RESEARCH ARTICLE OPEN ACCESS

Wireless Power Transfer System Including Dynamic Charging for Electric Vehicles Applications

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Abstract:

The basis of this concept is the dynamic wireless powering of electrical automobiles. Electric cars had a problem in that their batteries recharge lasted too long. the main source of energy, with a battery and a super capacitor acting as backup sources. The stability of the proposed control structure has been validated by the Lyapunov stability theory. The suggested control approach has been independently confirmed by modelling electric vehicles using the MATLAB/Simulink platform and the European extra-urban riding cycle. This study suggests a novel method for improving the efficiency of dynamic wireless recharge systems. Transmitter coils have been added to the suggested system to increase charging power by offering a dynamic computational framework that can describe and monitor source-to-vehicle power transfer while it is in motion. The proposed mathematical model presented and addressed all of the material characteristics of the model. The results showed that the suggested model was workable. Additionally, the modelling results were verified by experimental testing by putting two coil receivers underneath the car.

Keywords _Dynamic wireless charging, Electric vehicle,Wireless power transfer.

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I. INTRODUCTION

Batteries and sc are utilised together because they can balance high power and elevated energy density while also resolving the fc's cold start-up issue [3]. the sc and cells are interfaced with the dc bus employing a bi-directional buck-boost converters due to their recovery in the power-flow, while the fc is connected to the dc bus using a dc/dc boost converter due to its unidirectional power flow. wireless charging uses electromagnetic induction to send electricity as a magnetic field through the atmosphere. this means that, as long as the charger and the car are adjacent to one another, power can be transferred from one device to another without making physical contact. an efficient and appropriate electric car charging structure must satisfy three fundamental needs. the development of electric vehicle technology aims to reduce the consumption of fossil fuels, which are mostly used in transportation[4]. the current state of battery technology makes these issues difficult to tackle. when the wpt is used for ev charging, its efficiency and power needs for the mhz rate operation are challenging to meet. it is inefficient to change a few to a few million kilowatts of electric current at mhz power level using leading-edge power electronic equipment. air-core coils are particularly vulnerable to surrounding ferromagnetic materials. a magnetic field will reach the chassis of the car after an air-core coils is connected, causing significant loss in eddy current and a significant change in the coil's characteristics. to make the coil design more useful for ev charging, ferrite is often utilised as the flux guide and copper plate as a shield.ev owners prefer the wireless energy transfer (wpt) technology since it can do away with the inconvenient charging process. the wireless energy transmission to the electric automobile simplifies the charging procedure. in a permanent wpt system, the drivers merely possess to park their vehicles and proceed to drive. the electric vehicle could be powered as being driven & could run continuously for an endless amount of time having a dynamic wpt system. the capacity of the batteries of evs with wireless chargers could be 20% or less when contrasted with evs with conductive charging. a dynamic imposing system prototype with 1.5 kw of electricity is created. typically, efficiency when dynamic charging is 89.5%. the output power might differ by 9.5%.

II. PROPOSED SYSTEM:

In this study, the wireless recharging system, which consists of two main parts—one on the road and another within the car—is evaluated.

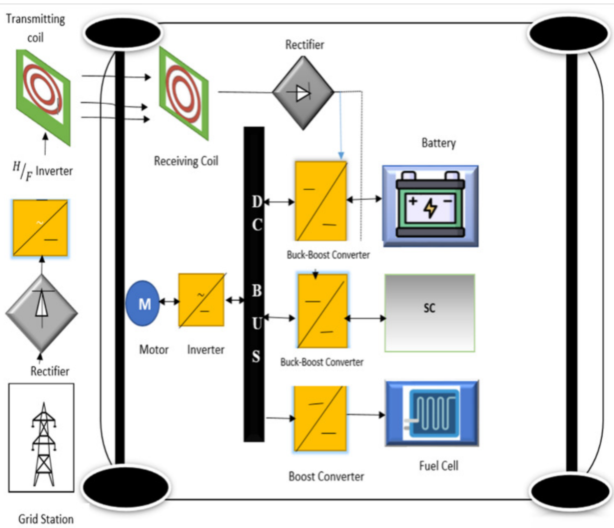


Fig. 1. Proposed block diagram.

