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Electromagnetic Induction Technique for Generation of Electric Power from Electric Car Wheels for the Charging Of Its Stacked Batteries

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ABSTRACT
Now a days electric cars play major roles as alternative to fueled car. Here batteries are used as an alternative to diesel and fuel. The basic law of physics says "Energy can neither be created nor be destroyed, rather it can only be converted from one form to another". In this project, emphasis is on how to improve the efficiency of pure electric cars especially the hybrid electric vehicles (HEV), by increasing the battery life duration so as to enable the car to cover a longer journey. This is achieved by converting the motion of the car to electrical power using electromagnetic principles which is applied on the rear wheels. During motion these electric D.C. machines acts like a generator which generates power as the car moves. The variable parameters are varied and speeds and corresponding currents, voltages and powers obtained are from Matlab and simlink . From The results obtained in chapter four (4) of this work, indicates that as the velocity of the car increases or is maintained , a corresponding increase in power generation is obtained as the car accelerates and as such it is used to charge the batteries stacked in the electric car. This enables the car to cover longer journey without having to stop and charge up halfway through. This type of system also extends the driving range of fully electric car.
Keywords; *Electric cars, Electromagnetic principles, D.C machine ,power generation , charges , batteries.*

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I. Introduction

Movement from one place to another has been the ancient habit of man and animals. People move from one place to another using different means. some use their legs, some use bicycle ,others use motorcycle while majority use car [9].As technology advances the movement from one place to another becomes automobile in nature. As such, hardly is any movement in the world that does not involve car or vehicle. Therefore in every car movement two things are paramount, ability to move from its state of inertia to another form of motion and ability to discontinue its state of motion and come to a halt or stop [10]. According to newton's which laws states *That body will continue in its state of rest or if it is in motion, will continue to move with uniform speed in a straight line unless is acted upon by a force* . This implies that cars have *"*a moment to start from rest and also a moment to stop when moving. Is at these basics that this paper focuses on, The part that says that a body will continue in its state of uniform motion until it is acted upon by an external force, before it will come to rest [8].It has been observed for years that most car system ran on only petrol or diesel. This results to pollution of our environment due to emission of carbon related gases. This contributes to the depletion of the ozone layer causing global warming resulting to affecting habitant at the temperate region. It also makes driving solely depended on filling stations for long journey [7]. In this paper, emphasis will be on the means of driving cars with low or zero dependence on petrol or diesel filling stations as well as recharging stations and at the same time keep the car moving and enable the car to cover any desired distance, this includes improving the battery charging especially on electric cars .In the course of this paper, focus is on recovering energy from the car motion and at the same time storing this recovered energy to be used when required.

II. Literature review

2.1 Electric Vehicles classifications

In this section, classifications of the different types of electric vehicles were presented, commenting on their main characteristics. Discussion was also made on the current market situation, analyzing the sales data of this kind of vehicles and sales forecast in different countries in the world. Nowadays, there are different types of EVs, according to their engines technology. In general, they are sorted in five types (See Figure 2.3):

• Battery Electric Vehicles are propelled by electric(BEVs):power. BEVs vehicles do not have an internal combustion engine and they do not use any kind of liquid fuel. BEVs normally use large packs of batteries in order to give the vehicle an acceptable autonomy. A typical BEV will reach from 160 to 250 km, although some of them can travel as far as 500 km with just one charge. An example of this type of vehicle is the [Nissan Leaf , 2019], which is 100% electric and it currently provides a 62 kWh battery that allows users to have an autonomy of 360 km.

• Plug-InHybrid Electric Vehicles (PHEVs): hybrid vehicles are propelled by a conventional combustible engine and an electric engine charged by a pluggable external electric source. PHEVs can store enough electricity from the grid to significantly reduce their fuel consumption in regular driving conditions. [4] provides a 12 kWh battery, which allows it to drive around 50 km just with the electric engine. However, it is also noteworthy that PHEVs fuel consumption is higher than indicated by car manufacturers .

• Hybrid Electric Vehicles (HEVs): hybrid v conventional internal combustion engine and an electric engine. The difference with regard to PHEVs is that HEVs cannot be plugged to the grid. In fact, the battery that provides energy to the electric engine is charged.

• In modern models, the batteries can also be charged thanks to the energy generated during braking, turning the kinetic energy into electric energy. The Toyota Prius, in its hybrid model (4th generation), provided a 1.3 kWh battery that theoretically allowed it an autonomy as far as 25 km in its all-electric mode [12].

