# Anti-Roll Mechanism for Commercial Vehicle

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**Abstract -** *Commercial vehicles are inevitable part of the society nowadays as the population is increasing drastically. Commercial vehicle are not only transporting Goods but also the humans. But the accidents in commercial vehicles are increased drastically. There are plethora of causes for accidents but one of which is vehicle rollover. Due to heavy parts and high load carrying there is always a tendency of vehicle to rollover at slopy road or at high speed. According to the report almost around 2.5 lacks trucks got roll overed in 2018 only in India. So, by putting an external counter weight which continuously changes its position according to weight transfer these accidents can be prevented.*

*Hence, the safety in the automotive domain can be improved by balancing vehicle internally so it can prevent the external arbitrary forces. Thus this research paper focuses on the anti-roll balancing mechanism for the commercial vehicles or heavy-duty vehicles having more play load and goods load.*

***Key words:*** *Sliding mechanism, heavy-duty vehicle, Anti-roll, Counter weight, Position sensors, Chain transmission*

## 1. INTRODUCTION

The rollover of the commercial vehicle (Trucks, Buses, dumper etc.) due to the heavy weight is one of the most common accident causes. The vehicle tends to roll over at sharp corner, at high speed or at very high side slope of the road as the centripetal force is acting on the C.G. continuously. Unlike the other accidents in this there are more chances of total breakdown of the vehicle and the injury of driver and passenger as well. This problem can be prevented by attaching the counter weight mechanism which slides continuously beneath the deck in opposite direction of the centrifugal force. The counter weight mechanism not only counters the centrifugal force but also lower downs the C.G. which aids in stability against the unbalanced forces. The mechanism takes the input from the position sensors and runs the motor in the appropriate direction causing the pulling of the chain attached to the counter weight hence due to the movement of the weight vehicle can be balanced. There are multiple numbers of the motors which pulls the counter weight and the specifications are depends upon the weight of the vehicle and counter weight. The displacement of the slab also depends upon the weight of the vehicle and also the required C.G. transfer in order to balance the vehicle properly. For example if the side slope of the road is 5° then the displacement required is less than it requires for the 10°, and the load plays the major role regard with the angle of slope.

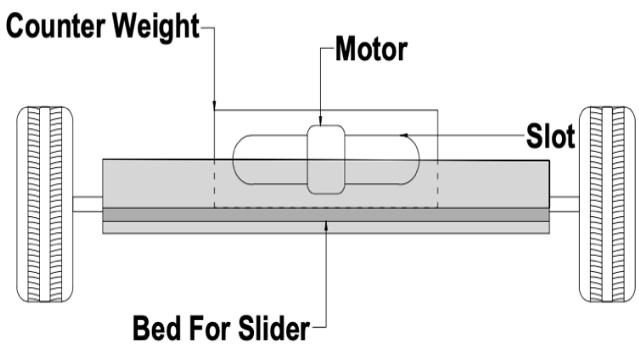



*Fig - 1 Principle*

As shown in Fig.1 the block or the counter weight has the slots(geared slots) in which the motors are fitted so when the motor rotes that causes the slab to move in the longitudinal direction. In other word this slots will help the mechanism to translate the rotary motion of the motor to the longitudinal motion of the block. There are few elements which plays major role besides the counter wight and motor which are sensors, Microcontroller and motor controller.

## 2. COMPONENTS

### 1.1 Steel Block

It is one of the main components of the system as it counters the forces which tend to roll-over the vehicle. Steel block is used because of its moderate density hence the block will not be too little so the weight concertation causes unwanted forces or not too big to occupy more space in the vehicle.

*Fig - 2 Steel block*

We know that the density of the steel is between 7355-8050 kg/m$^3$.

By taking 8000 kg/m$^3$ the dimensions of the block for 240 kg (≅ 243.76 kg) are 500mm*250mm*250mm.
(However the machining is required on this block in order to have groves for the motor to slide it.)

### 1.2 Motor

Electric motor is used to move the block in lateral directions to the center. Two motors are used in this case as its relatively light commercial vehicle and the weight required to balance it is less. For heavier vehicle number of motors can be used however.

*Fig - 3 BLDC motor*

Specifications:

**Table 1**

| | |
|---|---|
| Voltage | 60V |
| Rated Current | 45A |
| Speed | 3000±100 |
| Max. torque | 22Nm |
| Max. Power output | 3000 W |
| Number of poles | 8 |
| Efficiency | >83% |

### 1.3 Microcontroller

Arduino Mega 2560 Rev3(A000067)

Microcontroller takes input from the gyro sensor about the position of the vehicle deck and then it will send signals to the motor controller about the direction of rotation and speed of the motor.