The second part, which is put underneath the vehicle, is called the moving receiver. Each of the two parts has their own electronic system, and they are isolated from one another by a vacuum. The transmitter block generates a magnetic flux with a high frequency. This magnetic flux is converted into electric energy and utilised for charging the EV battery when it is connected to the receiver coil. Fig. 1 shows two electric cars (EVs) that are equipped with wireless charging stations and are parked on a road. In comparison, both has two receivers.

2.1 Compensation topologies:

There are four possible resonant circuit topologies that the internet power transmission (WPT) system could use. They were indexated after inserting the capacitor in either side. assuming that there are two possible configurations for the coil and connection. The topologies include Series-Series (SS), Series-Parallel (SP), Parallel-Series (PS), and Parallel-Parallel (PP). Both the initial and second inductances' values, as well as those of the filters (L1, L2) or (C1, C2), are fixed for managing the filter. In order to improve power transfer, lower the apparent magnitude of the input source, and ensure the passage in active power to the load, the main and secondary circuits of the coupler, which control resonance and capacitance, which respectively, are used. The authors looked at several topologies and demonstrated their designs using real prototypes.

2.2 Wireless vehicle assistance charging system

The person in charge can ask other electric cars along the road for help to charge the car when its power source is running low. This procedure makes use of a number and auxiliary methods, including as communication between vehicles, GPS, batteries state of state sensors, etc. The driver can find donor vehicle energy supply automobiles that show availability donor vehicle energy, pricing, distance, and other statistics using an app available for their smart smartphone. This concept might help to relieve a potential EV buyer's concerns over range anxiety.

2.3 High Frequency Inverter (HF)

The two areas where a low-frequency inverters outperform high-frequency inverters are peak power output and dependability. Low-frequency inverters are designed to withstand greater power spikes for a longer period of time than high-frequency inverters. High frequency inverter welders use closed-loop feedback and submillisecond pulse width modulated (switching) technology to control the weld current in submillisecond increments. A three-phase input current is completely wave rectified to DC at the welding transformer's primary, where it is switched fast (up to) 25 kHz to produce an AC current. The welding current is then created with a low-level, forced AC ripple after the secondary current has been rectified. The fast connectivity feedback circuitry allows the inverter supply of power to adapt to variations in the loop's final obstruction and the dynamics within the welding process.

2.4 Vehicle to Grid Benefits

The car to grid idea, which investigates the relationship between widespread battery charging and the power system, is a well-liked study topic in the disciplines of smart grids and electric vehicles. It is agreed that streamlining the procedure for charging electric vehicles would have a significant positive impact on the grid. The EV might balance the loads by reducing peak loads and filling in valleys. Some unreliable new energy generating sources, like the power of wind, may be able to be connected to the grid as the charges in electric vehicles act as an energy bank. Active switches are used in place of secondary rectifier diodes to perform a bidirectional WPT function.

2.5 Boost converter:

The applied DC input is step-up converted using a DC-to-DC converter known as a boost converter. Because the provided fixed DC input is increased (or enhanced) to a adjustable DC voltage that is generated in the boost converter, the output value of the booster converter is always larger than the input voltage. A boost converter is also known as a step-up converter with step-up chopper. It performs the reverse operation of the buck converter, converting higher DC input become lower DC output. A converter for boost is used to increase an input voltage in accordance with the requirements of the load. The boost converter does this step-up conversion by storing energy in an inductor, which is then transmitted to the load at a greater voltage.

2.6 Rectifier:

The transformer's job is to securely separate the second phase, which is adjusted to control the output voltage of the rectifier, from the input AC voltage. At locations that offer a number of setting possibilities, these adjustments are frequently made using tap rods attached to the opposite side of the windings. Because these semiconductors or plates are arranged so that rotating AC flowing in one way while they are obstructions in the other, the AC wave travels in the precise same direction in both directions. These components are carefully housed in the cabinet, which also contains the test panel and enables observation and other sophisticated activities.

2.7 Wireless Communications:

In order to provide feedback, wireless information exchange between the electrical grid to the vehicle side is essential. As a result, managing the power flow might be done using the methods described in Section V. The communication architecture can be categorised based on either the signal contains modulation on an electric carrier as well as uses a distinct frequency range. In this way, any extra antennas and communications management chips might be saved. The communication and control system needs to have its components isolated due to the elevated voltage on the electricity-generating radiators in the Volt WPT system as well, which could increase the cost. Information exchange could be improved by using general standards for wireless communication like the use of Bluetooth, Near Field Communications (NFC), and others.

