(1-D)/nL + x_1 D/L - \dot{x}_{2d} \qquad (17)$$

Let take

$$x_3 = x_{3d}$$

$$\dot{z}_2 = z_1/L - c_2 z_2$$

C2 – gain constant

Therefore equation (17) becomes,

$$x_{3d} = nL/(1-D)(x_1 D/L - z_1/L + c_2 z_2 - \dot{x}_{2d}) \quad (18)$$

New variable z3 becomes,

$$z_3 = x_3 - x_{3d} \quad (19)$$

$$x_3 = z_3 + x_{3d} \quad (20)$$

Substitute equation (20) in equation (17)

$$\dot{z}_2 = -(z_3 + x_{3d})(1-D)/nL + x_1 D/L - \dot{x}_{2d} \quad (21)$$

Substitute equation (18) in equation (21);

$$\dot{z}_2 = -z_3(1-D)/nL + z_1/L - c_2 z_2 \quad (22)$$

Substitute equation (15), (9), and (5) in equation (18) we get;

$$x_{3d} = (nL/(1-D)(x_1 D/L - (\dot{x}_1 - \dot{V}_{pvr})/L + c_2(x_2 - x_{2d}) - \dot{\hat{w}}^{T}\alpha + \dot{\hat{w}}^{T}\alpha c_1 - c_1 x_2 - Lc_1\dot{V}_{pvr} - L\ddot{V}_{pvr} \quad (23)$$

Substitute equation (8) in equation (23)

$$x_{3d} = (nL/(1-D)(x_1 D/L - (\dot{x}_1 - \dot{V}_{pvr})/L + c_2(x_2 - \hat{w}\alpha + Lc_1 z_1 - L\dot{V}_{pvr}) - \dot{\hat{w}}^{T}\alpha + \dot{\hat{w}}^{T}\alpha c_1 - c_1 x_2 - Lc_1 V_{pvr} - L\ddot{V}_{pvr} \quad (24)$$

$$x_{3d} = nL/(1-D) * A_2 \quad (25)$$

Take;

$$A_2 = (x_1 D/L - (\dot{x}_1 - \dot{V}_{pvr})/L + c_2(x_2 - \hat{w}\alpha + Lc_1 z_1 - L\dot{V}_{pvr}) - \dot{\hat{w}}^{T}\alpha + \dot{\hat{w}}^{T}\alpha c_1 - c_1 x_2 - Lc_1 V_{pvr} - L\ddot{V}_{pvr}$$

Differentiate equation

$$\dot{x}_{3d} = nL/(1-D)(A_1 + \dot{D}/(1-D)(x_{3d}(1-D))$$

(26)

Substitute (25) in (26)

$$\dot{x}_{3d} = nL/(1-D)(A_1(1-D) + \dot{D}\,nL\,A_2)$$

Differentiate equation (19)

$$\dot{z}_3 = \dot{x}_3 - \dot{x}_{3d} \quad (27)$$

Substitute x3 from equation (3)

$$\dot{z}_3 = x_2(1-D)nC - x_3/RC - \dot{x}_{3d} \quad (28)$$

Lyapunov function to make the system stablebecomes;

$$V_1 = 1/2 * z_1^2 + 1/2 * z_2^2 + 1/2 * z_3^2 + 1/2\tilde{w}\,p^{-1}\,\tilde{w} \quad (29)$$

Taking time derivation of equation (30);

$$V_1 = z_1\dot{z}_1 + z_2\dot{z}_2 + z_3\dot{z}_3 + \tilde{w}\,p^{-1}\,\dot{\tilde{w}} \quad (30)$$

Substitute equation (13), (22), (28) in (30);

$$\dot{V} = -c_1 z_1^2 - c_2 z_2^2 - c_3 z_3^2 - \tilde{w}^{T}(p^{1}\dot{\tilde{w}} + \alpha z_1/L) + z_3(-z_2(1-D)/nL)$$
$$+ x_2(1-D)nC - x_3/RC - \dot{x}_{3d} + c_3 z_3) \quad (31)$$

Solving equation (31);

$$\dot{V} = -c_1 z_1^2 - c_2 z_2^2 - c_3 z_3^2 \quad (32)$$

Online weight update law;

1st term = 0

$$\tilde{w}^{T}(p^{1}\dot{\tilde{w}} + \alpha z_1/L) = 0 \quad (33)$$

$$\dot{\tilde{w}} = p\alpha z_1/L \quad (34)$$

To find the duty cycle;

