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ELECTRICAL UNITS FAULT ANALYSIS IN AUTOMOBILES

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Abstract: Safety of automobiles and its environmental protection is increasingly dependent on the correct functioning of its electrical and electronically controlled systems. Presently, there are insufficient data about the consistency of these systems and how their faults could be perfectly resolved in Nigeria. This study evaluated the frequent electrical faults of some automobile brands commonly used in Kwara State of Nigeria. Available data on the reliability of such systems was obtained from a number of sources across Kwara state. Analysis of data involved five brands of automobiles frequently used within Kwara state. Most electrical faults were observed to occur more frequently in older models of vehicles.

Keywords: Electronic Control Unit (ECU); Anti-lock Braking System (ABS); Satellite navigation unit (Sat/Nav); Engine Management System (EMS)

INTRODUCTION

Fault analysis is a method used to determine the various chains of effects that would cause a system to fail, compromising that systems safety or its stability. The automobile is one of the world-wide technologies which are in constant evolution.

Modern vehicles employ dozens of electronic systems. These systems are responsible for operational controls such as throttle, brakes and steering controls as well as many comfort and convenience systems such as the heating, ventilation and air conditioning, HVAC, info/entertainment, lighting systems etc. It would not be possible for automobiles to meet modern safety and fuel economy requirements without electronic controls. (Engineering Overview, 2014.)

BACKGROUND

Electronically controlled systems of increasing complexity are being fitted in growing numbers to new vehicles as vehicle safety and environmental protection is increasingly dependent on the correct function of these systems. Since the introduction of electronic systems in the 1960's there has been a rapid growth in their use on vehicles.

From the earliest examples such as cruise control and the replacement of dynamos with alternators, to the current Anti-Lock Braking System (ABS) and engine management systems (EMS), the market has been overwhelmed with technological developments. Presently, there are only but a few available data concerning these electrical faults and their hazardous evaluation in Nigeria (Eckermann, 2011). In recent times, mechatronics is applied in automobiles for outdoor locking, collision avoidance and in ignition and antiroll systems (Singh *et. al.*, 2006).

METHODOLOGY

— Study Area

Kwara state with the latitude: 8.5 and longitude: with latitude (DMS):8^0 30' 00^0N and longitude (DMS) 5° 00' 00'E N. Kwara state shares boundaries with the Republic of Benin at the west and the Niger River at her North. The capital city of Ilorin is situated 306km inland from the coastal city of Lagos and 500km from the Federal Capital Abuja. Major towns include Offa and Jebba, located on the Niger River.

— Data Acquisition

Electronic faults data was obtained and compiled from auto mechanic workshops across Offa and Ilorin in Kwara state through the use of questionnaire and public interviews. Five commonly used automobiles brands was considered in this study. These brands include Toyota, Volkswagen, Mercedes, Peugeot and Nissan. The faults of these brands were analyzed using their models ranging from the year 2000 to 2016.

— Data analysis

The descriptive statistical analysis was generated from the data and information obtained in the course of this study using SPSS and comparison of result obtained from this process.

Table 1(a): Common Electronic Related Faults

Brands	Common Electrical Failed Parts
Mercedes	Anti-lock brake system (ABS), airflow meter, airbags, body control module (BCM), central locking system, seat controllers, throttle bodies, transmission control and climate control (CCU).
Toyota	ABS, climate control unit, ECU, satellite navigation units (Sat/Nav), EPS, dash board/ instrument cluster, information display unit and throttle bodies.
Volkswagen	ABS, yaw sensor, anti-theft lock, airbag, body control unit, central lock system, ECUs and ECMs, EPS/EHPS, information display unit, instrument cluster, throttle bodies, transmission control module, radio, turbo actuator.

Table 1(b): Common Electronic Related Faults

Brands	Common Electrical Failed Parts
Peugeot	ABS, airbags, airflow meters, body control, climate control, display unit, ECUs/ Engine control module (ECM), EPS/EHPS, instrument clusters, radios, roof controllers and pumps, throttle body and stalk control.
Nissan	ABS, Body control unit, climate control unit, ECMs/ECUs, Electric power steering (EPS), Electric hydraulic power steering (EHPS), instrument clusters and throttle bodies.