IV MATHEMATICAL MODELLING:

The exhibits a DC voltage source and a variable series resistance that depends on a variety of variables as shown in Eq.(1).

$$U_{batt} = \begin{cases} U_{batt-charge=E_b+R_{batt}} \cdot I_{batt} \\ U_{batt-discharge} = E_b - R_{batt} \cdot I_{batt} \end{cases} \quad (1)$$

The battery remaining capacity Q to P is given as,

$$Q(t) = Q(0) - \int_0^t (\eta_{batt} \cdot I_{batt}) dt \quad (2)$$

Where, η_{batt} de represents battery performance, t represents discharge time, and I_{batt} the battery is powered. State of charge, or SOC, can be expressed as,

$$SOC(\%) = \left(\frac{Q(t)}{Q_{max}}\right) * 100 \quad (3)$$

Battery voltage when charging and discharging (E_b) is a result of the battery's internal parts and is given as: $E_b =$

$$\begin{cases} E_0 - K_b\left(\frac{Q}{Q-it}\right)i^* - K_b\left(\frac{Q}{Q-it}\right)it + Ae^{(-Bit)}, \rightarrow Discharge i^* > 0 \\ E_0 - K_b\left(\frac{Q}{0.1Q+it}\right)i^* - K_b\left(\frac{Q}{Q-it}\right)it + Ae^{(-Bit)}, \rightarrow charge i^* < 0 \end{cases} \quad (4)$$

E_0-denotes the constant voltage,
K_b -denotes the polarization resistance,
i*- denotes the low-frequency current dynamics,
A -denotes the exponential voltage,
B- denotes the exponential capacity.

$$P_{WT} = I_P^2\left(\frac{(\omega m)^2}{R_L}\right) \quad (5)$$

$$Z_1 = X + Y \quad (6)$$

$$\{X = \frac{(m\omega)^2}{j\omega(L_b+m) - \frac{1}{\omega c_s} + R_S + R_L} \quad (7)$$

$$I_P = \frac{V_1}{Z_1} \quad (8)$$

$$C_P = C_s = \frac{1}{\omega^2(L_b+m)} \quad (9)$$

Equation can be used to determine the WPT system's energetic effectiveness.

$$\eta = \left\{\frac{|\vec{I_S}|^2 R_L}{|\vec{I_P}|^2 R_P + |\vec{I_S}|^2 R_S + |\vec{I_S}|^2 R_L}\right. \quad (10)$$

It is clear from Eq. (10), that M controls the system gearbox strength. Studying the stability of gearbox power and system efficiency, as given in Eq. (11)), is made simple by reducing the number of variable parameters.

$$\eta = \frac{R_L}{R_L + R_S + \left(\frac{R_P(R_S+R_L)^2}{(\omega m)^2}\right)} \quad (11)$$

to enhance the connection of the coils. The total reflected impedance can be expressed as stated in (12) when more than one receiver is being used. where n_c is how many receiver coils there are.

$$\sum_{i=1}^{n_c} Z_{ri} = n_c\left(\frac{\omega^2 M^2}{Z_s}\right) \quad (12)$$

$$Kn_c = K\sqrt{n_c} \quad with\ 0 \le k \le 1 \quad (13)$$

The updated magnetic coupling coefficient (K_{nc}) is then expressed in (13) the distinct mutual inductance, (M_{nc}) is expressed in Eq. (14)

$$Mn_c = M\sqrt{n_c} \quad (14)$$

Eq. (15) provides the revised expression for the mutual inductance of the two coils.

$$M = \frac{\mu_r r_1 r_2}{4\pi}\int\oint\left[\frac{sin\theta sin\phi cos\alpha + cos\theta cos\phi}{r_{12}}\right] d\theta d\phi \quad (15)$$

$$r_{12} = |G + H + F|^{1/2}$$
$$G = r_1^2 + r_2^2 + h^2 + D_1^2 - 2hr_2 cos\phi sin\alpha$$
$$H = 2D_1 r_2\, cos\phi cos\alpha - 2D_1 r_1 cos\theta \quad (16)$$
$$F = -2r_1 r_2(cos\theta cos\phi cos\alpha + sin\theta sin\phi)$$

