Quest Journals
Journal of Research in Mechanical Engineering
Volume 9 ~ Issue 4 (2023) pp: 13-19
ISSN(Online):2321-8185
www.questjournals.org

Research Paper

Development of Automotive Electrical System Training Model

David Silwano Mtunguja[1*], Seba Abel Maginga[1] Baraka Kichonge[2]
[1]Department ofAutomotive Engineering, Arusha Technical College (ATC), P.O. Box, 296 Arusha, Tanzania
[2]Department of MechanicalEngineering, Arusha Technical College (ATC), P.O. Box, 296 Arusha, Tanzania.

Abstract
An Automotive Electrical Systems Training Model is a set of automotive electrical wirings that have been isolated from the rest of the vehicle for training purposes. In this project, an attempt has been made to incorporate as many wires and harnesses as possible into the room so that the students can see and understand during instructions/demonstrations. For students pursuing/undertaking a degree program in Automotive Electronics Engineering, the model will provide the simplest means of obtaining knowledge and abilities on automotive electrical wiring, installation, troubleshooting faults, and measuring power consumption losses in automobiles.

Keywords: *component; formatting; style; styling; insert (key words)*

***R**eceived 02 Apr., 2023; **R**evised 12 Apr., 2023; **A**ccepted 15 Apr., 2023 © The author(s) 2023.*
P**ublished with open access at **www.questjournals.org

I. INTRODUCTION

The surveys show that most of the higher learning institutions there have no simplified automotive training models for vehicles, electrical and electronics systems. Most of the degree holders in Automotive Electronics Engineering and those of Automotive Engineering are not capable of solving automotive electrical faults.In most of the workshops and in the market, there is very little expertise that is really competent in automotive electrical wirings, even those who completed a degree in Automotive Electronics Engineering and Automotive Engineering.The increasing use of electronics in the vehicle has made it important to study the effect on power consumption and losses in transmission due to an individual components.

An Automotive Electrical System is the master controller of all automotive operating systems. Generally, the automotive electrical systems are complicated for the students to learn while in the vehicle, which makes it difficult to comprehend the required knowledge and skills of the students according to the market demands. In this project, we made an attempt to incorporate wires and harness in such a way that the student can understand the circuit and it works during instruction and demonstration.It is the simplest way to provide knowledge about the wiring in automobile electrical component.In this model, we have kept provisions to take the reading of voltage and current across various components which will help them to understand the power consumed by each device and the losses occurring during transmission.

Completion of the project will help in the training program of Automotive Electronics and to produce highly qualified Automotive Electronics experts.

II. SYSTEM

System is a group of devices serving a common purpose. It describes a collection of related components, which interact as a whole. A large system is often made up of many smaller systems, which in turn can each be made up of smaller systems and so on. Systems approach helps to split extremely complex technical entities into more manageable parts.

The modern motor vehicle is a very complex system and, in itself, forms just a small part of a larger transport system. It is the ability for the motor vehicle to be split into systems on many levels that aids both in its design and construction.

A. Vehicle as a System.

Once a complex set of interacting parts, such as a motor vehicle, has been systemized, the function or performance of each part can be examined in more detail. Functional analysis determines what each part of the system should do and, in turn, can determine how each part actually works. It is again important to stress that the links and interactions between various subsystems are essential consideration. An example of this would be how the power requirements of the vehicle lighting system will effect on the charging system operation.

B. Open Loop System.

An open-loop system is designed to give the required output whenever a given input is applied. A good example of an open-loop vehicle system would be the headlights. With the given input of the switch being operated, the output required is that the headlights will be illuminated. The feature that determines that a system is open loop is that no feedback is required for the system to operate.

C. Closed-Loop System.

A closed-loop system is identified by a feedback loop. It can be described as a system where there is a possibility of applying corrective measures if the output is not quite what is desired. A good example of this in a vehicle is an automatic temperature control system. The interior temperature of the vehicle is determined by the output from the heater, which is switched on or off in response to a signal from a temperature sensor inside the cabin.