*Fig - 4 Microcontroller*

Specifications:

**Table 2**

| | |
|---|---|
| Operating Voltage | 5V |
| Digital I/O pins | 54 |
| Analog input pins | 16 |
| SRAM | 8 KB |
| EEPROM | 4 KB |
| Clock Speed | 16 MHz |

### 1.4 IMU

An Inertial Measurement Unit is an electronic device that measures and reports a body's angular rate, specific force and orientation of body using combination of gyroscope and accelerometer.

NAME: REES52 GY-521 Mpu6050 Module


*Fig - 5 IMU*

### 1.5 Motor controller

Motor controller is the device used to control motor by running it to achieve required speed and torque.

NAME: MAXON motor controllers (MAXPOS)


*Fig - 6 Motor controller*

These are the major components that are used in the system other components like wires, PCB boards, relay and connectors.

## 3. CALCULATION FOR THE SPECIFIACTIONS

- Calculation for counter weight:

By considering the Medium sized Pick-up Truck having Gross vehicle weight of almost 2300kgs.

Assumed maximum angle of slope is 20°.
The force acting on the vehicle when it is plying on the slope = mg sinθ
= 2300*9. 8*0.39
= 7709.13 N

On the other hand the counter balance which is located at the bottom will work in the opposite direction to the normal force. So the force component of it will be,
= mgcosθ
=240*9.8*0.93
=2187.3 N

For, the 20° slope angle the counter force to balance the vehicle should be at least 20-25% of the vehicle weight and by 150 kg block the desired result can be effectively achieved.

- Calculation for motor specification:

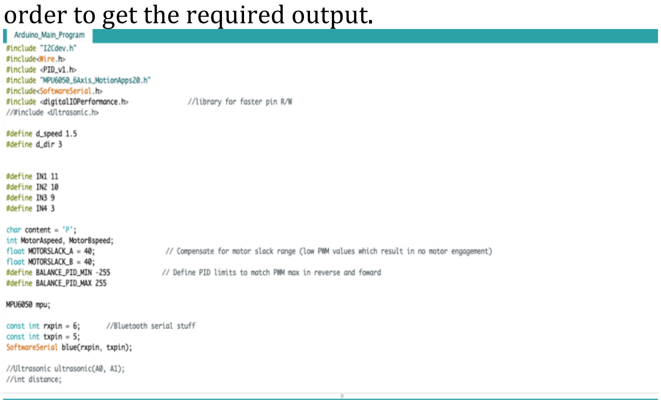
The wight of the block is 240 kg, in order to calculate the required torque and power of the motor.
By assuming the track width distance 1.8 meter. And the block width is 0.25 meter. So both side there is a 0.65meter distance for the block to be displaced.
For torque required to move the block at the required distance is, W*d
Where W is weight of the block
d is the distance from center to motor gear radius

here in this case the block is mounted on the slot of bed, but let's assume that there is no friction and the mass acts again the gravity.
In order to calculate the power of the motor,
P = Force * Velocity
Force(F) = mass * gravitational acceleration
= 240 * 9.8
= 2352 N

P = F * v
= 2400 (~2352) * 1.5 m/s
(We required to move the block very rapidly so assume that the required velocity is 1.5 m/s)
= 3600 Nm
Since we are using two motors the power is distributes in half for each motor.
So, the required power for the motor is 2000 W for each motor. (As mentioned in the components)

## 4. PROGRAMMING FOR MICROCONTROLLER

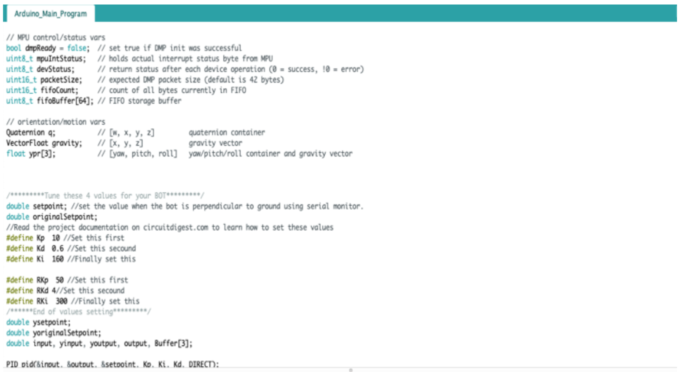
Arduino is the open-source programming software for microcontroller. In order to control the both motor we need to specify the values like speed and running time in order to get the required output.