As variations of $\alpha, \varphi and \theta$ do not take place in this study a new expression of the mutual inductance can be derived as follows, in which D_1 in (17) is a variable that changes according to how the transmitter-facing receiver moves.

$$M = \frac{\mu_0 r_1 r_2}{4\pi}\int\oint\left[\frac{1}{r_{12}}\right] d\theta d\phi \quad (17)$$

$$r_{12} = [r_1^2 + r_2^2 + h^2 + D_1^2 + 2D_1 r_2 - 2D_1 r_2 - 2r_1 r_2]^{1/2} \quad (18)$$

The new manifestations of power that the wireless system offered indicated P_{WT}, and the expression of the wireless power transfer, denoted η, can be expressed as given in (19) and (20), respectively It can be seen in Eq. (20)

$$P_{WT} = \frac{V_1^2\omega^2}{Z_{L_a}^2 R_L}\left(\frac{\mu_0 r_1 r_2}{4\pi}\int\oint\left[\frac{1}{r_{12}}\right] d\theta d\phi\right)^2 \quad (19)$$

$$\eta = \frac{R_L}{R_L + R_S + \frac{R_P(R_S+R_L)^2}{\left(\omega\left(\frac{u_0 r_1 r_2}{4\pi}\int\oint\left[\frac{1}{r_{12}}\right]d\theta d\phi\right)^2\right.}} \quad (20)$$

$$\phi_2 = \beta\phi_1 \quad (21)$$

The formulation of the flux expression for the primary coil flux transmitter is provided in (22).

$$\phi_1(t) = L_1 i_p(t) + M i_s(t) \quad (22)$$

The typical range of b is 0 to 1, which is identical to the D_1 value shown in equation (23). Even though the receiver coil is separated from the transmitter, n still represents the current flux linkage.

$$\beta = \begin{cases} 0 < \beta < 1 & if\ 0 < D_1 < coil\ radius \\ 1 & if D_1 = 0 \\ \xi & if D_1 < coil\ radius \end{cases} \quad (23)$$

The specified period of flux transmission affects the precise expression of b. $T_{transfer}$ that is expressed in (24).

$$T_{transfer} = \left(\frac{10^{-5}Dcoil}{S_P}\right)3600 \quad (24)$$

The secondary coil's output voltage will be provided as follows:

$$\beta = Sin^2\left(\frac{2\pi}{T_{transfer}}t\right) \quad (25)$$

$$V_2(t) = \beta\left(R_S i_P(t) + L_P\frac{di_p}{dt}\right) + M\frac{di_p(t)}{dt}$$

$$L_1(\mu H) = \frac{r^2N^2}{8r + \pi\omega} \quad (26)$$

The number of receivers listed in (27), which can be standardised, can be used to standardise the suggested model.

$$V_{2nc} = n_c V_2 \qquad (27)$$

Results

Changes the low-frequency AC to DC supply input. Then, the ac supply is moved from the linear transformer's primary winding to the secondary winding via the mutual induction concept. The rectifier receives the AC supply and converts it into a DC supply that powers the batteries. Super capacitors are used to deliver the converted DC supply to the battery. In this case, the super capacitor serves as a power supply for the battery to lessen battery damage. To automatically tap the number of turns based on different ground clearance, a separate control system is engaged.

Figure 4.2 depicts the input voltage of 440 v from the grid to the Vin and its range.

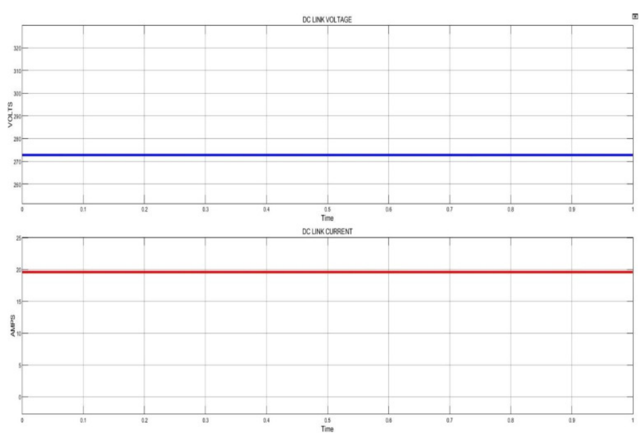
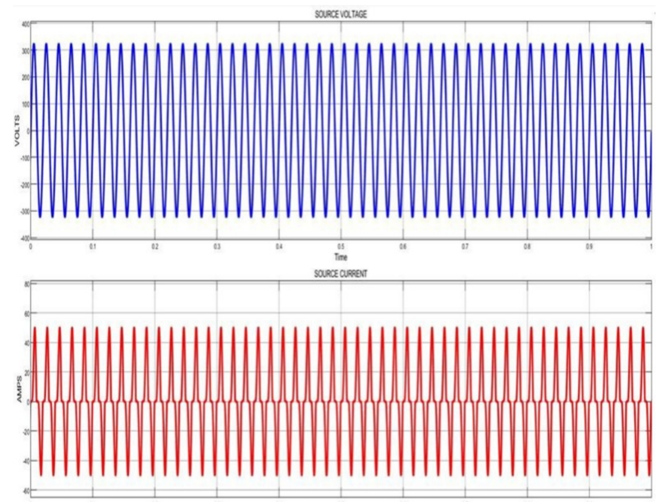