III. SYSTEMS ATTACHED TO THE MODEL

The systems attached to the Automotive Electrical Systems Model designed are as follows:

1. StartingSystems.
2. Horn System.
3. Lightning System:

a. Head Lamp Circuit.
b. Indicator Light Circuit.
c. Parking Light Circuits.
d. Reverse Light Circuits.
e. Brake Light Circuits.
f. Hazard Light Circuit.

A. Starting system

The starting system is for cranking the Engine during starting, In this training model the starting circuit comprised of **battery** is the source of electrical power , **fuse** for protecting the circuit in case of any electrical fault it breaks ,**starter switch** opens and closes the circuit when required,**starter relay** uses low current to control high current, **4mm square** wire specified wire standard for the starting circuit to run the motor, **starter solenoid** acts as a relay its function is to connect battery voltage to the starter motor in some starter motors solenoid performs two tasks connecting the battery voltage to the starter motor and pushes the pinion to engage with the flywheel during starting the engine by means of fork leverand **Starter Motor** the motor to crank the engine during starting. Thus the mentioned components are connected in this training model as per technical specifications and the system is working.

Typical starting limit temperatures are a_18 °C to _25 ° C for passenger cars and _15 ° C to _20 °C for trucks and buses. Figures from starter manufacturers are normally quoted at both _20 ° C and _20 ° C.

B. Horn System:

Horn system comprises of fuse, button switch, horn relay, and one set of horns, the components in this model are connected as per technical specifications tested and is working.

Operation of horn circuit;

The standard horn operates by simple electromagnetic switching. As the current flow causes an armature that is attached to a tone disc to be attracted to a stop, a set of contacts is opened. This disconnects the current allowing the armature and disc to return under spring tension. The whole process keeps repeating when the horn switch is on. The frequency of movement and hence the fundamental tone is arranged to lie between 1.8 and 3.5 kHz.
speed of travel.

IV. SYSTEM DESIGN

Cables used for motor vehicle applications are almost always copper strands insulated with PVC. Copper, besides its very low resistivity of about 1.7 x 10-8 Ωm, has ideal properties such as ductility and malleability.

The choice of cable size depends on the current drawn by the consumer. The larger the cable used, then the smaller the volt drop in the circuit, but the cable will be heavier. This means a trade-off must be sought between the allowable volt drop and the maximum cable size.

A. Starter Motor Selection.

The starter motor must fulfill the criteria discussed earlier. From the comparison of the engine cranking torque with the minimum cranking speed, the torque required from the starter can be determined.

The curve represents the torque, speed, power, and current consumption of the starter at 293 K and 253 K. The power rating of the motor is provided as the maximum output at 253 K using the recommended battery. A greater torque is required for engines with a lower number of cylinders due to the greater piston displacement per cylinder.

As a very general guide, the stalled starter torque required per liter of engine capacity at the starting limit temperature is:

1. 12.5 Nm/1 for twin- cylinder engine.
2. 8.0 Nm/1 for four- cylinder engine.
3. 6.5 Nm/1 for six- cylinder engine.
4. 6.0 Nm/1 for eight- cylinder engine.
5. 5.5 Nm/1 for twelve- cylinder engine.

Consideration for selecting the starter motors:

To illustrate the link between torque and power, we can assume that, under the worst conditions (-20° C), a four-cylinder 2-litre engine requires 170 nm to overcome static friction and 55 nm to maintain the minimum cranking speed of 100 rev/min. With a starter pinion-to-ring gear ratio of 10:1, therefore,the motor must be able to produce a maximum stalled torque of 17 nm and a driving torque5.5 Nm.

The relation between the torque (T) generated by motor and power (P) is the product of torque and angular velocity, given as:

$$P=T\times\omega$$

Where, $\omega = 2\pi n/60$.

n is rpm.

Therefore, the output power developed at 1000 rpm with a stalled torque of 5.5 Nm (at the starter) is about 600 W. In Figure1 the ideal choice appears to be the starter with frame size ø78 mm.

