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Functionality, Electrostatic Discharge and Power Quality Magnetic Analysis of the Speed Limiter Integrated Fatigue Analyzer (Slifa)

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Abstract

Safety devices of the truck and bus critically needed to minimize the possibility of road accident. There are various factors that influenced to accident such as external, attitude, over speed, fatigue and technical vehicle (maintenance shortfalls). Therefore, the objective of this research is to investigate the functionality, electrostatic discharge and power quality magnetic analysis of the Speed Limiter Integrated Fatigue Analizer (SLIFA). The dimension of SLIFA is length,width and height 154 mm x 76mm x 57 mm. The electronic simulation component was conducted by PROTEUS software. The result shows that the SLIFA successfully limit the speed through function test using simulator, on vehicle and on the road with selected speed up to 100km/h. ESD test shows all components working at various current of 0.5, 1, 2, 3 and 4 kV in both polarity. PQM result shows that no degradation of function and damage occur during the test indicated by empty step size and fail value.

Background, Motivation and Objective

The need of speed limiter and fatigue analyzer was very critical due to high fatalities caused by road accident. There are 556 fatalities from 6,231 truck and bus accident cases in Jakarta in 2015. It may contributed by drivers reckless, fatigue and other cases related to road infrastructure and attitude. Enforcement by the traffic police continues to be important step that must be carried out on drivers in order to ensure the safety of traffic to the community (Ari Sandhyavitri et al., 2017). Traffic accidents lead to losses human life, economic, social cost and maintenance or repair cost (WHO, 2015).

Currently ranked ninth leading cause of death and is predicted to be the fifth in 2030. More than one million people die in the world due to Road Traffic Accident (RTA) every year, and more than 2500 fatalities each day of 90% that occurred in low and middle-income countries (WHO, 2009). Hidayati et al., (2012) in her study to analyze the human factors that become to the existence of RTA, insufficient safety distance. There were twelve of 23 rear end crashes that caused by inadequate safety distances. The mean speed reported for these 12 RTAs was 78.6 while the mean safety distance was 4.8.

The road infrastructure in Indonesia experienced slow growth and some cities have shown the poor road maintenance. It influenced by high-density of traffic that cause higher numbers of traffic accidents (Hidayati et al., 2012 and Arowolo et al., 2014). Figure 1 shows the conditions of poor road infrastructure in some areas in Indonesia that influenced by poor conditions and maintenance of the pavement (Arowolo *et al.*, 2014).

