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Automatic Traction Motor Control using Arduino for Conventional Loco

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ABSTRACT

A locomotive used for traction which is powered by electricity from overhead line is known as electric locomotive. While the time of run of the locos, there arise situations that the motor consumes current that is above the maximum or below the minimum ratings. This phenomenon causes the motor to rotate abnormally which leads to wheel slipping problem, flashover, burning out of contactors etc. If we could prevent these undesirable abnormalities a lot of money can be saved and also the maintenance works gets reduced. This obliged the development of a system that assists us in detecting the unusual current consumption so that most of the undesirable abnormality can be avoided. Presently there are mechanical systems that help us in detecting this problem which operates after the abnormality occurred. This paper aims in developing such a system using a ARDUINO that monitor the important parameters like current, voltage, speed, temperature consumption of each motors of the loco continuously and alerts the loco pilot for any unusual current consumption. If that situation arises the specific faulty motor can be isolated by the loco pilot or by the proposed system before it gets damaged.

***KEYWORDS:* Locomotive, Traction motor control, Arduino.**

I. INTRODUCTION

The Railway is the largest means of transportation in India and it is ranked in the world as the fourth largest railway network. The electric Locomotives (WAP4 & WAG7) uses 1.5 kV DC around Bombay and 25Kv ac is used in rest of the country. The traction OHE required 25 kV supply, so only two phases are taken and step down to single phase 25 kV through a transformer which is present at traction substation. This 25kV is fed to the OHE from feeder then to loco via pantograph which is at the roof of loco. The electric Locomotives (WAP4 & WAG7) used by the Indian Railways uses 6 DC series motors. The improvement of adhesion characteristics is important in an electric commuter train.

A. Operation of locomotives

The electric locomotive basically works at 25 KV, 50Hz supply. The 25KV AC supply is drawn from overhead equipment. It is shown in the Figure-1.

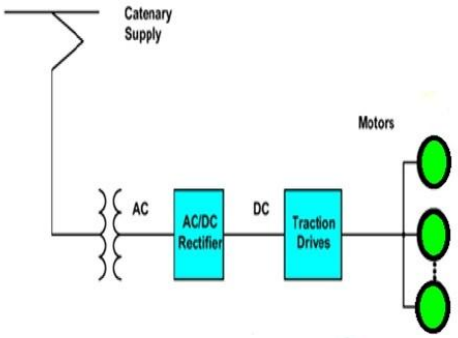

Figure-1 Supply unit of locomotive.

The supply of electricity is through an overhead system of suspended cables known as the catenaries (OHE). A contact wire or contact cable actually carries the electricity. The locomotive is equipped with two pneumatically controlled pantographs. The supply from overhead wires is drawn through these pantographs inside to the loco. The pantographs transfer the power to transformer after passing through the normally the tap changer is fed to the primary of the main transformer. The main transformer steps down the voltage to a lower level. The voltage from the secondary of main transformer is fed to bridge rectifier and then fed to traction motor through the motor contactors. There are 6 traction motors which works parallel to provide the tractive effort for hauling the train. Conventional loco employed the DC motors which are known as the traction motors.

B. Wheel Slip

In the case of traction, wheel slip is the major problem which required more attention. At present, Wheel slip on locos (WAP-4/WAG-7), is detected by a relay which is known as 'QD' and it is a current differential relay. It detects the difference in the current flow between the two traction motors.

If all the traction motors are running at uniform and equal speeds, the armature of the relay remains balanced. However, if any of the axles are slipping, the current to this motor is slightly reduced producing a current imbalance in relay QD which is then triggered. QD gives a repeat to a relay 'Q48' which in turn may activate some automatic wheel-slip reduction procedures. Operation of relay Q48 also activates the LSP (Signal lamp to indicate Wheel-Slip) on the driver's desk.WAG-7 and WAP- 4 has been provided with mainly two methods to minimize wheel slip:

- SANDERS
- AUTO REGRESSION OF THE TAP CHANGER

Though the differential relay is used to detect wheel slip, it intimates to the LP after the fault state is reached. On that time, the LP (loco pilot) has to execute the control operations only by the self assumptions. The solution for this problem is proposed in this paper.

II. EXISTING SYSTEM

The conventional loco currently used the mechanical systems for preventing a motor from behaving abnormally. Continuous consumption of current is enough to overheat and cause failure of the motor. Presently there is no reasonable ways for the loco pilot to understand the current consumption behavior of a motor and avoid the flashing and other problems related to these motors. Probability for a faulty traction motor in the locos received for maintenance in the loco shed is comparatively high. The traction motors consumes a reasonable amount of the total cost that is used to build up a locomotive hence its frequent failures and maintenance is not really appreciated. The lesser the failure the more efficient it is and the lesser the maintenance required.