Source: Jack (2007)

A bar chart for comparison of the percentage of electrical faults analyses between the five brands of automobiles was generated using an SPSS package. Table 1(a) and (b) shows the faults that frequently occur in brands of vehicles plying Nigerian roads.

RESULTS

— Fault Analysis on Toyota

The faults that commonly occur in Toyota Avensis include the engine sensor, horn, dashboard/instrument cluster and ABS pump. This study shows that ABS pump was estimated as 28.6, dashboard/ instrument cluster as 23.2, engine sensor as 21.4 and the horn as 26.8% as shown in Figure 1.

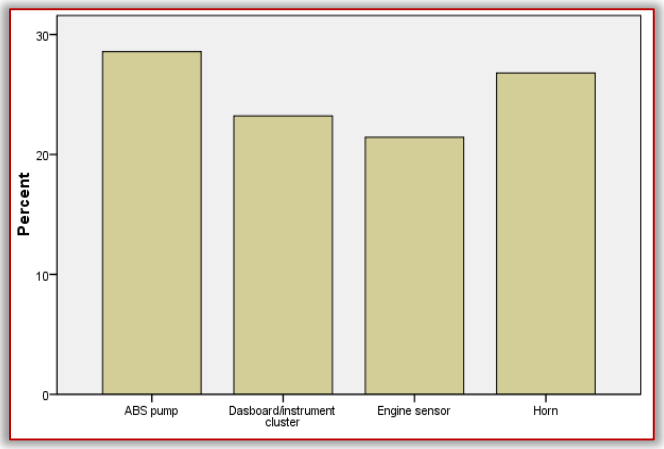

Figure 1: Comparative chart of electrical faults in Toyota Avensis

The faults that frequently occur in Toyota Camry include the dashboard/instrument cluster throttle body and alternator. Figure 2 shows the frequency of occurrence of these faults. The dashboard/ instrument cluster failure was estimated at 42.1, throttle body as 23.7 and the alternator as 34. 2%.

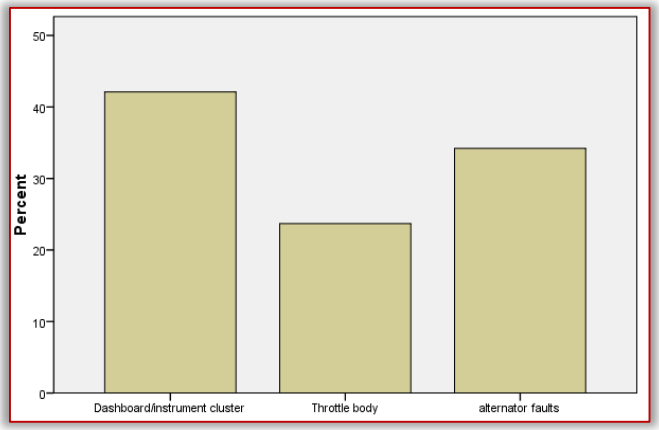

Figure 2: Comparative chart of electrical faults in Toyota Camry

The faults that commonly occur in Toyota Rav4 include the dashboard/instrument cluster ABS modulator, ABS pump, climate control unit, ECM ECU and SRS ECU. The dashboard/ instrument cluster failure was estimated at 26.2, ABS modulator as 16.4, ABS pump as 11.5, climate control unit as 6.6, ECM ECU as 21.3 and SRS ECU as 18.0% as shown in Figure 3.

The faults mostly experienced by users of Toyota highlander include the CCU and the information display unit. The CCU failure was estimated to be 31.6 while that of information display was estimated to be 68.4% as indicated in Figure 4.

