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LOW COST SELF POWERED SAND ROVER SYSTEM FOR DESERT REGION SURVEILLANCE

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ABSTRACT

General land locomotives for surveillance systems are not highly efficient when compared to the sand locomotives because of slipping in sand. In loose sand the coherent force between two particles is very less thus making the system slip easily. Thus the rover should have contact up to some depth in the sand and now with that grip in it, it should move to the next step. Similarly the proposed sand rover system here has the capability to move in the loose sand of desert regions. It can also move as a normal vehicle which can be transformed manually. A surveillance system is placed in it along with a solar panel for supply. It is controlled through wireless DTMF (dual tone multiple frequency) system. This method is efficient in all terrains in for the purpose of surveillance

Keywords—Sand rover; DTMF ; Surveillance ; coherent ; Slip ; Efficient ; Grip

INTRODUCTION

The sand rover system is majorly designed and analyzed for desert area surveillance. The major advantage of this system is that it can move on an inclined plane with a maximum of 500 inclination which is very difficult to achieve in conventional sand locomotive system used, if it is possible then its cost will be very high and the rover will be using high power with low efficiency due to slip .This proposed sand rover system is 100% slip free theoretically and thus has a high efficiency. It is also capable of moving in land areas too by a slight change which is done manually. This sand rover system is a complete product to do surveillance.

It can be sub divided into three major components ,they are:

A. The rover (mechanical structure that moves)
B. Power source system
C. Communication and surveillance system

ROVER

The rover part consists of many components namely

A. Body or chassis
B. 4 motors
C. 2 legs

A. *Main chassis or Body :*

The main chassis is the connecting part of the two legs along with motor and dummy wheels.The solar panel, electronic circuits, battery, and camera are mounted in the chassis of the sand rover. The design of the chassis is shown in the figure 1 and figure 2. The design is obtained after a series of experiments. The main chassis consists of four holding grooves for the motor and the dummy wheels for balance.

B. *Motor:*

Totally there are four motors. Each side has a primary and a secondary motor. The primary motor is the one which drives the rover when the rover is in horizontal surface.

C. *Leg:*

A leg is a complete component . It consists of shafts, bearings , sprockets and chain mechanisms. These are attached mainly for the movement of the foot. The foot is designed in such a way that it attains at most level of grip. The leg consists of a chassis with six holes fitted with bearings in each hole. 3 shafts are tightly fitted in those bearings as shown. Since these operate under muddy conditions the chain and the sprocket should be enclosed. The foot design is accurately made to reduce the amount of sand coming above the foot and also for extra grip

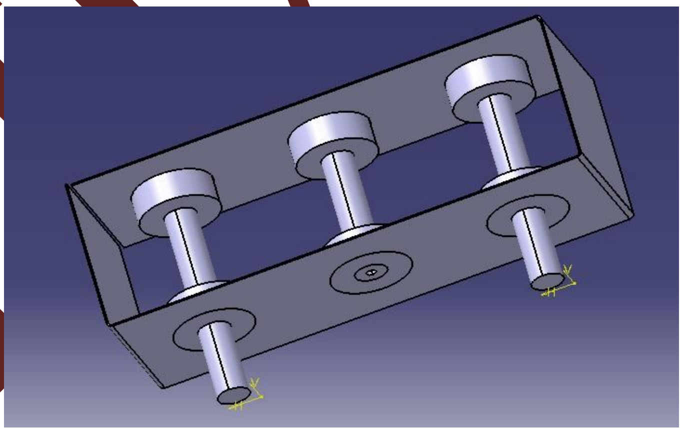

Fig.1. Sand rover leg setup

The central and the outward shafts are connected by means of a chain and sprocket as shown in figure2. Now the foot pad is attached to the outer shaft by means of fasteners

