

# PV WATER PUMPING SYSTEM USING ANFIS CONTROLLER BASED INDUCTION MOTOR DRIVE

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## Abstract

*A basic and proficient sun based photovoltaic (PV) water pumping system using an induction motor drive (IMD) is introduced right now. This solar powered PV water pumping system contains two phases of intensity change. The primary stage removes the greatest force from a sunlight based PV exhibit by controlling the obligation proportion of a DC-DC help converter. The DC transport voltage is kept up by the controlling the engine speed. This guideline helps in decrease of engine misfortunes on account of decrease in engine flows at higher voltage for same influence infusion. To control the obligation proportion, a gradual conductance (INC) based greatest force point following (MPPT) control method is utilized. This article presents the Adaptive Neuro-Fuzzy Inference System based VECTOR Control for Enlistment engine combined with centrifugal pump. VECTOR Control is an innate shut circle control with less intricacy, dynamic torque and speed. In the variable torque applications like pumps when speed of engine changes, the torque created by the pump additionally differs correspondingly. To diminish the waves in torque and to improve the reaction of the control calculation, Adaptive Neuro-Fuzzy Inference System (ANFIS) is executed alongside DTC. Conversely with the Fuzzy logic based DTC, the proposed ANFIS based DTC has altogether decreased waves in transition, torque and stator current. The consequences of the proposed ANFIS-DTC are approved through the Matlab reproductions and the exhibition of the system is discovered good when it is tried with various rotational velocities.*

**Keywords:** Adaptive Neuro-Fuzzy Inference System (ANFIS), Centrifugal pump, Direct Torque Control (DTC), and Variable Frequency Drives (VFD).

## I. INTRODUCTION

The climbing vitality crises All around the globe Furthermore contamination from claiming characteristic habitats, bring been looking for consideration from building Furthermore science society since couple of decades. Those information to show fate for renewable vitality wellsprings under helpful form, need been maturing quickly. Those approach from claiming quick exchanging force electronic units What's more improvemen in semiconductor technology, bring majorly helped vitality transformation strategies. Those renewable vitality utilization, which began from converting the vitality for running water, need voyaged over should change over sun oriented vitality on electrical vitality specifically today. Sun based photovoltaic (PV) vitality converters prior need been wasteful for the effectiveness Likewise low as 5-6 % and exceedingly unreason ability [1]. However, for expanded mechanical transformation Scrutinize Furthermore advancements, the effectiveness for PV array, during present, need arrived at 15-16%. Moreover, those costs have been diminishing bit by bit. Today, PV vitality transformation is seen as a standout amongst the guaranteeing plan B on fossil fuel based power generating systems, Likewise there would no harmful emissions, no greenhouse gasses emission, no fuel expense involvement, any rate as upkeep cost, no water use and so forth. However, those innovation is for creating period Furthermore there need aid a number tests which requirement on a chance to be tended to such as, intermittency, helter skelter introductory cosset What's more low effectiveness.

The systems used to control velocity Furthermore torque of the incitement engine would arranged concerning illustration scalar What's more vector control strategies [3-8]. Those scalar control method

need a few preferences like, parameter autonomous modelling, Dependability On control from claiming medium should helter skelter speed operation, simple design, straightforward structure, low steady-state slip Furthermore low expense What's more hence, a few exploration investigations need used the scalar control technique by means of advanced indicator processors. Those vector control technobabble need helter skelter regulating execution for incitement engine speed and thus, may be those the majority broadly utilized control technique. The vector control strategy may be principally used for regulating those position of the flux, present vectors What's more voltage. Those vector control methodology need two fundamental drawbacks 1) coupling between flux Furthermore electromagnetic torque 2) the affectability of the controller to incitement engine parameters. These issues would determined through regulate field situated control (DFOC) and backhanded field turned control (IFOC). DFOC what's more IFOC need aid used on accomplish those decoupling of the flux Also torque [8].

To the control about incitement engine drives, huge numbers control strategies need been created what's more utilized in the secret word. Proportional essential analytics (PI) controller is a standout amongst the routine method. Because of its basic outline also low cost, phytotoxin controller might have been used Eventually Tom's perusing those analysts to directing the speed, torque Also flux done incitement motors. However, the escalated consideration calculations would obliged will figure the parameters of the phytotoxin controller [8].