• Fuel ElectricCell Vehicles (FCEVs): these vehicles are provided with an electric engine that uses a mix of compressed hydrogen and oxygen obtained from the air, having water as the only waste resulting from this process. Although these kinds of vehicles are considered to present―zero emissions‖, it is worth highlighting th hydrogen is extracted from natural gas. [3] an example of this type of vehicles, being able to travel 650 km without refueling.

• Extended-rangeEVs(ER-EVs): these vehicles are very similar to those ones in the BEV category. However, the ER-EVs are also provided with a supplementary combustion engine, which charges the batteries of the vehicle if needed. This type of engine, unlike those provided by PHEVs and HEVs, is only used for charging, so that it is not connected to the wheels of the vehicle. An example of this type of vehicles is the[BMW i3, 2019], which has a 42.2 kWh battery that results in a 260 km autonomy in electric mode, and users can benefit an additional 130 km from the extended-range mode.

III. RESEARCH METHODOLGY

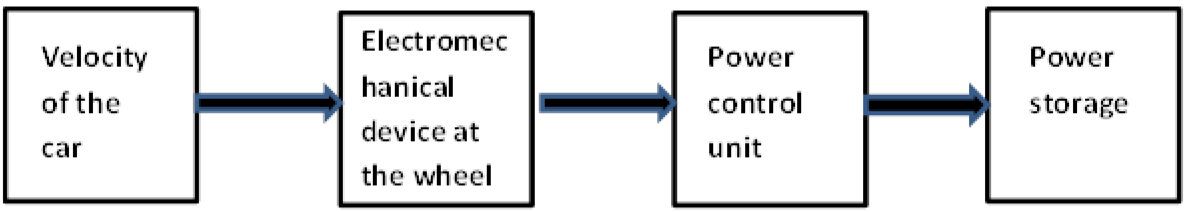


Fig. 3.1 Block diagram of the System

3.1 The block diagram functions

These are the functions of the basic blocks that make up the system.

I. **Velocity via inertia** ; This is the block where the velocity of the car is generated, which occur as a result of the motion of the car .

II. **Electromechanical device at the wheel**; This is the point at which the mechanical energy resulting from the kinetic motion of the car is converted to electrical energy. Here the motion of the car is harnessed from the rear wheels through the electromechanical device, which is mounted at the wheel.

III. **Energy control unit** ; This is the block at which the generated power from the electric motor at the wheel is monitored, harnessed and regulated to suit the storage system.

IV. **Power storage**; This is the block at which the regulated energy from the electric motor through the control system is stored, and ready for use in the car.

3.2 MODELING OF THE CAR TIRE

As earlier stated, the electromechanical device used in this project can be likened to an electric machine which is being run as generator. The drawing below shows an electric generator.

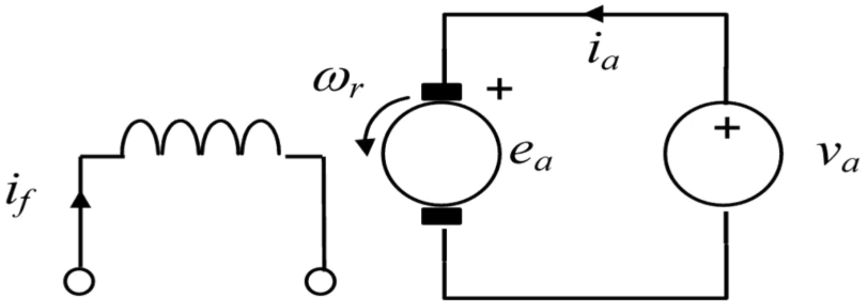


Fig 3.2 D.C machine with a voltage source

If the armature has a resistance R_a Kirchhoff's voltage law gives that

$$v_a = R_a\, i_a + e_a = R_a\, i_a + k_f w_r\, \Phi \qquad (3.1)$$

If current flows in the direction of the reference arrow for i_a the source supplies power to the armature, so the machine is operating as a motor. If current flows in the opposite direction, the power flow is reversed, and the machine operates as a generator. The conditions are ;

Motor operation;	ea < va	i_a	is positive
Generator operation;	ea > va	i_a	is Negative

Since the generated voltage e_a depends on the rotational speed w_r , it follows that a small increase or decrease in the speed can alter the direction of power flow, changing the operating mode from motoring to generating. This is very important consideration in applications such as electric car.