Arduino_Main_Program

```
#include "I2Cdev.h"
#include<Wire.h>
#include <PID_v1.h>
#include "MPU6050_6Axis_MotionApps20.h"
#include<SoftwareSerial.h>
#include <digitalIOPerformance.h>            //library for faster pin R/W
//#include <Ultrasonic.h>

#define d_speed 1.5
#define d_dir 3


#define IN1 11
#define IN2 10
#define IN3 9
#define IN4 3

char content = 'P';
int MotorAspeed, MotorBspeed;
float MOTORSLACK_A = 40;              // Compensate for motor slack range (low PWM values which result in no motor engagement)
float MOTORSLACK_B = 40;
#define BALANCE_PID_MIN -255          // Define PID limits to match PWM max in reverse and foward
#define BALANCE_PID_MAX 255

MPU6050 mpu;

const int rxpin = 6;       //Bluetooth serial stuff
const int txpin = 5;
SoftwareSerial blue(rxpin, txpin);

//Ultrasonic ultrasonic(A0, A1);
//int distance;
```

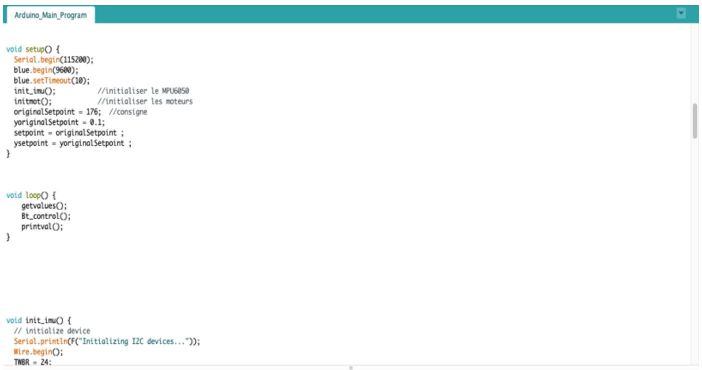
*Fig - 7 Arduino program*



Arduino_Main_Program

```
// MPU control/status vars
bool dmpReady = false;  // set true if DMP init was successful
uint8_t mpuIntStatus;   // holds actual interrupt status byte from MPU
uint8_t devStatus;      // return status after each device operation (0 = success, !0 = error)
uint16_t packetSize;    // expected DMP packet size (default is 42 bytes)
uint16_t fifoCount;     // count of all bytes currently in FIFO
uint8_t fifoBuffer[64]; // FIFO storage buffer

// orientation/motion vars
Quaternion q;           // [w, x, y, z]         quaternion container
VectorFloat gravity;    // [x, y, z]            gravity vector
float ypr[3];           // [yaw, pitch, roll]   yaw/pitch/roll container and gravity vector



/*********Tune these 4 values for your BOT*********/
double setpoint; //set the value when the bot is perpendicular to ground using serial monitor.
double originalSetpoint;
//Read the project documentation on circuitdigest.com to learn how to set these values
#define Kp  10 //Set this first
#define Kd  0.6 //Set this secound
#define Ki  160 //Finally set this

#define RKp  50 //Set this first
#define RKd 4//Set this secound
#define RKi  300 //Finally set this
/******End of values setting*********/
double ysetpoint;
double yoriginalSetpoint;
double input, yinput, youtput, output, Buffer[3];

PID pid(&input, &output, &setpoint, Kp, Ki, Kd, DIRECT);
```

*Fig - 8 Arduino program*



Arduino_Main_Program

```
void setup() {
  Serial.begin(115200);
  blue.begin(9600);
  blue.setTimeout(10);
  init_imu();           //initialiser le MPU6050
  initmot();            //initialiser les moteurs
  originalSetpoint = 176;  //consigne
  yoriginalSetpoint = 0.1;
  setpoint = originalSetpoint ;
  ysetpoint = yoriginalSetpoint ;
}



void loop() {
    getvalues();
    Bt_control();
    printval();
}




void init_imu() {
  // initialize device
  Serial.println(F("Initializing I2C devices..."));
  Wire.begin();
  TWBR = 24;
```