FIG4.2INPUTVOLTAGE(VOLTAGEVSTI
ME

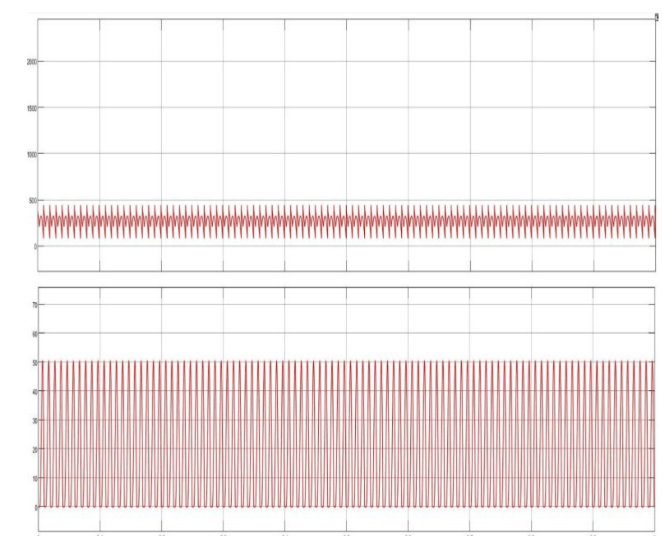
The features of the DC link current that is drawn between time and current are depicted in the figure. After the peak time, when the current is 20A, it continues to flow at a constant rate.The circuit is given an input current in amps, and Fig. 4.3 shows the range of that current.



FIGNO.4.3INPUTCURRENT
(CURRENTVSTIME)

The features of the Source voltage that is drawn between time and current are shown in the figure. After the peak time, when the current reaches a value of 40A, the current continues to flow

FetchedFinaloutputCurrenttoLoadisshowninFigno.4
.4



FIGNO.4.4OUTPUT CURRENT(CURRENTVSTIME)

The features of the current that are drawn between time and current are depicted in the figure. After the peak time, the current flows continuously until it reaches the output current to the load.

Inputvoltage50vgiventoLoad isdrawninFigno.4.5

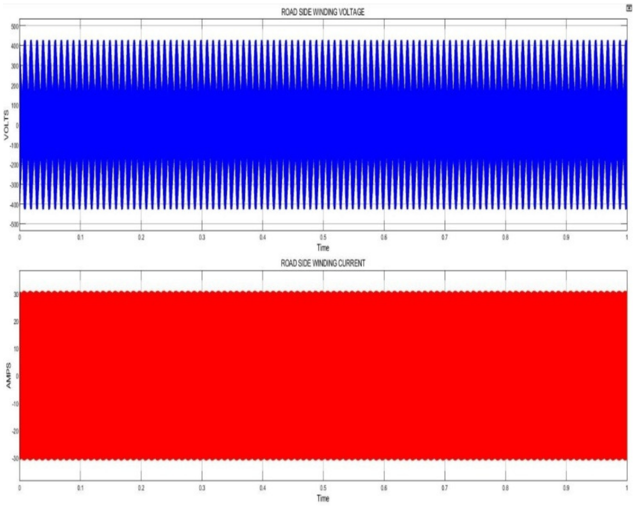
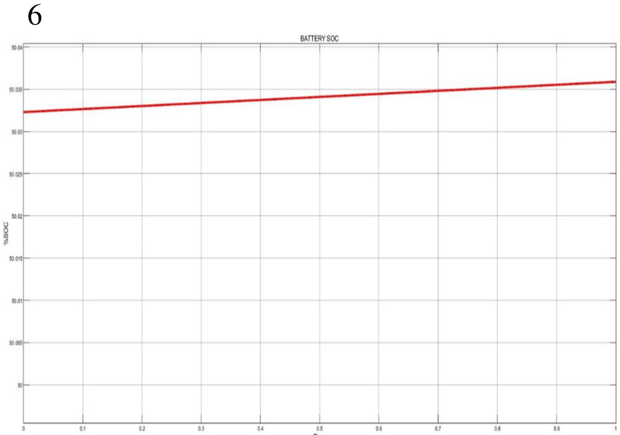