Since during the car acceleration, the friction on the road, the spring effect and damping between the tire and the road, the spring effect and damping between the tire and the body of the car and the mass of the car are all concerned. Thus we ill model them and get the mechanical /electrical analogy of the process

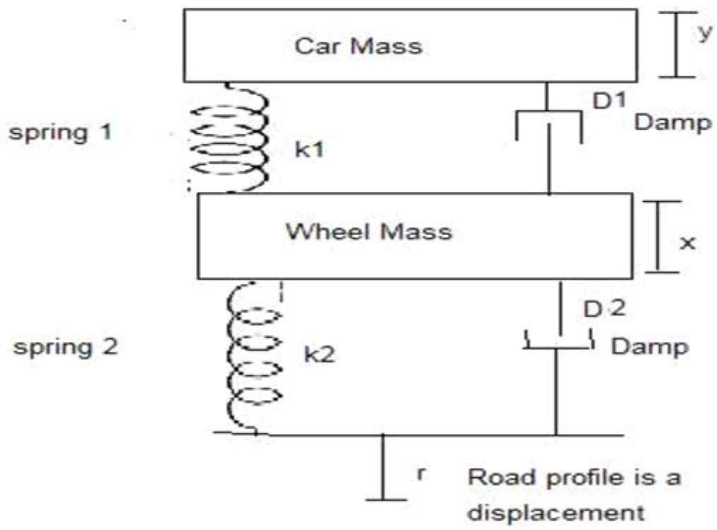


Fig.3.3 mass, spring ,damp analogy of the system

In the diagram above y is the vertical displacement of the car body, x is the vertical displacement of the wheel and r is the road profile displacement, D is the coefficient of viscous friction, K is the spring constant and M is the mass .Thus the standard mass-spring-damper system is represented as shown below.

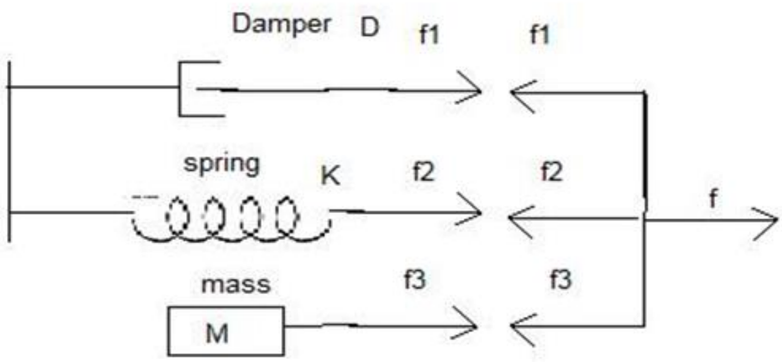


Fig.3.4 standard mass-spring-damper system

Therefore the total force f will be

$$F = M\frac{d^2x}{dt^2} + D\frac{dx}{dt} + kx \qquad (3.2)$$

u which is the velocity is

$$U = \frac{dx}{dt} \qquad (3.3)$$

Thus F which is the total force will be

$$F = M\frac{du}{dt} + Du + Kx \qquad (3.4)$$

With dx = u.dt from eq (3.3) , therefore F from eq (3.4) becomes

$$F = M\frac{du}{dt} + Du + K\int u\, .dt \qquad (3.5)$$

At this stage lets introduce the concept of an ideal moving coil transducer as shown below. It has some similarities with the ideal transformer.

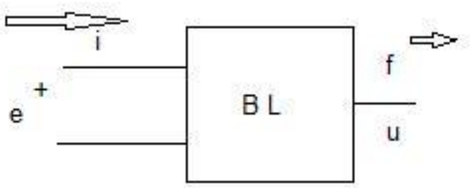


Fig.3.5 Ideal moving –coil transducer

Now that from moving coil transducer

$$f = Bli \qquad (3.6)$$

(3.7)

From eq(3.5)

$$u = \frac{e}{BL} \qquad (3.8)$$

Substituting eq(7) in eq(4) we have

$$f = \frac{1}{BL}\left(M\frac{de}{dt} + De + k\int e.dt\right) \qquad (3.9)$$

From eq(3.7) ,by making the current i the subject formula

$$i = \frac{f}{BL} \qquad (3.10)$$

Therefore I becomes

$$i = M\frac{1}{((BL)^2}\frac{de}{dt} + De\frac{1}{((BL)^2} + k\frac{1}{((BL)^2}\int e.dt \qquad (3.11)$$