*Fig - 9 Arduino program*

```
Arduino_Main_Program
  // Motor A control
  if (MotorAspeed >= 0) {
    analogWrite(IN1, abs(MotorAspeed));
    digitalWrite(IN2, LOW);
  }
  else {
    digitalWrite(IN1, LOW);
    analogWrite(IN2, abs(MotorAspeed));
  }

  // Motor B control
  if (MotorBspeed >= 0) {
    analogWrite(IN3, abs(MotorBspeed));
    digitalWrite(IN4, LOW);
  }
  else {
    digitalWrite(IN3, LOW);
    analogWrite(IN4, abs(MotorBspeed));
  }
}
void printval()
{
  Serial.print(yinput); Serial.print("\t");
  Serial.print(yoriginalSetpoint); Serial.print("\t");
  Serial.print(ysetpoint); Serial.print("\t");
  Serial.print(youtput); Serial.print("\t"); Serial.print("\t");
  Serial.print(input); Serial.print("\t");
  Serial.print(originalSetpoint); Serial.print("\t");
  Serial.print(setpoint); Serial.print("\t");
  Serial.print(output); Serial.print("\t"); Serial.print("\t");
  Serial.print(MotorAspeed); Serial.print("\t");
  Serial.print(MotorBspeed); Serial.print("\t"); Serial.print(content); Serial.println("\t");
}
```

*Fig - 10 Arduino program*

## 5. WORKING METHODOLOGY

The components of the system are arranged as shown in the figure (Fig - 11). The gyroscope which is basically IMU with accelerometer and gyroscope, it will induce the signal and the micro controller executes some command to the motor controller after reading signals. The motor controller rotates the motor at required torque and speed which are calculated by the microcontroller.

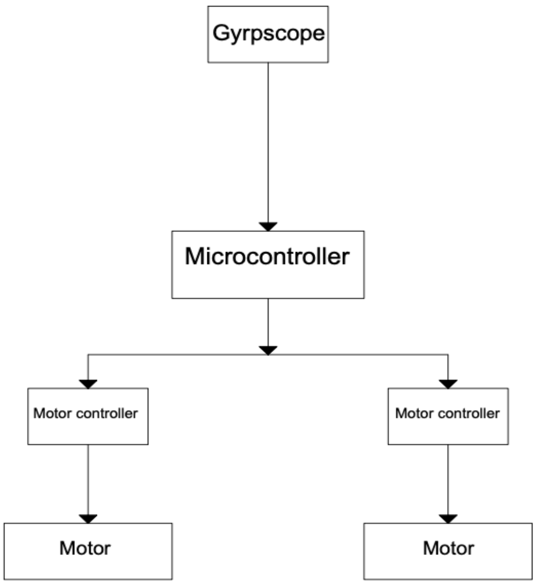



*Fig - 11 Working*

When the slope is on the left side the centripetal forces will act on the vehicle in the right direction, and that causes the vehicle to roll-over. But this movement will detect by the gyro sensors and a specific output will be generate and the signals are feed to the microcontroller. Microcontroller then will generate the controlling signals for the motor and feed it to the motor controller and it will control the motor such that the motor rotate in the appropriate speed and generate the specific torque so the required displacement of the block is archived on the left side.

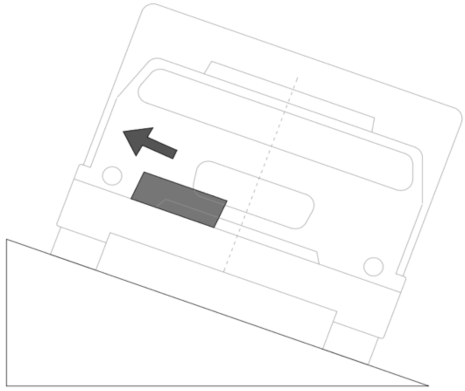


*Fig - 12 Left slope*

Same process for the right side slope in which the block will move to the right in order to prevent the roll-over at the left.

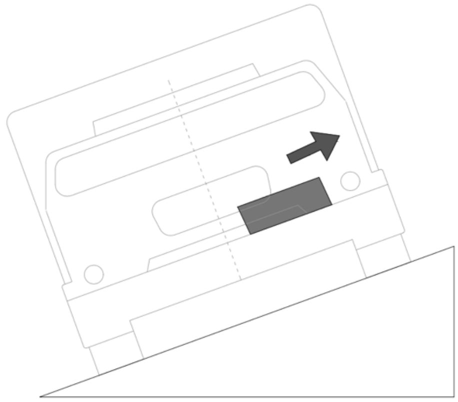


*Fig - 13 Right slope*

## 6. CONCLUSION

The system works effectively with given programming and components. This system is beneficial for industry and government as well because it increases the safety of the driver and stakeholders. However it works for the limited angle set and system become unstable during the power cut-off. For the very heavy vehicle the system requires a heavy block which is economically impractical as it increases the gross vehicle weight and hence the fuel consumption.

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## BIOGRAPHIES

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