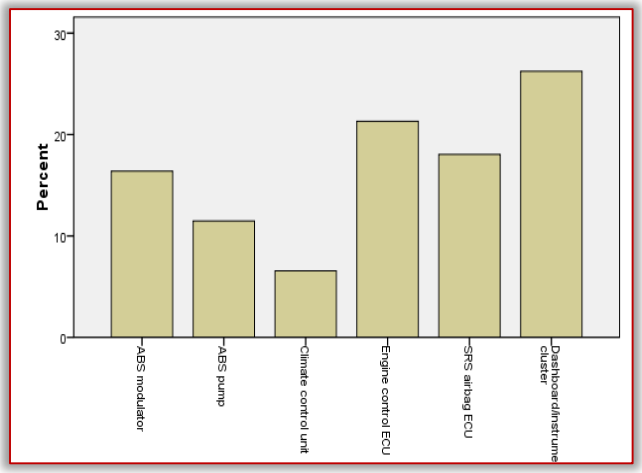

Figure 3: Comparative chart of electrical faults in Toyota RAV4

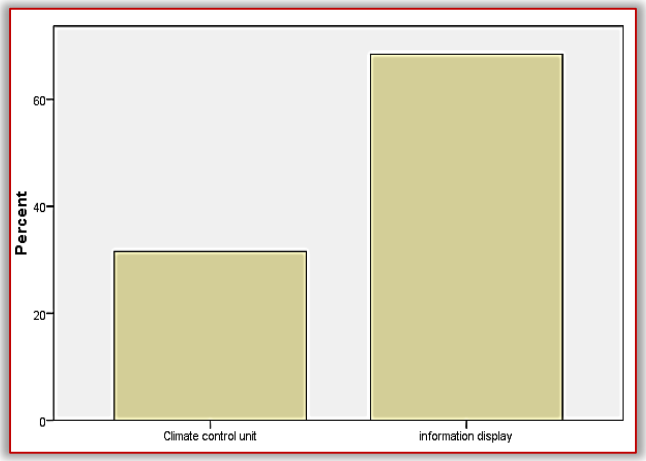

Figure 4: Comparative chart of electrical faults in Toyota Highlander

Faults commonly experienced by users of Toyota Corolla include the ABS pump, Sat/Nav display unit and the throttle body. Figure 5 shows how the faults varies. The ABS pump failure was estimated to be 39.4, Satelite navigation display unit as 30.3 and the throttle body as 30.3.

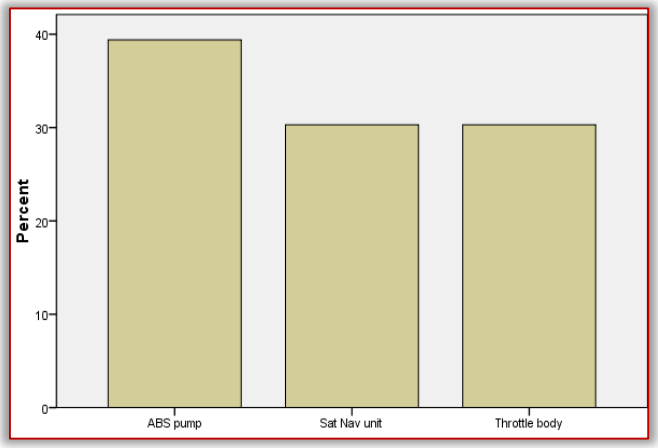

Figure 5: Comparative chart of electrical faults in Toyota Corolla

— Fault Analysis on Volkswagen

The faults commonly seen in Volkswagen Passat include the ABS pump, SRS airbag, BCM, ECU, multimedia control panel, dashboard/instrument cluster, throttle body and the hand potentiometer. The ABS pump failure was estimated to be 16.4, SRS airbag as 12.3, BCM as 9.6, ECU as 19.2, multimedia control panel as

8.2, dashboard/instrument cluster as 19.2, throttle body as 9.6 and the hand potentiometer as 5.5% as shown in Figure 6.