For the purpose of this work, the following values was used.
M which is the mass of the car is 1500kg,Rw which is the radius of the wheel is 0.280m, BL which is Electromechanical transducer is 8 N/A, D is the coefficient the damping force which is 0.01, and K which is the spring constant is 10. These are the values of constant used in the Simulink.
Considering the parallel combination of inductance, capacitance and resistance as shown below

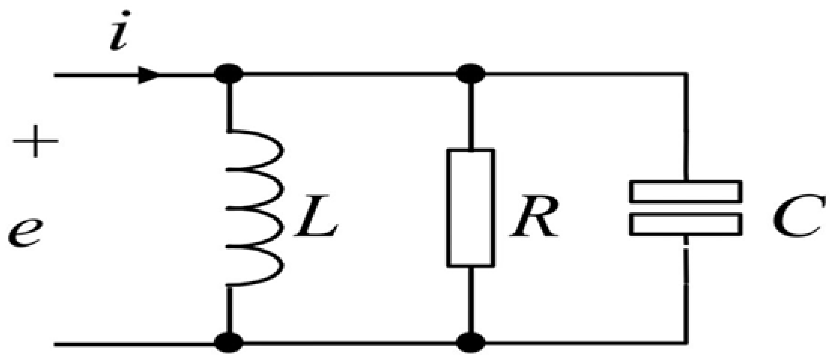


Fig.3.6 Parallel LCR Circuit

The current equation for this circuit is

$$i = \frac{1}{L}\int e\,dt + \frac{e}{R} + C\frac{de}{dt} \qquad (3.12)$$

This is identical to equation (3.11) if we make the following substitutions

$$L = (Bl)^2/K \qquad (3.13)$$

$$R = \frac{(Bl)^2}{D} \qquad (3.14)$$

$$C = \frac{M}{(Bl)^2} \qquad (3.15)$$

This establishes the important result that ,from the electrical terminals ,the mechanical system behaves as a parallel combination of inductance, capacitance, and resistance.
The complete system model can therefore be represented in a purely electrical terms, as shown below.

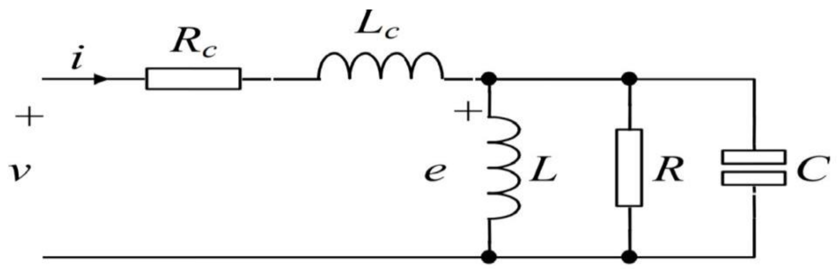


Fig. 3.7 Electrical system model of an electric car tire.

