Proposal for Enhancing Power Factor Correction (PFC) and Reducing Harmonic Distortion using FOPID -Based Control System

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Abstract: The development of a PFC and THD reduction-based FOPID controller is described using a novel approach in this paper. The drive's goal was to get a lower THD for PFC. The current method involves measuring the ac voltage, converting it to the dc voltage, and then applying a PWM while measuring the load result in between. In earlier work, the main elements of the recommended On-Board Charger are analyzed and detailed. On board charging involves connecting a device directly to an output source. Off-board charging is the delivery of separate charge results. After an AC-to-DC conversion, use a DC-DC boost inverter to stabilize the output. On/off switches in the form of 0 and 1 are used to request an output from a PWM generator. The recommended on-board charger is modeled and examined using the MATLAB simulation tool and PWM, resulting in unstable and variable outputs. To get around the existing problem, MATLAB software for simulation was used to simulate the suggested PFC and harmonic distortion circuit utilizing FOPID controllers, and associated data were generated and analyzed. The major goal of this research is to create a theoretical basis for the examination of wireless power transfer systems that are inductively coupled and resonant for recharging electric vehicle batteries. To show how the suggested strategy produces better outcomes, numerical simulations or original research are presented.

Keywords: Power factor correction(PFC), THD, FOPID, Battery.

I.INTRODUCTION

EV owners may charge their vehicles wherever there is an electrical outlet by using on-board battery chargers. As a result, the cost of the infrastructure network is lower as opposed to standalone (off-board) chargers, improving the distribution and coverage of the charge spots[1].

The on-board architectures can be divided into two groups depending on how they are connected to the drive train: independent and combined (integrated) circuit topologies[2].The on-board integrated chargers with PFC and harmonic distortion discussed in this study use the Fopid Controller. The classification tree is depicted in Figure 1.

The non-isolated embedded chargers fall within the first group, on the one hand. Depend on the motor drive elements utilize during charging, there are three groups that make up the overall number of options for these chargers. The inverter & machine windings are both used for charging in the first category. This subcategory can also be broken down into six different groups: those utilizing switching equipment, those adopted for delta linked ac devices, those utilizing split-phase machines, those that utilize SRM, and those accessing the neutral point of at least one motor [3]. Without utilizing the motor windings, the second subcategory makes use of the traction inverter. This method uses individual inductors rather than the motor leakage reactance. The inverter & the AC motor are not utilize in the third & final subcategory, which solely uses the DC/DC FEC.

On the other hand, second major group is limited to incorporated chargers that are galvanic ally separated. Two more groups have been created for these converters. Those depend on split-phase PM motors, those depending on wound-type rotor induction motors, & those utilizing switching reluctance motors make up the first type of system that employs the AC devices as a small frequency converter. In the second & final subcategory, a transformer off-board is necessary.

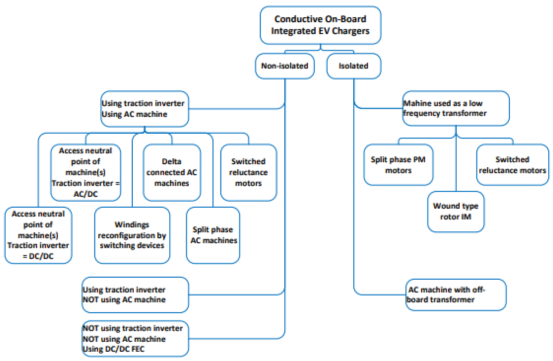

Figure 1: : EV on-board integrated charger categorization[1]

The potential & velocity of the device will be determined by the type of controller utilized. There are many different types of controllers, including hysteresis, dead beat, PI controllers, in both linear & non-linear contexts. Micro-grids frequently employ PI controllers, although due to their linearity, these are simplified. A significant amount of study articles have been published in the literature to address this problem. Using PID controllers with fractional orders is one of the better solutions. FOPID controllers feature two extra variables, FIO (a) and FDO(p), to manage in addition to Kp, K1, and Kn, making them more adaptable [4]. FOPID controllers improve device precision & robustness. FOPID controllers enhance the correctness & robustness of the system.

Rest of the work is organized as obeys. In section II explains the FOPID controller. Section III gives the literature Survey. Section IV contains the problem formulation and objectives. Conclusions and findings are included in Section V. Section VI concludes the essay with an ending and then follows by references..

II. FOPID CONTROLLER

The various definitions and approximations for fractional order controllers include Rieman-Liouville, Grunwald-Letnikov, the Caputo declarations, Carlson approximation, Matsuda estimation, the CFE technique. The fundamental transfer factor of the FOPID controller is, as seen in equation (1),

$$G(s)= K_p + \frac{Ki}{S^{\alpha}} + K_d S^{\beta} \quad (1)$$

where a,f_J are the positive FO and K_p, K_i and K_n are the proportionate gains. The use of S forces is extremely challenging since the differentiator or integration of the fractional order have infinite dimensions. Therefore, estimating the fractional powers is crucial.