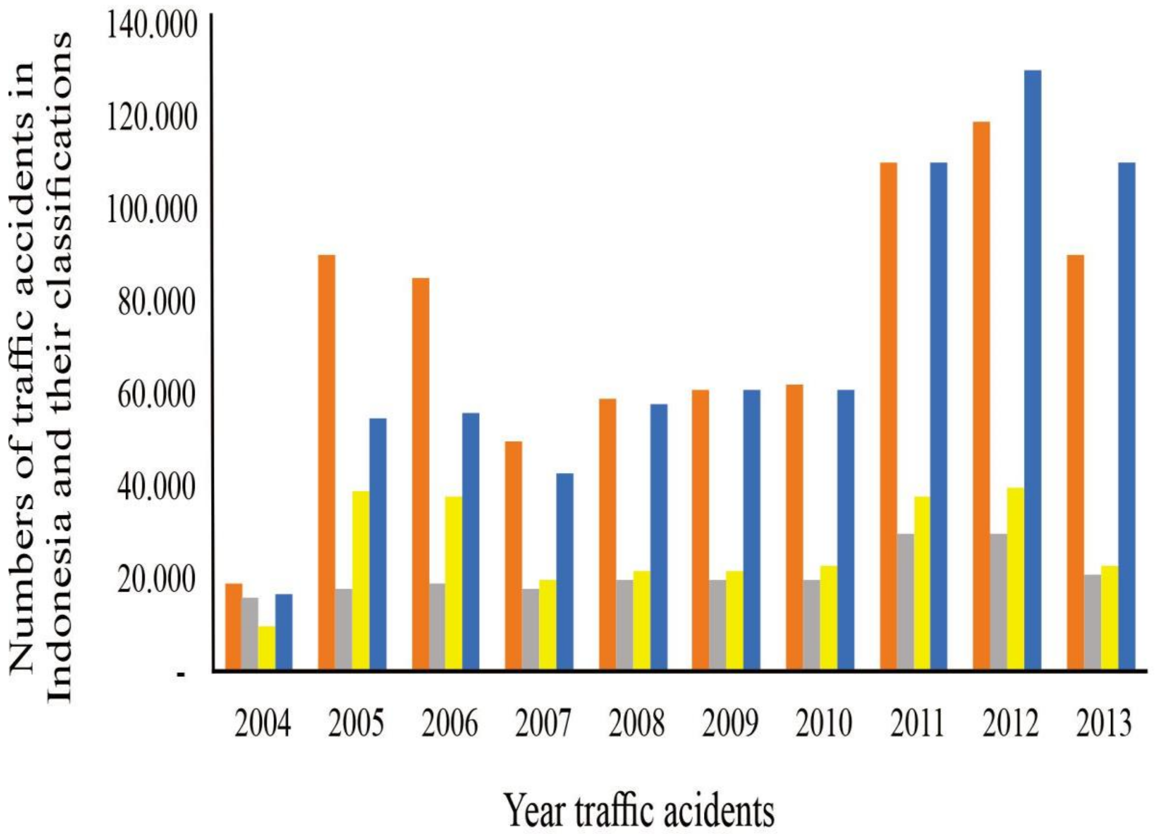

Figure 1. *Numbers of traffic accidents in Indonesia and their classifications (Hidayati et al., 2012 and Arowolo et al., 2014)*

One of the potential technologies of safety device on truck and bus is speed limiter and fatigue analyser. In current issue, the speed limiter devices and fatigue analyser was separately devices and not integrated with Global Positioning System (GPS). Therefore, it very challenging to develop the complete safety device to ensure the vehicle meet the traffic regulation and improve the driver attitude. According to Gawad and Mandourah, (2015), there are various types of speed limiter in controlling the vehicle speed such as accelerator control by cable types as shown in Figure 2 where motor will control the stroke length of accelerator pedal linkage into fuel pump, fuel breaker solenoid held the control cable, the fuel delivery termination will stop quickly and this control technique is easy to install due to it only limit a mechanical system that connected to gasoline or diesel engines.

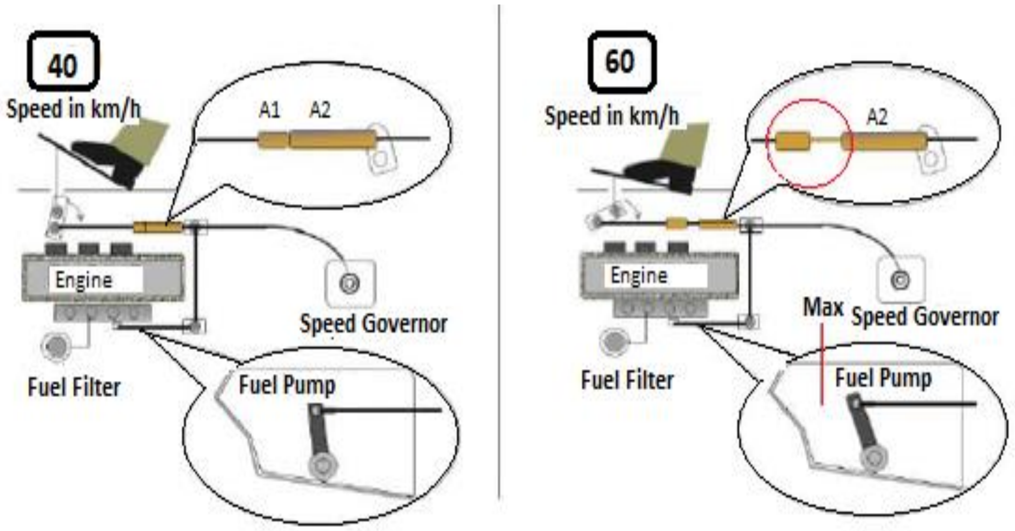

Figure 2. *Speed limiter of cable type (Gawad and Mandourah, 2015 and Mark et al., 2015)*