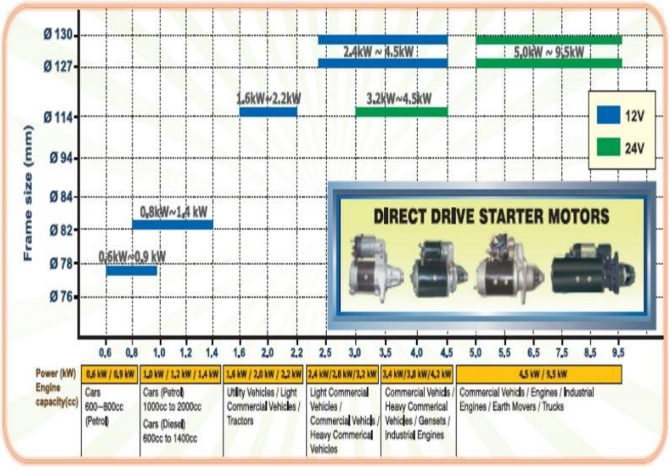

Figure 1. Starter Motor Selection Chart [3]

The selected starter motor is SM6Hstarter motor with a frame size of ø78 mm operating at 12.6 volts, which can be used to drive the engine of about 600 to 800 cc.

Losses in power transmission:

Power consumed by the starter motor: 600W.
Current Required: 50A
Available Voltage: 8.4V
Loss for $4mm^2$ wire of length 1 meter is3.6V

B. Head Lamp System

Head lamp system operates under two circuits, one is high beam circuit, and low beam circuit the components of headlamp system are two fuses one for high beam and the other for low beam, the headlamp switch which controls the high beam and the low beam two headlamp relays and the headlamps. To provide the required power we must calculate the voltage supplied by battery after losses in power transmission.

Losses in the power transmission:

Power consumed by Head Lamp: 55W x 2nos = 110W.

Current required: 9.16 Amp.
Available Voltage: 11.85 V
Losses in transmissionfor 2.5mm^2 wire of length 1 meter is 0.15V

C. Indicator Light System

The turn signal switch is mounted within the steering column and operated by a lever. Moving the lever left or right closes the contacts to draw current from the flasher unit and to the appropriate turn indicator lamps. A turn signal switch includes cams and springs that cancel the signal after the turn has been completed. That is, as the steering wheel is turned in the signaled direction and then returns to its normal position, the cams and springs separate the turn signal switch contacts. The bulbs used for turn signal lamps are the S-8 single-contact bayonet base.

Losses in power transmission:
Power consumed by indicator lamp: 21W x 2nos = 42W,
Power consumed by Flasher unit: 4W,
Total Power consumed: 46W,
Current required: 3.83Amp,
Available voltage: 11.91V,
Losses in transmission for 2.5mm^2 wire of length 1.5 meter is 0.09V

D. Parking Light System

These lamps usually share a single circuit because they must be lit at the same time. Since the main headlamp switch controls the lamps, they can be lit whether the ignition is on or off. These lamps are controlled by contacts within the main combination switch. They can be lit when the headlamps are off. A fuse protects the circuit. The bulb used for parking light lamps is the S-8 single-contact bayonet base.

Losses in power transmission:
Power consumed by parking lamp: 5W x 4nos = 20W,
Power consumed by Flasher unit: 4W
Total Power consumed: 24W
Current required: 2Amp
Available voltage: 11.94V
Loss in transmission for 2.5mm^2 wires of length 2 meters is 0.06V

E. Reverse Light System

These lamps are for other drivers to see while taking the reverse, it indicates the other driver of vehicle backward motion. The reverse switch is placed in the gear assembly. When the driver shifts to the reverse gear, it closes the contact of the reverse switch and connects the battery to the reverse lamp through fuse. The bulb used for reverse light lamps is the S-8 single-contact bayonet base.