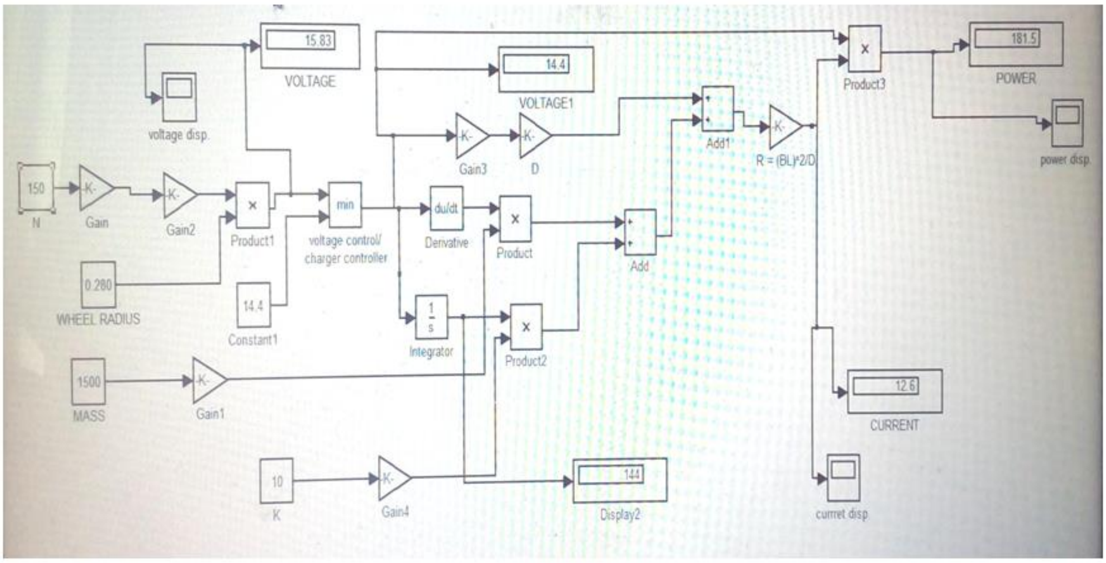


Fig.3. 12Simulink of the system

IV. RESULTS AND DISCUSSIONS

4.1 Simulation Results

As shown in the Simulink above the variables and constants defined with their values. For this results we will be varying the speed with respect to the output voltage, output current and output power respectively. This will be carried out as below

At a given mass and wheel radius of the car The rpm of the motor can directly be related to the speed of vehicle, as shown in equation 4.1

Motor rpm was considered as rotational speed vehicle speed can be found out from these test results. This is considered as input for simulation in Simulink.

With mass being 1500kg and wheel radius 28cm.

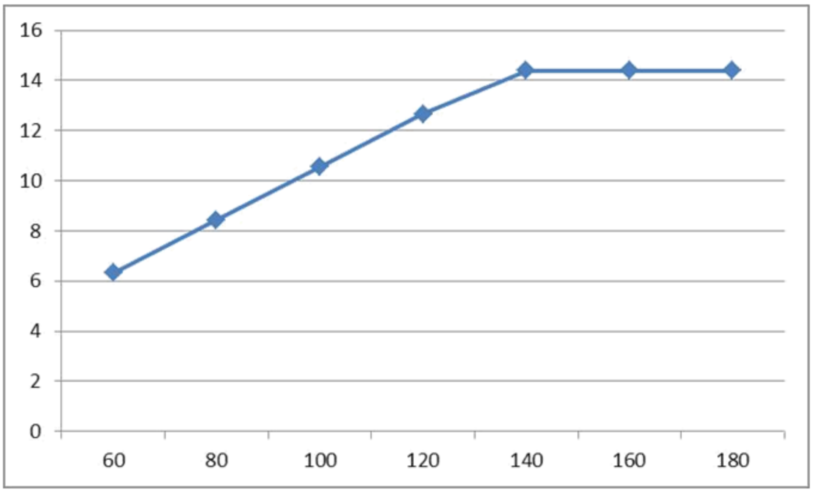
The table is as shown below.

Table.4.1. Experimental readings

s/n	speed in RPM	output voltage(volts)	output current (amps)	output power(watts)
1	60	6.33	5.54	35.09
2	80	8.44	7.39	62.38
3	100	10.55	9.24	97.47
4	120	12.66	11.08	140.4
5	140	14.4	12.6	181.5
6	160	14.4	12.6	181.5
7	180	14.4	12.6	181.5