In modern technology, all devices need compiled with Internet of Thing (IoT) system where the IoT is foundation for connecting things, actuators, sensors, and other smart technologies, thus sustain person to object and object to object communication. The applications fields of IoT are shown in Figure 3. They include intelligent shopping, smart transportation, smart meters, smart product management, home automation, sustainable urban environment, waste management and continuous care (Limin Liu, 2018).

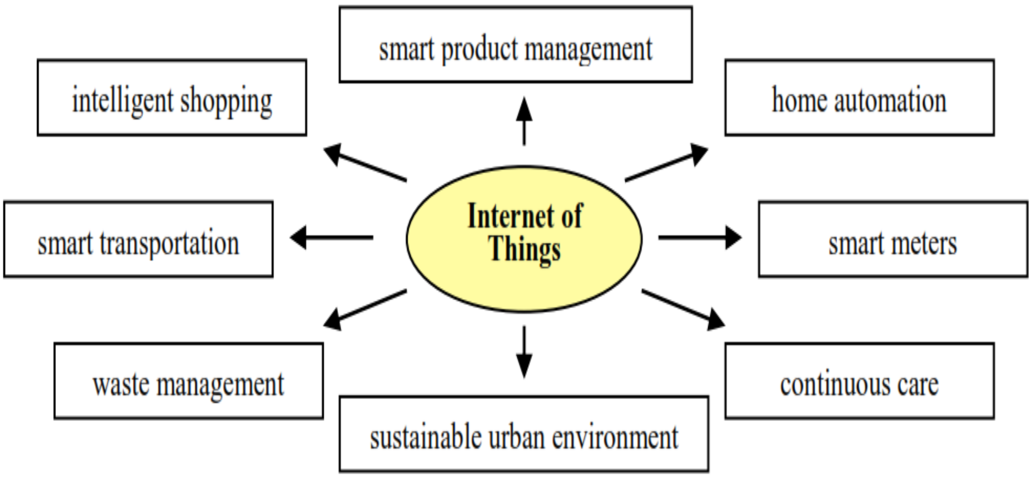

Figure 3. *Some applications of IoT (Limin Liu, 2018)*

Therefore was very challenging to develop Speed Limiter Integrated Fatigue Analyzer (SLIFA) that applied the IoT in that device. The development has been conducted by Hadi Pranoto (2016, 2017 and 2020) that the SLIFA was gradually developed and perfected by IoT system on that device. In addition, the investigation of functionality, electrostatic discharge and power quality magnetic will be conducted to analyse the performance of the SLIFA.

Methods

SLIFA development

Assembly process of the electronic component was conducted after an electronic simulation component by PROTEUS software. The electronics circuit of SLIFA engineered and rafted to control the engine stop motor operation and installed in the fuel injection pump. This circuit acted to resist the movement of accelerator cable and when installed on machine based on electronic control module (ECM), it able to compare the different resistant value in accelerator pedal with the speed sensor cable connected to the engine stop motor. Once this was done, the features were activated, and fuel not reach the engine combustion chamber. Fatigue sensors in pairs with a minimum threshold value heart rate of 50 and 100 bpm maximum, eye aspect ratio (EAR) < 5 mm/s and mount aspect ratio (MAR) > 0.8mm/s. The SLIFA have the dimension of length,width and height 154 mm x 76mm x 57 mm. The technical drawing is shown in Figure 4