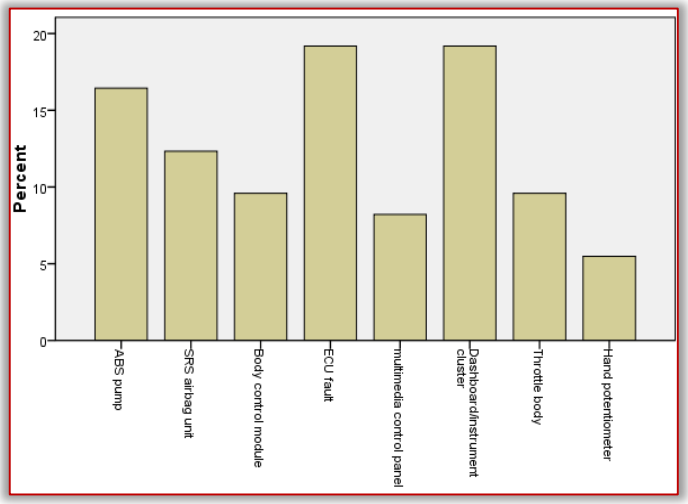

Figure 6: Comparative chart of electrical faults in Volkswagen Passat

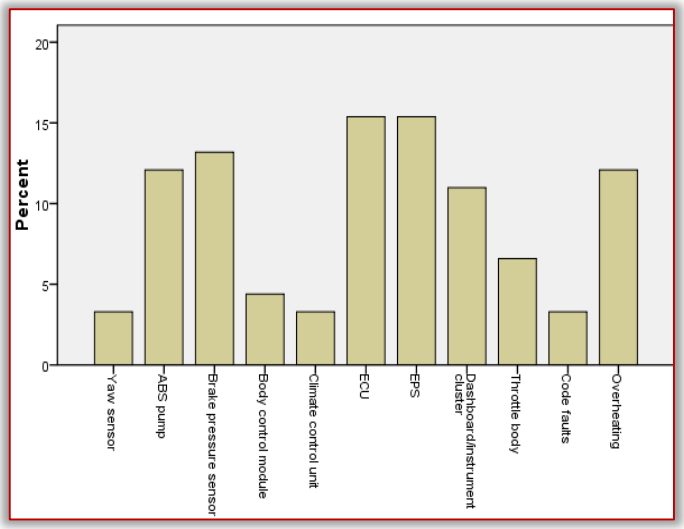

Figure 7: Comparative chart of electrical faults in Volkswagen Golf

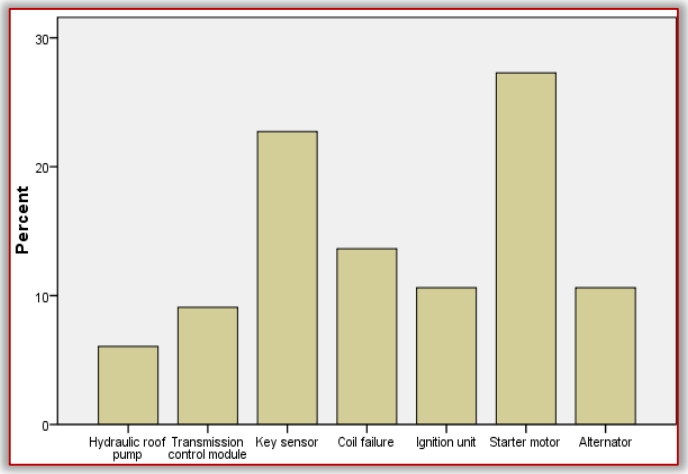

Figure 8: Comparative chart of electrical faults in Volkswagen Audi

Electronic faults common to Volkswagen Golf include the yaw sensor, ABS pump, brake pressure sensor, BCM, CCU, ECU, EPS, dashboard/instrument cluster, throttle body, code faults and overheating. The yaw sensor failure was estimated to be 3.3, ABS pump as 12.1, brake pressure sensor as 13.3, BCM as 4.4, CCU as 3.3, ECU as 15.4, EPS as 15.4, dashboard/instrument cluster as 11.0, throttle body as 6.6, code faults as 12.1 and overheating as 12.1. This detail is given by the chart in Figure 7.

Hydraulic roof pump, transmission control module, key sensor, coil failure, ignition unit, starter motor and the alternator are the faults common to Volkswagen Audi. The hydraulic roof pump failure rate was estimated to be 6.1, transmission control module as 9.1, key sensor as 22.7, coil failure as 10.6, ignition unit as 10.6, starter motor as 27.3 and the alternator as 10.6% as shown in Figure 8.

— Fault Analysis on Mercedes

Experimental results show that the ECU, airflow meter, immobilizer and key, actuator, EHPS, power steering rack, dashboard/instrument cluster, throttle body, gear control, transmission control and automatic clutch are the faults commonly associated with Mercedes A Class.

The chart in Figure 9 depicted that the ECU failure rate was estimated to be 21.0, airflow meter as 4.9, immobilizer and key as 4.9, actuator as 6.2, EHPS as 21.0, power steering rack as 4.9, dashboard/instrument cluster as 17.3, throttle body as 6.2, gear control as 4.9, transmission control as 6.2 and automatic clutch as 2.5%.