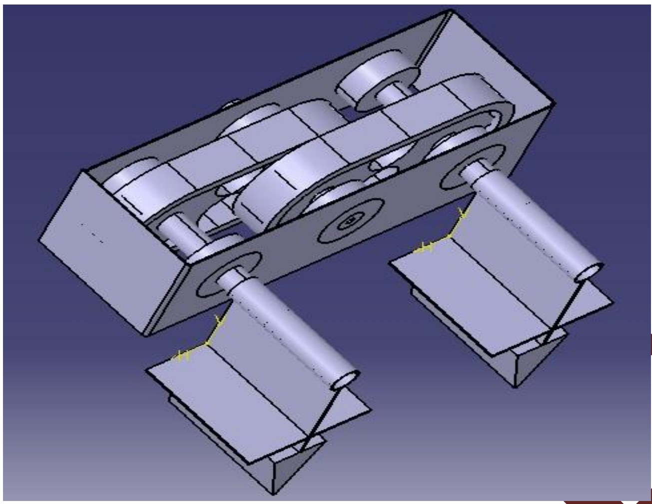

Fig.2. Total leg setup

MOVEMENTS OF ROVER

A. *During primary motor actuation* :

When the primary motor is actuated the secondary motor will be in off condition and thus remains in same position. Since we are using a geared motor very high torque is needed to rotate the shaft of the motor. Assume the shaft of the motor as rigid rod. This rigid rod is connected to the central shaft of the leg while the primary motor is used to rotate the whole leg chassis about its own central axis. Thus the primary motor and the leg chassis are connected by means of gears as shown in the figure2.

Now when the primary motor is actuated the secondary motor which acts as a rigid rod arrests all the degrees of freedom in the central shaft of the leg. Thus the outer shaft which is connected to the central shaft by means of chain sprocket also has zero degrees of freedom along with the foot too. This implies that even if the leg chassis rotate about its axis the foot will not rotate, it will only revolve around the central shaft and central motor.

B. *When the secondary motor is actuated* :

When the secondary motor is not actuated the primary motor will not revolve thus the leg will not revolve and it will remain in the same position, but since secondary motor is attached to the central shaft. When the central shaft will rotate, and thus the outer end shafts will also rotate along with wheels which are replaced instead of foot, so that the rover can run on normal surfaces

POWER SOURCE

Since the sand rover is used for surveillance in desert areas where the solar energy is enormously available. We use solar panels to power the entire system. So we use a photo voltaic cell (PV cell) to harvest power form the sun light and process it further and store the energy harvested by using the following block diagram.

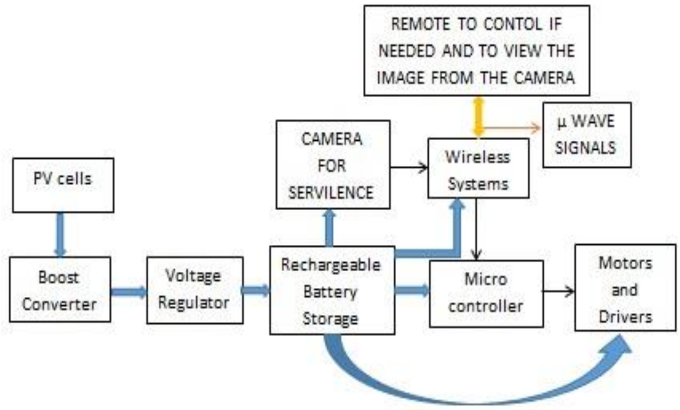

Fig.3. Power and signal flow block diagram

Boost converter are used after the PV cell because the voltage generated from the PV cell is very less to store in a battery so we have to boost up its voltage by using boost converters.

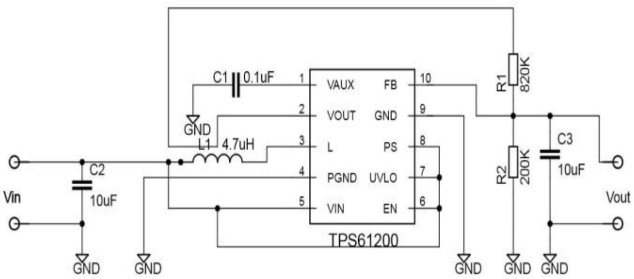

Fig.4. Boost converter Circuit Diagram

Then we use a voltage regulators to regulate the fluctuating voltage and make it a steady one . This steady voltage is then stored in a rechargeable battery. From the battery the power is given to the micro controller board , motor driver , wireless DTMF system and the camera for surveillance. The blue arrows in the block diagram above represent the power flow , the black thin arrows represent the signal flow , the yellow arrow represent the wireless signal flow.