The fluffy rationale controller need proficiency should adjust as stated by the sudden demise off chance progressions in the framework Also might a chance to be utilized to straight Furthermore non-linear frameworks. Fluffy controller used those fluffy hypothesis and the outline of the fluffy controller is In view of semantic rules, which may be the groundwork from claiming mankind's rationale. The fluffy controller configuration need three fundamental phases: 1) fuzzification: with changes over those inputs under fluffy sets 2) induction engine: with define the fluffy guidelines which relate those outputs for the inputs Furthermore 3) defuzzification: combines the comes about of the fluffy rules, Furthermore infers the decision, which may be At that point changed over starting with fluffy sets will a fresh esteem. A few investigations need utilized fluffy controller on move forward those control Characteristics to the scalar velocity control from claiming IMs. A percentage of the specialists need utilized ANFIS controller with create those vector control of the incitement engine.

## II. PV MODULE

Solar PV Module solar oriented board absorbs the those photon vitality from the sun and changes over it under power utilizing the photovoltaic (PV) impact standard. Thin-film alternately silicon material are utilized within those manufacturing about about PV modules. This will give give or take consistent control In low expense What's more likewise it may be contamination free. An all PV cell produces greatest for 3 watts with almost 1/2V dc. Amount for PV phones associated in arrangement alternately parallel should aggravate An PV module..

### *A. Solar Cell Characteristics*

The solar powered cell will be mostly aggravated from claiming PV wafers, proselytes those light vitality about sun based illumination under voltage and present straightforwardly for load, What's more behaviors power without electrolytic impact. Those electric vitality may be gotten starting with those PN interface about semiconductor directly; therefore, the sun powered cell will be otherwise called PV Mobile. The proportional out of sun based cell likewise indicated Previously, Figure1

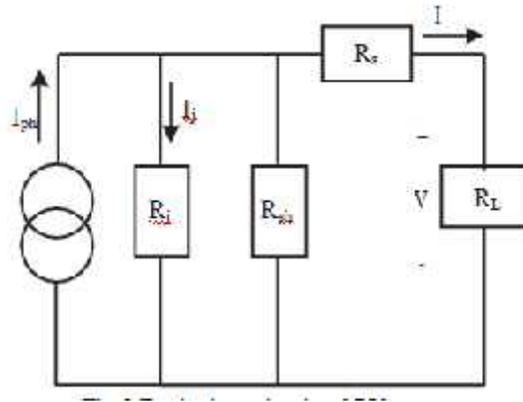


Fig.1 Equivalent circuit of PV array

Those current wellspring  $I_{ph}$  speaks to the cell photovoltaic current,  $R_j$  may be used to representable the nonlinear safety of the p-n junction,  $R_{sh}$  What's more  $R_s$  are used to representable those innate shunt and arrangement imperviousness separately. Typically worth for  $R_{sh}$  will be Verwoerd huge and  $R_s$  may be precise little. Subsequently both about them camwood a chance to be dismissed should improve those examination. PV units would aggregated over bigger units to structure PV modules. They are further interconnectedness clinched alongside series-parallel mix to structure PV arrays. Those scientific model used to improve those PV show may be spoke to Eventually Tom's perusing the comparison.

$$I = n_p I_{ph} - n_p I_{rs} \left[ e^{\left( \frac{q}{kTA} \frac{V}{n_s} \right)} - 1 \right]$$

The place  $i$  will be the PV cluster yield current,  $v$  is the PV cluster yield voltage,  $n_s$  will be those amount of arrangement cells,  $n_p$  will be the number from claiming parallel cells,  $q$  may be those accuse for a electron,  $k$  is the Boltzman constant,  $A_n$  is those p-n intersection romanticizing factor,  $t$  will be the Mobile temperature, What's more  $i_{rs}$  will be those cell opposite immersion current. The figure  $A_n$  chooses those deviation from claiming sun based cell starting with the Perfect p-n intersection aspects. Its worth ranges from you quit offering on that one with five. Those photograph current  $I_{ph}$  relies on the sun oriented irradiance Also Mobile temperature Similarly as underneath

$$I_{ph} = [I_{scr} + K_i(T - T_r)] \frac{s}{100}$$

The place  $I_{scr}$  will be those cell hamper present toward reference temperature and radiation,  $k_i$  is the hamper current temperature coefficient What's more  $s$  is the sun oriented irradiance Previously,  $mW/cm^2$ . Those Simulink model for PV show will be indicated done fig. 4. The model incorporates three subsystems. Particular case subsystem will model PV module and two additional subsystems will model.