The most used approximate method for fractional order controllers is the oustaloup approximation, and so this article also makes use of this method [5-6]. It must first be modeled as a differentiator that use the Oustaloup approximation approach before being split by s to produce a fractional order integrator. The general expression for the approximation of the Oustaloup filter is

$$s^a = K\prod_{K=-N}^{N} \frac{s+\dot{\omega}}{S+\omega} \quad (2)$$

$$\dot{\omega}=\omega_b\omega_w^{(2k-1-a)/N},\ \omega=\omega_b\omega_w^{(2k-1+a)/N} \quad (3)$$

$$K=\omega_k^{a},\omega_b=10^{-a} \quad (4)$$

II.LITERATURE SURVEY

Enver Candan et al.,(2022) experimentally illustrate this idea using a hardware prototype for a six-level FCML invertors that is digitally controlled. The testing prototype's average output current at 48 V is 4.5 A, & its output energy is 216 W. The study has significantly advanced with the practical show an FCML buck inverter in a single-stage PFC use, where the flying capacitor charges swing at twice-line frequency according to portions of the inverted voltage at the input.

Xueshan Liu et al.,(2021) The suggested converter may obtain UPF & LICR in universal-input programmes, similar to standard boost PFC converters. The suggested inverter may additionally convert voltage in a step-down manner. Furthermore, single-stage power conversion results in outstanding effectiveness. The suggested converter's operating theory, VG, PFA, & important circuit variable selection are all examined. In order to validate the findings of the theoretical research, a 70-W prototype with 96.05% peak effectiveness is constructed.

Ju-Young Lee et al.,(2022) Through the incorporation of 3 inductive elements into a single magnetic core, the ICC can drastically reduce the entire system size. As a result, numerical outcomes from a 600 W rated prototype show that the input diode loss may be drastically decreased by about 10 W contrasted to the CPFC, & the input diode displays a low heat generation of 49.8 ° even in the absence of a heat sink. Furthermore, the small magnetizing current of the ICC, not the main input current, flows through input diodes. Particularly, the input diodes allow the ICC BPFC's EMI noise spectra to sufficiently meet the EMI standards. To support the reliability of the ICC

BPFC, comprehensive research, a design manual, & numerical findings from a 600 W rated prototype are offered.

Gundala Srinivasa Rao et al.,(2021) The two most important phases in OBC are the PFC phase & the DC/DC inverter phase. An AC-DC inverter plus a DC/DC inverter make up a PFC circuit. The PFC phase is made up of several phases, including the active front converter or the rear adapter. This stage includes both rectifying & . The entering AC is converted into DC using a DC/DC Buck-Boost inverter, which is subsequently utilized to raise the voltage using a DC/DC Buck-Boost converters.

S. Karthick et al.,(2022) In a hybrid energy system, the flow of electricity is controlled by a highly effective multi input transformer linked bidirectional DC-DC inverter, enabling it to extend demand, control power flows from various origins, inject surplus energy into the grid, & charge the batteries from the grid as necessary. In comparison to the proposed converter type, grid-connected hybrid devices or alternative ripple voltage filters call for more parts, stages, and losses in the power conversion process. In grid-connected systems, a PI & FOPID controller is also employed to enhance voltage regulation. Utilizing MATLAB/SIMULINK, the outcomes are simulated.

K. Durgadevi et al.,(2023) may be modified using the Improved Particle Swarm Optimization (PSO) method, which improves the power quality (PQ) on the supply side and produces output power with controlled DC voltage. An upgraded PSO technique is used to set up the FOPID controllers, and the particle's position is guaranteed within the designated hunt areas using the momentum factor. PSO and the evolutionary algorithm are outperformed by the control device focused on the fractional PID approach. Outstanding efficiency is ensured by the converter's controller layout, which is evaluated using simulation results. For DC load voltage management under varying load energy as well as supply voltage changes, the suggested Bridge Less Zeta converter is tested.

III.PROPOSED WORK

To increase electric mobility across the nation and lower greenhouse gas emissions, the automotive sectors are concentrating on electrification. As a result, electric & HEV have been originated & are readily available. Effective battery charging in electric vehicles is one of the major issues that both manufacturers and consumers must deal with.

A certain OBC is suggested to improve the charging device in order to address this issue. The primary elements of the suggested OBC are described & evaluated in accordance with the prior study. The MATLAB modeling programme is used to model and analyze the suggested On-Board Charger. The findings collected demonstrate that the suggested OBC is utilized to efficiently recharge the batteries of EV when parked in residential areas as well as in public locations such as offices or shopping centers. Power allowing the electric car's battery to be charged. The suggested OBC has a redesigned power conversion technology but is otherwise constructed similarly to conventional power conversion systems. The two most important phases in OBC are the PFC phase and the DC/DC inverter phase. An AC-DC inverter plus a DC/DC inverter make up a PFC circuit. The PFC phase is made up of several phases, including the active front converter or the rear adapter. This stage includes both rectification & . The entering AC is converted into DC using a DC/DC Buck-Boost inverter, which is subsequently utilized to raise the voltage using a DC/DC Buck-Boost converters.