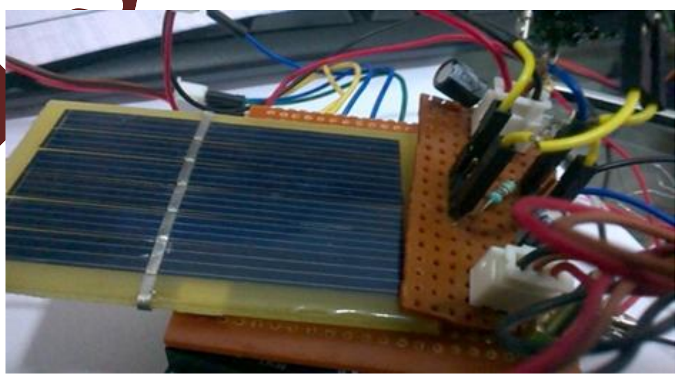

Fig.5. Power generation and processing circuit

COMMUNICATION SYSTEM

We are using DTMF technology for controlling the sand rover. The radio or network based communication system can also be used instead of it. DTMF means dual tone multiple frequencies. Each number in the dial pad has a separate and unique frequency tone. Thus decoding these frequencies is done using CM8805 decoder IC. These decoded signals can be used for the movement control of the sand rover.

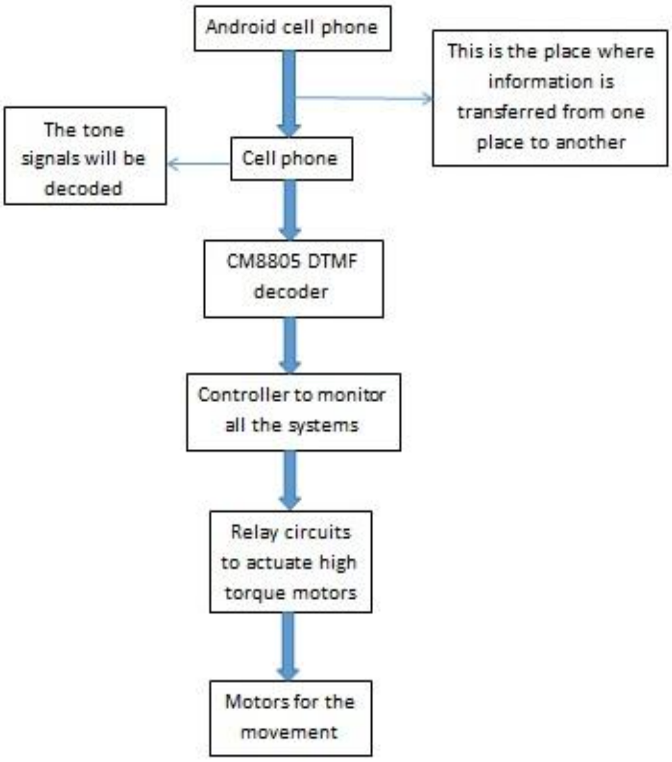

Fig.6. Block diagram of the communication system

HOW DOES THE SAND ROVER MOVE

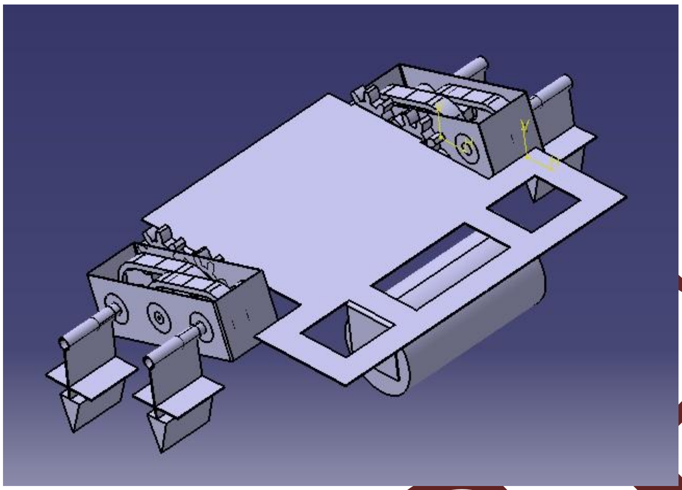

Fig.7. Overall picture of sand rover

As we know normal tyres or even advanced high friction tyres are incapable of moving in an inclined sand terrain even if it is capable, it need a high power to drive it. So it has very less efficiency. This system in contrary has a very high efficiency over the conventional one. The developed system is based on the animal movement as we see all the animal move with two feet in the land and two other moves forward to displace the body with it this same concept has been used in over rover. This sand rover also moves with two foot engraved in the sand for grip and remain stationary as if it is fixed meanwhile the other two foot moves forward and carry the rover body along with it. Now when they move, two feet comes forward and the fixed two feet remains backward. The movement continues with the front two feet as the fixed one. Thus the front feet are always fixed and rear feet always will be the moving one but the rear foot and the front foot will interchange for every 180 degree rotation of the legs. From this we can know that a very less rpm motor is enough to drive the rover at high speed hence we use reduction gears to reduce the motor output to the leg meanwhile the motor's power is used to lift the whole weight of the rover partially so we require a high torque motor. Any way by reducing the speed of the motor we can gain more torque.

A. *Velocity of the rover:*

Let the center to center distance of the foot be "d"(mm)
The reduction ratio of the gear be "x"
Speed of the motor be "s"(rpm)
Torque of the motor be "t"(n-mm)

We know that for every rotation of the leg the rover moves twice the distance of the center to center distance of the foot.

Thus for one rotation of the rover leg the distance moved by the rover is = 2×d(mm)

Speed of the leg depends upon the speed of the motor and the reduction ratio of the reduction gear used.