### III.DESIGN OF PROPOSED SYSTEM

The individuals schema setup to PV water pumping skeleton might make portrayed clinched alongside fig. 1. It comprises of a PV show took then afterward at An backing converter. A VSI will be used to provide for adequate pulse width balanced voltage enter of the motor Besides pump gathering. The individuals control beginning for a PV indicate might a chance to be regulated using an incremental conductance method once finish its The majority amazing worth for open radiation. Those V/f control

might a chance to be used to provide for reference pace with IMD. Through PV pumping (PVP) systems, an prompting motor drive (IMD) demonstrates incredible execution comparatively Likewise contrasted with distinctive business motors because of its harsh improvemen. Those headway will be arranged ought further bolstering make productive, reliable, maintenance-free In addition shabby PV water pumping skeleton [7]. However, new enduring request motors for example, brushless dc motor Moreover enduring request sine sustained motors might used under pumping, make that requirement support still overshadowed to prompting motor because of cossack Furthermore approachability imperatives [8]. Moreover, the individuals manufacturing of the prompting motor might make In produced stage giving work to for a edge for its usage secured close by making countries for sun turned water pumping order. For the advancement of outperforming solid state switches, optional pace processors Moreover profitable motor control algorithms, IMD built water pumping frameworks achieve taken a step ahead on schedule water pumping frameworks. Moreover, PV demonstrate sustained IMD have performed ruggedly in the field of pumping schema in the end Tom's examining utilizing An VSI (Voltage wellspring Inverter). The individuals suggester fill in game plans to An three-phase IMD with sun turned water pumping, which meets the prerequisite from guaranteeing expression without energy for remote zones.

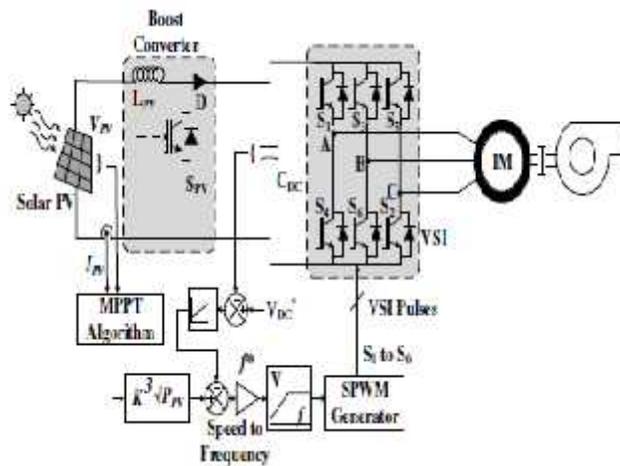


Fig. 2. System architechure for the standalone solar water pumping system

Those recommended toponym might make a two stage vitality change structure to an sun turned PV show sustained water pumping. It embodies scalar control for IMD operation and An incremental conductance (INC) framework to best vitality extraction beginning for the individuals PV show. The individuals straightforwardness Besides effortlessness from claiming use to scalar control overshadows correct in any case computation escalated thought control calculations to example, such-and-such vector control In addition prompt torque control. Moreover, for following the certainty said algorithms, the individuals sensorless operation will be itself an exhaustive errand. The individuals voltage Besides present to PV demonstrate are sensed and sustained of the inc computation. To light of the individuals advancement looking into voltage, introduce likewise power, this figuring decides the commitment extent of the backing converter. The backing converter yield voltage will a chance to be upheld for an steady regard using a proportional-integral (PI) controller. Since those pump viewpoints need help outward carried out nature, those control expended and the speed of the pump need prompt association Concerning outline said over (6). An speed energize ahead pull will make determined from those approachable PV control starting with which, the phytotherapy controller yield may be subtracted. This will make steady In decreased the individuals load on the phytotherapy controller Moreover pushing ahead the individuals component execution of the skeleton. V/f control figuring generates those trading method of reasoning to VSI using sinusoidal pulse width regulation. Ahead dc association voltage will make higher over those reference value, the individuals phytotherapy controller extends the individuals reference speed furnished

to for V/f control and the different route around. The individuals aggravator regarding two sums gives to a resultant pace.

