© 2017 IJSRST | Volume 3 | Issue 3 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
Themed Section: Science and Technology

# Design of Power Drive Asscender for Highly Inclined Terrains

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## ABSTRACT

This paper relates to a design that involves driving a four wheeled vehicle in highly graded planes. The primary use of the design discussed in this paper is to allow four wheeled rovers to climb highly inclined terrain and have a suspension system in place to provide frictional force for the wheels to come down and provide traction over the ground. Such a design allows the rover to travel unmapped terrain.
**Keywords**:Power Drive Asscender; Inclined terrarin; High Torque Motors; Four Wheel Drive

## I. INTRODUCTION

Mobile robots, or Rovers play a significant role to increase our explore in current and future surveillance missions. To achieve advanced mission goals, rovers are expected to travel much longer distance over more challenging terrains and perform more complex rescue tasks. Corresponding to such growing attention, there are an increasing number of research activities conducted in various institutions.

Recently, intensive research has been made on a physics based design that involves traction mechanics between the wheel and terrain. This approach recalls a classical terra-mechanics design then successfully applies it to simulate, plan and control the rover motion for improved performance developed a non-line method to identify terra-mechanic parameters of plane.

## II. METHODS AND MATERIAL

### 1. Comparison Factor

### A. Terrain Capabilities

Terrain capabilities refer to ability of the robot to traverse on various type of terrain such as flat ground, grassland and rubble, and to overcome obstacles such as step, ramp, ditch and staircase. In comparison, legged robots will have the best abilities followed by re-configurable robots; both types of robots are able to traverse on the various types of terrain and overcome most of the obstacles. Tracked robots have the ability to traverse in most terrain but unable to overcome most obstacles. However, with the addition of one or two pairs of articulated tracks, they are able to traverse on most terrain and overcome most obstacles. Wheeled robots only have the ability to traverse on flat terrain.

### B. Stability

Stability is the ability of the robot to remain controllable during movement or obstacle negotiation and it is usually related to the contact area of the robot to the terrain. Better stability means that the robot has lower risk to be overturned or trapped by obstacle, it allows more payloads that can be carried by the robot. Tracked robots have excellent stability while wheeled robots have good stability due to their large contact area to the terrain. Similarly, re-configurable robots have moderate stability while legged robots have poor stability.

### 2. System Configuration

The robot is made up of four main sub-systems, the vehicle platform, the vehicle electronics, the mission command console and the various modular payloads.

### A. Vehicle Platform

The vehicle platform shown in Fig.1, consists of three sub-modules: a vehicle chassis and two vehicle track modules. The vehicle chassis houses and protects the vehicle electronics, vehicle drive and flipper motor systems, while the vehicle track modules house all the pulleys, tracks and the vehicle power packs.

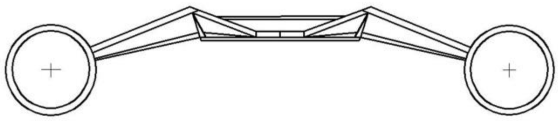

**Figure 1:** Vehicle Platform

### B. Vehicle Electronics

The vehicle electronics shown in FIG.2, is made up of a microcontroller form factor, which comprises of a CPU module, a multi-serial communications port module, a motion controller module and a PC/104 power management module. In addition, it is integrated with RF receiver, tilt/compass sensor, ultrasonic sensors and video multiplexer.

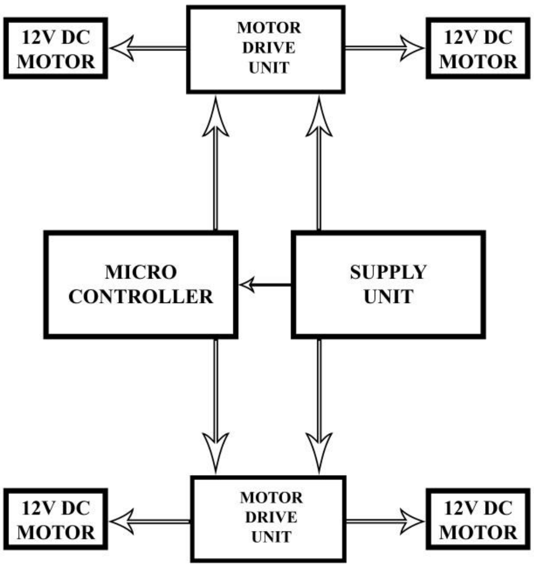


**Figure 2 :** Circuit Connection

### C. Command Console

The console is made up of a wearable remote (WC) together with a wireless data modem, a wireless receiver, a head mounted display (HMD) and remote control unit (RCU).

### D. Modular Payloads

Two modular payloads, a pan-tilt zoom camera and a pan-tilt thermal imager have been designed for the robot.