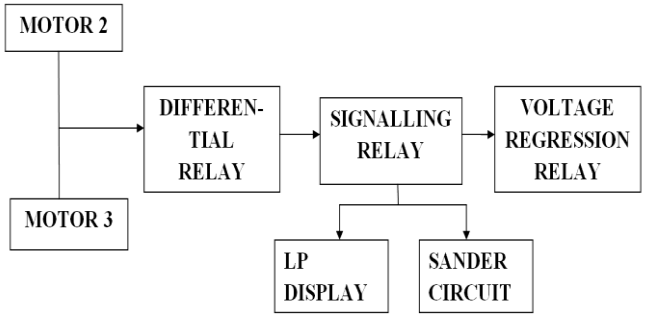

Figure-3 Existing system

A. Detection of wheel slip

Wheel slip on locos is detected by a current differential relay named as QD. It detects the difference in the current flow between two traction motors. If all the traction motors are running at uniform and equal speeds, the current through the relay remains balanced. However, if any of the axles is slipping, the current to this motor is slightly reduced producing a current imbalance in relay QD which is then triggered. QD gives a repeat to a relay 'Q48' which in turn activate some automatic wheel-slip reduction procedures. Operation of relay Q48 also lights the LSP (Signal lamp to indicate Wheel-Slip) on the driver's desk.

B. Auto-Regression of the Tap-Changer to reduce tractive effort

Q-48 also gives an impulse to relay Q-51 (Relay for Auto-Regression of Tap-Changer) to reduce the notches which in turn lowers the voltage to the traction motors thereby reducing the tractive effort.

C. Limitations

In previous method, LP (loco pilot) is not able to identify which motor works abnormally. To monitor parameters like voltage, current, speed, temperature of each motors separate units are required. Traction motors 1 and 6 are not considered by this method. Loco pilot take more time to clear the fault by assumption method. It may lead to the major accident in a fraction of time. It reduces the efficiency of the engine. These considerations will promote the proposed system design.

III. PROPOSED SYSTEM

In this paper, the system is developed such a way that would help the loco pilot to find out which motor is actually consuming the unusual current. For that we have to continuously monitor the power flow in all traction motors and isolate the fault motor by receiving the signal from the control unit so that the other motors work and produce the necessary effort to pull the load. This would help a lot to increase the efficiency of the engine. The present system is an electromechanical system. To achieve this Arduino is proposed here.

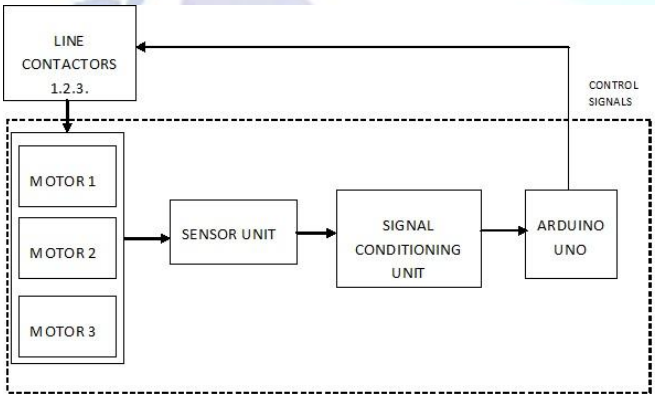

Figure-3 Block diagram of proposed system

From the line contactors motors of the conventional loco powered which is enclosed in the dotted lines shown in Figure-3. The control actions are implemented by the system which contains sensor unit, signal conditioning unit and Arduino.

A. Sensor unit

The traction motors are continuously monitored for the proper and safety traction. Various sensors used to detect the multiple parameter of a single motor to avoid a major problem. Current sensor, voltage sensor, speed sensor, temperature sensor, smoke detector are used here. They are used to monitor the motors continuously and the data are stored in the memory unit of an Arduino.

B. Signal conditioning Unit

The received signal from the sensor unit is given to the Arduino controller through the signal conditioning unit. Where the received signal is conditioned and made ready for the next stage of processing.

C. Arduino

Arduino Mega 2560 Rev 3 Microcontroller Board is based on the Atmel ATmega2560 8-bit microcontroller (MCU). Arduino Mega 2560 features 54 digital input/output pins (15 of which can be used as PWM outputs) and 16 analog inputs. This Arduino MCU board also includes 4 UARTs (hardware serial ports), a 16MHz crystal oscillator, a USB connection, a power jack, an In-Circuit Serial Programming (ICSP) header, and a reset button.