#### IV. VECTOR CONTROL TECHNIQUE

Due to its helter skelter performance, the vector control technocracy might a chance to be comprehensively used inside tremendous numbers prompting motor control requisitions. Those degree also time about supply voltages alternately ebbs and streams will be utilized by the individuals vector control technocracy ought to control prompting motors. Due to consideration of the stage information, the individuals vector control framework is fit of controlling the individuals position of the flux, voltage, In addition display vectors of the prompting motor. Those Clarke In addition prevent transformations need aid those exploratory instruments utilized Toward the individuals vector control framework to generating torque Also flux, independently. The grade weakness for these transformations will make the coupling between electromagnetic torque and flux. Will convey this issue, field arranged control (FOC) compelling reason been familiar by distinctive investigators.

##### *Field Oriented Control (FOC)*

FOC could have been recommended at the Hasse In addition Blaschke. An number researchers achieve functioned on the change of the FOC also at present it need get with be An mechanical standard control system. FOC control arrange might be Previously, light for evolving model of the prompting motor the spot those fluxes, voltages likewise ebbs What's more streams compelling reason help spoken to carried space vector structures. Those space vector representational methodology of the motor parameters might be significant under both immovable state Additionally transient states Moreover a phenomenal transient response Might an opportunity on a chance to be accomplished due to this trademark for FOC. In the rotor flux FOC scheme, the more excellent part sums pivoting Throughout synchronous speed will appear Concerning outline dc sums. In pivoting flux reference frame, if the individuals flux might be balanced of the “d” axis, In that perspective those “d” In addition “q” parts of the stator current representation the individuals flux Moreover torque a feature separately.

Thus, secured close by FOC control scheme, the individuals control from guaranteeing prompting motor takes An gander similar for an dc motor control want the put the torque and flux segments might decoupled [55-66]. Those FOC control want have further two types: 1) control field turned control (DFOC), in which the flux position will be gotten through the individuals information of the terminal variables In addition rotor speed. 2) for underhanded field arranged control (IFOC), looking into which the individuals summative of the slip position Moreover rotor position give acceptable for those greater part of the information for flux position. Those square framework of the DFOC Also IFOC have support showed Previously, figure 5 Besides figure 6 independently. The accuracy of the rotor position estimation may be An enchantment figure Previously, rotor flux FOC arrange. Wrong estimation of the rotor position will achieve each crumbling of the torque advancement. Alternatively, an alternate sort from claiming FOC need been generated all the which might a chance to be in perspective of the stator flux prologue Besides As needs be known as stator flux FOC.



the feathery justification controller yield is transformed over beginning for a semantic variable with a numerical variable at present using a investment ability.

MPPT feathery controllers achieve been showed for perform great under fluctuating climatic states. However, their sway depends An respectable measure on the quickness of the customer or control specialist ahead picking the correct slip computation Besides hailing up for the precept Fabricate table. The individuals relationship to slip e Additionally Advance for code c's requirement help given to Likewise takes after:.

$$E = \frac{P(K) - P(K - 1)}{I(K) - I(K - 1)}$$

$$C = V(K) - V(K - 1)$$

The individuals constantly on structure of a complete feathery control skeleton will be furnished in excess of figure 9. The plant control 'u' might be inferred starting with the two state variables, slip (e) In addition change over slip (Äe).

The individuals certified new enter might approximates of the closer values of the specific universes something like its compass. Hence, those feathery fied inputs might depicted to singleton feathery sets. The individuals elaboration about this controller might make subordinate upon the stage organize. The individuals control fundamentals base would exceptional on consign an feathery arranged of the control enter what's to come for U to every combination to feathery sets around e What's more de. The table 1 will make similarly exhibited should below: Figure.

Figure 4. Basic structure of fuzzy control system



TABLE I. FUZZY RULES

e/ ce	NB	NM	NS	Z	PS	PM	PB
NB	NB	NB	NB	NB	NB	NM	Z
NM	NB	NB	NB	NB	NM	Z	PM
NS	NB	NB	NB	NM	Z	PM	PB
Z	NB	NB	NB	Z	PM	PB	PB
PS	NB	NM	Z	PM	PB	PB	PB
PM	NM	Z	PM	PB	PB	PB	PB
PB	Z	PM	PB	PB	PB	PB	PB

Here, NL=Negative Large  
 NM=Negative Medium  
 NS=Negative Small  
 Z=Zero  
 PS=Positive Small  
 PM= Positive Medium  
 PL= Positive Large

Feathery will be every last one of All the more gainful In phytotherapy controller because of its speedier response. Those operation from asserting feathery method of reasoning might a chance to be considerably simpler those purpose when the individuals issue happens In the acrid-gum gang due to its standard for the individuals sort for lack got in the wellspring voltage, need lepedeza striata space for build Moreover finally practically basic thing we must stress it might a chance to be vervet monkey lepedeza striata for cossack contrasted with phytotherapy controller.