Equate the final term of equation (31) to zero;

$$(-z_2(1-D)/nL)$$
$$+ x_2(1-D)nC - x_3/RC - \dot{x}_{3d} + c_3 z_3) = 0 \quad (35)$$

Substitute equation (9) and (19) in (35);

$$(-(x_2 - x_{2d})(1-D)/nL)$$
$$+ x_2(1-D)nC - x_3/RC - \dot{x}_{3d} + c_3(x_3 - x_{3d}) = 0 \quad (36)$$

Substitute equation (5), (36), (28) in (36);

$$(1-D)^3(1/nL(L\dot{V}_{pvr} + x_2/nC - Lc_1(x_1 - V_{pvr}) + x_2 - \tilde{w}^{T}\alpha)) + (1- \ldots$$
$$+ (1-D)(-nL\,A_1 - c_3 nL\,A_2) - L^2\dot{D}A_2 = 0 \quad (37)$$

Consider;

$$a = -1/nL(L\dot{V}_{pvr} + x_2/nC - Lc_1(x_1 - V_{pvr}) + x_2 - \tilde{w}^{T} \ldots$$
$$b = x_3(c_1 + c_2 + c_3 - 1/RC)$$
$$c = -nL\,A_1 - c_3 nL\,A_2$$
$$d = -L^2\dot{D}A_2 = 0 \quad (38)$$

The equation (37) becomes;

a(1-D)^3+b(1-D)^2+c(1-D)+d=0 (39)

Solve equation (39) using Cauchy function; with limits 0<D<1;

The duty cycle becomes;

$$D = (1-3)\sqrt{(q + \sqrt{q^2 + (r-p})^3) + 3\sqrt{(q - \sqrt{q^2 + (r - p^2)^3} + p \ldots$$

Where p=-b/3a;qp^3+(bc-3ad)/6a^2 and r=c/3a.

4. SIMULATION RESULTS AND DISCUSSIONS

The Adjustable chebyshev back stepping neural network controller is proposed for the fly back converter to get the desired output voltage. Table 1 provides the data of parameters used in simulation. The ABCN controller is simulated using the MATLAB software with the two constants of C1 and C2 is maintained to get the higher accurate of output voltage. The responses of output voltage and the output current is simulated for variation in the load parameters. Thus the ABCN controller is compared with the Backstepping controller (BC) and PI controller in Figure 5. C

Table 1: Data of Parameters used in simulation

Parameters	Values
Output reference voltage	20 V
Input voltage	100 V
Input capacitance	0.002µF
Frequency	1 KHz
Load Resistor	90Ω
Input Inductance	20 mH
Transformer Primary Voltage	200 V
Transformer Secondary Voltage	400 V

Figure. 1. Block Diagram of BLDC Motor

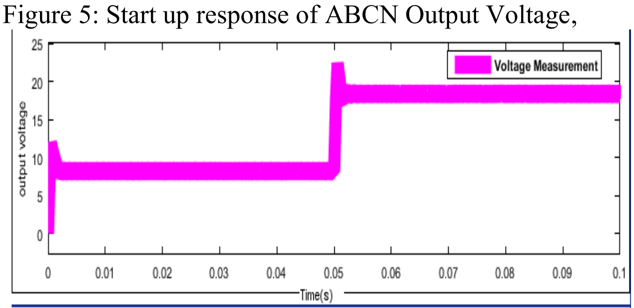
4.1 Case 1: Start-up response analysis:

In case 1 the output voltage and output current of ABCN, BC, and PI controllers are compared in Figure 6 and the proposed ABNC shows a better response for load variation and fast settling time. This has less ripple response as compared to another conventional controller.

4.2 Case 2: Change in reference voltage from 20 to 30 V:

Case 2 illustrates the change in reference voltage from 20 v to 30 v. The simulation results shown in figure 7 and 8 provide good response for the output voltage of abcn, bc and pi controller. Table 2 shows the fast settling time as compared with both bc and pi controller. The uncertainty is also reduced when the system shows good response for load variations.bldc motor working.

