Traction Control System –
An Integrated Safety for Two Wheeler

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Abstract—A Traction Control System (TCS) is an active feedback based system whose purpose is to prevent wheels of a vehicle from losing traction which results in improved safety and performance. The basic idea behind the need of a traction control system is the difference between traction of different wheels evidencing apparent loss of road grip that compromise steering control and stability of vehicles. Difference in slip may occur due to turning of a vehicle or differently varying road conditions for different wheels. Compared with cars, the most critical vehicle factor for a motorcycle is the fact that it uses only one-track instead of two. So tilting of the motorcycle has to be avoided by steering which leads to the seriousness of wheel locking while braking when the gyro forces and, even more important, the stabilizing forces at the front wheel diminish. We aim to present an algorithm for implementing TCS (Traction Control System) and its hardware implementation on low-cost real-time system. The systems must be capable of detecting any slip occurring and must be able to cut off a portion of the spark to reduce the torque supplied to the wheel and regain grip thus reducing slippage.

Keywords—Traction control, Arduino microprocessor, Ignition spark, wheel speed sensor.

I. INTRODUCTION

The introduction of TCS in two wheelers is not a recent advancement, but it has remained very exclusive to high end and expensive motorbikes. Also the parts used in these systems were relatively rare and hard to find, since they are used only by a couple of manufacturers in the country. Although no present commuter or sports motorbike manufactured in the country features a TCS, an initiative by even one of the manufacturers may revolutionize the safety of passengers, most of which rely on motorbikes as their sole means of transportation. The number of accidents would drastically reduce as the motorbike would be much more stable on slippery, loose ground surfaces and even on wet surfaces. The rider has to be less cautious about appropriate throttle actuation while accelerating and taking turns and this would greatly influence driveability.

When it comes to driving safety, one of the most misunderstood features available today is traction control. It sounds simple enough to say that traction control has something to do with traction and controlling it. But in actuality, traction control is a more sophisticated system that not only manages traction in specific situations but also enables complete safety to the driver reducing his mental strain during driving and avoiding more damage to the vehicle as well as to the driver. If one is stuck in deep snow and ice, traction control won't help, but in other situations like while taking a turn at high speeds on slippery or loose grounds, accelerating, etc. it will.

In modern vehicles, traction-control systems utilize the same wheel-speed sensors employed by the antilock braking system. These sensors measure differences in rotational speed to determine if the wheels that are receiving power have lost traction. When the traction-control system determines that one wheel is spinning more quickly than the others, it automatically "pumps" the brake to that wheel to reduce its speed and lessen wheel slip [3]. In most cases, individual wheel braking is enough to control wheel slip. However, some traction-control systems also reduce engine power to the slipping wheels. On a few of these vehicles, drivers may sense pulsations of the gas pedal when the system is reducing engine power much like a brake pedal pulsates when the antilock braking system is working.

Motorbikes in comparison have only one driven wheel as compared to four-wheelers which may have 2 or all 4. Hence the control of traction cannot be achieved by redistribution of torque to different wheels. This leaves moderation of torque as the only available option. In a motorbike, the traction control system only monitors the rear and front wheel speed and processes the difference in values to obtain the slip at the rear wheel [1].

It then uses inputs from various other sensors and cuts off the ignition spark for a very small interval or retards the spark to moderate the torque supplied to the rear wheel. Traction control is not just used for improving acceleration under slippery conditions. It can also help a driver to corner more safely. If too much throttle is applied during cornering, the drive wheels will lose traction and slide sideways. This occurs as understeer in front wheel drive vehicles and oversteer in rear wheel drive vehicles [2]. Traction control can prevent this...
from happening by limiting power to the wheels. It cannot increase the limits of grip available and is used only to decrease the effect of driver error or compensate for a driver's inability to react quickly enough to wheel slip.

In general, traction control is achieved by one or more of the following: Reducing or suppressing spark sequence to one or more cylinders. Reducing fuel supply to one or more cylinders. Brake force applied at one or more wheels. Close the throttle, if the vehicle is fitted with drive-by-wire throttle. As of now TCS is available only on high end modern bikes which have high torque outputs which makes them much more vulnerable to skidding and render them unsafe to drive without a TCS. A TCS is also required on modern low torque bikes from a safety point of view but the downsides of high production cost and marketing strategies of the manufacturers reduce the possibilities of any near future production of any such bikes. But a low cost model which is presented here can be fitted to the existing bikes easily to enhance the safety of the driver.