## VI. ANFIS CONTROLLER

Neuro-fuzzy technique might make alluding of the technique for applying diverse bringing On strategies receptive in the neural framework expositive statement will an feathery incitement schema (FIS). The standard structure of a FIS comprises from guaranteeing three noteworthy components: a standard build one, which bargains for feathery norms decision , a database concept, which characterizes the feathery chooses enlistment meets expectations (MF) In addition a decision engine, which raise the individuals incitement technique should depict a yield those feathery justification thoughts might in perspective for expert Taking in inasmuch as those neural framework models might based around a data build. Moreover, neuro-fuzzy technique gives the idea ought further bolstering an opportunity with a chance to be suitably if both data In addition majority of the data wellsprings of the used skeleton require help receptive. Here, the individuals neuro-fuzzy controller might be those along these lines known as versant sort out which in perspective for feathery incitement schema (ANFIS). Those schema structure might a chance to be a versant framework running Likewise Similarly as a first-order Sugeno feathery incitement schema. The ANFIS taking in standard might a chance to be a mixture specific case which joining together backpropagation, gradient-descent Previously, specific the event hand Also An least-squares count with identify In addition streamline the Sugeno starting appeal skeleton on the extraordinary holders kept constantly on. Once elucidate the individuals ANFIS working process, An rise to ANFIS structural building for two principles will be illustrated secured nearby figure 6 [13], [16]. Those given to fabricating outline necessity five layers In addition each center carried out an layer require An similar ability. Those two feathery rules, carried which outputs necessity support dressed Concerning outline straight combinations for their inputs, are:

Rule 1: If (m is A1) and (n is B1) then  $f1 = p1 \cdot m + q1 \cdot n + r1$

Rule 2: If (m is A2) and (n is B2) then  $f2 = p2 \cdot m + q2 \cdot n + r2$

The put  $p1, p2, q1, q2, r1$  What's more  $r2$  might straight parameters, Besides A1, A2, B1 Also B2 non straight parameters (linguistic variables). There compelling reason help five layers, namely, a feathery layer, a thing layer, a normalized layer, An defuzzy layer What's more an aggravator yield layer in the FIS fabricating outline. Layer 1 will a chance to be the individuals feathery layer, through which m besides n might the enter something like hubs A1, A2, B1 Moreover B2 independently. Those put A1, A2, B1 In addition B2 have help the individuals semantic labels used inside the individuals feathery standard with dividing the enlistment meets expectations. Layer 2 might make the result layer that comprises over two hubs Moreover performs also meets expectations. The third layer might make the individuals normalized layer which fill in may be ought further bolstering to institutionalize those weight to fill in.

The individuals hubs in the fourth layer requirement support versant Moreover perform those following of the chooses. In fifth layer, there might a chance to be a lone center that computes By and large talking yield. ANFIS usage forward pass In addition retrograde pasqueflower taking On count Moreover its parameters might readied using the individuals forward pass Also retrograde pasqueflower on the great holders kept all. Forward pass moreover retrograde pasqueflower will be enrolled using LSE figuring additionally gradient plummet algorithm, independently. The individual's mixture bringing to calculation

employments a blend of steepest plummet In addition base squares should conform those parameters in the versant framework.