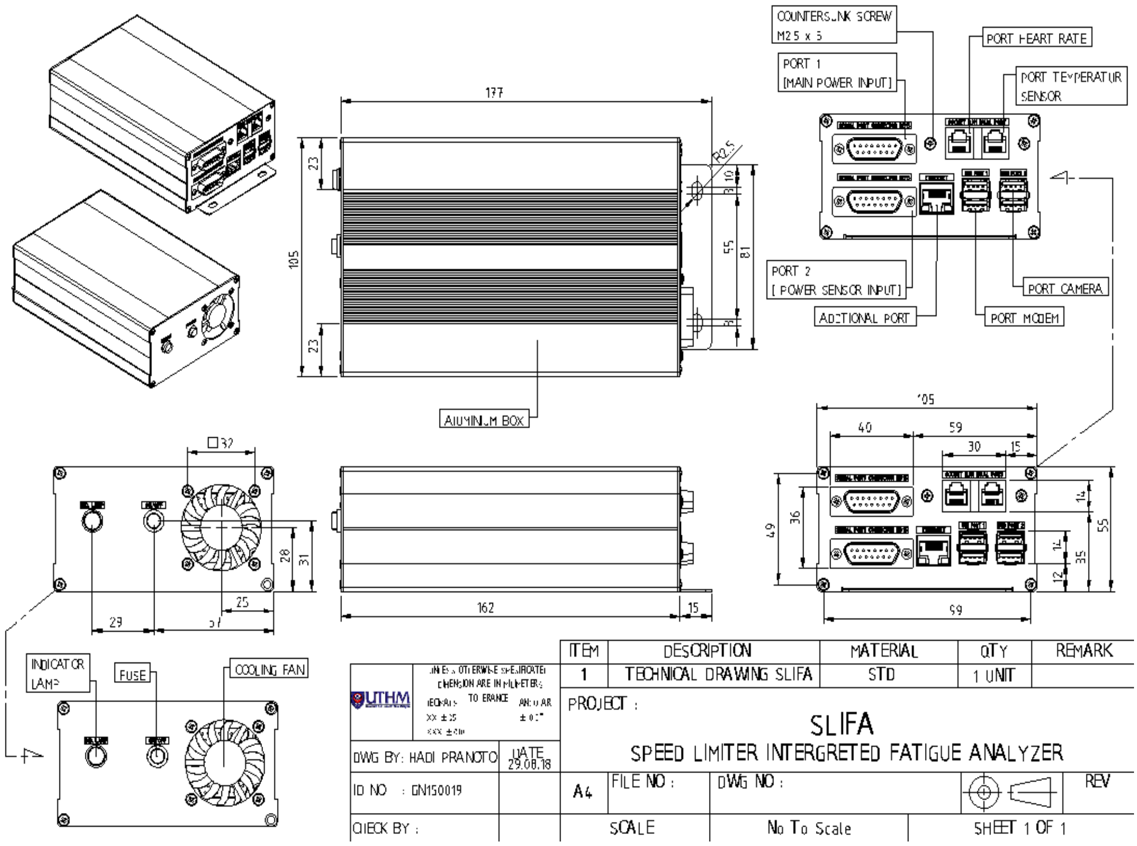

Figure 4. *Technical drawing of SLIFA device*

Functional Test

Functional test using simulator was conducted through the EUT (Equipment under Test) placed in the room and get power supply from main supply. SLIFA's speed controller was connected to simulator. SLIFA's speed limiter was set manually. Speed cut off and alarm was inspected and recorded when it was triggered in certain speed displayed on simulator speedometer.

Functional test on vehicle was performed through the EUT was placed in the vehicle and was powered by the vehicle (truck). The SLIFA's speed controller was connected to the vehicle. The truck propeller was disconnected so that the vehicle was not move during the test. The SLIFA's speed limiter was set manually. Speed cut off and alarm was inspected and recorded when it was triggered at certain speed displayed on the vehicle speedometer

Functional test on the road was conducted through the EUT was placed in the vehicle and was powered by the vehicle. The SLIFA's speed controller was disconnected from vehicle.