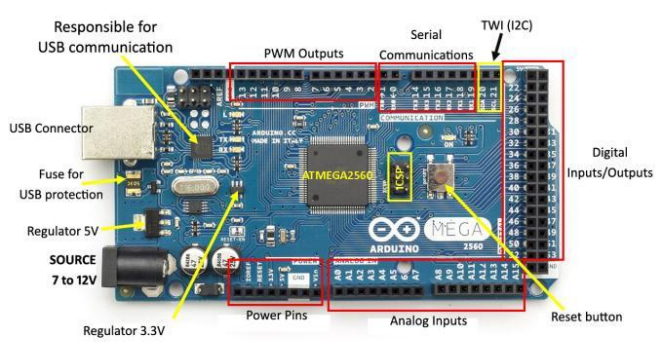

Figure-2 Arduino mega 2560

ATmega 328 includes everything the user needs to support the MCU. The user can get started by connecting the ATmega 328 to a computer with a USB cable or by powering it with an AC-to-DC adapter or battery. ATmega 328 is an update to the earlier Arduino Mega board.

IV. SYSTEM IMPLEMENTATION

The system which is shown below contains motors, Arduino controller, sensors which is developed in the Proteus 8 Professional software platform. The Arduino is programmed in the separate Arduino software and it is called into the

simulation. We have connected the display board to understood the working condition of the each motors to help the LP.

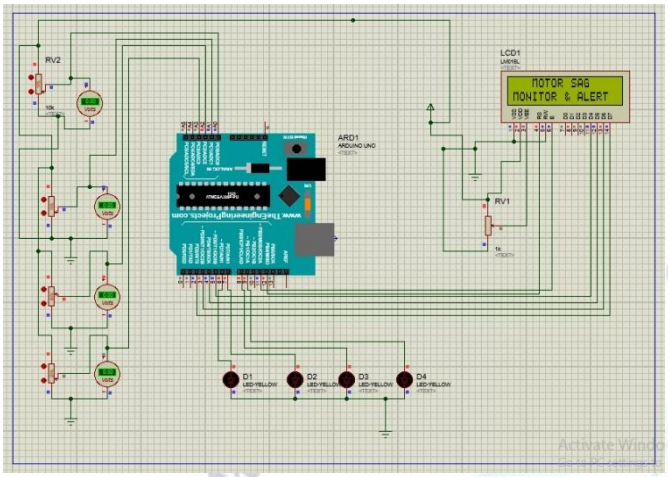

Figure-4 system implementation

Traction motors 1, 2, 3 along with sensors are connected to pin numbers 23, 24, 25 (PC0, PC1, PC2) which are known as analog input of Arduino board respectively where the motor data are monitored. The led indicators are connected to the pin numbers 5, 6, 7 (PD7, PD7~) which are commonly known as digital pin outputs. These are indicators used to alert the LP. In addition, to notify clearly about the particular motor LCD display is connected to the digital pin of the board.

V. RESULT

When all the connections are made, the train is ready for safe run. When the loco is started to working, all the sensors get ready to read the data like current, voltage, speed, temperature and smoke of a individual motors. Initially, we set the permissible value for all the parameters in the control unit. Compare the sensed data with the set value.

A. CASE 1:

If the sensed data are within the limits, it remains the normal operation that is the loco is running without interrupt and the values of sensed data are displayed in the LP desk.

B. CASE 2:

If it is exceed the permissible limit, the alarm will be enabled to alert the LP. He can able to know which motor works abnormally and what type of fault is occurred. If the fault is cleared, the alarm will be disabled. And the loco remains the normal operation. The LP can recognize the fault motor by the particular LED. (Every motor has its own individual LED). And in this case, if the LP failed to take the action to clear the fault (i.e., the time delay exceeded) the system automatically cuts down the supply to the motor hence the loco comes to off state.

VI. CONCLUSION

The need of electric locomotives in the future of railway network is very high. The punctuality of Express trains is important to maintain reliability of the service. To avoid any unwanted wheel slips in locomotives and thereby causing time loss on run the maintenance as well as driving methods need improvement. The implemented SCADA based system is useful to identify the exact location of fault among all traction motors by monitoring the real time data of traction motors and the intimation is given through a text on LCD via alarming system. The fault of the traction motor is detected with the help of multiple sensors. This project ensures the safety of the conventional loco and reduces the time taken for the fault clearance.

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