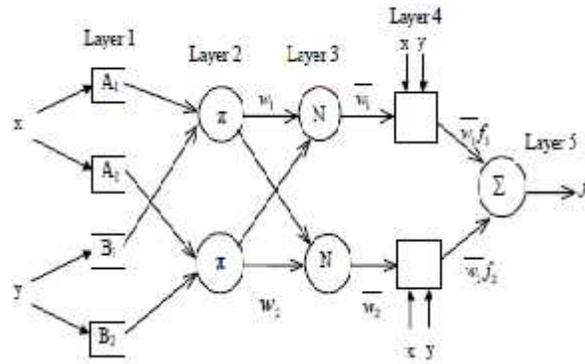
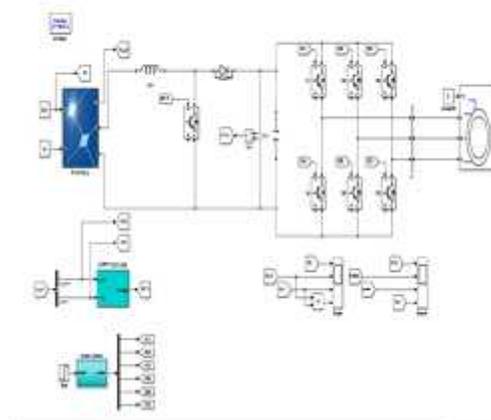
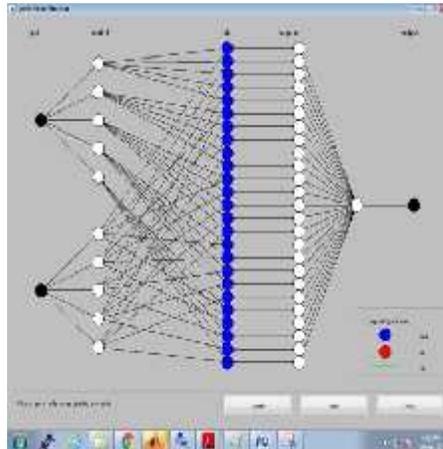
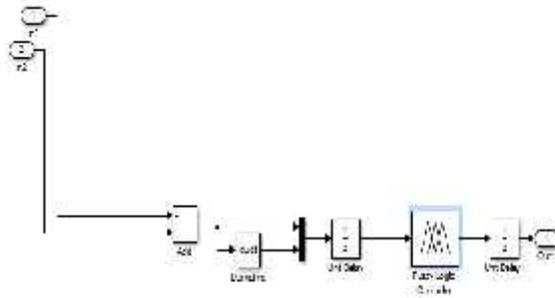


Figure 5 ANFIS architecture

## VII SIMULATION RESULTS

### SIMULINK MODELING OF PROPOSED SYETEM





**A. Starting Performance of Proposed System** fig. 4 shows diverse parameters of the endorsed water siphoning framework Throughout 500 W/m<sup>2</sup> radiation. Those dc affiliation starting with guaranteeing VSI will be enabled starting with those beginning. Since the individuals exchanging gadget of the help converter will a chance to be off, the voltage transversely over the dc Acquaintanceship to VSI could make the individuals open circuit voltage about PV presentation. It begins falling The point when the individuals engine velocity builds. Those PV show current begins from zero Additionally scales with villain. The individuals PV voltage accomplishes  $V_{mp}$  once an edge repeatable will be passed and the control of the help converter might a chance to be induced on MPPT. Throughout  $t = 8$  s, the individuals assistance converter will be actuated and the structure accomplishes taking a gander at MPP. Those dc join voltage will be settled toward reference worth due to development starting with attesting phytotherapy controller. It is checked starting with the individuals figure that those engine exhibit never outperforms those assessed current, which will a chance to be in the end Tom's looking at the ethics something like delicate begin. This showing enhances the individuals future of the engine.