## 3. Vehicle Platform

The scope of this project is only limited to the sub-system, vehicle platform. The vehicle platform consists of a vehicle chassis (VC) and two vehicle track modules (VTM).

### A. Vehicle Drive Mechanism

There are two such mechanisms within the platform to drive the tracks at the left and right sides of the vehicle. On each side of the vehicle, there is a drive motor geared down by a planetary gearhead that rotates the drive pulley via a set of spur gears transmission. The rotation of the drive pulley will drive the main track and the drive idler at the other end of the main track. As two identical flipper pulleys are attached to the drive pulley and drive idler respectively, the rotation of the drive pulley and drive idler will rotate these two flipper pulleys in the same direction as well. The rotation of the two flipper pulleys will then drive the respective articulated tracks and the flipper idlers at the other end of articulated track. Hence through this vehicle drive mechanism, each drive motor is able to drive all the three tracks at the same side of the vehicle chassis. .

### B. Motor Sizing

The sizing of both the drive and flipper motors is the most important design consideration for the vehicle platform. It directly affects the performance and the weight of the robot. A more powerful motor can allow the robot to overcome obstacle easier, but is heavier and require more power, which will eventually result in a heavier power pack and a heavier robot. The sizes of the motors are calculated based on the most stringent conditions:

Vehicle weight of 3kg;
Translation up a slope of $45^o$

Translation up to a maximum of 0.9m/s on flat ground; The most stringent condition that dictates the size of the drive motor and the ratio of its planetary gearhead is translation up a slope of  at a speed of V m/s..

### C. Symmetry of Robot

During the design of the robot, symmetry is one of the major design considerations. This is because symmetry of the robot means that there are identical parts within the robot. Identical parts will cut down the number of unique parts that build up the robot. This will reduce the time to purchase, fabricate or customized these parts. During the prototype developments when spare parts are few, identical workable parts are used to replace suspected faulty parts in order to confirm that the parts are faulty.  In order to achieve articulated tracked mechanism with minimum number of different parts, symmetry within the robot was considered during the placement of the motors. It was observed that the placement of the two vehicle drive mechanisms and the two vehicle flipper mechanisms could achieve rotational symmetry within the robot.  Symmetry of Motor Placement within the Robot  With the exception of on-board electronics, the robot is designed to have rotational symmetry about the centre of the robot. Within the vehicle chassis sub-module, it is made up of the vehicle electronics module and two identical flipper compartments at the front and the rear. The two vehicle track module sub-modules are also identical. Within each vehicle track module, the two flipper arms that are attached to the drive pulley and drive idler at both ends of the module are identical too.

### 4. Torque Equation of DC Motor

When choosing a DC motor for an application, or when emerging a powered prototype there are numerous calculations and formulas shown in Fig.3, which must be considered to produce a well-functioning, sufficiently-powered, and safe device. Further down we have provided some important formulas and calculation details to determine mechanical power requirements of a DC motor, to calculate torque, and for determining the steady state temperature increase of a motor.

The equation for torque developed in a DC motor can be derived as follows.

The force on one coil of wire F =il φ x B Newton
Note that l and B are vector quantities.

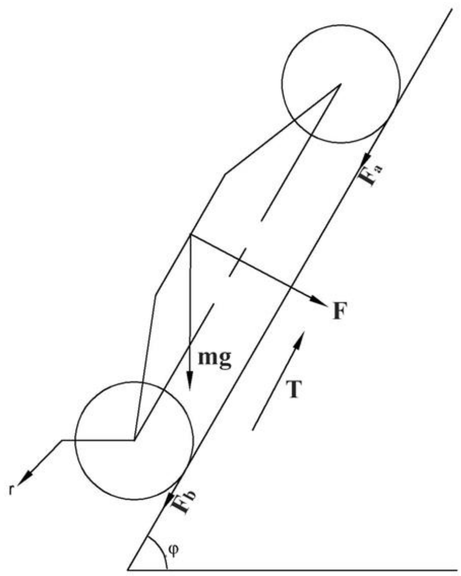


**Figure 3 :** Torque Diagram

Since B = φ /A  where A is the area of the coil, Therefore, the torque for a multi turn coil with an armature current of Ia:

$$T = K\ Ia\ \varphi$$

Where o is the flux/pole in weber, K is a constant depending on coil geometry, and Ia φ  is the current flowing in the armature winding. Torque T is a function of force and the distance, equation lumps all the constant parameters in constant K.  The mechanical power generated is the product of the machine torque and the mechanical speed of rotation. It is interesting to note that the same DC machine can be used whichever as a motor or as a generator, by reversing the terminal connections.

## III. CONCLUSION

The vehicle platform with differential loads and the motor with torque reqired for climbing a highly inclined terrains are made to be possible in planar surfaces too.

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