Figure 5: Start up response of ABCN Output Voltage,



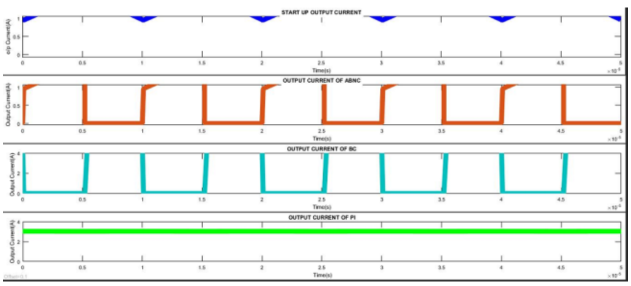
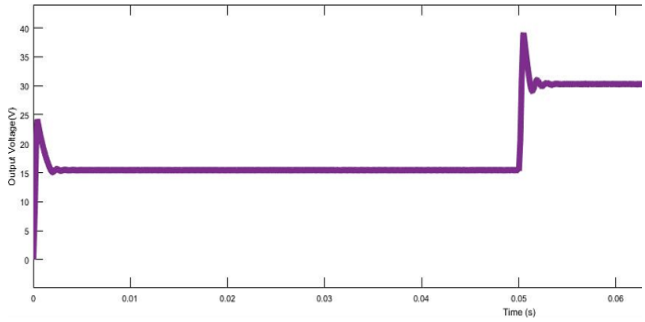
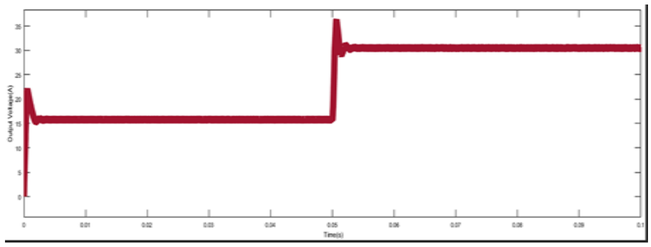


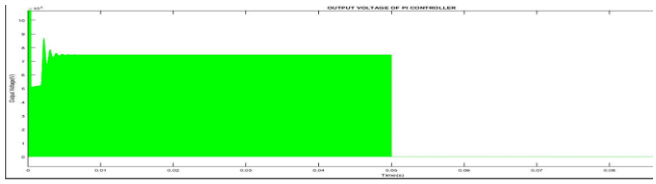
Figure 6: Start up response of Output current in ABCN, BC and PI Contoller



(a) ABCN



(b) BC



(c) PI Controller in Case 2

Figure 7: Response of Output voltage

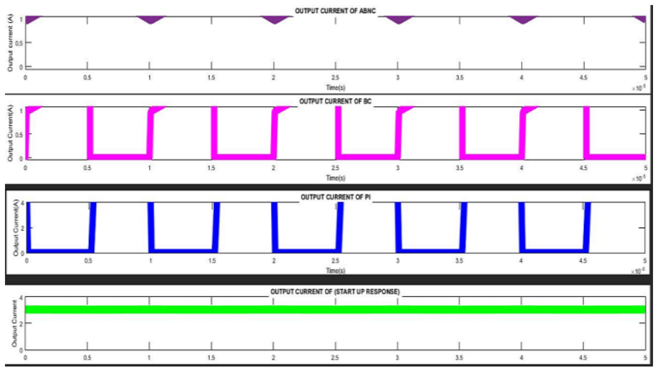


Figure 8: Response of Output Current of ABCN, BC, PI Controller in Case 2.

Table 2: Comparison table of conventional to proposed controller

Controllers	Settling Time(s)	Peak overshoot
ABNC	0.12s	0.2
BC	0.23s	11

PI	0.29s	15

4. CONCLUSIONS

The smart grid system faces not only the problem of output voltage regulation but also there are several risks to the SG network. To avoid such risk, the proposed model defines the block chain technologies with IOT for the modern power system. To stimulate good voltage regulation, the ABCN is used, and it regulates the power level in the system. The blocks will be identified, and transactions could be made by using the block chain technology which makes the system as a decentralized one. The blocks given a information which is stored there and corresponding data will be analyzed and it is stored in IOT to make the better voltage at the consumer side. The block chain has also the control over the consumer side and transmission line to make the system as an efficient one. Thus, the overall output voltage of 30 V is maintained even though the variation in load side and power quality of the system is improved with the duty cycle of 33% and it is simulated using MATLAB. The peak overshoot and settling time of the conventional model is compared with the proposed one which shows better power quality.

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