Loss in power transmission:
Power consumed by reverse lamp: 21W x 2nos = 42W,
Current required: 3.5Amp,
Available voltage: 11.94V,
Loss in transmission for 2.5mm^2 wires, of length 1 meters is 0.06V

F. Brake Light System

Brake lamps which are always red. When the brakes are applied, the brake switch is closed and the stop lamp light. The brake switch receives current from the fuse panel when the brakes are applied; the filament receives a steady flow of current through the brake switch and special contacts in the turn signal switch. The bulb used as stop signal lamps are the S-8 double-contact bayonet base

Loss in power transmission:
Power consumed by reverse lamp: 26W x 2nos = 52W,
Current required: 4.33Amp,
Available voltage: 11.93V
Loss in transmission for 2.5mm2 wires of length 1 meter are 0.07V

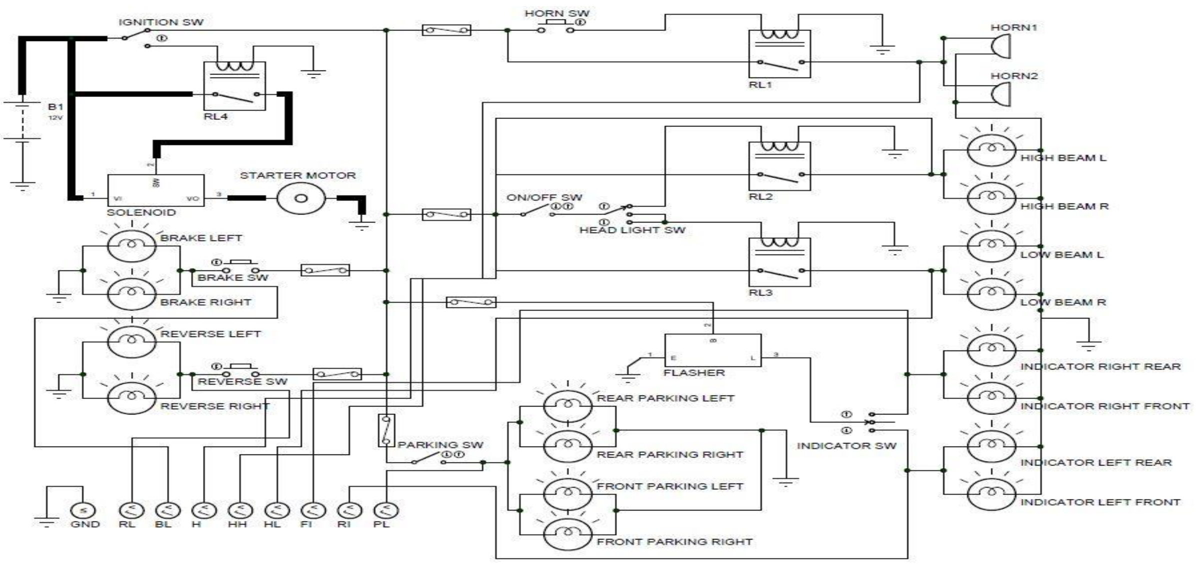

Figure 2. Circuit Diagram

G. Hazard Light System

It is designed to warn other drivers of possible danger in emergencies. The hazard warning lamp circuit uses the turn signal lamp circuitry, a special switch, and a heavy-duty flasher unit. The switch receives the battery current through the fuse panel. When the switch is closed, all car's turn signal lamps receive current from the flasher unit. An indicator bulb in the instrument panel provides a parallel path to the ground for some of the flasher current. The hazard warning switch can be a separate unit or it can be part of the turn signal switch. In both cases, the switch contacts routes battery current from the fuse panel through the hazard flasher unit to all turn signal lamps at once.

Loss in power transmission:
Power consumed by parking lamp: 21W x 4nos = 84W,
Power consumed by Flasher unit: 4W,
Total Power consumed: 88W,
Current required: 7.33Amp,
Available voltage: 11.76V,
Loss in transmission for 2.5mm^2 wires of length 2 metersare 0.23V

H. Horn System

An automobile horn is a safety device operated by the driver to alert pedestrians and other motorists. Battery current is supplied to the horn circuit through the fuse panel, or from a terminal to the starter, relay, or solenoid. Normally an open horn switch is installed between the power source and the grounded horn.

When the driver pushes the horn button, the normally open relay the contacts are between the power source and the grounded horn. The horn switch is between the relay coil and ground.When the horn switch is closed, a small amount of current flows through the relay coil,this closes the relay coil and allows a greater amount of current to flow through the horns. The car with more than one horn, each horn will form a parallel path to ground.

The horn switch is normally installed in the steering wheel or steering column. Contact points can be placed so that the switch will be closed by pressure at different points on the steering wheel. All of these designs operate in the same way: Pressure on the switch causes contacts to close. When the pressure is released, the spring tension opens the contacts.