Critical conditions in driving a motorcycle are the rearing up or when the motorcycle is in bend. The objective of the proposed control system is to help the driver in maintaining a secure control of the motorcycle in rearing up and in bend. In both cases, the excessive torque of the engine on the rear wheel may cause the loss of control of the motorcycle. The motive of the proposed work is to provide an easy and inexpensive solution to all this problems that too by cheap and simple means.

II. METHODOLOGY

The main feature of the proposed system is its simple applicability to existing motorcycle independent of the kind of ignition control system. The torque applied to the rear wheel can be controlled reducing the gasoline injected by closing the butterfly valve or reducing the electrical current to the sparking plug. The former cannot be easily obtained without changing the injection controller or carburetor, while the latter has been tried successfully for traction control.

In a motorcycle for basic traction control, front and rear-wheel speeds are monitored with sensors. A loss of traction is indicated by the rear wheel turning faster than the front, and a control unit decreases power by any one of several available means until both wheels are turning at the same speed. These systems reduce the torque to the rear wheel by retarding the ignition timing in case of small slip and skipping firing a cylinder or bypass spark in case of large slippage taking place. Figure 1 shows a general scheme that gives the electrical current to the sparking plug. Every motorcycle has a manual switch used to turn off the engine; the switch simply bypasses to ground the electrical current flowing in the sparking coil. The proposed system modifies the sparking scheme by inserting an additional switch in parallel to the manual turn off switch as shown in Fig 2. This switch is controlled by a microcontroller on the basis of the output of some additional sensors. The different sensors used are

- Wheel speed sensing unit – This unit is responsible for sensing the speed of the wheels, shown in Fig 5. To determine the wheel speeds, hall effect sensors are used at each wheel. The sensors would show a change in output voltage each time a wheel spoke would be in close proximity. The sensors showed the same applied voltage as output when the spokes are in the proximity. The sensors are mounted on the shock absorber shell of the bike in reach of the wheel spokes and also provided with steady mounting points. Hall effect sensors were preferred on optical or magneto motive sensors because of their simple construction and quick sensing capabilities.

- Steering position sensing unit – This sensor senses the angle by which the steering is turned to compensate for any changes in the turning radius of the wheels and to compensate for the difference in wheel speed due to it. It is shown in Fig 6.

- Ignition spark cutoff – This unit is in the form of a switch which must be able to quickly turn on and off and short the spark plug, so that spark duration can be reduced and so does engine torque. It is shown in fig 2.

- Processing unit – An Arduino based microprocessor is used to compare the wheel speed data from the various sensors and actuate the ignition spark cut-off switch. It is shown in Fig 7. The Arduino Duemilanove (“2009”) is a microcontroller board based on the ATmega168 (datasheet) or ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It can be connected to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

III. RESULTS AND DISCUSSION

The effect of the traction controller is shown in Fig 3 and 4. Figure 3 shows the voltage applied to the spark plug during a normal sparking and cut in the pulse, introduced by the traction controller. The cut on the electrical current of the spark plug is obtained in two ways: defining the cut-off delay between the start of the ignition spark and the intervention of the traction control, as shown in Fig 4, and defining the number of consecutive ignition sparks for which the traction control takes action. The ignition spark cut off, imposed by the
traction controller, modifies the torque applied to the wheel.

**Fig 2.** Proposed modification in the sparking circuit of the motorcycle

**Fig 3.** Voltage applied to the sparking plug (top) without traction control and (bottom) with traction control

**Fig 4.** Low and High traction control intervention on the ignition spark.

**Fig 5.** Wheel speed sensor mounted on the front wheel (top) and rear wheel

**Fig 6.** Steering position sensor mounted on the handlebar

**Fig 7.** Arduino microprocessor used for the purpose

A computer code is written in C++ programming language to execute the algorithm. The programme would coordinate the signals from all the sensors and execute the traction control. Spark timing in a CDI (Capacitive discharge ignition) system is achieved by sensing the position of the crankshaft by means of a pickup coil placed in close proximity of the flywheel. The
flywheel has a certain marking or protrusion, which when passes by the pickup generates low voltage DC signal. This signal is used to discharge the capacitor in the CDI unit which is further used to produce the spark. This pickup signal is picked up by means of a comparator circuit and fed into the arduino. The signal marks the start of a spark and the cycle of the arduino starts with respect to it. The sensors are connected to the microcontroller and mounted on the motorbike. A Mosfet switch is connected in the proposed circuit. The microprocessor has data logging capacities when connected to the laptop.