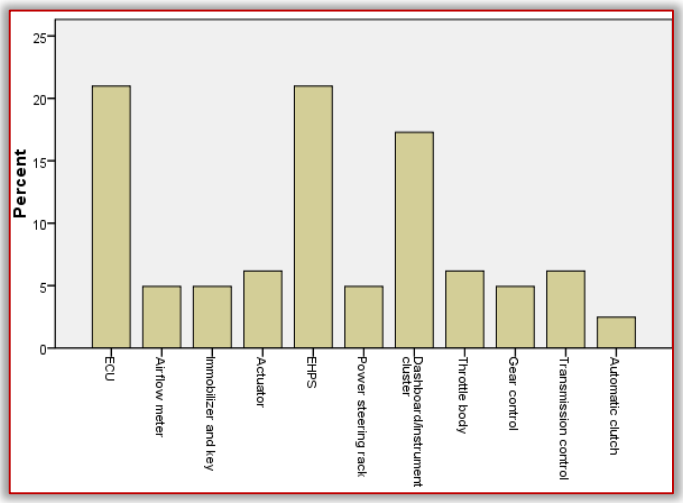

Figure 9: Comparative chart of electrical faults in Mercedes A Class

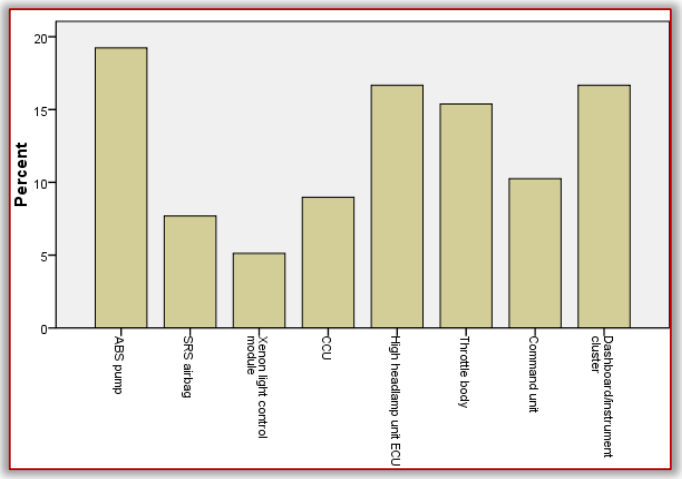

Figure 10: Comparative chart of electrical faults in Mercedes S Class

The faults commonly experienced in Mercedes S Class include the ABS pump, SRS airbag, xenon light control module, CCU, high head lamp unit ECU, throttle body, command unit and

dashboard/instrument cluster. The ABS pump failure was estimated to be 19.2, SRS airbag as 7.7, xenon light control module as 5.1, CCU as 9.0, high head lamp unit ECU as 16.7, throttle body as 15.4, command unit as 10.3 and dashboard/instrument cluster as 16.7% as indicated in Figure 10.

The faults associated with Mercedes C Class include wire expiration, fuel pump, injector nozzle, dashboard/instrument cluster and the throttle body. Figure 11 shows the wire expiration failure rate was estimated to be 5.6, fuel pump as 33.3, injector nozzle as 11.1, dashboard /instrument cluster as 35.2 and the throttle body as 14.8%.

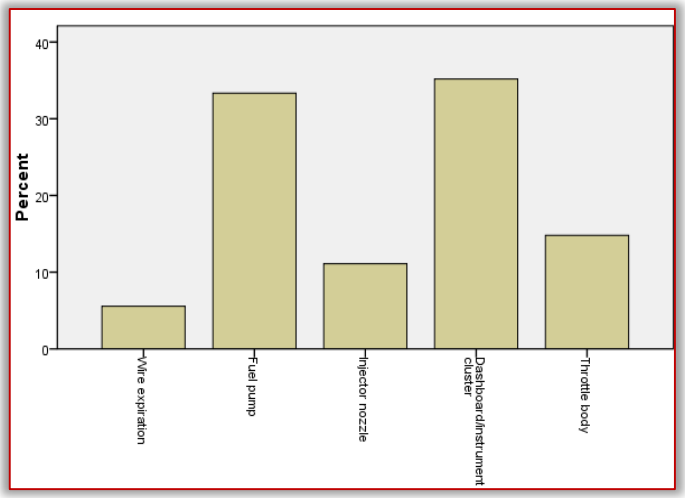

Figure 11: Comparative chart of electrical faults in Mercedes C Class

The faults common to Mercedes SL include the anti-theft security, central lock pump, BCM, climate control panel, heater control, cruise control, audio amplifier, Sat/Nav unit and dashboard/instrument cluster. According to the chart in Figure 12, anti-theft security failure rate stands at 11.4, central lock pump as 7.6, BCM as 11.4, climate control panel as 10.1, heater control as 5.1, cruise control as 5.1, audio amplifier as 15.2, Sat/Nav unit as 7.6 and dashboard/instrument cluster as 26.6%.