Fig.4.5outputvoltage(voltagevstime)

The features of the road side winding voltage and road are shown in the figure.between the time and the current drawn side winding voltage.In the current achieves the peak value in 3.5A following the peak time the current flows through constant.The%ofsocandbatteryofsocshowinFig:4.6



Inputvoltage andtimeis drawninFigno.4.7

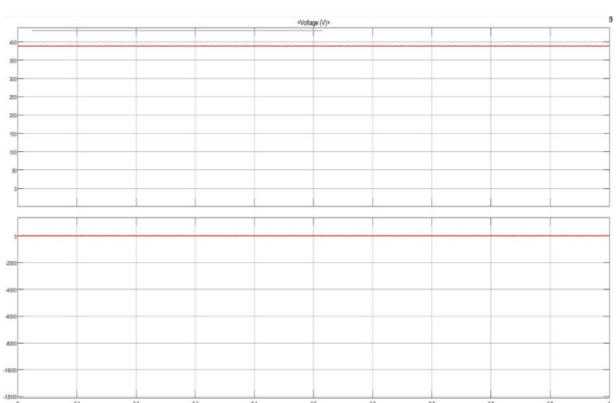


FIG4.7INPUTVOLTAGE(VOLTAGEVSTIME)

The characteristics of battery current and voltage are depicted in the figure. When the current reaches the input voltage to the load after the peak time, it flows through continuously.

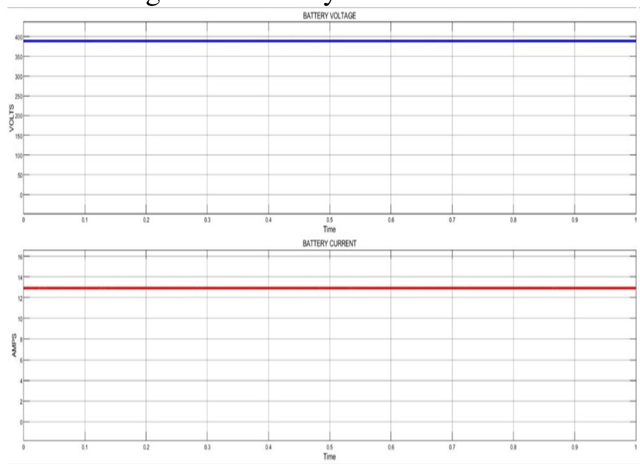


FIG4.8BATTERY(CURRENTANDVOLTAGE).

IV Conclusions

The final remaining chord connections needed to recharge portable electronics may one day be replaced by wireless charging technologies. This technology has advanced greatly over the last few decades and offers a huge variety of applications. The implementation of wireless charging on bus routes has been examined in this article, and we have created an initial investment cost analysis for each of the three types of wireless charging: stationary wireless charging (SWC), quasi-dynamic wireless charging (QWC), and dynamic wireless charging (DWC).The development of sustainable cities is faced with both new opportunities and constraints due to the integration of wireless charging with current transportation networks. This study demonstrated the evaluation of wireless power charging's possible application to a real bus route, lowering emissions and enhancing traffic operations and planning. For the purpose of demonstrating the system's effectiveness in dynamic and diverse settings, simulation and experimental data were given.

ACKNOWLEDGMENT

The heading of the Acknowledgment section and the References section must not be numbered.Causal Productions wishes to acknowledge Michael Shell and other contributors for developing and maintaining the IEEE LaTeX style files which have been used in the preparation of this template.To see the list of contributors, please refer to the top of file IEEE Tran. Cls in the IEEE LaTeX distribution.

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