The SLIFA Android application was set at speed of 20 to 60 km/h in highway and 40 to 80 km/h in toll road. Alarm was inspected and recorded when it was triggered at certain speed displayed on the vehicle speedometer.

Electrostatic Discharge (ESD)

Electrostatic discharge (ESD) tests are applied to the external part of EUT. ESD tests consist of air discharge and contact discharge. ESD discharge is applied to points which are accessible by operators without the use of tools. Air discharge is applied to non-conductive parts. Whereas contact discharge is applied to conductive parts. Every test point is applied test voltages of both polarities, positive and negative, 5 times for each.

Power Quality Magnetic (PQM)

The EUT placed at table top and was at “RUNNING” condition or normal operation (speed at 37-41 km/h). The magnetic field strength is generated by passing a current through the induction coil. Testing is done on both the vertical and horizontal planes.

For horizontal testing, the EUT and induction coil are positioned such that the EUT is placed on the centre of the coil and placed on the test bench. The coil pole is positioned beside the bench, and the angle of the coil varied such that the coil tubing surrounds the middle of the EUT. The distance from the EUT to the coil tubing should be equal on all sides.

For vertical testing, the coil angle is adjusted such that the coil tubing is vertical. The distance from the EUT to the coil tubing should be equal on all sides.

Results and Discussions

Function test of SLIFA was conducted through 3 methods which is using simulator, on vehicle and on the road and that data is listed in Table 1, 2 and 3, respectively. The SLIFA was succesfully limit the speed at 30, 50, 60, 70 and 100 km/h with the average roatation speed of 488.3rpm at 30 km/h, 825.7rpm at 50km/h, 1055rpm at 60km/h, 1162.7rpm at 70km/h and 1697rpm at 100km/h. The frequency and voltage is the characteristic of the truck or bus engine when it perfomed by the SLIFA safety devices.

Table 2. *Data of function test using simulator*

No	Speed Limit Setting (km/h)	Measured			
		RPM	Speed (km/h)	Frequency	Voltage
1.	30	503	30	404.7	11.795
2.	30	481	30	398.6	11.797
3.	30	481	30	387.3	11.797
4.	50	832	50	368.6	11.797
5.	50	823	50	366.3	11.793
6.	50	822	50	363.4	11.797
7.	60	1024	60	460.6	11.794
8.	60	1117	60	466.1	11.797
9.	60	1024	60	369.7	11.796
10.	70	1149	70	370.6	11.797
11.	70	1161	70	374.5	11.798
12.	70	1178	70	377.1	11.797
13.	100	1738	100	387.9	11.793
14.	100	1680	100	407.0	11.796
15.	100	1673	100	423.1	11.797

Function test on vehicle was conducted using truc and it installed by SLIFA to analyze the performance of SLIFA. This analysis was performed before function test on the road to minimze the failure during the test. This analysis shows that the SLIFA was effective to limit the speed at 50 and 70 km/h and it begin from the alarm indicator is turn on when the speed reach the maksimal speed and speed cut off automatically limit the fuel distribution into the engine.

Table 3. *Data of function test on vehicle*

No	Speed Limit (km/h)	Speed Cut Off (km/h)	Alarm Triggered (km/h)
1	70	70	70
2	50	49	49

Function test on the road was performed in two different road area which is urban road and toll. The speed limit of urban road is varied by 20, 30, 40, 50 and 60km/h while the test in toll was set at speed limit of 40, 50, 60, 70 and 80 km/h. The aram triggered at speed of ±1-8km/h with selected speed limit. The alarm purposed to remind the driver that the vehicle speed almost reach or exceed the speed limit and the driver need to decelerate the speed or the SLIFA will automatically decelerate the speed through fuel cut off system when the drive not decrease the speed.