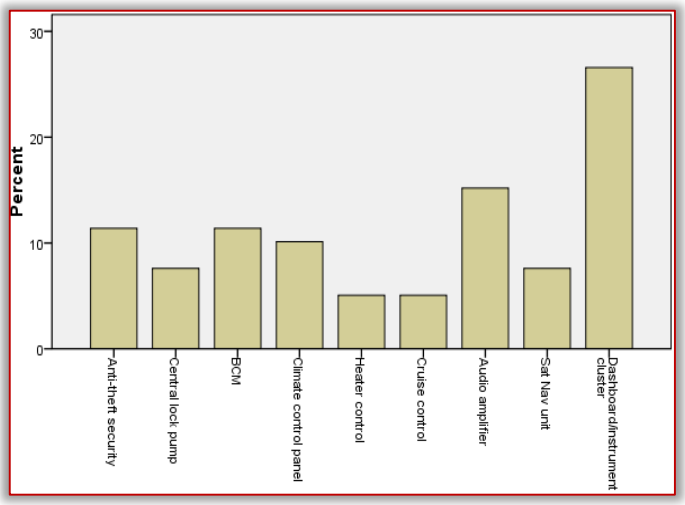

Figure 12: Comparative chart of electrical faults in Mercedes SL

— Fault Analysis on Nissan

The faults mostly experienced by users of Nissan Almera include the ABS ECU, ECU fault codes, BSI, Steering angle sensor, and EPS. The ABS ECU failure was estimated at 25, ECU fault codes as 29.7, BSI as 10.9, Steering angle sensor as 10.9 and EPS as 23.4% as shown in Figure 13.

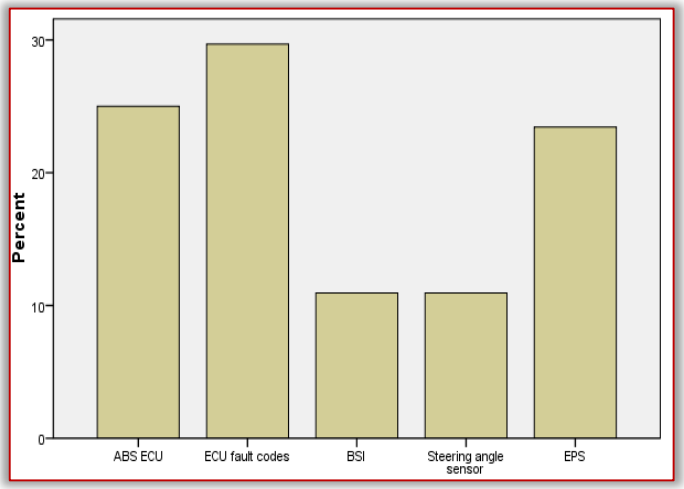

Figure 13: Comparative chart of electrical faults in Nissan Almera.

Common faults in Nissan Primera include the ECU fault codes, CCU, EPS ECU, Dashboard/instrument cluster, Sat/Nav reversing camera screen and throttle body. The chart in Figure 14 shows that ECU fault codes failure was estimated as 29.0, CCU as 9.7, EPS ECU as 14.5, Dashboard/instrument cluster as 24.2, Sat/Nav reversing camera screen as 8.1 and throttle body as 14.5%.