The horn circuit often shares a 15- to 20-ampere fuse with several other circuits. It may also be protected by a fusible link.

Loss in power transmission:
Power consumed by horns: 24W x 2nos = 48W,
Current required: 4 Amps,
Available voltage: 11.93 V,
Loss in transmission for 2.5mm^2 wires of length 1 meters is 0.07V

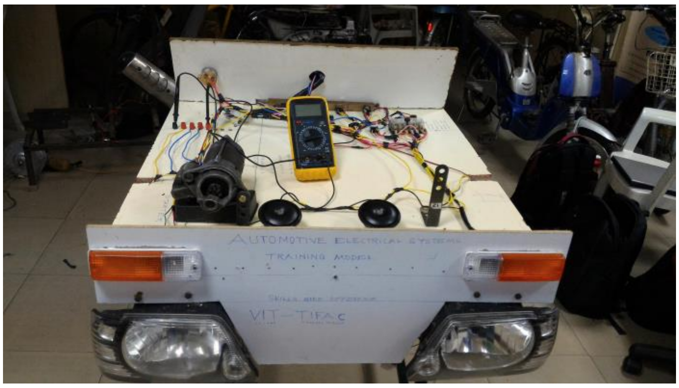

Figure 3. Designed Model

I. Selection of cable

Wire length also must be considered when designing electrical systems or repairing circuits. As the conductor length increases, so does resistance. An 18-gauge wire can carry a 10-ampere load for 10 feet without an excessive voltage drop. However, to carry the same 10-ampere load for 15 feet, a16-gauge wire will be required. Thus, the volt drop in a cable can be calculated as follows:

Calculating the current: $I = P/V$

Volt drop: $V_d \rho IL/A$

Where:

I =current in amps,
P=power rating of component in watts,
V_s=system supply in volts,
V_d=volt drop in volts,
ρ =resistivity of copper in Ωm,
L=length of the cable in m,
A =cross sectional area in m2

Table 1. Types of Cables

Conductor		Loomed Wires		Unloomed Wires	
Cross Sectional Area (mm^2)	Number & Diameter of Wires	Current Rating (Amps)	Volt drop per Amp per meter (mV)	Current Rating (Amps)	Volt drop per Amp per meter (mV)
1.0	1@1.13	11	40	13	40
1.5	1@1.38	13	27	16	27
2.5	1@1.78	18	16	23	16
4	7@0.85	24	10	30	10
6	7@1.04	31	6.8	38	6.8
10	7@1.35	42	4.0	51	4.0
16	7@1.70	56	2.6	68	2.6
25	7@2.14	73	1.6	89	1.6
23	19@1.53	90	1.2	109	1.2

Cable is available in stock sizes and Table 1 lists some typical sizes and uses. The current rating is assumed that the cable length is not excessive and that the operating temperature is within normal limits.

References

[1]. G. Eason, B. Noble, and I.N. Sneddon, “On certain integrals of Lipschitz-Hankel type involving products of Bessel functions,” Phil. Trans. Roy. Soc. London, vol. A247, pp. 529-551, April 1955. (*references*)

[2]. J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68-73.

[3]. I.S. Jacobs and C.P. Bean, “Fine particles, thin films and exchange anisotropy,” in Magnetism, vol. III, G.T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271-350.

[4]. K. Elissa, “Title of paper if known,” unpublished.

[5]. R. Nicole, “Title of paper with only first word capitalized,” J. Name Stand. Abbrev., in press.

[6]. Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, “Electron spectroscopy studies on magneto-optical media and plastic substrate interface,” IEEE Transl. J. Magn. Japan, vol. 2, pp. 740-741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].

[7]. M. Young, The Technical Writer’s Handbook. Mill Valley, CA: University Science, 1989.

[8]. Denton, Tom. Automobile electrical and electronic systems. Routledge, 2004.

[9]. Chart, Chek. Automotive electrical and electronic systems: Classroom manual. Vol. 1. Prentice Hall, 2000.

[10]. http://www.lucas-tvs.com/lucastvs/starter.aspx