Table 4. *Data of function test on the road*

No	Position	Speed Limit (km/h)	Alarm Triggered (km/h)	Gap (km/h)
1	Urban Road	20	28	8
2	Urban Road	30	33	3
3	Urban Road	40	48	8
4	Urban Road	50	54	4
5	Urban Road	60	64	4
6	On Toll	40	44	4
7	On Toll	50	55	5
8	On Toll	60	61	1
9	On Toll	70	72	2
10	On Toll	80	80	0

The electrostatic discharge (ESD) test was performed in two sides which is contact discharge and air discharge. Contact discharge consists of casing bolts, fan bolts, VGA port and indicator lamp while air discharge consists of USB port, antenna port, RS232 port 1 and RS232 port 2.

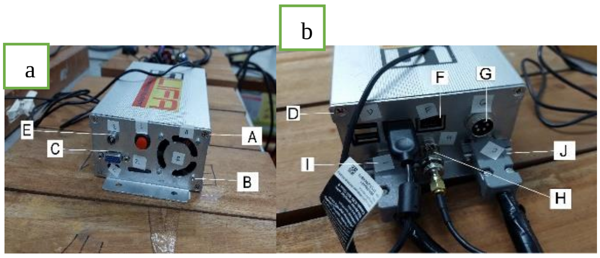

Figure 5. A: *contact discharge and b: air discharge*

ESD test was conducted at tempearture of 26,8 °C, humidity of 56%, DUT supply frequency of 50 Hz. and the result of ESD test is listed in Table 5. The result shows that all SLIFA components was succescfully work at various current of 0.5, 1, 2, 3 and 4 kV with 5 times repetition and on both polarity. Therefore, the SLIFA was pass the ESD test and it safety to perform and installed on the engine. It means that no degradation of function and damage occur during the test

Tabel 5. *The data of ESD test*

SLIFA	n-Times each location	0.5 kV		1 kV		2 kV		3 kV		4 kV	
		Polarity									
		+	-	+	-	+	-	+	-	+	-
Casing bolts	5	√	√	√	√	√	√	√	√	√	√
Fan bolts	5	√	√	√	√	√	√	√	√	√	√
VGA port	5	√	√	√	√	√	√	√	√	√	√
USB port	5	√	√	√	√	√	√	√	√	√	√
Inidicator lamp	5	√	√	√	√	√	√	√	√	√	√
LAN port	5	√	√	√	√	√	√	√	√	√	√
5 pin male connector	5	√	√	√	√	√	√	√	√	√	√
Antenna port	5	√	√	√	√	√	√	√	√	√	√
RS232 port 1	5	√	√	√	√	√	√	√	√	√	√
RS232 port 2	5	√	√	√	√	√	√	√	√	√	√

Power Quality Magnetic (PQM) test was performed in two position which is horizontal and vertical. The Horizontal position was analyzed using various parameters of frequency of 50 Hz, coil type of 4 Amp--> C.F 1.04, and in Horizontal position, temperature: 25,7^{0}C and humidity of 51%. Meanwhile, in vertical position use a different parameters in terms of temperature of 26.8^{0}C and humidity of 50%. The data of PQM analysis in horizontal and vertical position is listed in Table 6 and 7, respectively. The results shows that in static operation and in field parameters from 1A/m indicate no degradation of function and damage occur during the test due to no step size and fail valued appear during test. It can be concluded that the SLIFA have not issue on its electrical components.

Table 6. *Data of PQM test in horizontal position*

Parameter	Operation	From	To	Step size	Fail value
Field	Static	1A/m	---	---	---

Table 6. *Data of PQM test in vertical position*

Parameter	Operation	From	To	Step size	Fail value
Field	Static	1A/m	---	---	---

Conclusions

SLIFA as safety device that purposed to limiting the speed and detecting fatigue that integrated with IoT was developed. The analysis regarding function, ESD dan PQM has been investigated and the result shows that the SLIFA effective to limit the speed of 60km/h in urban road and 80km/h in toll road. ESD dan PQM analysis shows that all the SLIFA components have no degradation of function and damage occur during the test

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