Thus the speed of the leg = x×s(rpm)

Now the velocity of the rover is equal to the product of speed of rotation of leg and distance moved by the rover in one rotation

Thus velocity of the rover = 2×d×x×s(mm/min)
That is =2×d×x×s×60/1000000

Therefore the velocity of the rover is=.00012×d×x×s(km/hr)

Now let us see we are using a 400 rpm motor with rover center to center distance as 150mm and a reduction ratio of 0.5

Therefore speed of our vehicle is = 0.00012×150×0.5×400

= 3.6(km/hr)

B. *Mechanical power transmission system* :

Reduction gear train is used in sand rover for reducing the speed of the rover and to increase the torque output we can achieve a gear reduction using two gears but using even number of gears will give us an undesirable reaction force which will put the whole vehicle upside down

The condition for the stability of the vehicle is that the roller must always be rested on the ground to do that the motor must give reaction force in clockwise direction this is possible only if we use odd number of gears because we know that in external gears if driver wheel rotates in clockwise than the driven wheel rotates in anticlockwise direction. As we know that the leg should rotate in anticlockwise direction by using odd number of gears the motor will be made to rotate in same anticlockwise direction, this will result a reaction force in clockwise direction thus forcing the roller to stay down. And one more important thing is that the cog should be in-between the motor and the roller so that the loads are balanced.

C. *Motor rating*:

Let the weight of the motor be “w”(kg)
Friction factor of the dummy wheel be “f”
Angle of inclination of the rover be “α”(degree)
Velocity of vehicle be “v”(m/s)

Now if we see the rover's legs actually lifts half of the rover's weight and then moves the rover so the weight of the rover must also be considered

Thus the net force required to carry the rover is = (w/2)+(w×f)+(w×sin α)/2
(The equation divided by 2 because two motors are used at a time)

Now the motor rating for one motor can be considered as = (((w/2)+(w×f)+(w×sin α))×g×v)/2 (watts)

In our rover,

Weight is 10 kg
f = .3 in case of mud(assume)
α =40 degree
v = 3.6×1000/3600 =1 m/s

Thus the rating of our motor is = (((10/2)+(10×0.3)+(10×sin40))×9.81×1)/2 = 71.485(watts)

We used 84 watt motor.

EXPERIMENTAL RESULT

We have done a trial model for experimental purpose and tested the performance in sand terrain. We have found that the locomotive model suggested here will definitely satisfy our need.