In this phase, it is verified that the waveforms of the entering current and AC voltage are the same. The OBC continues to have a power factor that is near 1, giving the impression that it is a resistive load. The fundamental PWM, which uses a pulsation signal to convey a message, is the modulation method utilized in the planned OBC. These methods of modulation are primarily employed to enable electrical equipment to track the power supply, particularly inertial loads like engines. They are also used to encrypt gearbox data. Rapidly turning on and off the supply load regulates the average voltage value delivered with the charge. The load produces more power and uses more time the longer the switch is active.

The suggested OBC circuit is constructed using MATLAB computation software, & the necessary findings are obtained and verified. PFC converters are utilized at one point in the process and DC to DC converters at others. There are a PFC & an AC-DC buck-boost inverter. The major goals of PFC are to reduce overall HD and normalize the waveform to enable a sinusoidal waveform. In addition, this could enhance charging effectiveness, hence reducing charging costs.

This proposal's main goal is to overcome the drawbacks of the current power supply system, which uses PWM to monitor average output voltage & energy as well as for power factor correction (PFC) and harmonic distortion analysis. By applying an updated control method based on FOPID control, which is anticipated to produce more satisfying outcomes, the proposal seeks to improve the system's efficiency.

Objectives

1. To design FOPID based controller to improve control strategy
2. To implement FOPID based control strategy in electric vehicle charging concept
3. To perform comparative analysis of proposed work with existing method

IV.RESULTS

Currently, ac voltage is measured, converted to dc voltage, and then a PWM is applied with load result measurement in between. The essential elements of the suggested On-Board Charger are described and examined in previous work. On-board charging entails simply plugging in and getting results. Off board charging refers to the provision of independent charge outcomes. Apply a DC-DC boost inverter after an AC-to-DC conversion to stabilize the output. To require an output from a PWM generator, switch on/off in the form of 0 and 1. The MATLAB simulation tool and PWM are used for modeling and analyzing the suggested on-board charger, producing outputs that are unstable and full of variations. The suggested PFC and harmonic distortion circuit using FOPID controllers was therefore simulated using MATLAB computation software, & related data were produced & evaluated, in order to address the current difficulty.

V_{ref}=330 v

We create a circuit, Take an AC supply, a transformer, and apply rectifying in the first phase. The output produces ripples that are balanced by the load's capacitor resistance. Next, a DC-Dc boost conductor with capacitors and a value inductor for balancing fluctuations is used. In the suggested design, capacitors are used to eliminate fluctuations and connect to the battery. The output dc circuit is generated by Vout and SOC and is stable after 0.5 seconds. The suggested method keeps the value of the Vout and circuit output Control strategy constant.

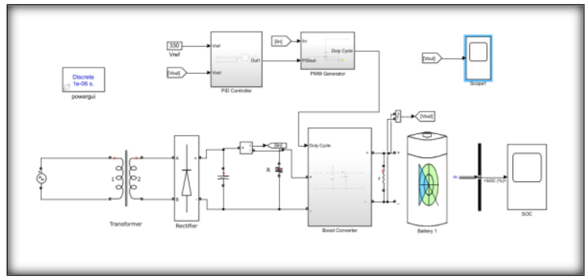

Figure 2 :Simulation setup

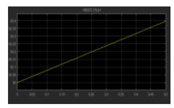

Figure 3: SOC

Figure 3 displays the SOC charge percentage at 50.4% at time t=0.5 sec.

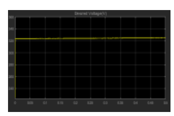

Figure 4:Desired Voltage

Consider the three variables Kp-0.001, Ki=0.0145, Kd=0, and three orders in the FOPID. Integrated fractional order, derived fractions, integral fractions, and their Control Circuit current plus voltage together form the PWM generator's combined output. Create a duty cycle (DC) for the mistake, and then use a ramp generator to apply that amount of time for circuit on/off stabilization.

The final outcomes are sent to the circuit and are then attached, in the form of a 0 or 1, to the comparison circuit. The suggested circuit features a stable output, which reduces the risk of damage to the control output.

V.CONCLUSION

EV are becoming more famous in daily life. In the upcoming 10 years, it is estimated to rise 2 or 3 times.

Therefore, there needs to be a reliable, strong charging infrastructure so they may use electric vehicles without too many problems. To show how the recommended approach produces better outcomes, numerical simulations or original research are presented. The circuit receives the final results, which are subsequently coupled to the comparison circuit as a 0 or 1. The proposed circuit has a stable output, which lowers the chance that the control output will be harmed.

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