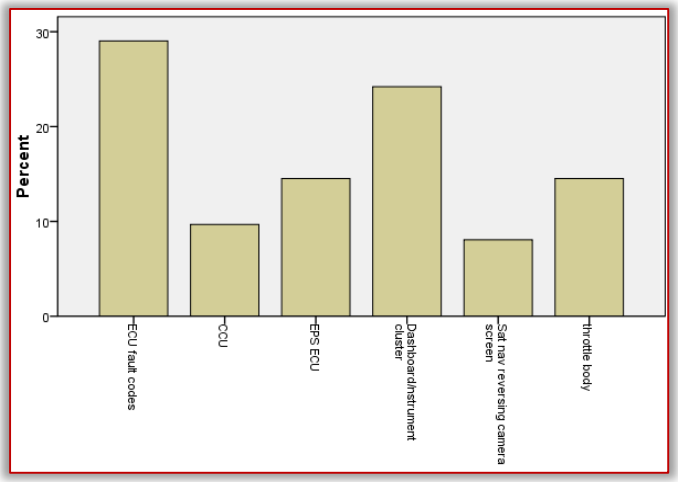

Figure 14: Comparative chart of electrical faults in Nissan Primera

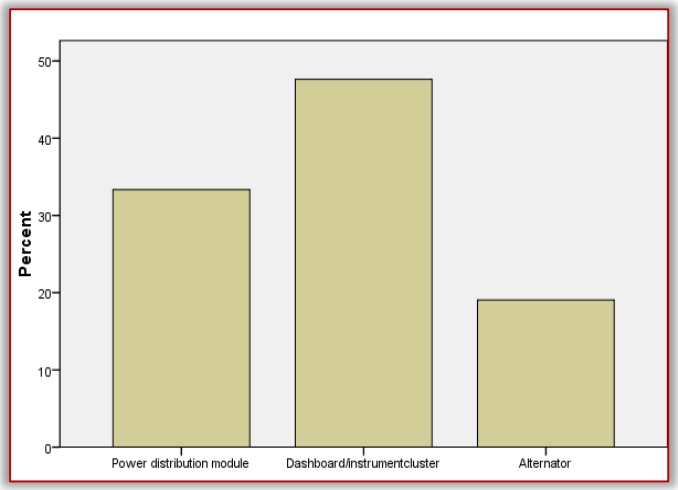

Figure 15: Comparative chart of electrical faults in Nissan Murano

Faults seen to frequently occur in Nissan Murano include the power distribution module, dashboard/instrument cluster and an alternator. The chart in Figure 15 shows that power distribution module failure was estimated to be 33.3, dashboard/instrument cluster as 47.6, and the alternator as 19.0%.

— Fault Analysis on Peugeot

Common faults in Peugeot 206 include the BSI fuse box, Heart control panel, SRS ECU, Radio, Sat/Nav unit, Roof controller, Dashboard, Display unit. Figure 16 shows the frequency of occurrence of these faults. The BSI fuse box failure rate was estimated to be 12.5, Heart control panel as 8.3, SRS ECU as 22.2, Radio as 18.1, Sat nav unit as 6.9, Roof controller as 4.2, Dashboard as 20.8, Display unit as 6.9%.

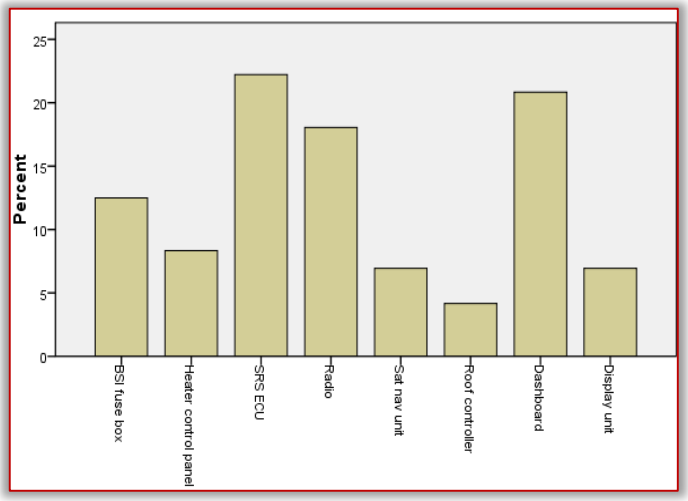

Figure 16: Comparative chart of electrical faults in Peugeot 206

The faults mostly seen in Peugeot 207 include the Roof controller, dashboard/instrument cluster, CCU, ABS unit, ABS ECU, SRS ECU. Figure 17 shows the manner in which these faults occur. Roof controller failure rate was estimated to be 9.6, dashboard/instrument cluster as 23.1, CCU as 7.7, ABS unit as 25.0, ABS ECU as 19.2 and SRS ECU as 15.4%.