The respective results is as follows in the graphs below

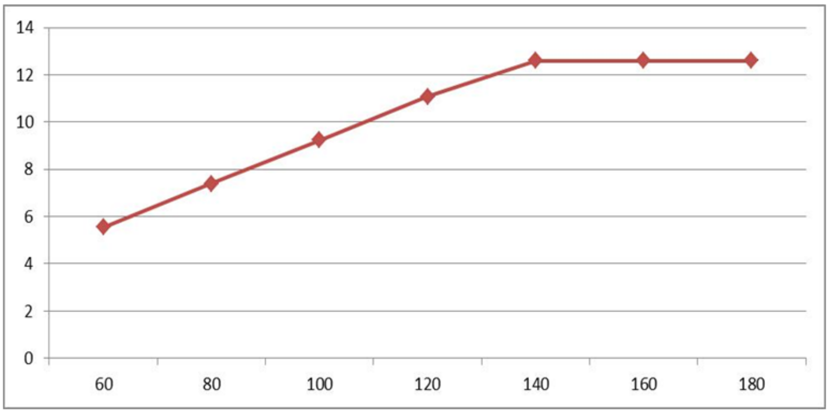
Output voltage



Speed in RPM

Fig 4.1 output voltage verses speed in RPM

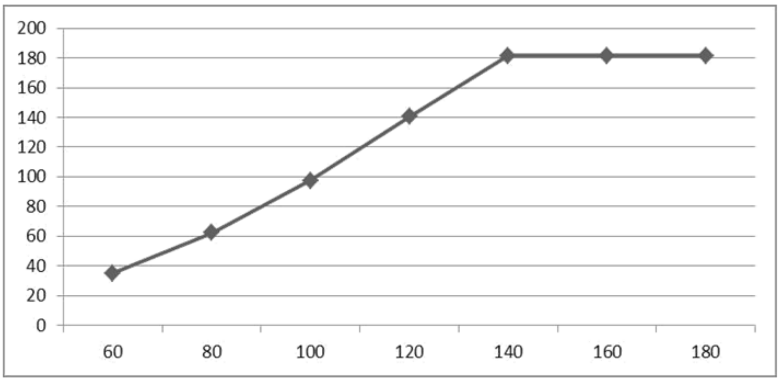
Output current



Speed in RPM

Fig 4.2 output current verses speed in RPM

Output power



Speed in RPM

Fig 4.3 output power verses speed in RPM

From table 4.1 , it will be observed that as the motion of the car increases the speed also increases, this results to increase in the output voltage, output current and power. It was also observed that at 140 RPM, the curve maintained a given height in both voltage, current and power.

The wheel radius is considered to be 0.280 m. Hence, vehicles expected speed for 150rpm motor speed will be,

(4.1)

$$V = \frac{2\pi N}{60} r_w \times \frac{18}{5}$$

$$V_1 = \frac{2\pi \times 150}{60} \times 0.28 \times \frac{18}{5}$$

$$V_1 = 15.83 \text{ km/hr}$$

At the Simulink in the previous chapter, the respective conversion from RPM to km /hr. as expressed in the formula above is displayed respectively .

Table.4.2. equivalent of the RPM to KM/HR

s/n	speed in RPM	Expected speed in km/hr
1	60	6.33
2	80	8.44
3	100	10.55
4	120	12.66
5	140	14.78
6	160	16.89
7	180	19
8	200	21.11
9	220	23.22

V. CONCLUSION AND RECOMMENDATION

5.1 Summary of Discussion

From the discussions above, it was observed that as the speed of the car increases the current, voltage and power increases as well. This means that as the motion of the car increases, energy is being generated from the electromagnet which is being used to charge the battery. Looking at the objectives as stated in chapter one, the achievements of the objectives are as follows.

i. The lost during the acceleration of the car was harnessed using electrical machine, whose generator mode of operation was used to convert the mechanical movement in the car in the form of energy to electrical energy, using the principle of electromagnetic principle for the generation of electrical powers as can be seen in chapter three.

ii. The needed generated energy required to charge the battery as to extend its life span is also optimized using Simulink in Matlab, as well as analyzing the results obtained, so as to get effective speed together with other constants, variables and parameters that are necessary for the effective power generation in the battery as can be seen in chapter four of this work.

iii. The generated energy is then stored in an energy storage device. In this case battery was selected because of its advanced usage in the car as can be seen in chapter two and 2.8 to be precise.

5.2 summary of findings

From the results above it was also observed that at a certain limit of the speed, both the current, voltage and power are constant. This is because the voltage regulator is pegged at 14.4 volts, as such even if the speed is increased the regulated voltage of 14.4 volts will be delivered as output to charge the battery. This is done so as not to over charge the battery.

It was also observed that change in masses does not affect the output, rather change in the radius of the wheel have a significant effect on the output.

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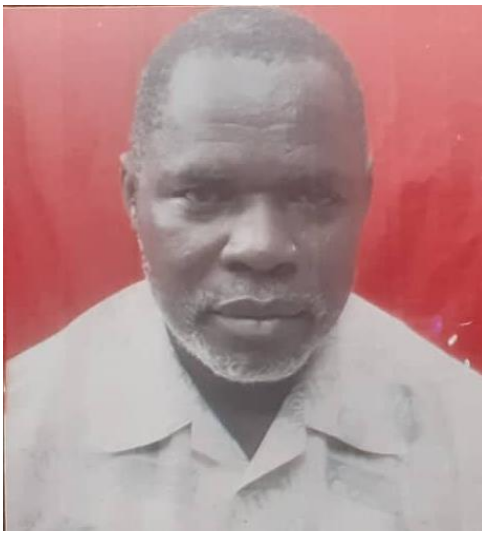

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