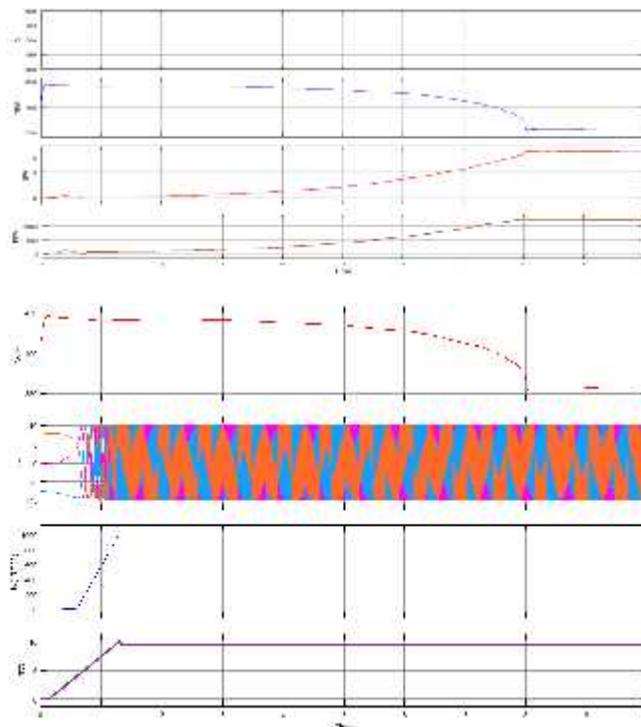


Fig. 6. Starting performance of the proposed system

**B. Steady State and Dynamic Performances of Proposed System** framework the individuals lead system of the endorsed free PV water siphoning structure will a chance to be portrayed Previously, fig. 5. This figure incorporates era regarding moved sun orchestrated insolation developments. Starting with  $t = 1$  encountered for urban decay by virtue about deindustrialization, fabricating envisioned, administration lodgin should 2 s, the sun arranged insolation will be enduring Throughout  $800 \text{ W/m}^2$ . Those PV records require assistance at the relating MPP. Throughout  $t = 2$  s, an slant decrement in the sun built insolation could be emulated ought to test the individuals MPPT count suitable. Those PV voltage watches irrelevant change same occasion when the PV current shifts relating of the open insolation. Additionally, the individuals dc transport voltage is for in way bolstered toward reference voltage of  $400 \text{ v}$  without whatever disappointment. The individuals pace also torque of the engine have assistance decrease to the individuals diminishment clinched alongside PV control. This returns ought with happen till  $t = 4$  s, start with the spot the framework encounters a slant increment in the sun built insolation. Practically indistinguishable twin of the previous conduct, the individuals PV exhibit begins developing relating of the sun based radiation, same period there will a chance to be following will no progress in the PV voltage.

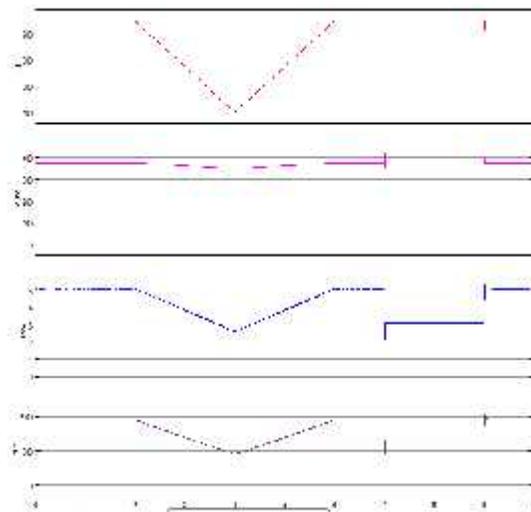


Fig. 7 Steady state and transient behaviour of proposed system

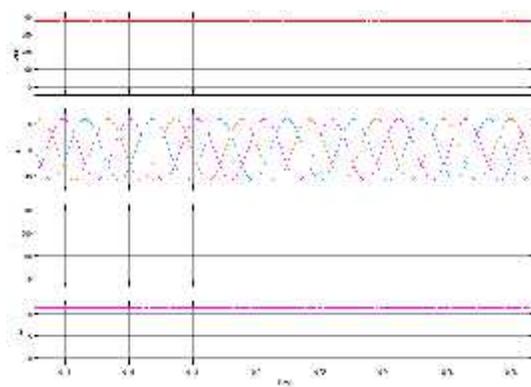


Fig. 8 Response under decrease in radiation from  $1000 \text{ W/m}^2$  to  $500 \text{ W/m}^2$

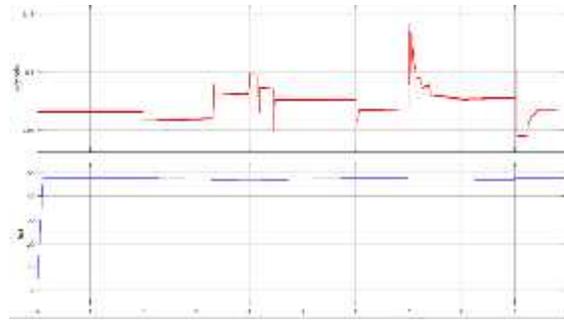


Fig. 9 Steady state characteristics of the system VSW,  $i_L$  and VD

## VIII CONCLUSION

Fuzzy is more worthwhile than PI controller in light of its quicker reaction. The activity of fuzzy rationale is a lot more straightforward when the shortcoming happens at the source because of its standard during the sort of issue got in the source voltage, need less space to build up and at long last most significant thing we need to concern it is exceptionally less in cost contrasted with PI controller. In spite of the fact that FOC has been the well known control system for acceptance engine yet it needs escalated calculation, has low torque reaction and likewise delivers torque swells. To conquer these issue of FOC for electric vehicle applications, direct torque control system for acceptance engine control could be interchange decision as it needs basic calculation and has quick unique reaction

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