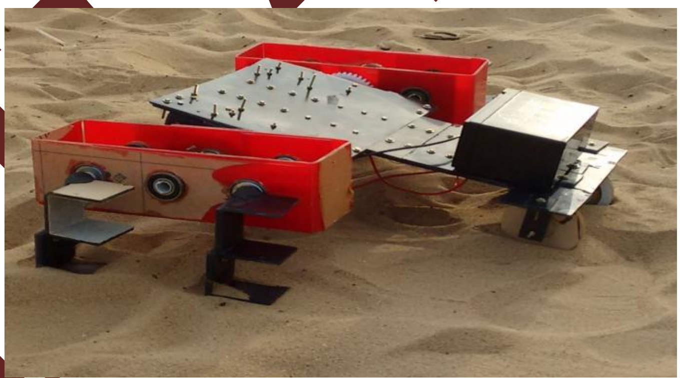

Fig.8. Sand rover at rest position

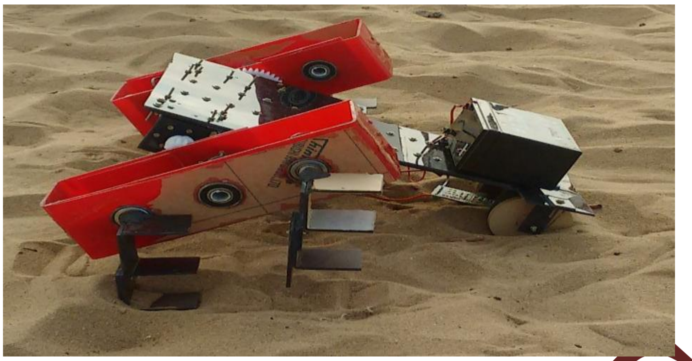

Fig.9. Sand rover completes quarter step

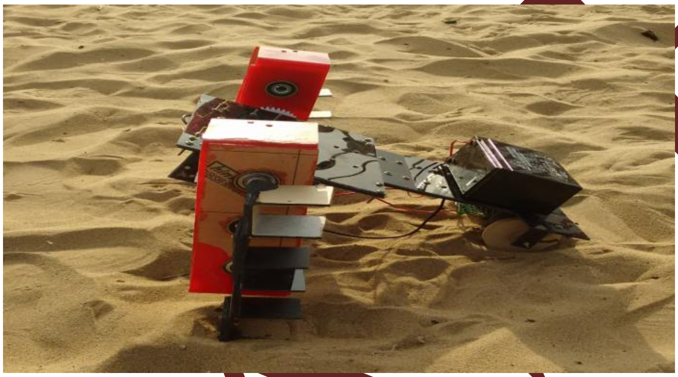

Fig.10. Sand rover completes half step

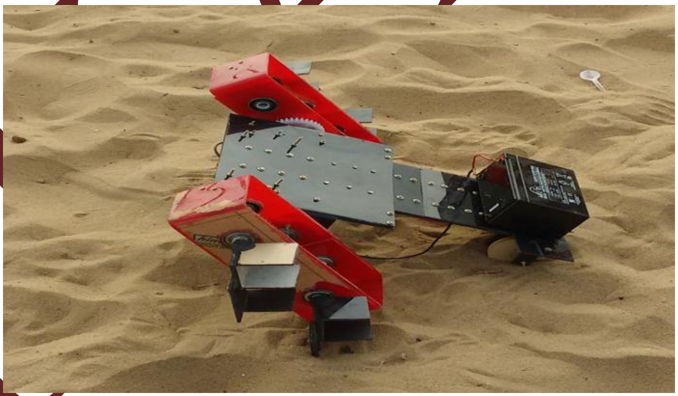

Fig.11. Sand rover completes three fourth of step

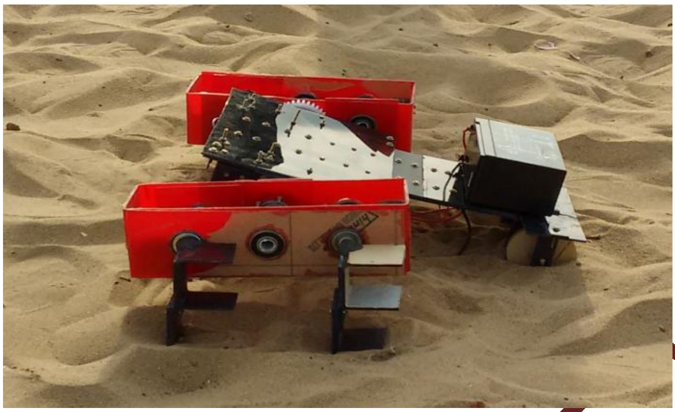

Fig.12. Sand rover completes one step

CONCLUSION

Thus we have seen a very good and efficient model for locomotion in sand. Even though this model has its own complications it is worth for its efficiency over the conventional locomotive. We are using this sand rover system for a surveillance purpose so we don't need to worry about its weight only a camera will be placed over it. Hence the weight of the sand rover system will be nominal and efficiency will be more when compared with the conventional system.

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