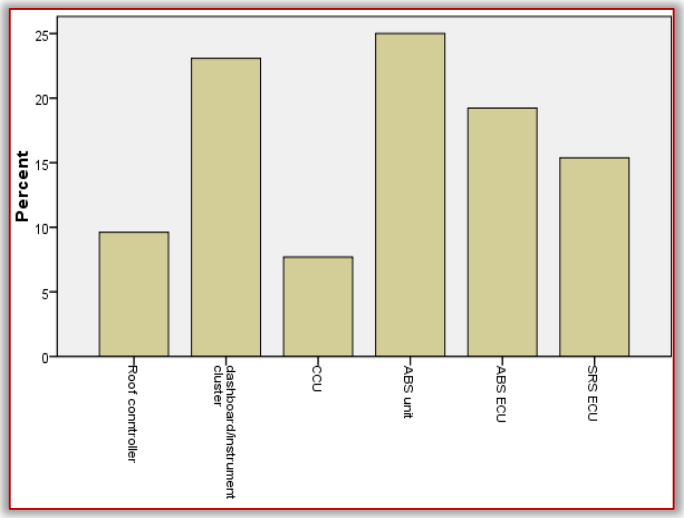

Figure 17: Comparative chart of electrical faults in Peugeot 207

In Peugeot 307, common faults are BSI, BCM unit, SRS ECU, Gear box ECU, Dashboard/instrument cluster, EHPS, Stalk control unit and Fuel pump. Figure 18 shows that BSI failure rate was estimated as 8.5, BCM unit as 9.9, SRS ECU as 9.9, Gear box ECU as 19.7, Dashboard/instrument cluster as 14.1, EHPS as 8.5, Stalk control unit as 12.7 and Fuel pump as 16.9%.

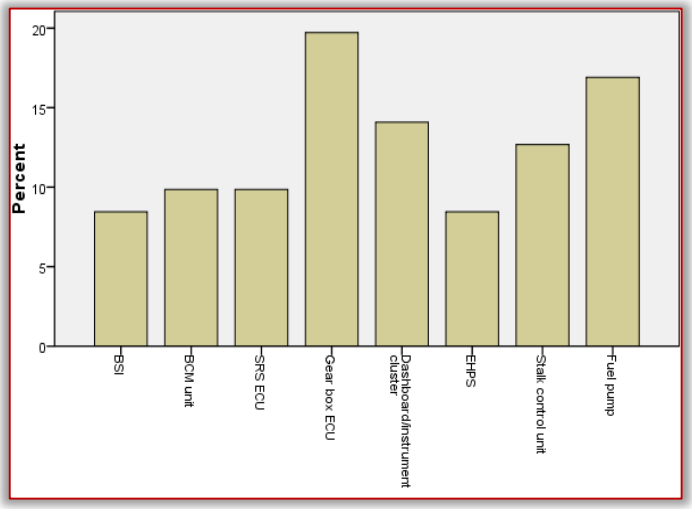

Figure 18: Comparative chart of electrical faults in Peugeot 307

CONCLUSION

This study shows the frequency of incidence of faults on electrical units in common automobile brands used in Nigeria. Electrical faults like Dashboard and instrument cluster occurs more frequently in all the five brands of automobiles considered in this study. While Yaw sensor and CCU related faults record lowest incident rate.

Dashboard and Instrument cluster have an average occurrence rate of 40%, alternator faults have an average occurrence of 40%, and yaw sensor and CCU faults as an average occurrence of 3.3%.

Besides, most of these faults have a least occurrence in Toyota brand and mostly occurs in the Nissan brand.

References

[1] Eckermann, E. (2001). The World History of the Automobile. S.A.E Press

[2] Columbia House New York, (1974). The World of Automobiles: An Illustrated Encyclopedia of Motor Car. 1. Pp.65.

[3] Jack Erjavec, (2007). Today's Technician: Automatic Transmissions and Transaxles. Fifth Edition, 353-354.

[4] Engineering Overview (2014). *Automotive Manufacturing* [online]. Accessed June 2018.

[5] Dolan J.A. (1974). Motor Vehicle Technology and Practical Work. Vol. 1and 2, Chp.30-33, Pp.575, 628,633.

[6] Singh M.D.and Joshi J.G. (2006). Mechatronics. Eastern Economy Edition, Chp.1, Pp.6.

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