After all the components are mounted on the motorbike, it was tested in running condition. The data logging capacities of the microprocessor helped to obtain experimental data related to the performance of the bike. The bike was tested on a track in a parking lot.

The steering tilt sensor is used to show the position of the steering with respect to the alignment of the bike. The sensor is a potentiometer type, which showed a change in the output resistance to indicate the steering tilt. Knowing the steering tilt gives the information about the exact turning radius for the wheels which would affect their turning speeds for a turn taken at a certain speed. The system would then compensate for the difference in wheel speeds.

The front wheel speed and rear wheel speed are estimated, and their difference is used to calculate the width of the cut on the electrical current of the spark plug. When the microcontroller receives an interrupt from the wheel speed sensors, it evaluates if the ignition spark cut must be actuated or wait for the cut off delay. When it receives the signal that indicates that the ignition spark started, it eventually waits for a time equivalent to the cut off delay and operates the ignition spark cut. The algorithm has been translated in assembly code and implemented in the Microchip PIC18F6527 microcontroller with 40MHz clock, 10MHz bus clock, and 100 nanoseconds instruction time.

The time required for the traction control by the microcontroller is negligible compared with the minimum time between two consecutive ignition sparks. The average time interval between two pulses coming from the hall sensor is used to estimate the wheel speed (about 20 milliseconds for a speed of 20m/s). Therefore, the digital controller implemented is able to control in real time the traction of the motorcycle.

The control algorithm used is shown in Fig 8. The parameter settings are stored in the memory, but they can be modified by the driver during the running using push-buttons to increment or decrement the values of $\varepsilon$ and $\delta$. The parameter $\delta$ is the minimum increment or decrement of the cut off delay represented in Fig 3. When the ignition cut is higher than a fixed value, the ignition spark is completely eliminated and the width of the successive ignition spark is reduced.

The complete elimination up to three successive sparks does not affect the performance and driving, as it has been verified by experimental results in a real track [4].

Fig 8. Control algorithm implemented in the microcontroller.

IV. TESTING

The output signal of the system is tapped in the form of an LED connected to the microprocessor. The system is rigged onto a Bajaj Pulsar 150 motorbike. The sensors were mounted very close to the wheel axis on the shock absorber.
Sensor Test:
This experiment is performed to check the accuracy and sensitivity of the sensors. The wheel speed sensor is first rigged to the brake hub of the front wheel and the bike is run. A microprocessor is programmed to trigger an LED each time a spoke passed by it when the wheel is rotating. Also the compiler is programmed to print the value when the LED is triggered after each second. The approximate wheel speed values are noted at that instant of time and a rough estimation is done. The results are shown in Fig 9.

Front wheel RPM test:
The experiment is performed to produce the values of wheel speeds in the form of RPM of the wheel. The microprocessor was programmed to register the number of spokes passing the sensor every second and display the value in the compiler by means of print command. The same arrangement of sensors is used on the front wheel. Fig 10 shows the details of the front wheel RPM vs. vehicle speed as shown by the speedometer. It agrees perfectly with the theoretical RPM.

CONCLUSION
From the results obtained it can be concluded that traction control mechanism is effective in determining very accurate wheel speeds and comparing them.
The system is able to effectively control the traction and is very useful for the safety of the two wheelers.
The system can be connected to the two wheeler as an add-on system at any time so that it is very cost effective.

The system is also effective in reducing the torque to the rear wheel by trimming or skipping the spark efficiently. The experimental results show good agreement with the theoretical.

A more accurate tuning of the parameters of the controller will result in more efficient track control and more safety to the driver.

Fig. 9 Frequency of blinking of an indicator LED vs wheel speed

Fig. 10 Theoretical and experimental values of the front wheel speeds in RPM vs the vehicle speed.

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